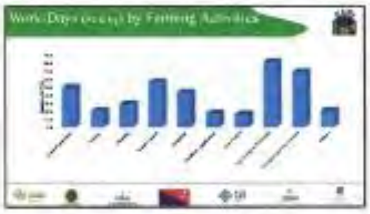
Appendix 2b

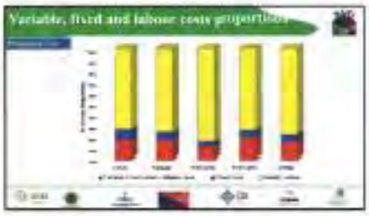
Assessment of labour use and costs and returns in vegetable production in Rigo-Koiari


LIMITATIONS
Low Literacy Level - farmers
Planned Bi-Weekly farm visits were at times affected
SOME harvests have been estimated

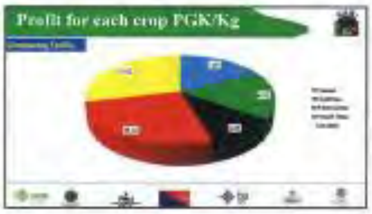

Average Work-days of Vegetables


by Farming Activities


Average Work-days (Tomato)


Variable, fixed and labour costs proportion


Unit Production Cost of Vegetables


Profit for each crop PGK/Kg


Methodology: Sampling (Part B)
Tape Measure
Weighing Scale
Watch
Data recording sheets
Desk Calculator
Digital Camera
SPSS 17.0
Microsoft Excel


Profit and Unit Production Cost (PGK/Kg)


Economic Benefits


Economic Benefits

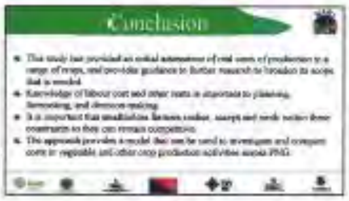

Economic Benefits


Economic Benefits


Economic Benefits


Summary
This study is the first of its kind in vegetables, and results are from interviews and surveys of farmers in one district.
The cost of production for the crops surveyed varied from crop to crop due to farmers sharing cost
Zucchini with the lowest production unit cost K0.38/kg and Capsicum high PGK5.24/Kg while profitability, Zucchini with the highest K11.62/kg and watermelon low PGK4.25/kg.


Recommendation
Develop standardized grading for vegetables i.e Communication material to increase knowledge and awareness of farmers.
Average figures may change as time elapses due to new farming technologies adopted, population increases and improved infrastructure.


Conclusion
Knowledge of labour cost and other costs is important to planning, forecasting, and decision making
The approach provides a model that can be used to investigate and compare costs in vegetable and other crop production activities across PNG.


Thank You

APPENDIX III

SMCN/2008/008 Increasing vegetable production on Central Province, Papua New Guinea, for Port Moresby Markets

PUBLICATIONS, PRESS ARTICLES and TRAINING MATERIALS

(August 2010 to June 2015)


TASMANIAN INSTITUTE OF AGRICULTURE

and

PARTNERS

in

SMCN/2008/008 Increasing vegetable production on Central Province, Papua New Guinea, for Port Moresby Markets

PUBLICATIONS, PRESS ARTICLES and TRAINING MATERIALS

(August 2010 to June 2015)


C. J. Birch

Project Leader 28/8/15

NOTE TO READERS

The copies of publications in this compendium are outputs from the ACIAR funded project SMCN/2008/008 Improving vegetable production in Central Province, Papua New Guinea for Port Moresby Markets. They represent a range of outputs from contributions to scholarly journals to press articles in print and electronic media. These are provided in good faith, however, some report on progress (especially the non-refereed documents), rather than final results, so where similar materials appear in two documents, the later dated document should be used as the authorative source.

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Please note: Manuscripts that have been submitted are included and noted as such.

Scholarly Journals

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Refereed Conferences

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Sparrow, L., Birch, C., Boersma, M., Doyle, R., Bonney, L., Kambouo, R. and Kapal, D. 2011 The role of soil organic matter additions in viable, sustainable temperate vegetable value chains in Central Province, Papua New Guinea: a short review. International Symposium on Organic Matter Management and Compost Use in Horticulture, Adelaide, April 2011. **148**

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Palaniappan, G., Birch, C., Chambers, B. and Bonney, L. 2011 Strengthening local vegetable production in Papua New Guinea using value chain analysis. Farming Matters Magazine (online) http://www.agriculturesnetwork.org/magazines/global **186**

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Birch, C., Sparrow, L., Bonney, L. and Doyle, R. 2011. Increasing vegetable production in Central Province, Papua New Guinea (PNG) to supply Port Moresby markets. p37 in Scott, J. (Ed) Research Development and Extension in the Vegetable Centre: sustaining vegetable production in vegetable and allied industries in Tasmania., Proceedings of the 2011 Tasmanian Institute of Agricultural Research Vegetable Centre Industry Communication Forum, 14th July 2011, Longford, Tasmania. University of Tasmania, Hobart. **191**

Palanappian, G., Bonney, L., Chambers, B. and Birch, C. 2011. Chain members perception of vegetable value chains in Papua New Guinea (PNG) p38 in Scott, J. (Ed) Research Development and Extension in the Vegetable Centre: sustaining vegetable production in vegetable and allied industries in Tasmania., Proceedings of the 2011 Tasmanian Institute of Agricultural Research Vegetable Centre Industry Communication Forum, 14th July 2011, Longford, Tasmania. University of Tasmania, Hobart. **192**

Training Manual

Journal articles

Local capacity building through Transformational Learning – PNG Case Study

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Keywords: Capacity building, action research, training needs, Papua New Guinea

Abstract

Small farmers in Papua New Guinea (PNG) have long practiced subsistence farming that involves simple, labour intensive technologies using limited capital and few purchased inputs, and continue to do so due to poor transport infrastructure and lack of market information. Consequently, productivity, income and return on labour have been low leading to poverty and food insecurity. In the work reported, the traditional approach of improving farm income by increasing production and productivity solely through technical capacity building of small farmers was not followed. Instead a mixed method approach was used by establishing value chains, and engaging actors in the chain involved in production, processing, transport, marketing and consumption and by using visual methods of identifying training needs of smallholders to enhance their capacity to participate. The challenges that small farmers faced were identified in a training needs workshop, using visual ethnographic techniques. Specific training needs were identified as horticulture production, business management and marketing. Small farmers from the Central Province were trained to improve their capability to capitalize opportunities in the value chain. This paper focuses on transformational learning theory and methods that contributes to instrumental (skills and knowledge) learning and communicative understanding (about values and beliefs), and how it was applied in the socio-economic context of PNG.

INTRODUCTION

Papua New Guinea (PNG) has a population of 6.7 million. Traditional, rural subsistence style of living is common for more than 80% of the population, but is under threat from the rapidly increasing population placing pressure on land resources. Allen & Bourke (2001) argue that the rapid increase in population will become a long term threat to the subsistence lifestyle coupled with land degradation and low income of the rural population. Short term threats identified include environmental factors such as excessive rainfall and droughts. These threats are likely to disadvantage people who are heavily reliant on agriculture for their living.

This includes small farmers in Papua New Guinea (PNG), practicing subsistence farming that involves simple labour intensive technologies using limited capital and few purchased inputs. Also contributing to persistence of subsistence agriculture are poor transport infrastructure and lack of market information. The small farmers farm on customary lands that are owned by clans, this also limiting their access to capital from banking institutions. The customary lands provide the ability of local communities to continue access to food, water and shelter for survival but do not foster effective control over land or natural resources (Tararia and Ogle 2007). This has slowed down agricultural growth in the country (National Department of Agriculture and Livestock (NDAL), 2007). Isolation and remoteness have prevented access to services to improve production and marketing in Papua New Guinea (Willson and Bourke 1976). Gibson and Rozelle (2002) state that incidence of poverty doubles for those who live 60 minutes on foot (which could represent only a few kilometres) from the nearest formed road. Consequently, productivity, income and return on labour have been low leading to low cash income, poverty and food insecurity (Cate et al. 2009). To address this complex issue the project aimed to bring practice change in farmers from production to markets by following action research framework (Dick 2004).

MATERIALS AND METHODS

Action research is a methodology which has two aims as follows (Dick 2004):

- an action aim (to bring about change in some community or organization or program or intervention) and
- a research aim (to increase knowledge and understanding on the part of the researcher or the client or both, or some other wider community).

To bring practice change in small farmers in PNG, the challenges that small farmers faced were identified by the research team in a training needs workshop, using visual ethnographic techniques. As an outcome of the training needs workshop specific training needs were identified as horticulture production, business management and marketing supports (Palaniappan, Chambers et al. 2013). The research team constituted staff from Australia, National Agriculture Research Institute (NARI), Fresh Produce Development Agency (FPDA). This paper focuses on training, applying transformational learning theory and associated a method that contributes to instrumental (skills and knowledge) and communicative understanding about values and beliefs, and how it was applied in the socio-economic context of PNG.

RESULTS AND DISCUSSION

Following action research framework (Dick 1992), trainings were provided to bring change in practice in small farmers in PNG. The trainings needs were identified prior to delivering the training using visual ethnographic techniques. Small farmers from Rigo/Koiari, Sogeri and Tapini identified Business Management, Horticulture Production, Post harvest and Marketing as their training needs.

Training was provided on Business Management, Horticulture Production and Marketing for 28 male participants from Rigo/Koiari especially farmers affiliated to the Rigo/Koiari Cooperative Association, Sogeri and Tapini in the first week of August 2013 at the National Agriculture Research Institute (NARI), Port Moresby. The training was facilitated by the Australian research team, Fresh Produce Development Agency (FPDA) and NARI staff.

In the training, opportunities were provided for integrated and inclusive thinking and decision making by participants (as proposed in Franz 2003) through mixed methods including lecture mode with technology (power point presentation), problem solving activity and purposeful talk to examine and evaluate issues in village based small groups and whole group and experience real life situations like interactions with banking and marketing institutions. The trainers took a teacher-learner centred approach rather than an exclusive learner centred approach (Mezirow 1991; Mezirow 2000).

Business Management and Financial Literacy training module

The training began with basic financing and book keeping topics, which included topics such as income, expenses, savings, cash flow, profit, loan, record keeping and business planning. Tok Pisin, a local language widely spoken in PNG village communities was used during instruction and participants were encouraged to use Tok Plas in their small group work.

1. Whole group activity to understand household income and expenditure After giving an overview of the training, an exercise to understand where the income was coming from, where it was spent and distinguishing needs and wants was completed on the power-point (Table).

The discussion was undertaken in a large group with men from Rigo-Koiari (in the coastal lowlands south east of Port Moresby and Tapini, a highland location to the north west of Port Moresby. The different sources of income could be categorised as produce sales, social obligations and labour. The household income generated through selling can be further categorised as growing and selling (pigs, garden produce, and coffee), collecting and selling (betel nut and fuel) and catching and selling (fish). Social obligations like bride price and compensation were also mentioned as sources of income (Table).

Participants listed their expenses to meet physiological needs (food, education, health, production cost, transport) and needs for love, affection and belongingness (funeral, flex cards for mobile phones) (Maslow 1954) (Table). Security needs like saving money for future was discussed during the session on savings, concurring with the views of Bourdieu (1984) that at low level income the choices made by individuals focus on the primary needs.

Distinguishing wants from needs was discussed to encourage participants to understand opportunities to save money to reinvest in their businesses. As a result, participants listed their wants as bride price, beer, gambling and, social expenses. Although participants stated that social obligations like bride price can be considered as want rather than a need, they also agreed that one cannot ignore or avoid these expenses. This agrees with Bourdieu’s (1984) views on social structure on habitus, where individual’s behaviour is unconsciously constructed from the social structure. Participants mentioned that beer and gambling as wants and they could avoid these expenses if they so chose. Clothes and Flex cards for mobile phones were debated and it was concluded that they can be both need and want.

Taylor (2000) reports that in transformational learning, expression and recognition of feelings of participants will allow critical reflection. In this activity participants’ underwent self examination and expressed their dilemmas on social obligations which can be both income and expenditure in the social system. The facilitator also provided a safe and trusting environment that allowed participants to reflect on their actions like expenses on beer and gambling. This shows that the facilitator provided favourable situation for self examination questioning their values and beliefs to achieve transformational learning (Cranton 1997; Taylor 2000).

2. Village based small group activity on income generation Small village based groups from Rigo-Koiari, Tapini and Sogeri were given exercises on income generation activity. Participants were asked to form village based groups and choose a farm activity that they thought was profitable for them. Each group worked on writing cash flow for an income giving activity. The members of the group showed enthusiasm and interest in the discussion and were keen to make their village based group activity outstanding when presenting to the larger group. As reported by Mezirow (1990) and Taylor (2000) groups were provided with opportunities for new ways for income generation.

The Sogeri group worked on the cash flow based on income from their gardens, the Tapini group presented their case study on Pigs, and the Rigo-Koiari group mentioned that their costs of rearing pigs were less than reported by the Tapini group. The Rigo-Koiari group let the pig feed on the bush or garden and also used family labour, whereas the Tapini group have to buy pig feed as not enough feed was available from the bush. This tested the assumptions of participants from Tapini and Rigo-Koiari as how best they could manage their resources to improve their income from pigs. This process of testing their practice assumptions through group based activity promoted new ways for income generation (Mezirow 1990; Taylor 2000).

3. Village based small group activity on savings Small village based groups from Rigo-Koiari, Tapini, Hiri (near Sogeri), Sogeri were given exercises on savings. Participants were asked to explain the purpose of savings. All groups mentioned that the purpose of saving was to manage unexpected income, unexpected disaster, school fees, security, and emergency situation, and agree with the security needs discussed by Maslow (1954). The informal methods to save money mentioned were safe place in the house and lending to wantoks. Participants were asked to state the risks involved in the current method of saving thereby allowing the participants to rationalise and reflect on the consequences of their current practices (Mezirow 1991; Mezirow 2000). Firstly, stealing was mentioned as a risk. Secondly, fire accidents could burn down the house and as a result the savings is at a risk. Thirdly, lending to wantoks also involves risk as they might not return the money which could cause serious disputes and loss of lives. The facilitator then introduced the formal method of saving in the banks and also mentioned the benefit of gaining an interest on saving money. Participants were also asked to state the risks involved in the formal method of saving money in the bank. Most participants stated that there would be minimum or no interest for their savings, deductions on administration and money withdrawals from the bank. Some of the participants from Rigo-Koiari mentioned that they had to have bank accounts in order to sell their produce to a Supermarket so that the Supermarket could credit the money for the produce supplied. Participants from Tapini expressed their concerns of operating through banks as they are a considerable distance from Port Moresby with poor transport and other infrastructure. A readiness to change was created through purposeful talk to participants by examining and evaluating the informal and formal methods of credit systems.

4. Participants experience real life situation by meeting banking institutions At this stage the Bank of South Pacific (BSP) guest speakers attended to observe the group at NARI. BSP guest speakers explained different options to operate their bank accounts. Nationwide Micro Bank (NMB) guest speaker joined the group and briefed about their service to farmers and small business people. The purpose of inviting NMB guest speakers was to provide participants with choices of service providers. Mobile Phone banking was explained to participants. Majority of participants were hesitant to open an account before they experienced the real life situation of speaking with guest speakers from the bank. Subsequently, some participants opened their bank account. This demonstrated that mixed methods (Taylor 2000) of purposeful talk to participants by examining and evaluating the informal and formal methods of credit systems coupled with the real life experience (Mezirow 2000) changed the attitude of participants. It also concurs with Mezirow’s (2000) views where participants went through dilemmas about the choice of saving through formal or informal system. Participants had the opportunity to validate their new perspective with other participants operating through a formal system (bank). Finally, an opportunity to action on the new perspective was provided through the banking institutions.

Horticulture production

The second session was on horticulture production that included topics on soil management, crop rotation, fallowing, irrigation, manuring and crop protection. A power-point presentation was given as an overview of the module and printed manual was provided to participants. A variety of activities from whole group activities to small group and paired work, with individuals allowed respondents to improve their learning (Mezirow 2000; Taylor 2000). The demonstrations provided opportunity for participants for hands on activities that fostered instrumental learning (skills and knowledge) and built competence and self confidence in their roles.

1. Village based small group activity on production Small village based groups from Rigo-Koiari, Tapini, Hiri and Sogeri were given an exercise to list the crops grown and reflect on their current practices in regards to fallow, intercropping, crop rotation and mulching that were presented to them by the trainer. The most common practice followed in all villages was leaving the garden fallow for 2 to 3 months. Intercropping was practiced in Rigo-Koiari more commonly compared to other villages with vegetables like banana, pineapple, tapioca, yam, taro and KauKau. Crop rotation was practiced in Tapini and Sogeri with banana and Kaukau respectively. Mulching was practiced for a few crops like taro, yam and tapioca in Rigo-Koiari and taro, banana and kaukau in Tapini to control weeds. The purposeful talk to participants allowed the introduction of new practices like soil management through composting, weed management through mulching and irrigation techniques. The group exercise allowed participants to reflect on their current practices (Mezirow 2000) and plan to incorporate new techniques based on their instrumental learning.

2. Demonstrations on production Visual representation of how to manage pest using local resources like chillies as bio-pesticides or insect repellents, was demonstrated by a guest speaker from NARI. The guest speaker also explained that any local resource like tobacco leaves, neem seeds and bark could also be used as insect repellents. This method of explaining why and how they function as pest repellent allowed participants to think what would work best in their fields.

The speaker cautioned about handling inorganic and organic pesticides and showed best practices of protective clothing to avoid any contact to prevent harmful effects. Problem solving activities including identification of pests and diseases was conducted. Participants actively engaged in demonstrations as they experienced hands on learning. Posters on biological control were displayed for participants at the demonstration site as a reinforcement of the activity.

Another speaker from NARI conducted a demonstration on composting. Composting was very effective and the hands-on building of a ‘barni compos’ was appreciated by all the men and is evident that participants will be able to replicate this practice back in their villages. The participants observed the status of compost on the last day of training.

Participants were driven to Sogeri to view vegetable trials conducted by NARI and efficient irrigation technique using drum was demonstrated.

Marketing

The trainer encouraged active learning through oral presentation and whole group discussions on where they sell their produce and what they practiced to attract consumers.

1. Whole group activity on where they sell their produce Participants were encouraged to tell their views on the differences between supermarket (market managed by private sector) and Wet Market (market managed by Government). The majority of the participants were selling their produce in the wet market or on the road side market (opportunistic stalls). Participants agreed that the supermarkets paid a higher price, had better quality and was purchased in kilograms compared to the road side or government managed markets, where good and bad quality could be sold and a price per piece was practiced. This exercise tested participants' actions based on habits of selling surplus produce in opportunistic stalls or wet markets rather than aiming for higher profits through quality produce as discussed by Bourdieu (1984).

2. Whole group activity on how they sell their produce Following the exercise on where they sell their produce, participants were encouraged to tell their views on what they practiced to attract consumers in the wet market. Participants stated that they kept produce fresh (by sprinkling water), arranged and graded visibly so consumer can see difference, good quality, kept their allocated portion of the market clean and tidy, presented themselves well to impress customer, kept talking to get attention, and use of nominal price.

CONCLUSIONS

Mixed methods of learning, from formal instruction to group work and practical, simulations and hands-on activities fostered instrumental and communicative learning that could lead to transformational learning. Whole group activities and village based small group activities allowed participants to undergo self examination and explore options for new ways of acting. Demonstrations and hands on learning activities built self confidence and competence in their new roles. For instance during training on crop production, men were engaged by the hands on process of building a 'barni compos' and said they would replicate this process when they returned home. Participants agreed to keep record on the cost and benefit to understand and plan for the future. Participants agreed that all the profit obtained during the crop season must not be spent but some amount need to be saved to re-invest in their business. It may be concluded that creating opportunities for learners to self examine, explore options for new ways of acting and facilitating to build competence and confidence in the new roles can result in capacity building.

ACKNOWLEDGEMENTS

The authors wish to acknowledge men participants who agreed to participate in the training. The financial support of the Australian Centre for International Agricultural Research for this research is gratefully acknowledged.

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Tables

Table I Whole Group Activity on House hold Income and Expense to differentiate need and want

	Household Income					Expense	
		Selling	Social obligation	Labour		Need	Want
1	Pig	x			1 School fees	x	-
2	Garden Produce	x			2 Bride Price		x
3	Betel Nut	x			3 Transport fare	x	-
4	Fish	x			4 Funeral	x	-
5	Coffee	x			5 Beer	-	x
6	Fuel	x			6 Gamble	-	x
7	Bride Price		x		7 Clothes	x	x (Plenty)
8	Compensation		x		8 Food	x	-
9	Work Contract			x	9 Production cost	x	-
					10 Hospital	x	-
					11 Social Expenses	-	x
					12 Flex cards for mobile phones	x	x

An Integrated Approach to a Vegetable Research, Development, Extension and Training Project in a Developing Country, Papua New Guinea

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Keywords: project design, project implementation, resources, socio-cultural

Abstract

Vegetables are a major part of the diet in Papua New Guinea (PNG), and demand for temperate vegetables is growing from the emerging middle class and increasing expatriate population. In 2010 we began a number of research, development, extension and training activities (RDE&T) aimed at increasing the capacity of smallholders near Port Moresby to meet this demand. Rapid value chain analysis (RVCA) and appreciative enquiry (AI) methodologies were used to identify priority activities for production and resource management research, the locations for such research, and activities to improve value chain performance. AI also revealed socio-cultural constraints and needs for training of participants in the value chain, in particular training of youth and women in production and marketing activities. Production research concentrating on resource assessment, adaptation and performance of selected temperate vegetables were undertaken over three years in contrasting environments in Central Province. Training to meet identified needs of key demographic groups (women and their daughters, men and their sons) was designed and implemented. This paper describes the processes used in designing this project and discusses how they can be applied in scoping, designing and implementing any RDE&T project in a developing country.

INTRODUCTION

Papua New Guinea (PNG) remains predominantly rural, with people obtaining a large proportion of their food requirements from subsistence production on customary (community) land producing predominantly vegetables. However, yields per unit area are declining. Suitability of land resources, land management, soil fertility decline, pressure on land and renewable resources from population increase, pests and diseases and lack of market information are some of the major constraints limiting vegetable production. Also, there has been long-standing concern about fresh food supplies to the PNG capital, Port Moresby. Food importation symbolises external dependence (Benediktsson 1998) as is evidence that PNG production is inadequate (Liripu 2008).

It is often proposed that an integrated multidisciplinary approach is appropriate to resolve complex problems involving multiple areas for research and intervention. However, the intended benefits of multidisciplinary approaches are rarely optimised, perhaps because boundaries of systems and their component sub-systems are either inadequately defined or their overlap (intersection) not recognised. This can be overcome by use of the Value Chain Analysis (VCA) approach, a systems approach that helps to 'drive integration'. VCA identifies where consumer value is created and destroyed (waste) in a value chain, and then prioritises bio-physical, economic, institutional and social changes that will improve value creation and waste reduction (Bonney et al, 2007). A common outcome of VCA in developing countries is the need for smallholder farmers to collaborate to achieve critical mass and continuity of supply to enable them to benefit from emerging modern retail food markets ((Louw et al. 2009,The Nielsen Company 2012). This frequently improves market dynamics and infrastructure, and practices of local retailers (Reardon & Berdegué 2008).

This paper describes the use of an integrated approach to deliver a project to improve vegetable production in Central Province of PNG during 2010 to 2014, its implementation, what worked effectively and where improvements could be made.

PROJECT IMPLEMENTATION

Initial Stages of Research – Defining the Project Scope

RVCA was used in a scoping study (Birch et al 2009) to identify market preferences, resource and production limitations, post farm gate influences on final product quality, and infrastructure, socio-economic and marketing constraints. The scoping study included consultation with PNG agencies including the National Agricultural Research Institute (NARI), Fresh Produce Development Agency (FPDA), Pacific Adventist University (PAU), Central Province Administration (CPA), agribusiness and marketers and farmers. The findings of this study were used to develop the substantive research project, as a significant number of researchable topics were identified e.g. agricultural systems research, land resource assessment, crop physiology and adaptation, cultivar evaluation, farm costs and production economics. It also identified areas for investment to overcome infrastructure constraints e.g. roads, transport, storage, refrigeration/cool chain facilities, but these were beyond the scope of the project. Because of the complexity of issues to be confronted it was clear that addressing only one or a few of the topics would not provide a pathway to improved and sustainable system performance and human capacity enhancement. Consequently, multidisciplinary teams, addressing specific topics but working together, were essential. The findings were applied to identify appropriate crops for production-oriented research and prioritise potential areas of research and capacity building through training of men and women (Birch et al 2009, Bonney et al 2011, Palaniappan et al 2011).These findings can best be summarised by a 'best practice' model of the production and marketing system (Figure 1), to highlight improvements required on-farm and beyond. It also emphasises that that successful implementation depends on collaboration among chain participants.

Research, development and extension priorities that emerged were:

- Value Chain - consistent supply of volumes of standardised quality vegetables; sale by weight and quality grade; improved post-harvest handling; a dedicated, regular freight service into Port Moresby; availability of regular market, quality,and price information .
- Land Resources – land availability, land tenure, soil physical and chemical characteristics and fertility, soil management
- Agronomy and plant physiology – production systems, crop and cultivar adaptation to biotic and abiotic environments, crop growth and development,
- Socio-economic - develop understanding of value chains; collaboration among farmers for adequate and consistent supply, and among members of the chain to address production, supply, training in agronomy, post-harvest handling, business and marketing, and provision of safe marketing environments, particularly for women.

Using Participative Action Research to Achieve Value Chain Improvements

The value chain and socio-economic components employed Participative Action Research (PAR) (Bradbury & Reason, 2001) to address complex, real-life situations confronting farmers in PNG. Complexity requires thoughtful methodology to address relationships, place based knowledge and skills and the total context of the value chain: we employed three widely used methods that all have their origins in PAR:

- Rapid Value Chain Appraisal (Rapid VCA) a method to rapidly scope the value chain as a dynamic system (Collins and Dunne, 2008) as described earlier.
- Appreciative Inquiry (AI) a cooperative and participatory search focussing on appreciating 'what is', dreaming of the goals, and actions, empowerment and learning necessary to achieve those goals.. It is less judgemental of the host culture than a traditional problem-centred methods (Cooperrider, Whitney & Stavros 2003).
- Organic Research and Collaborative Development (ORCD), a collaborative process for solving development problems (Chambers & Spriggs, 2009), which provides the iterative and cyclical basis for problem solving.

The Project – Getting It Done

The diversity of organisations involved – three Universities, a Research Institute, a Development and Extension Authority, a Provincial Government, commercial entities individual and groups of farmers presented challenges arising from differing organisational cultures and sociocultural norms of PNG and their respective skill sets. The need for early development of effective relationships was reflected in the project proposal (Birch et al 2009b). The challenge was to meld organisations with differing foci into a functioning team that transcended boundaries, yet allowed specialist staff freedom to operate in their chosen fields, and contribute their perceptions to others. Having personal as well as organisational stakes in the project quickly emerged as 'key factors', contributing to motivation of individuals and strong organisational support. This meant that all organisations and participants received recognition for their contribution to and shared in project outputs e.g. research publications, participation in extension. Project partners met regularly with one another and collectively, focussing on both immediate and longer term activities. Vitally important was engagement with other stakeholders e.g. value chain participants, input suppliers, smallholders, bodies such as Women in Agriculture, and local cooperatives to ensure the relevance of and interest in project activities implementation. This engagement provided communication channels from researchers and value chain innovators to smallholder beneficiaries. It gave them a direct stake in effective project implementation, whether conducted on NARI or CPA facilities (Laloki and Tapini), or, as at Sogeri and Rigo-Bautama, in villagers' fields.

During project implementation, relationships and responsibilities of partner organisations, value chain participants, farmers and cooperatives were negotiated before undertaking project activities. This avoided 'on the run' decision making.

PROJECT ACTIVITIES, OUTPUTS and OUTCOMES

In addition to work in PNG, some complementary value chain and crop adaptation work was done in Tasmania by TIA. The success of the project is shown by the activities completed and outputs produced summarised in Table 1. Outcomes from the project have been reported in several publications eg. Boersma et al 2011, Palaniappan et al 2011, Palaniappan et al 2013, 2014, Waken et al 2013, include increased knowledge and capacity of research and extension staff, farmers and farmer cooperatives, and improved understanding of value chain function and effectiveness. A total of 11 PNG-based staff in a range of disciplines gained national and international exposure by contributing as senior or co-authors to a range of scholarly publications. Co-learning by PNG and Australian staff was a key contributor and key outcome of the project, which we attribute to mutual commitment and recognition of the specific skills of project team members.

PROJECT MONITORING AND EVALUATION

Monitoring of project progress is required in ACIAR funded projects with regular reporting against target dates for project activities, ethical approvals where human subjects are involved, and external mid-project and end of project reviews with participation of all project partners. These formal reporting and review activities provide broad measures of achievements against objectives. However, they take a largely retrospective view, whereas project implementation requires a prospective view. This was achieved by semi-regular project team meetings, and regular collaborative engagement by staff from the Australian lead agency (TIA), with PNG based staff. However, it is essential to reiterate that the motivation and commitment of PNG staff was a key factor in providing confidence to the Australian team that the project was being implemented efficiently and effectively by the PNG team. Nothing demonstrated this more than the impressive field trials conducted by PNG staff at Tapini, a remote, difficult to access and economically disadvantaged location. The PNG team was proactive in monitoring the project and in seeking solutions to the inevitable challenges of working with constrained resources and limited infrastructure. Perhaps predictably, adjustments to timing of project activities were required to accommodate socio-cultural obligations, which affect availability of staff and land resources, and security concerns around the PNG national elections in 2012. Some project activities were delayed or compromised by staff turnover, an inevitability in a project of over 4 years duration.

Perhaps unsurprisingly, ‘life cycles’ of interest emerged during the project. It is fair to say that interest in production activities and associated training remained high and the commitment of smallholder farmers remained strong during the project. However, in ‘post farm gate’ activities, the vulnerability of the value chain to participant enthusiasm, commitment and trust became evident. Consequently, close monitoring of the performance of value chains is imperative during the development and early implementation stages when vulnerabilities would be expected to be most severe. In this project, one intended value chain could not be established, largely due to infrastructure constraints. By contrast, another initially successful value chain subsequently failed because of dissatisfaction with funds distribution from sale proceeds – an alternative chain is now being sought.

These examples illustrate the imperative of having monitoring and evaluation activities embedded in projects – and that these activities can be both formal and informal, the latter providing for necessary adjustments to project activities in the intervening period between more formal milestone, ethical and review reports.

Some areas for improvement have been identified, including the need for longer term trials, a greater range of sites for experimentation, additional work in land resource assessment and resource management, plant nutrition and plant protection, to enhance the technological packages available in PNG.

CONCLUSION

This project has provided a model for undertaking similar projects in developing countries, with cultural awareness, engagement, mutual commitment, openness to co-learning, and respect for skills and competencies being core values on which its success relied. As always, improvements to project design and implementation can be made – however, it was the people oriented aspects that fostered the success of this project.

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Table 1. Summary of research activities, locations and major outputs.

Type of activity	Detail of activity	Locations of activities	Outputs and outcomes
Agronomic research and demonstration	Production systems study	Laloki (NARI), Sogeri	Information on comparative performance of alternative systems Crop phenology, pest and disease incidence and severity Improved knowledge, extension material
	Crop species adaptation, yield and quality Demonstration/extension	Sogeri, PAU, Tapini	Crop phenology, yield and quality data, pest and diseases incidence and severity Improved knowledge, extension material, farmer information
	Broccoli phenology and adaptation studies under controlled environment conditions (temperature and photoperiod as variables)	TIA	Detailed data on crop phenology for PNG broccoli cultivars Data on response to temperature and photoperiod
Land Resource Assessment	Land resource assessment using GIS data with overlays for production constraints	Laloki Rigo – Kwikila Tapini Sogeri	Maps of land suitability for agriculture
	Soil profile description and fertility assessment by soil analysis	Laloki (NARI), Sogeri, PAU, Tapini	Soil profile description Soil analytical data

		Rigo-Bautama	
Value Chain	Set up new value chains into Port Moresby Understand reasons for value chain failure	Tapini, Rigo-Bautama	Established one successful chain grossing PGK5-7,000 per week. Identified contextual and socio-cultural constraints.
	Understand functioning of a high volume provider of fresh produce into Port Moresby	PAU	Confirmed the Best Practice model.
	Understand requirements and relationships of retailers, assist setting up of value chains into Port Moresby	Port Moresby	Confirmed the Best Practice model
	High value vegetable value chain study	Tasmania	Identified the common factors and underlying principles
Socioeconomic research and training	Understand roles of women and men in smallholder production and business Determine training needs Evaluate effectiveness of training	Rigo Koiari Rigo Bautama Tapini	Identified and delivered high priority training necessary to improve chains.
	Determining costs of production, economic outcome	Rigo Bautama	Data on costs and economic outcome Understanding of costs by farmers

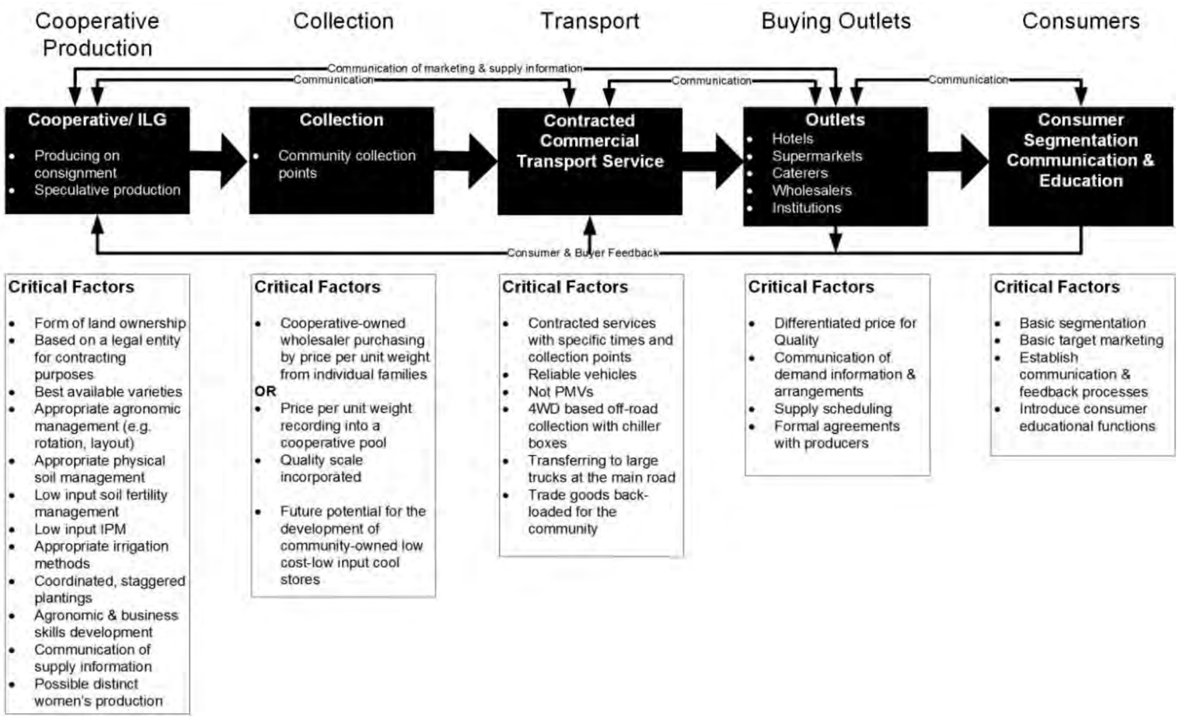

Fig.1: Best practice vegetable production and marketing system for Central Province, PNG.

Improved vegetable production systems for community cooperatives in the Central Province, Papua New Guinea

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Abstract

We compared the performance of three vegetable production systems using one variety each of tomato 'Money Maker' and round cabbage 'Racer Drumhead' in the hot, seasonally dry lowland and cool intermediate locations of Central Province (CP), Papua New Guinea (PNG). The three systems used were Traditional Farmer's Practice (TFP), Improved Production System (IPS) and Commercial High Input Practice (CHIP). TFP was based on traditional techniques using local knowledge and system descriptions from other earlier work; IPS supplemented the traditional practice with low cost technologies and practices expected to produce high returns and CHIP employed techniques and technologies likely unattainable by most farmers due to high fixed and working capital requirements and other barriers.

In TFP pest and disease infestation were high, and responsible for lower fruit quality and yield than in IPS and CHIP. IPS produced crop yield and quality comparable to or better than that of CHIP, indicating that the use of additional low cost technologies and practices in the TFP may enable higher production and create opportunities for smallholder farmers to increase their disposable cash income. The results are discussed in the context of the Improved Practice Vegetable Production System being adopted by smallholder farmers and community cooperatives in CP, PNG and how these improved systems should be able to contribute to vegetable supplies for major local markets, especially Port Moresby.

Keywords: adoption, vegetables, smallholder farmers, best practice, Central Province, commercial practice, community cooperatives, production systems, traditional practice

INTRODUCTION

Agricultural systems in PNG need to produce more food to sustain a rapidly increasing indigenous and ex-patriot population (Bourke 2001, Birch *et al.* 2009). At the same time, most farmers in PNG are both rural and poor and, while able to grow vegetables to meet their immediate family's nutritional needs, low cash incomes limit their ability to obtain other primary needs such as healthcare and adequate shelter. Temperate vegetables are grown successfully in the highland regions of PNG but timely transport of these goods to the lowland capital, Port Moresby, is expensive and product quality often deteriorates. Conceptually, these vegetables can be grown in highlands surrounding the capital, taking advantage of the environmental lapse rate, and in lowland areas during the cooler dry season months (May to October). If this were possible, larger scale vegetable production would provide an income stream for local gardeners and villages. The biophysical component of the project described here was developed to support the establishment of a vegetable value chain into the capital to increase farmers' incomes. The conclusions drawn from initial investigations were that a lack of suitable varieties and agronomic systems, particularly irrigation, were the greatest limiting factors (Birch et al 2009).

Agricultural practice varies widely throughout PNG but has been defined and catalogued into agricultural systems. Bourke *et al.* (1993) defines an agricultural system as a set of similar agricultural crops and practices that occur within a defined area. Six criteria are used to distinguish one system from another: 1. Fallow type (the vegetation which is cleared from a garden site before cultivation). 2. Fallow period (the length of time a garden site is left unused between cultivations). 3. Cropping intensity (the number of consecutive crops planted before fallow). 4. The staple, or most important, crops. 5. Garden and crop segregation (the extent to which crops are planted in separate gardens; in separate areas within a garden; or are planted sequentially). 6. Soil fertility maintenance techniques (other than natural regrowth fallows). These agricultural systems and the categories within are used in this study to provide a basis upon which to investigate low cost high return improved systems to support the development of supply chains into the capital.

MATERIALS AND METHODS

Locality of research: This investigation was conducted at the National Agriculture Research Institute Southern Regional Research Centre (NARI SRC), Laloki (09º24 S and 147º16 E, 40 masl; temperature- max 32–30°C and min 23–19°C) in the hot, seasonally dry lowlands and at Vesilgo Village, Sogeri (9°00 S and 147°00 E,800 masl; temperature - max 30–27°C and min 19–16°C) of the cooler intermediate conditions of Central Province, Papua New Guinea. The NARI SRC soil profile comprised dark silty clay loam with moderately well developed structure and moderate drainage (Doyle *et al.*, 2012). The soil at Sogeri was a compacted silty clay red ferrosol, with moderate drainage (Doyle *et al.*, 2012). The Sogeri soil had higher organic C (3.0%) compared to the NARI SRC soil (1.4%). Olsen P (34 mg/kg) and exchangeable K (0.46 cmol/kg) were higher in Laloki than Sogeri which had very low Olsen P (4 mg/kg) and exchangeable K (0.20 cmol/kg). Laloki's climate is characterized by a marked dry season with dry southeast winds from May to October (PNG National Weather Service, 2009). The wet season with variable northwest winds is from December to April and the area has an average annual rainfall of 1,100 mm. The climate of Sogeri is different with an average of 3000 mm annual rainfall per year and temperatures are on average several degrees lower (Weather online; Sogeri, 2013, PNG National Weather Service, 2009, Hanson *et al.*, 2001). This experiment was conducted and data collected over three years (2011, 2012 and 2013) at the NARI SRC while at Sogeri, Vesilogo Village, the experiment was conducted and data collected in one year (2013). Hence, at Vesilogo village, 2012 was used to rehabilitate the soil (Table 1) before the trial was planted out.

Experimental design: Three production systems were planted (using seedlings) in a randomized complete block design (RCBD) with four replicates at the NARI SRC and three replicates at Sogeri. These three production systems were based on the agricultural systems (Bourke *et al.*, 1993) endemic to the area, with the unmodified system referred to as the Traditional Farmer's Practice (TFP) (Table 1). The local system implemented at each site was modified to include low cost high return technologies and practices (e.g. Affordable Micro-irrigation Technology (International Development Enterprise, 2011), and was termed the Improved Production System (IPS). A third high input high output system, typically unobtainable by farmers due to high fixed and working capital requirements was included for comparison and is referred to here as the Commercial High Input Practice (CHIP).

Seedlings were hand raised in a nursery and transplanting took place at the 5 true leaf stage at both locations during the dry seasons. Cabbage cv. Racer Drumhead was grown at Sogeri and Tomato at the NARI SRC. Transplants of tomato cv. Money Maker were planted within rows at 0.6 m and between rows at 1.2 m. Cabbages cv. Racer Drumhead were planted within the row at 0.4 m and between rows at 0.6 m. Tomato grown at the NARI were harvested 90-105 days after planting (DAP) from October 3rd to November 11th 2011; 13th August - 24th September 2012; and July 15th - 6th August 2013. Experimental units were 3.6 m x 12.6 m and data collected from a subplot of 1.2 m x 11.4m. Cabbage at Sogeri was grown in experimental units 1.8 m x 9.6 m and harvested from subplots of 0.6m x 7.6m on 7th November 2013 at 95 DAP..

Plants were harvested when they had formed full heads (cabbage) and at breaker stage (tomato).

During crop development and at each harvest multiple parameters were recorded. These included crop phenology (head initiation - cabbage, cluster and fruit initiation- tomato) fruit and head characteristics and quality, yield, pest and disease incidence on a weekly basis until harvest. TFP was irrigated by hand watering on a need basis while IPS and CHIP were irrigated by the surface micro-drip irrigation kit.

Table 1: Details of the traditional farmers' practice (TFP), low input improvements (IPS) to TFP and commercial high input (CHIP) system and parameters of data collection/harvest dates.

Site	**System**	Inputs
Laloki (2011, 2012, 2013) Tomato 'Money Maker'	TFP	Irrigation – hand watering Soil Management - slash and burn, manual preparation Pest and disease management – culling for disease, hand removal of pests and weeds, applying wood ash, growing merry-gold around the plots
	IPS	Irrigation – surface micro-drip irrigation Soil management - machine preparation, drainage, composting and mulching (kunai grass, to approximately 7.5 cm on average) Commercial fertilizers (NPK and Urea @rate of 200 kg/ha, 150kg/ha respectively) as and when needed Pest and disease management – plant derived pesticides, inorganic pesticides, fungicides (e.g. mancozeb) as and when needed, culling for disease, hand removal of pests, weeds
	CHIP	Irrigation – surface micro-drip irrigation Soil Management - machine preparation, N, P, K fertilisers (mixed and urea) (Commercialised fertilizers -NPK & Urea @ rate of 200kg/ha, 150kg/ha respectively) Pest and disease management - commercial pesticides and fungicides (Karate, Othene & mancozeb using their respective rates) culling for disease, hand removal of weeds
Sogeri (Vesilogo village) (2013) Cabbage 'Drumhead Racer'	TFP	Irrigation – hand watering Soil management - slash and burn and manual land preparation, wood ash Pest and disease management – culling of diseased crops, hand removal of pests and weeds, applying wood ash, growing merry-gold around the plots
	IPS	Irrigation – surface micro drip irrigation Soil management - manual preparation, drainage, composting and mulching (kunai grass, to approximately 7.5 cm on average), wood ash. Commercialised fertilizers (NPK & Urea @ rate of 200kg/ha, 150kg/ha respectively)as and when needed Pest and Disease Management – plant derived pesticides (e.g. chilli and soap, neem powder), inorganic pesticides and fungicides (e.g. mancozeb) as and when needed, culling for disease, hand removal of pests and weeds

CHIP	Irrigation – surface micro drip irrigation Soil Management - manual preparation, Commercialised fertilizers -NPK & Urea @ rate of 200kg/ha, 150kg/ha respectively), agricultural lime @rate of 383g/m^2 Pest and disease management – Commercial pesticides and fungicides (Karate, Othene & mancozeb using their respective rates) culling for disease, hand removal of weeds.

Statistical Analysis: All data were assessed by analysis of variance, using Genstat Discovery Edition 4. All differences are reported at the P=0.05 level of significance and significantly different results were identified from New Duncan's Multiple Range test.

RESULTS

At the low altitude site (Laloki), there were no phenological differences for tomatoes in any season between the different systems (Table 2). Yields were low in all treatments in the first and third years of the trial. A comparative increase in individual fruit weight accompanied an increase in gross yields in only one season, 2012-13, this under the IPS and CHIP systems (Table 4). This increase in yield was not due to pest and disease control which remained similar between the systems in all three seasons. In 2012-2013, CHIP and IPS both out yielded TFP though yield was not significantly different between the different production systems in 2012. Fruit quality of the IPS was comparable to that of CHIP (Table 3). Similar to the Laloki site, Sogeri crops (Cabbage cv. Racer Drumhead) in IPS and CHIP were early maturing while crops in TFP were late (Table 5). IPS was high yielding (19 t/ha) compared to CHIP (14.8 t/ha), and had a comparatively low infestation by pests and diseases followed by the high input system and finally the traditional practice system (Table 7). Head quality in IPS and CHIP was comparable (Table 6). TFP performed unexpectedly poorly in the 2013 trial.

DISCUSSION

The trials at Laloki and Sogeri so far indicate that the low input improved system (IPS) is comparable to the commercial high input system (CHIP) in terms of yield, pest and disease incidence and quality. The traditional production system (TFP) had a high incidence of pests and disease and was low yielding. These results would be expected based on the definition of agriculture systems provided in Bourke *et al*. (1993). It is interesting that the trials reported here were in quite different agro-ecological zones (high temperature, seasonally dry coastal lowlands and a milder mid – altitude, though seasonally dry area, yet they provided broadly similar results. Land resources in Papua New Guinea are highly variable in terms of topography (Hanson *et al*., 2001, Bourke *et al*., 1993), climate, which is influenced by local geographic conditions as well as broad climatic zones (Climate and Weather, 2010), and soil physical characteristics and soil fertility (Doyle *et al*., 2012). That broadly similar results were achieved in contrasting environments, even though over only a short time frame, suggests that these findings are likely to be applicable in other areas and environments. However, there are differing socio-economic conditions across the country, and in some areas high intensity production might occur e.g. where larger land areas may be available and accessible by machinery e.g. coastal lowlands. In addition, as pressure on land resources intensifies, pressure for intensification of cropping practices, with the attendant need for purchased inputs, will increase.

Having had these trials only for a very short time the results can only be expected to provide some guidance about the most appropriate farming system in the longer term. They also need to be considered in relation to land tenure, resource constraints and the economic opportunities. Given the nature of the environment in Central Province of PNG and socio-economic realities such as lack of basic infrastructure and high prices of agricultural consumables (fertilizers, pesticides etc.), use of high intensity production systems (CHIP) on smallholdings or community cooperatives is unlikely in the foreseeable future. However, low input improvements (IPS) to traditional production systems (TFP) appear to provide benefits that could be widely adopted within current technologies available to smallholders or community cooperatives and within their socio-cultural practices, customary land tenure and preferences for meeting immediate personal and family needs and commercial activities.

Nevertheless, these trials need to be continued over the longer term to achieve conclusive results and derive appropriate recommendations for long term sustainable production. Further, maintenance of these trials in the long term will provide guidance to appropriate practices as land use intensifies – the trials would provide guidance to emerging practices, and hence more appropriate crop and land management.

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Table 2: Crop phenology and days from sowing to emergence, and days from transplant to floral initiation and fruit set for tomato, var. Money Maker grown at low altitude (Laloki) in 3 agro-systems; Traditional Farmers' Practice (TFP), Improved Production System (IPS) and Commercial High Input Practice (CHIP). *n*=3, LSD (p=0.05)

Production System	Days to emergence (50%)			Days to flowering (50%)			Days to fruit set (50%)			Days to maturity			Mat.
	2011	2012	2013	2011	2012	2013	2011	2012	2013	2011	2012	2013	
TFP	6	6	6	58	59	59	70	70	70	81	85	85	Late
IPS	6	6	6	57	57	57	70	70	70	79	80	80	Early
CHIP	6	6	6	56	57	57	69	69	69	78	80	80	Early
SE	0.58	0.81	0.33	0.94	1.3	3.2	1.4	3.9	3.5	5.2	2.7	2.4	
LSD	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	

Table 3: Quality parameters of tomato, var. Money Maker, grown at low altitude (Laloki) in 3 agro-systems; Traditional Farmers' Practice (TFP), Improved Production System (IPS) and Commercial High Input Practice (CHIP). Quality was rated as: 1-2= very good; 3=good, 4-5=poor. Firmness was assessed as: 1-2=very firm-firm; 3=moderate; 4-5=easily damaged. Fruit sizing data: >0.9 kg = Large; 0.5kg-0.9kg= Medium; <0.5kg=Small. *n*=3, LSD (p=0.05)

Production System	Fruit Shape	Firmness	Fruit size	Fruit Colour	Quality Rating
TFP	Deep globe	3	Small	Dark red	3
IPS	Deep globe	2	Medium	Dark red	2
CHIP	Deep globe	2	Medium	Dark red	2
SE		0.47			0.47
LSD		ns			ns

Table 4: Yield, yield attributes and pests and disease rating of tomato, cv. Money Maker, grown at Laloki in 3 agro-systems; Traditional Farmers' Practice (TFP), Improved Production System (IPS) and Commercial High Input Practice (CHIP). Pests and disease infestation rated on a scale of 0-5 (0=no infestation, 1-2=low infestation; 3=moderate infestation; 4-5=high to heavy infestation). *n*=3, LSD (p=0.05), different lower case letters within a column indicate a statistical difference.

Production System	# clusters/ plant			# flowers/ clusters			#fruits/ clusters			#fruits/ plant			Fruit market weight (g)			Yield (t/ha)			Pests & disease infestation		
	2011	2012	2013	2011	2012	2013	2011	2012	2013	2011	2012	2013	2011	2012	2013	2011	2012	2013	2011	2012	2013
TFP	-	15.7	8.9	-	11.7	5.7	-	7.8	2.8	-	32	18.3	80	50	40^{b}	9	7.3	3.4^{c}	4	3.3	3
IPS	-	17.3	9.1	-	11.9	7.1	-	8.4	3.1	-	44	24.7	90	60	60^{a}	6	13.6	4.3^{b}	3	2.3	2.3
CHIP	-	16.7	9.1	-	11.3	6.5	-	8.6	3.1	-	42	23.3	90	60	60^{a}	6.3	11.3	6.8^{a}	2	2	2
SE		0.8	0.6		0.24	0.5		0.6	0.31		4.3	0.9	4	10	3	0.19	1.3	0.18	0.3	0.3	0.43
LSD		ns	ns		ns	ns		ns	ns		ns	ns	ns	ns	10	ns	ns	0.67	ns	ns	1.2

Table 5: Crop phenology and days from sowing to emergence, and from transplant to floral initiation and fruit maturity for English cabbage, cv. Racer Drumhead grown at mid-altitude (Sogeri) in 3 agro-systems; Traditional Farmers' Practice (TFP), Improved Production System (IPS) and Commercial High Input Practice (CHIP). *n*=3, LSD (p=0.05)

Production System	Days to 50% emergence	Days to 50% head initiation	Days to maturity	Maturity
TFP	6	70	91	Mid
IPS	6	64	85	Early
CHIP	6	60	85	Early
SE	1.7	3.9	3.8	
LSD	ns	ns	ns	

Table 6: Quality parameters for English cabbage, var. Racer Drumhead grown at mid-altitude (Sogeri) in 3 agro-systems; Traditional Farmers' Practice (TFP), Improved Production System (IPS) and Commercial High Input Practice (CHIP). Quality was rated as: 1-2= very good; 3=good, 4-5=poor. Outer leaf wrapping was assessed as: 1-2=very tight to tight; 3=moderate; 4-5=loose. Head sizing data: >0.9 kg = Large; 0.5 kg-0.9 kg= Medium; <0.5 kg=Small. n=3, LSD (*p*=0.05)

Production System	Head Shape	Outer Wrapping	Head Size	Quality Rating
TFP	Long; dome and bulky	3	Large	3
IPS	Long; dome and bulky	2	Large	2
CHIP	Long; dome and bulky	2	Large	2
SE		0.47		0.47
LSD		ns		ns

Table 7: Yield, yield attributes and pests and disease rating of English cabbage, cv. Racer Drumhead grown at mid-altitude (Sogeri) in 3 agro-systems; Traditional Farmers' Practice (TFP), Improved Production System (IPS) and Commercial High Input Practice (CHIP). Pest and disease infestation rated on a scale of 0-5 (0=no infestation, 1-2=low infestation; 3=moderate; 4-5=high to heavy infestation). Inner leaf wrapping was assessed as: 1-2=very tight to tight; 3=moderate; 4-5=loose. *n*=3, LSD (p=0.05), different lower case letters within a column indicate a statistical difference.

Production System	Inner Leaf Wrapping	Head diameter (cm)	# Marketable Heads	Sibs (%)	Marketable weight/ head (kg)	Yield (t/ha)	Pests & disease
TFP	3.0	18.1	18	10	1.1^{b}	12.5^{b}	3.3^{b}
IPS	2.3	18.1	20	0	1.3^{a}	19^{a}	2.0^{a}
CHIP	2.3	19.4	20	0	1.1^{b}	14.8^{b}	2.3^{a}
SE	0.61	2.17	0.88	4.4	0.02	1.1	0.27
LSD	ns	ns	ns	ns	0.09	2.9	0.76

Labour Costs are an Issue in Agriculture in a Developing Country

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Keywords: production cost, smallholder farmers, vegetables

Abstract

Labour cost by smallholder farm producers in Papua New Guinea (PNG) is an important factor but is usually ignored by farmers in calculating it as part of the production cost. Typically, farm labour is provided by family members but normally unpaid, and therefore is erroneously not included as a cost. A production cost survey was conducted for twenty smallholder vegetable growers in Rigo, Central Province, to determine labour and other costs of production. Farmers were supplied with cost and time recording sheets, and were trained to record costs. The study, which was conducted over three cropping seasons, identified that the labour costs are very significant. Unit production cost of vegetables was between PGK0.38 and K3.24 before labour cost included and PGK1.72 and K5.92 inclusive of labour. Variable and fixed costs were also determined, and farm-gate price and margins determined. The challenge is to make labour more efficient while at the same time appropriately account for it. Farming will inevitably become increasingly competitive, and therefore knowing the cost of production is an important tool in planning, forecasting, and decision-making and should be a routine practice for smallholder producers in PNG.

INTRODUCTION

Labour cost in Papua New Guinea (PNG) is an important factor but is usually ignored by smallholder farmers in calculating the cost of production, being mostly supplied by family members. Farming in PNG dates back 10,000 years ago, and over time farming practices have changed. Farming in PNG works through different groups of people with different cultures, landscapes and locality. For example, those in the highlands region farm different crops and use different practices from those in the coastal regions.

Crop based farming systems, livestock production and the harvesting of fish and other foods from aquatic systems are the main sources of food (Kambuou, 1996). Farming systems in PNG are diverse, sometimes complicated and often not easily defined. Most farming is carried out on small areas of land that can be effectively operated without machinery. Farmers, who may be either male or female, may grow subsistence food crops of which any surplus to family requirements can be sold in local markets. Some, though some is transported over considerable distances, predominantly on Public Motor Vehicles (PMV) to markets in major centres of population, such as Port Moresby (Birch et al 2009). Yet farmers may also hunt, collect food from the forest, harvests fish from waterways and collect marine products from the sea. Farmers are also expected to participate in traditional and social events in the village to which they belong.

The indigenous people of PNG belong to some form of tribal groupings, and are based in villages. The land is owned by the clan or families and an individual is given the right as a member of that clan/family to use the land. There is no individual ownership of the land unless a person is the sole heir to the ownership of the land. Labour in farming is mostly supplied by the family but once the farm increases in size and/or intensifies production farmers can seek additional labour from the extended family or from community, in which case paid labour maybe involved, the pay being mostly in kind rather than cash (Kambuou,1996).

The help from extended family members comes at no cost, because later they will in turn receive help when it is required under a system of social obligation called the 'wantok' system, literally 'one talk' or involving those who speak the same language. However, it is not considered by farmers as a cost of production when, for example, calculating farm profitability. For this study the government rural minimum rate of PGK1.45 per hour was used to provide estimates of the real cost of labour input. This is the rate commonly paid for hired labour in plantations and the general agricultural sector. As labour is usually a hidden cost the main objective of this study is to understand the farm economy and quantify the hidden cost of labour so farmers can start accounting for this cost.

The specific objectives were to;

1. produce information on farm-gate value of the vegetables;
2. understand cost structure of smallholder vegetable farms and quantify costs of production of a range of crops
3. quantify labour input and assess its impact on cost of production of specific crops;
4. Train farmers to understand that unpaid family labour input is a 'real cost', and to account for it in profitability assessment.

MATERIALS AND METHODS

According to Doyle et al (2012) land resource assessment for Rigo area shows sustainable production of vegetable can be expanded. The farmers who were actively involved in vegetable farming were selected with additional criteria based on willingness to participate and their experience in vegetable production.

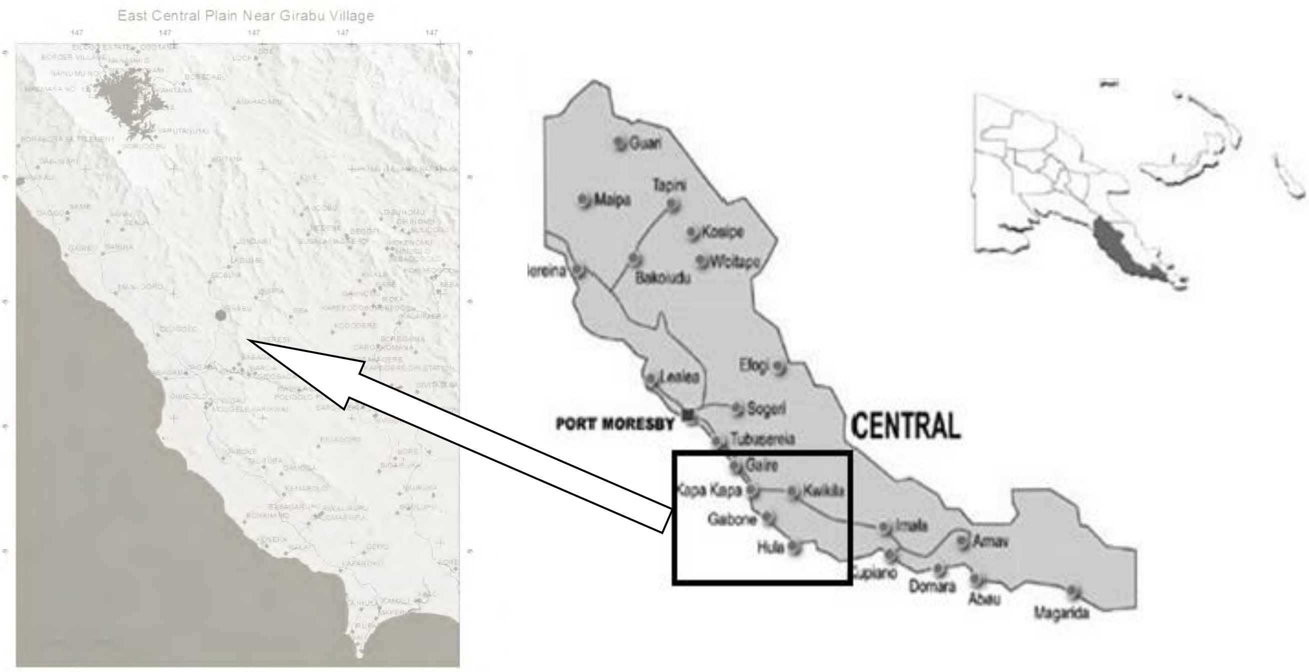

Figure1. Map Showing Girabu Village-site of study in black dot. Data Source: MASP and PNGRIS database.

The crops included in the study were tomato, capsicum, watermelon, zucchini and French beans. The main baseline data requested from farmers in the questionnaire were labour (man-days), costs of inputs used in production, crop yield and the sales (in PGK). Farmers were supplied with 100kg weighing scales, questionnaires, pencils, and mini-table clocks. Microsoft Excel was used for data assembly and Statistical Packages for Social Science (SPSS) for data analysis and presentation. Also, though smallholders have areas that are usually less than 1ha, data have been up scaled to a per hectare basis for comparative purposes.

A production cost survey was conducted to determine labour and other costs incurred in producing vegetables. On site surveys were conducted with twenty vegetable farmers (though most only grew some of the five crops involved - tomato, capsicum, watermelon, French bean and zucchini) over three cropping seasons in Rigo district, Central Province.

Farmers were supplied with data recording sheets (Appendix 1) and asked to record expenses and labor hours for different activities, including land preparation, nursery production of seedlings, planting, weeding, irrigation, harvesting and transportation. Unpaid labour was converted to a monetary based on the minimum rural wage of PGK1.45 per hour. Other input costs were recorded for both fixed (e.g. tools, small tractor) and variable costs (fertilizer, pesticides, seeds). However, because land is transferred from generation to generation by family and village ties, it was not practical to include land value in this study. Bi-weekly visits to the farms were made by the research team and the records were updated to the master copy. These visits enhanced consistency and quality of records, and were used to gain additional information and confirm entries in the self-reported data sheet through interviews.

The crops that were included in the study are the tomato, capsicum, watermelon, zucchini and French bean. The main baseline data requested from farmers in the questionnaire were labour (man-days), costs of inputs used in production, crop yield and the sales (in PGK). Farmers were supplied with 100kg weighing scales, questionnaires, pencils, and mini-table clocks. Microsoft Excel was used for data assembly and Statistical Packages for Social Science (SPSS) for data presentation. Also, though smallholders have areas that are usually less than 1ha, data have been up scaled to a per hectare basis for comparative purposes.

RESULTS AND DISCUSSION

The number of man-days used in vegetable production was highest in capsicum (225/ha), followed by tomato and watermelon, these being the most labour intensive, followed by zucchini and French bean, which required less than one sixth of the labour of the other three crops (Figure 2). They were, though, comparatively low yielding. Figure 3 shows the distribution of labour among specific farm activities, using tomato as an example crop. Labour distribution to specific activities had similar patterns in other crops, though the relative proportions varied.

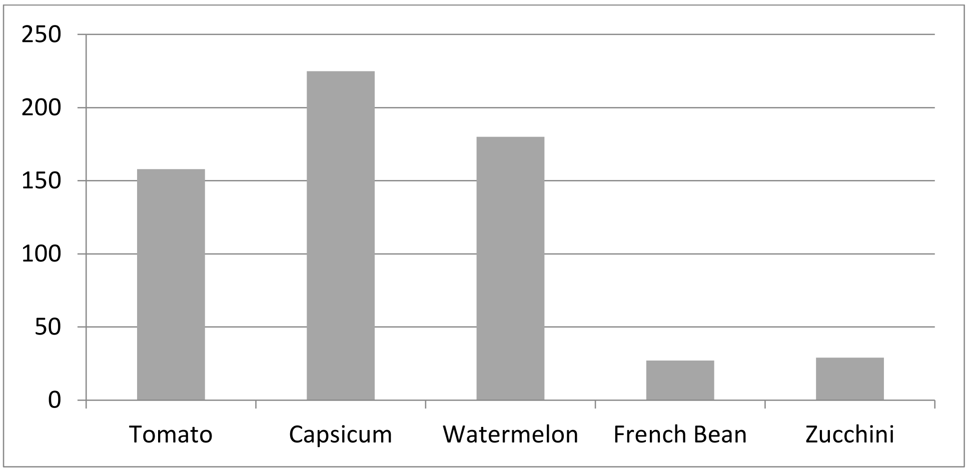

Figure 2. Labour utilization (man-days/ha) in the production of tomato, capsicum, watermelon, French beans and zucchini in Girabu village, Rigo District.

Harvesting and packaging was the activity which involves the most labour in all crops. The high cost of harvesting and packaging is partly explained by having multiple harvests in each crop (maximum of five harvests per crop). Transport to the roadside was the second most labor intensive activity, as most farms are distant from the village and also from the road linking the village to the main highway. Most of this transport was done by people carrying products over typical travel distances of 9 km. Hence, the requirement for labour is substantial. Labour for pest control and fertilizer application is minimal as both are applied on an as needed basis, and individual applications take comparatively little time.

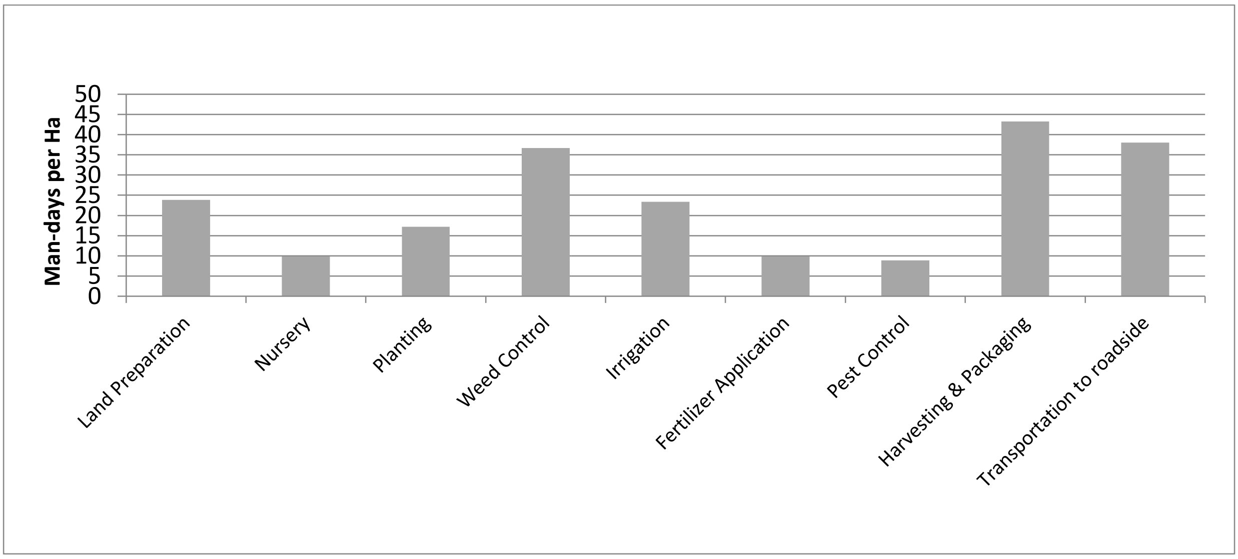

Figure 3: Unpaid labour (man-days) used in specific activities in tomato production (excluding minor activities)

Production costs of the vegetables are summarized in percentage terms in Figure 4. Labour cost was separated from other variable costs and shows the major contribution of unpaid labour to overall cost, when using a notional labour charge of PNGK1.43/hr, and exceeded 70% of costs in all five crops.

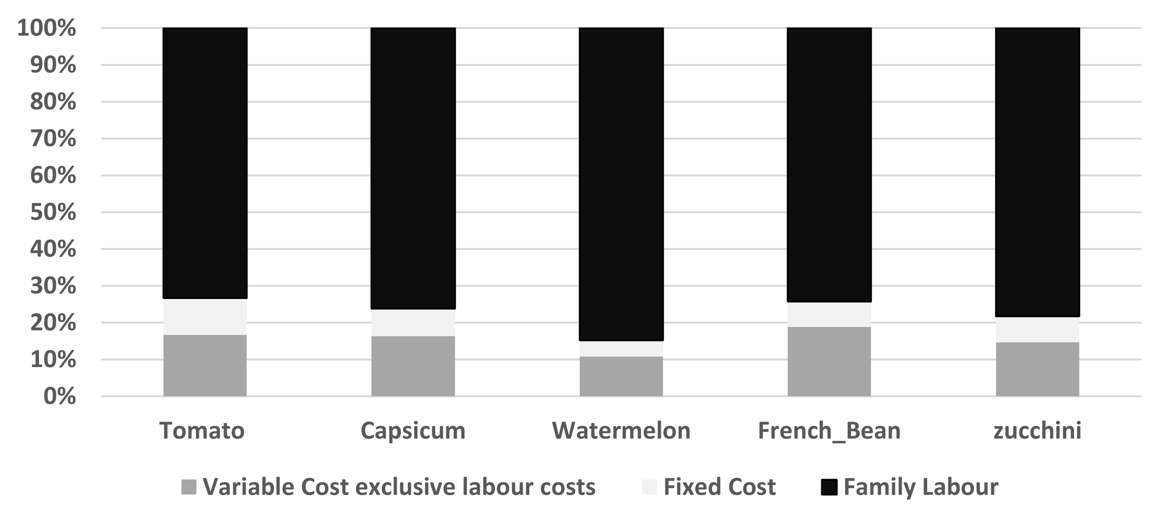

Figure 4 Variable, fixed and labour costs as proportions of total costs of production in tomatoes, capsicums, watermelons, French beans and zucchinis.

With the unit cost of production calculated, the profitability of each crop is easier to determine. Capsicum (PGK3.24/kg excluding labour) cost the most to produce. Zucchini was the least expensive to produce, and had a higher return than French beans, watermelon and capsicum , which showed negative margin after labour was included, but less than tomato which had the highest margin of the crops assessed (Table 1).

DISCUSSION

The study shows that the smallholders' total costs of production of vegetables were high, and more than 80 % of this cost is attributable to labour. This dominance means that labour costs are likely to overwhelm efficiencies introduced in other aspects of production, especially as expectations for improving capacity to meet living, education, medical and other costs rise (Palaniappan et al 2013). Loss of labour to cities to access improved opportunities and services (Bourke and Harwood 2009) is also likely to increase pressure for higher wages for labour.

In terms of relativities between operational activities, the most labour intensive activities were harvesting and packaging and transporting to the roadside. The requirement for harvesting and packing arises from the nature of the activities and that they are not mechanised in any way. Labour requirement for transport arises from the remoteness of the production areas from the farmers' delivery point and the distance from the village to the main highway. If these accessibility constraints could be addressed, it is likely that farmers would increase vegetable production due to the saving in effort and time. In this instance, cost would not be a major influence because farmers do not generally cost their time in transporting produce to market. The requirement for harvesting and packing arises from the nature of the activities and that they are usually not mechanised in any way. Labour requirement for transport arises from the distance of the production areas from the farmers' delivery point and the distance from the village to the main highway. If these accessibility constraints could be addressed, it is likely that farmers would increase vegetable production, as they would benefit economically from

Crop	Tomato	Capsicum	Watermelon	French Bean	Zucchini
Price (PGK/kg)	8.50	10.00	5.00	12.00	12.00
Yield (kg/ha)	1420	500	940	140	470
Revenue (PGK/ha)	12070	500	4700	1680	5640
Variable cost (PGK/ha)	1060	1100	490	160	120
Fixed cost (PGK/ha)	660	1620	700	220	180
Total cost (PGK/ha)	1720	1620	700	220	180
Margin before labour (PGK/ha)	10350	3380	4000	1460	5460
Cost/kg before labour	1.21	3.24	0.75	1.57	0.38
Cost/kg inclusive labour	4.50	13.50	4.81	5.92	1.72
Labour (PGK/ha)	4670	5120	3880	610	620
Margin after labour (PGK/ha)	5680	-1740	120	850	4740

Table 1. Costs and returns for tomato, capsicum, watermelon, French beans and Zucchinis in Girabu village, Rigo district, PNG.

reduced transport cost. Labour requirements for harvesting and packaging addressed, it is likely that farmers would increase vegetable production, as they would benefit economically from reduced transport cost. Labour requirements for harvesting and packaging may be able to be reduced by use of improved materials and facilities for cleaning and storing of produce and improvements to packing practices e.g. avoid double handling.

Labour requirements for weeding were also comparatively high because of the nature of the environment, in particular seasonal conditions. The study area is characterised by distinct wet and dry seasons. For crops planted in the wet season, weeding is done four to five times, while dry season crops are normally weeded twice. Some opportunities exist to reduce weeding by more appropriate timing of planting and use of herbicides, though this study did not explore the economics of alternative agronomic practices.

To reduce labour requirements, training of farm labour in more efficient methods and use of improved farming technology for weed control, irrigation and harvesting techniques are required.

Data and information from other developing countries suggest that agriculture in less developed countries falls largely into the informal sector and that the problem of lack of data on labour input is widespread. This contrasts with the detailed data on employment in the more formal manufacturing sector, where detailed records of production costs are kept. In reality, most labour in the farming sector is not paid - farmers simply buy their needs from surplus funds after non-labour production costs are paid (Hansen et al, 2001).

This study shows how much labour is used in production and delivery of vegetables, the value of this labour and the impact of labour costs on overall costs of production. Improvement of labour productivity would reduce labour cost and improve profitability of smallholder farmers. How this might be achieved was not an objective of this study, however, the adoption of technology, small scale mechanisation (micro-mechanisation) and staff training as reported in Palaniappan et al. (2011, 2014) would be appropriate strategies. Further, as crop yields are quite low, actions could be taken to improve these so that labour costs, which might also increase, were able to be distributed across more production.

A more comprehensive study than possible here is needed to gain a system wide ‘picture’ of where (and thus how) improvements could be made, This could use the ‘Best Practice’ framework developed for PNG and outlined in Birch et al (2014). Further, this study provides some guidance to further research and training in economics of vegetable production. It also suggests that economics of vegetable production would be improved by provision of infrastructure to, in particular, reduce labour requirements for transport.

This study is the first of its kind in vegetables, and results are from interviews and surveys of farmers in one district. Whilst the weaknesses of self-reporting are widely acknowledged this was the most appropriate method in these circumstances. Clearly, the type of work reported here needs to be repeated in other districts and for a wider range of crops, and will also need to be repeated regularly at intervals of say five years, to provide information on changes over time in both costs and returns. The only similarly comprehensive information currently available is for commodity crops such as cocoa and coffee, and importantly the only data available for labour requirements relate to tree and other commodity crops (Bourke and Harwood, 2009).

CONCLUSIONS

Though labour is normally supplied by family members, placing a monetary value on it demonstrates that it is the dominant cost of production. With social changes such as migration of people to urban areas reducing labour availability and increasing expectations for enhanced standard of living and education of children, expectations of payment for labour in cash will emerge. This will then place pressure on the amount of labour used in farming activities, and knowledge of the real costs of production will become imperative. This study has provided an initial assessment of real costs of production in a range of crops, and provides guidance to further research to broaden its scope that is needed. As farming has become increasingly competitive, knowledge of labour cost and other costs is important to planning, forecasting, and decision-making. It is important that smallholder farmers realise, accept and work within these constraints so they can remain competitive. The approach used here provides a model that can be used to investigate and compare costs in vegetable and other crop production activities across Papua New Guinea.

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APPENDIX 1

Data collection sheet provided to farmers

Cost collection Data Sheet for the Girabu Village **Date:__________**

Mandays

Project: *ACIAR Vegetable*
Vegetable Type: ______________
Area of plot/field: ______________ (Ha)

NO.	Farm Activity	Start		Labour[1]			Finished	
		Date	Time	M	W	C	Time	Total No. of hours worked
1								
2								
3								
4								
5								

[1]M=Man, W=Woman, C=Children of Working age (>10)

Palaniappan, G., Chambers, B., Bonney, L., Simeon, L, and C. Birch 2013. **Pictures provide insight: PNG village women assess their development needs.** Action Research Journal. *(In Press)*

Pictures provide insight: PNG village women assess their development needs

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Pictures provide insight: PNG village women assess their development needs

Abstract

Participatory tools have aided in engaging vulnerable sectors of communities in developing countries, so they become actively involved in addressing their concerns. In the context of a recent research project in the Central Province, Papua New Guinea, women and youth participation was given equal priority with men in horticultural production to address the needs of families and wider community, using a non-textual participatory tool. In this paper we discuss how the 'pictorial method' was trialled to identify the training needs of marginalised women to improve their livelihood. The article is presented in the following broad categories: the need to improve gender equity for agriculture production; need for women's participation in agriculture production for development; developing pictorial tool for training needs assessment; training needs assessment. Outcomes include iterations of knowing – presentational knowing, practical knowing, experiential knowing and propositional knowing that revealed tacit, explicit and potential knowledge.

Introduction

The human development index is measured in terms of three basic dimensions of development: a long and healthy life; knowledge; and decent standard of living. The human development index of Papua New Guinea (PNG) was 0.466 in 2011 compared to 0.313 in 1980 (UNDP, 2011). In spite of the increase during the 21 intervening years, PNG is placed 153rd out of 187 countries. It is classified as a low human development index country because it has performed below the regional average of East Asia and the Pacific Region, where an increase of the human development index from 0.428 in 1980 to 0.671 in 2011(UNDP) has been achieved. This clearly implies that improvement in PNG is necessary, especially in the three basic dimensions: a long and healthy life; knowledge; and decent standard of living to achieve human development. It is also vital for PNG to achieve human development by including women in all development activities for the economic growth to be effective in reducing poverty.

Current records on PNG's gender inequality index show that the benefits of growth are not evenly distributed between the genders. PNG's gender inequality index is 0.674 and it ranks 140th out of 187 countries (UNDP, 2011). Inequality between women and men is measured in three dimensions: reproductive health; empowerment; and participation in the labour market. PNG's gender inequality index shows gender discrimination to be evident. In spite of women playing significant roles in various sectors, especially in farming, discrimination against women remains (Gibson & Rozelle, 2004) as a result of cultural and social bias. Gibson and Rozelle (2004) found that there was more cultural and social bias against girls in rural areas than in urban areas. The inequality potentially impacts on economic growth and in turn increases poverty. In countries with initially high levels of inequality as that of in PNG, economic growth is less effective at reducing poverty (Bigsten & Levin, 2001; Lustig, Arias, & Rigolini, 2002).

Women's roles in farming lack adequate recognition in PNG. Women's access to information is limited and so women are deprived of farming skills and market information. A lack of safe and effective market outlets for rural women means they are forced to sell their farm produce at lower prices in the roadside markets. When selling their produce in more formal markets, women often experience health problems resulting from harassment by other actors in the chain due to gender inequity (Jimenez, Au, & Sandeka, 2012; Spriggs & Chambers, 2007).

Dangerous road conditions, lack of transport and lack of basic infrastructure facilities in the markets prevent women from participating in major markets. This has resulted in a considerable percentage of women in PNG being trapped in poverty with limited access to opportunities. Gibson and Rozelle (2004) reported that the incidence of poverty is understated because average household data misses the fact that females in some households may have access to fewer resources than other household members, so their individual consumption level falls below the poverty line. The latest UNDP Human Development Report (UNDP, 2002) stated that Papua New Guinea was ‘far behind’ in achieving its millennium goals relating to poverty reduction by 2015.

In the context of current research, engaging women in the development planning process was attempted to improve the agricultural sector and thus women’s livelihoods. Various institutions are recognising the need for women’s development and encouraging women to take part in their action plans for development. However, the engagement process in the current research activity was done with caution, being mindful of Eves’ (2007) observation that ‘helping women to gain greater financial independence and to be more assertive of their rights seems to bring more rather than less domestic violence’ in PNG.

Need to improve gender equity for agriculture production

The Organisation for Economic Co-operation and Development (OECD, 2009) reported that US$24.9 billion in 2009-2010 was spent on aid relating to gender equity, 8% of it being delivered through agriculture and rural development. Agriculture and rural development is recognised as a growth ‘engine’ for countries such as PNG receiving aid, as a majority of the population’s main occupation is agriculture (Cheryl, 2011). Papua

New Guinea's population is around seven million, with 85% of the population living in traditional societies and practicing subsistence agriculture (Lilly, 2012).

Ravallion and Datt (1994) and Bourguignon and Morrisson (1988) argued that agricultural growth was more effective in reducing poverty, as 37% of the population lived below the poverty line. These reports provided support for PNG's economic development strategy being placed on agriculture, fisheries and forestry rather than capital-intensive resources sector such as mining (Feeny, 2003). Emphasis on agriculture and allied sectors is likely to provide greater equity from economic growth by greater distribution of benefits to the wider community (Basu, 2000; Feeny, 2003), and this could be furthered by addressing gender equity through agriculture and rural sector (OECD,2009).

Need for women's participation in agricultural production for development

Gender inequality and violence restrict the ability of women to participate in economic, social and political life. This is a contributing factor to many development challenges in PNG. Women face additional problems of inadequate and inappropriate facilities, in spite of being substantially involved in production and marketing of fresh produce (G Palaniappan et al., 2011), particularly in the local informal markets (Spriggs & Chambers, 2007). Women face harassment, bullying and difficulties in retaining income for family purposes (Spriggs & Chambers, 2007). This situation contributes the World Bank (2011) finding that gender based violence can seriously affect development of a country, and also lead to undesirable reproductive and health outcomes, stress in caregiving roles and reduced efficiency and effectiveness of workers at the workplace. This confirms earlier reports of Bigsten and Levin (2001) which states that high levels of inequality will increase poverty. Sepoe (2002) states there are two crucial components of a democratic system namely democratic state and a democratic civil society which can facilitate participation. Both democratic state and a democratic civil society are weak in PNG and the society is characterised by a great deal of turbulence due to cultural conflicts limiting social democracy (ie civil society). Women do not have economic and social rights commensurate with their role/s in society. Women do the bulk of the agricultural work: preparing the ground, planting, weeding, harvesting, processing of crops and marketing the produce. They were also responsible for rearing pigs, the most valuable commodity used in exchanges, but had no ownership rights over them and could not participate in their exchange (Wendy, 1985).This is due to socio-cultural barriers, religious beliefs, leadership, education level and reproductive roles in their families (Sepoe, 2002). Wendy (1985) argues that the capitalist development in PNG rests on the firm base of women's domestic subsistence production: despite the passage of over two decades since Wendy's report, the situation remains largely unchanged (Kelep-Malpo, 2008; Spriggs & Chambers, 2007). It is for these reasons that in the context of an ACIAR project 'Increasing Vegetable Production in Central Province, Papua New Guinea to Supply Port Moresby Markets', women and youth participation was given equal priority with men in horticultural production to address the needs of families and wider community. Women were engaged in the current research activity with caution as suggested earlier by Rosi and Zimmer-Tamakoshi (1993) and Eves (2007) with an understanding of the patriarchal society avoiding any cultural turbulence.

The research reported here was approached using a number of strategies that were compatible and culturally appropriate with the role/s of women, youth and men in society, and also considered the low literacy rate in rural areas engaged in agricultural production.

Developing pictorial tool for training needs assessment

The World Bank defines a 'method' as a combination of tools held together by a guiding principle. 'Tools' are the means by which practitioners facilitate and encourage participant involvement in creating inspiring solutions, gathering data, and investigating or analysing issues/problems (WorldBankInstitute, 2001). This project employs an appreciative inquiry-based value chain analysis method from the participatory action research paradigm which is bottom-up, positively-oriented and respectful of cultures (Msukwa, Svendsen, & Moyo, 2003) .

Of the various research tools used to ascertain knowledge, experience and attitude, such as surveys, questionnaires, pictorials, interviews, focus groups, nominal and Delphi techniques, the pictorial method of engaging participants in dialogue was chosen. This method was chosen due to the low level of literacy among rural women (UNDP, 1999), with the male-to-female ratio in literacy at the national level 100:61 and even worse in rural areas. The low adult female literacy level is attributable to their reduced access to education compared with men over a long period. The National Literacy and Awareness Secretariat (NLAS, 2008) reported very little change since 1999, as the requirement for community-based life skills development for the large neo-literate population was projected to be a major priority in PNG. This would be provided to women in agriculture, which is being feminised as women spend more time (80%) compared to men (20%) in agriculture (Chambers, 2012; G Palaniappan et al., 2011; Spriggs & Chambers, 2007). The pictorial method was chosen over the text method to overcome women's limitations in participation in the decision making process and identification of their needs. The pictorial method also encourages group participation compared to individual participation, and is culturally appropriate for women (Chambers, 2012).

The pictorial method is based on Freire’s (1973) principles of enabling people to participate and think critically using visual images. Participatory photography, an advanced form of the pictorial method, has been widely used in community-based participatory research projects (Allen, 2012) and in public health-related disciplines (Catalani & Minkler, 2010; Wang & Burris, 1997). The method involves participants being given digital cameras to take pictures of their observations and talk about them duing discussions. The participatory photography method is closely associated with participatory action research where participants will experience presentational knowing (in this case, visually represent their experiences), practical knowing (in this case, learning how to take photographs), experiential knowing (as above), and propositional knowing (as above) ((J Heron, 1996; Prins, 2010; Reason & Bradbury, 2001, 2008a). The research team chose to use the pictorial method of developing visual images reflecting participants’ experience to identify training needs. The pictorial method is also closely associated with action research where participants experience presentational knowing (visual recall on represented experiences), practical knowing (learning how to identify their needs), experiential knowing (interacting with people in new ways), and propositional knowing (developing new conceptual understandings) (Prins, 2010; Reason & Bradbury, 2001, 2008a). Both the pictorial method and participatory photography aim to understand the tacit (professional knowledge embedded in people) and explicit knowledge (codified knowledge implemented for higher production and improved living) of participants (John Heron, 1989; Gomathy Palaniappan, 2009; Smedlund, 2008) . The pictorial method differs from the participatory photography method in terms of practical knowing. The latter method views practical knowing as participants learning how to take photographs, whereas in the pictorial method it is viewed as participants learning how to identify their needs. By learning how to identify their needs, participants are directed towards gaining potential knowledge which is creation and acceptance of new knowledge through trainings (John Heron, 1989; Gomathy Palaniappan, 2009; Smedlund, 2008). The reason for viewing practical knowing differently is explained in the next section.

Practical knowing being viewed differently in this research, the research team collected the photos taken during the field visits and developed the photos into posters and individual pictures as visual stimuli. Participatory photography, which involves providing cameras, in this case, to women in the villages of a patriarchal society, might not represent women's views. Women would be forced by men or elders in the community to make choices on the photos to be taken, thus limiting women's participation and contribution. Also, following the cautions raised by Eves (2007), the researchers wanted to avoid any unanticipated experiences of generating suspicion and embarrassment (Prins, 2010) for women by having them moving around the villages and elsewhere taking pictures for the research team.

Posters were developed from a broad selection of pictures representing the various horticultural tasks which had been taken on digital camera during previous field trips by the research team to villages Rigo-Koiari and Bautama in Central Province in PNG. The pictures representing the various horticultural tasks were initially compiled by female researchers in Australia in consultation with female extension staff from the Fresh Produce Development Agency in PNG. The selection of pictures representing the various horticultural tasks incorporated feminist theory (Williams & Lykes, 2003), and was designed as far as possible to avoid the male bias that has previously dominated participatory research (Maguire, 1987; Williams & Lykes, 2003).

The various horticultural tasks represented were soil preparation, planting, irrigation, crop management, harvesting, packaging, marketing, transport, banking and book keeping. From this, the picture categories of four horticulture tasks (H1-soil preparation, H2-planting, H3-irrigation, H4-crop management), three marketing tasks (M1-harvesting, M2-packaging, M3-marketing) and three business tasks (B1-transport, B2-banking and B3-book keeping) were chosen. Thus 10 posters were prepared. To ensure ethical compliance and avoid invading the privacy of participants or revealing embarrassing facts about individuals, 'best practice' pictures were selected from a previous ACIAR project publication (*(QualityManagementofFreshProducefromtheHighlandsofPapuaNewGuinea:APostharvestManual, 2007)*. Ethical clearance was also obtained from the Social Science Human Research Ethics Committee Network (Tasmania), through the University of Tasmania. Two pictures on business tasks – B2-banking and B3-book keeping – were constructed by the research team without human subjects being portrayed. The approach was informed by the discussion of ethical dilemmas in developing posters without human subjects being portrayed, as in PNG people were willing to appear in pictures (Prins, 2010; Williams & Lykes, 2003). The final selection of pictures representing the horticultural tasks was printed as poster sets of A3 size sufficient for 32 participants in groups of eight. Photos were selected by female staff of the Fresh Produce Development Agency (FPDA). Examples of some pictures and the reason/s for selection are given below.

Poster – Card for Horticulture: Soil preparation (H1)

This photo was ranked first among the photos by the FPDA staff because land is valued in everyday farming in rural areas. A picture of land cleared and prepared for agriculture said it all – more than pictures showing any process for soil preparation. This provides clear evidence that the staff of FPDA viewed the pictures as local women would, rather than viewing them to meet researchers' needs, as has happened in earlier studies, e.g. *Through Navajo Eyes: An Exploration in Film Communication and Anthropology* (Feitosa, 1991; Worth & Adair, 1972).

Poster – Card for Horticulture: Planting (H2)

The photo below was ranked first by the FPDA staff for planting because the women need to know about seed packaging, the content of that package, expiry date and growing locations.

Poster – Card for Marketing: Packaging (M2)

This picture was chosen as the ideal way to pack produce, such as onions, and it showed how to store them correctly. It was thought that storing produce on packing trays would not cause damage to crops and the picture showed the right packing material for the onions, i.e. open weave bags ideal for air circulation.

Poster – Card for Business: Banking and Savings (B1)

The main banks that operate in PNG are the Bank of South Pacific (BSP), ANZ and Westpac. However, it was decided, in consultation with FPDA staff,to symbolically represent savings as a piggy bank with money rather than identify any particular bank.

Poster –Card for Business: Book keeping (B2)

The poster for book keeping was chosen as appropriate and self explanatory.

The posters were used as a tool for a two-day consultative workshop in Port Moresby to identify training needs among female participants.

Training needs assessment

A consultative workshop was conducted in September 2011 to assess the training needs for women in PNG. Criteria were developed to guide the selection of women, including a range of ages and willingness to share training with other women. Other criteria used for selection were an active involvement in horticulture and/or intent to develop their gardens, and previous training of some kind. The outcome was better than expected, with 32 women and their daughters from the villages of Rigo-Koiari and Bautama attending the workshop. The pictorial method was trialled following Freire's (1973) principles of enabling people to participate and think critically using visual images. The participation was facilitated by contextualising, that is reflecting on participants' experiences in the village in regards to the task portrayed (Wang & Burris, 1997). As women engaged in discussions about the tasks it allowed them to progress to apply critical thinking and to analyse what they might need to complete the tasks. The cyclic outcomes of knowing build on previous iterations of knowing (John Heron, 1989). These are discussed below under the following headings: presentational knowing (visual recall on represented experiences), practical knowing (learning how to identify their needs) experiential knowing (interacting with people in new ways), and propositional knowing (developing new conceptual understandings).

Presentational knowing

In the consultative workshop the women from Rigo-Koiari were seated on three tables and the women from Bautama seated on one table to give an equal participatory voice in the workshop, as Rigo-Koiari women outnumbered Bautama women by virtue of the number of villages in the Rigo-Koiari cooperative. A leader representing each village was asked to talk briefly about her village and the produce they grew.

Each table was given 10 poster cards representing tasks on categories of horticulture, marketing and business. The participation of women was facilitated by contextualising as mentioned by Wang and Burris (1997) and Heron (1999) to reflect on participants' experiences in the village in regard to the task portrayed. The posters helped the women to imagine performing the task, which facilitated discussion and sharing of experiences and tacit knowledge. The poster cards 'portraying' activities helped participants to visually recall represented experience that grounded presentational knowing (J Heron, 1996; Prins, 2010).

The facilitator assisted participants to discuss which horticultural jobs women and youth found easy, more difficult and very difficult to do by visual recall stimulated by the 10 posters. They were then asked to allocate poster cards to one of three stacks based on those assessments as presented in

Table 1.

Some groups began with difficult tasks and others with easy tasks. Each group presented their findings to the whole workshop by posting the poster cards on the wall under the headings of easy, moderately difficult and most difficult, and explaining their ratings. The presentational knowing using posters helped the participants to visually recall represented experience (John Heron, 1989; Prins, 2010), reveal tacit knowledge and state what horticultural jobs women and youth found easy, quite difficult and very difficult to do. The tacit knowledge discovered through presentational knowing (visually recall represented experience) provides the grounds for practical knowing (learning how to identify their needs) discussed in the next section.

Table 1. Ranking of horticulture task based on difficulty by women participants in a workshop to determine training needs for women in horticulture in PNG

	Workshop participants' ranking of horticulture task		
	Very difficult	**Quite difficult**	**Easy**
Rigo Group 1	H1-Soil Preparation ("men's job") H3 Irrigation B3 Transport	H4 Crop management ("identification of pest and diseases is difficult") M3 Marketing	B2 Book Keeping B1 Banking M2 Packaging H2 Planting M1 Harvesting
Bautama group	H2 Planting H4 Crop management ("We know how to use chemicals. But the price is too high") B2 Book Keeping B1 Banking B3 Transport	M3 Marketing	H3 Irrigation M1 Harvesting M2 Packaging H1 Soil Preparation
Rigo group 2	H3 Irrigation M3 Marketing B3 Transport M2 Packaging	H1 Soil Preparation H4 Crop management H2 Planting M1 Harvesting	B2 Book Keeping B1 Banking
Rigo group 3	H4 Crop management ("Men attended training on application of chemicals and the knowledge was not transferred to us") B3 Transport M2 Packaging ("appropriate packaging is very difficult as there is a need to take it to longer distance")	B2 Book Keeping M1 Harvesting H3 Irrigation	H1 Soil Preparation H2 Planting B1 Banking M3 Marketing

Practical knowing

The tacit knowledge discovered through presentational knowing (visually recall represented experience) (John Heron, 1989; Prins, 2010) discussed in the previous section forms the grounds of practical knowing (learning how to identify their needs). The posters helped participants to engage in critical analysis of prioritisation of their needs to discover explicit knowledge through practical knowing.

Participants at the workshop learned how to prioritise their needs by engaging in critical analysis (John Heron, 1989; Prins, 2010). This 'practical knowing' will help participants in the process of prioritisation of needs in future as presented in **Table 2**. In the process of prioritisation women in each group had the opportunity to voice their needs individually (John Heron, 1999; Reason & Bradbury, 2008b). Gold and silver stars were handed out, with the explanation that gold represented the highest preference and silver the second highest preference for training: six of each were provided for women and youth in each of the categories of horticulture, marketing and business. The approach was similar to voting, in that the method gave every member of the group an opportunity to express their individual needs without influence from other members of the group, thus each individual in each group had their voice heard. Also, to differentiate the older mothers from the youth and/or younger mothers, the youth and young mothers were provided with green adhesive stickers so that they could place the stars on the stickers.

The older mothers of Bautama village identified and ranked their highest training need as crop management, followed by banking, irrigation and planting. The youth of Bautama showed a similar preference and ranking of training needs, though they also identified the importance of marketing (**Table 2**).

The older mothers of Rigo-Koiari village identified similar training needs in crop management, although their highest ranking was for book-keeping, followed by harvesting, soil preparation, marketing and packaging. Youth put their highest emphasis on soil preparation, crop management and irrigation and therefore prioritised quite differently than their mothers compared with Bautama younger women. It transpired that some older mothers had received training in soil preparation, packaging, irrigation and marketing, but other younger women were not aware of this and vice-versa for banking, harvesting and marketing training for youth. The importance of sharing knowledge in the community between older and younger mothers was recognised and discussed.

The two villages were quite different in terms of their priority training needs for both older and younger mothers. It appeared that the training needs at Rigo-Koiari were at another, possibly higher, level of management than those at Bautama, where basic horticultural and crop management needs were the priority. This established that the participants at the workshop learned how to prioritise their needs by engaging in critical analysis (John Heron, 1989; Prins, 2010; Reason & Bradbury, 2008b). In the process of prioritisation women in each group had the opportunity to voice their needs individually. Practical knowing (learning how to identify their needs) enabled to discover explicit knowledge that was established based on the presentational knowing (visually recall represented experience). By means of learning how to identify their needs participants were directed towards gaining potential knowledge which was creation and acceptance of new knowledge through training (John Heron, 1989; Gomathy Palaniappan, 2009; Smedlund, 2008). The potential knowledge gained became the grounds for experiential knowing discussed in the next section.

Table 2. Training needs priorities in horticulture identified by women from two locations (Bautama and Rigo-Koiari) in PNG.

Women participants	**Bautama**	**Rigo-Koiari**
Older mothers	Crop Management (I) Banking (II) Irrigation (III) Planting (IV)	Book Keeping (I) Harvesting (II) Soil Preparation & Crop Management (III) Irrigation (IV)

		Marketing (V) Packaging (VI)
Youth	Crop Management (I) Banking (II)	Soil Preparation, Crop Management, Irrigation (I) Book Keeping (II) Irrigation (III) Harvesting (IV) Packaging (V) Banking (VI) Marketing (VII)

Experiential knowing

Experiential knowing of interacting with people in new ways builds on tacit knowledge, explicit knowledge and potential knowledge established through previous iterations of presentational knowing and practical knowing, as discussed earlier (John Heron, 1989). Active workshop participation built confidence among the participants. As a result participants learned how to interact in new ways through co-learning which Heron (1996) and Prins (2010) describe as experiential knowing . Participants matched their training needs with the various institutions such as Fresh Produce Development Agency (FPDA), National Agricultural Research Institute (NARI) and Pacific Advent University (PAU). The participants felt empowered as the table facilitators from partner institutions agreed to design training activities to meet their needs.

Co-learning was evident from the following discussions among the participants. Young mothers from Rigo-Koiari identified that business skills need to be delivered by FPDA and NARI. The Rigo-Koiari cooperative leader mentioned having previous training in book keeping and banking and agreed to share the knowledge with other women from both villages. Participants quickly agreed to attend the training to be conducted by the Rigo-Koiari leader. Older mothers from Rigo-Koiari identified that horticulture, marketing and business skills training needs should be met by FPDA NARI and PAU. During the discussion it was noted that banking institutions provided training in microfinance. This provided insights to the research team to follow up training with the private banking institutions for the participants, and demonstrates that the participants learned how to interact and co-learn with other participants and table facilitators from local institutions as well as the Australian research team. Experiential knowing of interacting with people in new ways became the ground for the next iteration of learning: propositional knowing.

Propositional knowing

Propositional knowing of new conceptual understanding builds on previous iterations of presentational knowing, practical knowing and experiential knowing discussed earlier (John Heron, 1989)**.** The new conceptual understanding that the participants were engaged in was to dream about their future. Dreams are about envisioning the future and provide the entry point for exploring strategies to improve vegetable growing, and thus encouraging them to implement actions and provide feedback to the community (G Palaniappan et al., 2011; Watkins & Mohr, 2001).

Older mother's groups and young mother's groups from Rigo-Koiari and Bautama villages were organised into separate age groups to find out what dreams or ideas women and youth had for their futures. Women from different villages were combined as the participants felt comfortable in engaging in discussions with the same age group, whether or not they belonged to the same village. This freed them from the usual constraint imposed by inequality, in which they had to follow men's dreams. It could be argued that the pictorial tools set the scene for the older mothers to dream, as the majority of the dreams mentioned were to be achieved through improved horticulture production. However, in the case of the younger women, some of their dreams lay outside the strictly horticultural pictures presented. In essence, the wellbeing of the home and the community was high on the agenda of the older mothers. Children's education was seen to be the one of the most important dreams of the older mothers, followed by useful technology and improved infrastructure. The youth group, including young mothers, contrasted quite markedly, having individual and career-oriented dreams to become a broker/middle woman, small business owner, gain further education, have their own home and to be financially secure.

These outcomes contradicted assertions made locally that 'women don't dream' and that they 'wouldn't be able to answer questions' in relation to future wishes and aspirations.
The outcomes of presentational knowing (visual recall on represented experiences), practical knowing (learning how to identify their needs) experiential knowing (interacting with people in new ways), and propositional knowing (developing new conceptual understandings) confirmed cyclic outcomes of knowing built on iterations.

Discussion

PNG's gender inequality index shows that the benefits of growth are not evenly distributed among the genders. As previously mentioned, Gibson and Rozelle (2004) highlighted the existence of cultural social bias against girls in rural areas compared to urban areas. The inequality potentially impacts on personal growth and in turn increases poverty. The pictorial method was used to allow rural women to participate in spite of their low level of literacy. This selection of pictorial method was based on Freire's (1973) principles of enabling people to participate and think critically using visual images. The research team chose to use the pictorial method of developing visual images which is also associated with participatory action research (Prins, 2010), where participants will experience cyclic outcomes of knowing built on previous iterations of knowing (John Heron, 1989):

presentational knowing (visually recall on represented experiences), practical knowing (learning how to identify their needs), experiential knowing (interacting with people in new ways) and propositional knowing (developing new conceptual understandings).

The presentational knowing using posters helped the participants to visually recall represented experience (Prins, 2010) to discover what horticultural jobs women and youth found easy, more difficult and very difficult to do. The poster cards helped the women to imagine performing the task, which allowed them to engage in discussions and share their tacit knowledge. The poster cards portraying activities helped participants to visually recall represented experience The presentational knowing using posters helped the participants to visually recall represented experience, reveal tacit knowledge and state what horticultural jobs women and youth found easy, quite difficult and very difficult to do that grounded presentational knowing. Practical knowing enabled them to discover explicit knowledge that was established based on the presentational knowing. Participants at the workshop learned how to prioritise their needs by engaging in critical analysis (Prins, 2010). In the process of prioritisation women in each group had the opportunity to voice their needs individually. Experiential knowing of interacting with people in new ways builds on tacit knowledge, experiential knowledge and potential knowledge established through previous iterations of presentational knowing and practical knowing.

Propositional knowing of new conceptual understanding builds on previous iterations of presentational knowing, practical knowing and experiential knowing. Active participation by participants during the workshop built self confidence among the participants. As a result participants matched their training needs with trainers from the various institutions such as Fresh Produce Development Agency, National Agricultural Research Institute and Pacific Advent University. The new conceptual understanding that the participants were engaged in was to dream about their future, rather than following men's dreams. Most women were initially 'overwhelmed' by the process of the workshop as they had not previously experienced this approach or been treated with the respect and dignity it encouraged. However, they rapidly adapted to the workshop environment and responded enthusiastically. All the groups agreed that the workshop met most of their expectations. Some individual comments were: "This is first of its kind. We have never been to any workshops." "We appreciate the facilitators for including us as a part of the action plan." "Everything we learned from the workshop has been very fruitful." "We have learned many ideas from the Australian team and FPDA, NARI and PAU and just by talking to each other," "We have enjoyed being in this workshop." The findings of the workshop and the earlier work have demonstrated that women in PNG, whether older mothers or younger women (mothers and youth), see involvement on the vegetable (horticultural) value chain as an important path to alleviating poverty, achieving a level of equality and personal and financial independence, while achieving their family goals. The approach also revealed and gave voice to independence of thought and developed openness in communication once women were freed from patriarchal dominance, and felt empowered to be open and frank in identifying their needs and aspirations.

For complementarity and balance, a similar approach is needed with men in order to gain a fuller understanding of their perceptions and thus community expectations and pathways to support horticultural production and community development. This will be done as part of ongoing socio-cultural research in PNG.

Conclusion

The process used was successful, in that it achieved the objectives of the research, and provided participants with new-found confidence, understanding and feelings of independence and self worth. From this research, training needs and potential providers were identified which, on implementation, should provide for enhanced female participation in the vegetable (horticultural) value chain. Whether women were subsequently able to share their training with other women and implement learning in their practice remains to be seen and can only be assessed by follow-up research into capacity building outcomes and impacts of training that is implemented following the training needs analysis reported here. Further value will be added once the complementary research with men is completed.

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The Role of Soil Organic Matter in Temperate Vegetable Value Chains in Central Province, Papua New Guinea: a Short Review

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Keywords: compost, climate, soil type, shifting and continuous cultivation, nutrient recycling

Abstract

This paper reviews available literature on vegetable production systems in Papua New Guinea (PNG), including the role of composted organic matter in sustaining the practice of shifting cultivation. The implications for commercial temperate vegetable production in Central Province (CP), PNG, are discussed, taking into consideration the similarities and differences between CP and the traditional highland vegetable production regions.

INTRODUCTION

Agriculture in PNG has traditionally been practised on small holdings to produce staple foods such as sweet potato, taro and banana. Shifting cultivation, where land is cropped for periods of one or two years interspersed with several years of regrowth of natural vegetation, is common (Sem,1996; Sillitoe, 1998; Hartemink, 2004). However, PNG is a large and diverse country, and a range of both traditional and recently introduced production systems exist, including extended cropping over several years, perennial plantations, and even hydroponic production. With population growth over 2% per year (CIA, 2011) demand for food is increasing. Near the capital, Port Moresby (PoM), this is compounded by internal migration from rural regions to peri-urban areas and by the increasing demands of the expanding middle class and mining and gas developments for more diverse foods such as cool temperate vegetables (FPDA, 2009). To try to help meet this demand a project began in 2010 to establish viable value chains for the production of temperate vegetables in CP, near PoM (Fig. 1). Sustainable, profitable production of the required volume and quality is the foundation of such chains. However, the capacity of traditional smallholders to consistently deliver these requisites is low and, in particular, they lack the financial resources and resilience to manage risks associated with high input production systems. Thus, the management of soil fertility through organic matter is a fundamental part of viable value chains that enable greater indigenous benefit from the resources boom.

This review briefly considers the potential role of soil organic matter in underpinning value chains by examining how soil organic matter has been managed in traditional systems and by considering the implications of translating or adapting such practices to temperate vegetable production in CP.

ORGANIC MATTER IN PNG SOILS

Organic matter (OM) is widely accepted as a vital component of a healthy soil physical, chemical and biological condition (Dick and Gregorich, 2004) and its concentration in soil is the net result of biomass production and decomposition (Greenland and Nye, 1959). Of the five major soil-forming factors (climate, parent material, time, organisms and topography; Jenny, 1941) climate is possibly the strongest determinant of soil OM concentration because of its major influence on plant production and on the activity of decomposing organisms; rainfall being positively and temperature negatively correlated with OM concentration (Spain et al., 1983). In tropical and semi-tropical environments, temperature and rainfall are generally greater than they are at higher latitudes, and evidence from Australia suggests that tropical conditions, particularly the higher temperatures, result in lower soil OM concentrations (Spain et al., 1983).

Situated between the equator and 12°S, PNG lies in the tropics, but its soils somewhat confound the conventional view of tropical regions because of the country's relatively young and still active landscape, and significantly cooler climate in its highland areas (Bleeker, 1983). OM concentrations greater than 10% are common in surface soils under native vegetation, particularly in the highlands (Bleeker, 1983; Sillitoe and Shiel, 1999). Many PNG soils are much less weathered than the Oxisols (Soil Survey Staff, 2006) and Ultisols of tropical Africa and South America (Sillitoe, 1998), and retain some permanent surface charge (Bleeker and Sageman, 1990). They include Alfisols, Entisols and Inceptisols which are estimated by Bleeker (1983) to cover over 40% of PNG's land mass, and 60% by Hartemink (2004). These soils, compared to Oxisols and Ultisols, are therefore less dependent on OM as a source of CEC. Indeed, some Inceptisols developed on volcanic ash preserve OM from decomposition and show a negative relationship between OM and CEC (Bailey et al., 2008). This is thought to be due to the complexing of OM and its decomposition products by allophane, a mineral present in volcanic ash, which reduces the specific surface area of the allophane and blocks some negative charge on the humus (Bartoli et al., 2007; Buurman et al., 2007). PNG does have highly weathered soils, including Oxisols at Sogeri in Central Province and Ultisols in Western and West and East Sepik Provinces (Bleeker, 1983), but they are not widely represented. Reports of OM in lowland soils are few, but the higher temperature would be expected to give lower concentrations than in the highlands. This is borne out by data from Hartemink et al. (2000) from a sandy, alluvial Entisol at Lae (65 m altitude) in Morobe Province, which had only 2.4% organic carbon in the top 23 cm.

ORGANIC MATTER MANAGEMENT IN PNG CROPPING SYSTEMS

Shifting cultivation has been the system of agriculture traditionally practiced in PNG, and can include continual movement to new areas after one or two years of cultivation or a more systematic rotation between plots within a limited overall area (Bleeker, 1983; Manu and Halavatau, 1995). Fallow periods, during which the land is usually allowed to return to natural vegetation, extend from a few years to more than a decade, depending on available land. One of the main benefits of shifting cultivation in tropical environments is the recovery of soil OM and associated nutrient reserves during the fallow period, for it is by depleting this pool that nutrients are supplied for the cropping phase. For example, at Kerevat in the lowlands of East New Britain Province, (Bourke, 1980; cited by Bleeker, 1983) soil OM halved after 16 years of continuous cropping with sweet potato, taro and peanuts or cowpeas.

The fallow is generally considered to recover and recycle nutrients more than generate new stocks (Hartemink, 2004), but as increasing population pressure has led to shorter fallows (Szott and Palm, 1996), attempts have been made in some areas to introduce leguminous and other shrubs into this phase rather than rely on grasses such as *Imperata cylindrica* (kunai grass) which is a common invader after cropping ceases. In Morobe Province, Hartemink (2004) found that after a one year fallow, the leguminous shrub *Gliricidia sepium* held greater stocks of carbon, nitrogen, phosphorus, calcium and magnesium than either a non-leguminous shrub *Piper aduncum*, or kunai grass. Overall, *Piper* was the preferred fallow because it returned greater amounts of nutrients to the soil, rather than *Gliricidia,* which sequestered a large proportion into woody tissues. The greater return of potassium by *Piper* (200 kg/ha compared with 100 kg/ha for the other species) was of particular importance because of the high K demand of the root and tuber crops grown in the cropping phase by the local farmers.

In PNG, staple foods like sweet potato are widely grown in soil mounds or raised beds (Sillitoe, 1998; Fig. 2a), but the mounds take different forms in different districts. Some mounds are large (40-120 cm in height, 100-400 cm in diameter) and made by covering heaps of dried grass and compost with 20-30 cm of soil, while others are smaller and contain no added organic material (Waddell, 1972). Oral history credits Tuingi, an Engan man, with developing the first composted mounds for sweet potato cropping with the aim of increasing tuber yields for a 'mapu yae' feast. The practice then spread to areas outside Enga Province (Weissner and Tumu 1998). Hence, these special composted mounds became known more popularly as Engan mounds. Other food crops are often planted with sweet potato including corn, brassicas (e.g. cabbage, kale, rape, mustard), beans, peas, and highlands pitpit (*Setaria palmifolia*) as illustrated in Fig. 2b.

While shifting cultivation is widespread, some Southern Highlands farmers on volcanic ash soils (Andepts) were observed to keep gardens with large mounds containing embedded compost under cultivation for more than 10 years with only occasional, brief grass fallows (Sillitoe, 1998). Soil organic carbon was maintained above 10% throughout the cultivation period, aided presumably by complexing of soil OM with the mineral allophane (Bailey et al., 2008). In this situation, the compost, because of its concentration in the centre of the mounds, appeared to have minimal soil contact and consequent nutrient immobilisation but its nutrients are still directly accessible to crop roots. Increasing rates of compost have been shown to give a linear increase in sweet potato yields of a similar order to equivalent rates of inorganic fertiliser (Floyd et al., 1988), while Kapal et al. (2010) showed that, compared to burning or mulching, the composting of organic matter in mounds improved sweet potato yields. The reasons for the response to composting and mounding are thought to include increased soil depth and the establishment of soil physical conditions conducive to both tuber development and OM mineralisation, and less favourable for diseases including tuber rots (Sillitoe, 1998).

Evidence for yield decline under shifting cultivation in PNG is largely anecdotal (Bailey et al., 2008) and there is further anecdotal evidence (Sillitoe 1998) that yield decline is not universal. In the latter case, farmers in the Southern Highlands were able to sustain production by moving to a virtual sweet potato monoculture after an initial year or two of more diverse cropping. While soil fertility and OM declined with time, sweet potato appeared able to continue to produce with the regular addition of composted regrowth grasses (estimated at 20-40 t/ha fresh weight, equivalent to an estimated 3-6 t/ha dry matter) between successive crops. The potassium recycled in this way, and the ability of sweet potato to scavenge for soil phosphorus, were considered key attributes of the system's resilience (Sillitoe, 1998). While the nitrogen recycled at these rates of compost is modest (30-60 kg N/ha at 1% N in dry matter), Hartemink et al. (2000) found that sweet potato cv. Markham did not respond to more than 100 kg N/ha as ammonium sulphate, indicating that recycled N may be able to meet most of the crop's requirement.

TEMPERATE VEGETABLE PRODUCTION IN CENTRAL PROVINCE

The literature reviewed thus far is weighted towards the main vegetable production regions in the PNG highlands and to sweet potato, the staple crop in those areas. Our project aims to increase temperate vegetable production for commercial markets in CP, near PoM. Here the soils are not formed on volcanic ash but consist of other Inceptisols as well as Vertisols in the coastal lowlands (<200 m), and Oxisols at Sogeri (400-600 m) and Tapini (1100m). Other than the Oxisols, these soils are not as strongly structured and are less well drained than many in the highlands, particularly the volcanic ash soils. In addition, being mostly at lower altitude, temperatures are higher in CP than in the highlands, and rainfall is less (about 1000 mm per annum), with a more distinct dry season (Bleeker, 1983). Finally, unlike sweet potato, temperate vegetables are not efficient phosphorus scavengers and would be expected to respond strongly to inorganic P fertiliser.

Mounding is practiced in some CP agricultural systems, particularly in those higher areas where sweet potato is a dominant or sub-dominant staple, or in those lowland areas where highlanders have settled and brought sweet potato with them (Bourke 1985). However, mulching is not common, with burning the preferred way to deal with fallow regrowth (Allen et al., 2002). This represents a loss of carbon and nitrogen from the soil and presents our project with an opportunity to try to capture these losses for the benefit of our temperate vegetable production systems. The lower rainfall in CP means there will be relatively less vegetative regrowth during the fallow period and so less organic inputs at the time of land preparation. Combining this fact with the knowledge that temperate vegetables are relatively inefficient nutrient scavengers, especially for phosphorus, leads us to the conclusion that some NPK inorganic fertiliser will be needed if the volumes and quality of produce required by the market are to be supplied. Given that we also aim to produce our vegetables in the dry season to minimise the impact of pests and diseases, irrigation will also be needed, especially in the lowlands. This has previously been recommended for lowland onion production (Wiles 2000). Some system intensification thus appears inevitable. However, we believe only modest intensification is needed to meet market goals, and just as importantly, that modest changes are those most likely to be adopted. With this in mind, we aim to compare three production systems in our forthcoming field work: 1) a typical low-input system based on common production practices described in the Mapping Agricultural Systems Project (MASP), a survey of land and agricultural systems and practices in various PNG districts (Allen et al., 2002). These systems are slash and burn having long fallows and short cropping periods, with soil fertility maintenance restricted to legume rotation in sub-systems where longer cropping periods are practiced (e.g. Hiri District). 2) a best practice low-input system based on MASP but modified to incorporate low-cost practices such as gravity fed micro-irrigation, mulching, compost and minimal synthetic fertiliser application that offer a high return on investment and minimal capital expenditure; and 3) a high-input/high-output system resembling that used in developed countries.

Up to five cultivars of a range of temperate vegetables including tomato (*Solanum lycopersicum)*, capsicum (*Capsicum annuum* var. *Annuum)*, broccoli (*Brassica oleracea var. Italica*), headed cabbage (*Brassica oleracea var.* C*apitata* L.), carrot (*Daucus carota* L.) and French bean (*Phaseolus vulgaris* L.) will be grown at low altitude (50 m, max. 32–30°C; min. 23–19°C); mid altitude (400 m, max. 30–27°C; min. 19–16°C); and high altitude (1100-1800 m, max 23-19°C, min. 12-9°C). The land systems defined by MASP relevant to the selected areas (Allen et al., 2002) can be broadly characterised by fallow and rotational practices, maintenance of soil fertility, irrigation, physical soil management and bedding practices. All rely heavily on fallow to maintain soil organic matter, and very little irrigation is undertaken. Consequently, it is our view that the low-input best-practice system used to support value chain development should focus on the incorporation of organic matter as compost and mulch (Fig. 3), the inclusion of *Piper* and leguminous species during fallow, supplementation with low rates of synthetic fertiliser, and the implementation of low-cost micro-irrigation systems.

CONCLUSION

Translating knowledge about traditional vegetable production in the PNG highlands to viable temperate vegetable production in Central Province is challenging because of significant differences in climate, soils and crop species. Nevertheless, it is very likely that maximising additions of organic matter to soil will be a key part of sustainable production systems that are low-cost but which offer sufficient returns to be attractive to farmers.

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Figures

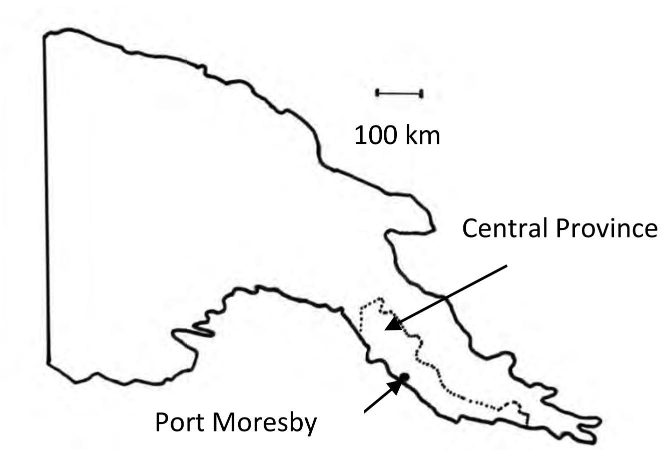

Fig 1. Map of mainland Papua New Guinea showing Central Province.

Fig. 2a. A vegetable gar (PNG Highlands) with sweet potato p ing embedded organic matter.

Fig. 2b. Sweet potato intercropped with vegetables on an Engan mound (photo courtesy of Issac Taraken).

Fig. 3. Mulched taro plot at Boze, Western Province (photo courtesy of James Ernest).

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A NOTE ON ENTREPRENEURSHIP AS AN ALTERNATIVE LOGIC TO ADDRESS FOOD SECURITY IN THE DEVELOPING WORLD

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The purpose of this paper is to explore an ongoing application of the entrepreneurial method applied to the problem of food security in the developing world as an alternative logic. Food production and marketing channels in the developing world are often based on scientific logic starting with an ideal outcome and then strategically designing a plan to achieve it. This study is unique in that it describes the application of an entrepreneurial approach to food product and marketing in less developed nations. A field study is used to illustrate how entrepreneurship is being harnessed to help build a more efficient and effective agricultural value chain in Papua New Guinea (PNG) based on a more entre- preneurial approach. Value chain analysis uses effectual logic to leverage innovation and create value for the consumer, the organization and society; thereby enhancing food security for the desperately poor in PNG. The use of the entrepreneurial method is offered as an alternative model for future international aid interventions and policy.

Keywords: Entrepreneurial method; developing economies; value chain.

1. Introduction

Too often, individuals blame business for poverty that affects much of the world; however, rather than being the cause of poverty, business is part of the solution. The ability to bring commerce to those in desperate need will encourage the economic development of these settings. Much of the world has made rapid economic progress over the last 20 years; however, that so many people remain in such desperate poverty should motivate management scholars to seek ways to encourage business and economic development in these places (Bruton, 2010).

2. Purpose

Sarasvathy and Venkataraman (2011) describe an entrepreneurial perspective as an approach to creating market opportunities that help alleviate the needs of the world's poorest through "unleash(ing) the potential of human nature." This paper explores how entrepreneurship as method has been harnessed to create a more efficient and effective agricultural system to better the lives of the poor using a case study of a developing nation, PNG. Specifically, we (1) investigate the exploitation of entrepreneurship as method within a vegetable production and marketing value chain that supplies food markets in Port Moresby, PNG; (2) illustrate the application of value chain analysis to create a better coordinated and more effective vertical marketing system designed to improve food security for the poor; and (3) explore how international development agencies, such as the Australian Centre for International Agricultural Research (ACIAR), leverage entrepreneurship as method to begin to enhance the quality of life for those bottom billion through the creation of value for consumers, organizations and society. This project extends the work of Collins et al. (2002) and Bonney et al. (2007a) on agricultural value chains by adapting Kotler and Keller's (2006) notion of a value creation equation and Morris et al. (2011) classification framework of corporate entrepreneurship to develop a framework of entrepreneurial value creation.

Bruton's (2010) recent call for action has stimulated scholars to consider how entrepreneurial initiatives may be used to improve the lives of those desperately poor residing in the world's less developed countries (LDCs) described by Collier (2007) as the "bottom billion." Sarasvathy and Venkataraman (2011) suggest that "large and abiding problems at the heart of advancing our species" that have not yet been solved through the "scientific method" may be potentially addressed through the entrepreneurial method. They argue that the entrepreneurial method reflects the increasingly resource-constrained reality of the rapidly growing and consumptive population. This entrepreneurial perspective uses an effectual conceptualization of problems to reframe "the problem space and reconstituting existing realities into new opportunities, whereas causal framing involves the discovery and exploitation of existing opportunities within a given problem space" (Dew et al., 2009). Effectuation logic has many advantages over the traditionally used causal logic-dominated scientific method for international development initiatives. Sarasvathy (2001) found that innovation and business creation is an effectual, creative and dynamic process starting with the means the entrepreneur can leverage and ending with a unique outcome. Instead of strategic planning to determine what the desired outcome is for the international development initiative, effectuation logic suggests the international development agency focus first on the means and resources that can be leveraged and use these means to create a new outcome.

With food security becoming more of a strategic issue for global geo-political stability because of rapid population increases in LDCs, increasing urbanization and rising demand for the use of agricultural resources for alternative sources of energy such as bio-fuels, world leaders are increasing their interest in food security (for example, see WikiLeaks, 2011). In this regard, Sarasvathy and Venkataraman's (2011) conceptualization of the entrepreneurial method has much to offer international development agencies when attempting to address the critical issue of how to create what the United Nations' Food and Agriculture Organization (2010)(www.fao.org) suggests when it proposes:

> Food security exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life.

Banerjee and Duflo (2007) report that among the very poor, "food typically represents from 56 to 78 percent of consumption among rural households and 56 to 74 percent in urban areas." The entrepreneurial methods would suggest the problem of food security for the very poor could be reframed to consider how this tragedy can be turned into an attractive market opportunity. For example, entrepreneurship scholars such as Prahalad and Hart (2002) and Hart and Christensen (2002), among others, suggest the very poor can be an economically attractive market segment with tremendous unmet needs when seen from this opportunistic entrepreneurial perspective.

International development agencies, such as ACIAR, have explored a more entrepreneurial perspective to leverage development resources. ACIAR provides funding to support the innovation of agricultural value chains in LDCs, attempting to use innovation-oriented social and bio-physical research to increase food security among the earth's poorest. This type of initiative illustrates the beginnings of a revolution in thinking from a scientific method-based causal logic to an entrepreneurship-as-method effectuation-based logic in international development agencies such as ACIAR.

3. The Entrepreneurial Method

The linear, scientific view that espouses entrepreneurs identify, evaluate and exploit opportunities has been criticized as not adequately reflecting the resource-constrained reality of our world (Shane and Venkataraman, 2000; Sarasvathy and Venkataraman, 2011). The entrepreneurial method, or effectual logic (Read et al., 2009; Sarasvathy, 2001; Sarasvathy and Venkataraman, 2011), espouses that entrepreneurs co-create opportunities with stakeholders to allow goals to emerge over time through this interaction, given a set of means. Effectual reasoning is a creative process that is of particular use during venture creation. For example, effectual reasoning starts with the means of "what I know, who I know and who I am," and then leverages these means to achieve an often stochastic array of potential outcomes. Sarasvathy (2001) argues that effectuation is underpinned by principles such as affordable losses, the importance of key relationships and the leveraging of contingencies, that when combined provides a logic of how successful entrepreneurs have forged new value creating organizations. These ideas have been seen in a number of entrepreneurial studies, both academic and practical. For example, Baker and Nelson (2005) show how resource-constrained firms do not allow internal or external limitations to create a barrier to enact opportunities, and instead, make do with what is at hand or by combining new resources. Reis (2011) also argues, from a more practical perspective, that this form of entrepreneurial thinking avoids waste, frequently adapts ideas, learns from mistakes and therefore, can do with fewer resources. These ideas may prove to be particularly useful in a developing economy in which resources are scarce, feasible opportunities are not obvious and relationships are crucial.

International development agencies are institutions grounded in the application of science and technology to the world's food and development problems. Schramm (2010) notes that, in the cases of Afghanistan, Haiti and Iraq, a scientific based command and control approach to economic reconstruction tends to fail. Although the scientific approach to problem solving has driven great advances in the production of food, such as the Green Revolution's hybrid seed technology's impact on reducing poverty and malnutrition in the LDCs from the 1950s to the 1980s (see Lipton, 2007), it does not help make a dynamic and prosperous economy (Schramm, 2010). With these technology interventions have also come unintended and undesirable consequences such as increased urbanization in LDCs, increased risk of large scale crop failure because of lower levels of bio-diversity and increased levels of debt incurred by substance farmers that adopt more sophisticated agricultural technology. An entrepreneurial dynamic perspective helps transform these problems into market opportunities to create value and generate wealth within the LDC. Instead of considering malnutrition as a problem primarily of food production, the entrepreneurial method forces an effectuation based systems approach, leveraging innovation to transform a series of spot markets into a more coordinated vertical marketing system and agricultural value chain.

Effectuation scholars (see www.effectuation.org) have suggested there is an effectual cycle that is recursive, dynamic and flexible; that results in both new outcomes and new means. The effectual cycle is divergent and expanding in contrast to the scientific method's convergent and contracting causal logic models and creates additional means through the interaction with customers and stakeholders. The process of effectuation logic begins with the "bird in hand principle," or the means, resources, partnerships and capabilities that can be initially leveraged. Then, effectuation logic suggests decisions are screened by potential loss. Actions that have an unacceptable loss are avoided, even if they might also result in a significant outcome. Interaction with customers, beneficiaries and partners is engaged in at the onset of the initiative to generate additional means and ends. Relationships are formed with various customers, beneficiaries and other stakeholders who commit to the co-creation of the future, creating new means and ultimately new outcomes. Figure 1 develops a generalized effectual cycle that illustrates international development initiatives.

Fig. 1. Generalized effectual cycle[1] for international development projects.

4. Value

4.1. Value to consumers

The need to craft specific value propositions for very poor consumers often requires radical innovation within the organization, its strategies, processes and, most importantly, its mental models. Porter's (1985) value chain framework maps the incremental value creation process within a firm based upon inputs, operations and marketing processes. Subsequent authors have extended Porter's concept of a value chain within a firm, to value chains as systems that extend from input suppliers, through primary and secondary processors, to wholesalers, retailers and most importantly, the final consumer (Bonney et al., 2007a; Evans and Berman, 2001; Walters and Rainbird, 2006). In developed countries and LDCs alike, each organization in a value chain must seek to create value for consumers, often achieved by process innovations and new value propositions for consumers. For organizations seeking to serve an LDC's $2-a-day market segment; however, the causal "ends-based" logic of traditional value chain analysis is sometimes simply not useful. To serve this market segment, the more effectual means-based entrepreneurial logic that considers the level of resource endowment, capabilities and constraints of the value chain's organizations can harness vertical co-innovation to reduce costs while enhancing benefits to consumers (Sarasvathy, 2001).

Kotler and Keller (2006) describe value for consumers as a function of the difference between total benefits derived from the product and total costs incurred from the purchase, consumption and disposal of the product. Their (2006) model highlights the benefits and costs of consumer value creation and can be used to explain the competitive position of a market offering in both developed and developing economies. In the present study's context, benefits accruing to the consumer generally include (1) product related–for example abundant, safe and nutritious food; (2) service–access to safe food; (3) reputational–social benefits derived; and (4) human, cultural and social benefits–if human capabilities are developed through better nutrition and experience. Costs include (1) monetary cost–the price of the product; (2) time and effort costs–in the case of produce, the time and effort to purchase, prepare, consume and dispose of it; and (3) psychological costs–if the produce is not fresh, safe or of sufficient quality, then there could be dissatisfaction, public health problems or even starvation.

4.2. Value to the organization

Entrepreneurship is the tsunami of innovation that overwhelms markets, wipes away entire industries and forces a recombination of resources into more valuable alternative uses (Schumpeter, 1934). Entrepreneurial initiatives are undertaken to achieve organizational objectives by meeting human needs, thereby creating social benefits. Corporate entrepreneurship (CE) is a creative and disruptive initiative in which an organization accepts the risks of pioneering radical innovation focused on the organization's products, processes, strategies or value propositions in the pursuit of competitive advantage (Covin and Miles, 1999; Morris et al., 2011).

Work by Miller (1983) and Covin and Slevin (1989) conceptualized firm-level entrepreneurship as proactive, risk accepting, innovative initiatives adopted to enhance organizational performance (Covin et al., 2006). CE, as conceptualized by Morris et al. (2011), has five generalized forms: (1) sustained regeneration; (2) organizational rejuvenation; (3) strategic renewal; (4) domain redefinition; and (5) business model reconstruction. Sustained regeneration is a focus of innovation on the product to create a more effective and/or efficient solution to consumers' latent and unmet needs (e.g., using genetically-modified seeds to create more desirable and useful produce). Organizational rejuvenation is directing innovation toward the organization and its processes to create superior effectiveness (e.g., adopting hybrid seed during the Green Revolution).

Strategic renewal transforms the organization's relationship with its external stakeholders and often reconfigures the rules and standards within a product market (e.g., establishing a coordinated vertical marketing system (see Etgar, 1976 for a discussion of vertical marketing systems). Domain redefinition is the application of innovation to create new markets and diversify away from an organization's core businesses into new product/ markets (subsistence farmers shifting from food vegetable cropping to cash crops such as tobacco or cotton).

Business model reconstruction alters (1) whom the organization creates value for; (2) what capabilities are leveraged to create value; (3) when the organization plans to grow, mature, and/or be harvested; (4) where the organization positions itself in the market; and (5) how the organization plans to sustain itself and remain economically viable? For example, during the green revolution, farmers who adopted hybrid seed technology were often forced to concurrently incur debt for the first time. Hybrid seeds are sterile, and therefore, seed for planting could not be retained from last year's harvest but would have to be bought for cash, something substance farmers often did not have, forcing the farmer to adopt the use of credit and financial leverage. These entrepreneurial initiatives directed at making a food value chain more effective and efficient force the re-conceptualization of how food is produced and marketed and how value is appropriated.

4.3. Value to society

Recently, efforts to extend the domain of entrepreneurship and broaden its scope to include a social context for opportunity creating initiatives have been made (see Sarasvathy and Venkataraman, 2011). Chell (2007); Dacin et al. (2010); Yunus et al. (2010); Luke et al. (2010); McMullen (2011); Trivedi and Stokes (2011); and Lumpkin et al. (forthcoming) are authors who have attempted to expand the domain of entrepreneurship to integrate traditional entrepreneurship with social issues and objectives. Scholars suggest social welfare objectives also acknowledge the importance of the financial performance of the social enterprise for its economic sustainability (Chell, 2007; Seelos and Mair, 2007; Yunus et al., 2010).

Can the transformative power of the entrepreneurial method be harnessed to create a better life for those who suffer in the despair of deep poverty and food insecurity? Can entrepreneurship be a potential solution to some of the systemic problems in the developing world, such as tribalism, tradition and political threats that constrain economic development and diminish social welfare? Recent work by Sarasvathy and Venkataraman (2011) suggests the answer is that entrepreneurship as method may be one alternative to solve the growing food security problem in the long run. Table 1 illustrates how innovation in the fresh food value chain can potentially generate value to society by enhancing food security and creating entrepreneurial capabilities. Table 2 illustrates the relationship

Table 1. A proposed social value equation: value to society of innovation in the agribusiness value chain.

Social Value of Innovation	Benefits to Society	Costs to Society
Inputs	Increase in importance of knowledge and technology Increase in marketing, communication, and relational capabilities of value chain members	Requires some form of continuing education of value chain members — both technical and managerial
Innovation Process	Lower cost, higher quality products Cultural change in orientation towards the consumer Management development experience Enhanced opportunity awareness, assessment and exploitation capability Potential to build wealth through the creation of intellectual property rights	Cultural push-back because of “outsiders — non tribal member” inputs Innovations too resource intensive and, therefore, increase financial and performance risk to value chain members A poor fit with cultural values may result in push back.

Table 1. (Continued)

Social Value of Innovation	Benefits to Society	Costs to Society
Outcomes — Superior Product, Management Development of Agribusinesses, and higher consumer satisfaction	Better nutrition for consumers Increased assortment and availability of higher quality produce Improved profitability or economic performance for value chain members Lower food costs Higher quality food Potential for exports Fewer imports Increase in technical capability Enhanced food security Access to education Employment	More efficiency may result in less employment Marginal land may be put into production Unintended environmental consequences Potentially greater differences between haves and have nots Political interference may redirect wealth? May lose some traditional products or services Value created may not be shared equitably among chain members.

between the Morris et al. (2011) forms of CE and the value equation in a typical LDC agricultural value chain.

5. Co-Organizational Innovation Interfaces

Co-organizational innovation linkages have been conceptually and tentatively explored by Teng (2007) as a mechanism of exploiting entrepreneurship to create competitive advantage in a highly developed economy. Likewise, Thorgren's et al. (2009) empirical work on inter-firm linkages and corporate entrepreneurship in Sweden found a self-reinforcing positive relationship between corporate entrepreneurship and inter-firm knowledge transfer. Work by Bonney et al. (2007b) and Bonney et al. (2007a) showed that co-innovation in agribusiness value chains results in lower costs, higher consumer value and performance advantages.

Although inter-firm innovation can provide synergistic and other benefits, a number of disadvantages specific to the LDC context must be considered. Discontinuities between organizations in terms of their operations, values, staffing and risk perception, coupled with lack of trust, relationship diversity and clashing cultures, may hamper innovation. This complexity is intensified when the firms are heterogeneous, for example exhibiting significant differences in organizational size, orientation, technological capability, processes, or ethics. Although these differences commonly occur between local firms within LDCs, when multi-national corporations (MNCs) set up in LDCs, the problem can be far greater. Despite their obvious differences, MNCs must rely on local partnerships because leveraging existing capabilities through this form of collaboration has low opportunity costs, can provide scale and helps with the development of new firms in the host country. Local partner-MNC differences can stifle normal operations, let alone the practice of innovation.

Table 2. Form of corporate entrepreneurship value chain initiative and its impact on consumer value in the case study.

Value[2] to Consumers	Sustained Regeneration[1]	Organizational Rejuvenation[1]	Strategic Renewal[1]	Business Model Reconstruction[1]
PRODUCT INNOVATION		PROCESS INNOVATION	INNOVATION OF STRATEGY	

Product[2] Providing the product attri-
butes preferred by con- sumers including innovation of
quality
Service[2] Complementary services to
product innovations, such as training to use new products
People[2]/Human and
Social Benefits

Altering the distribution network to lower
costs (including human costs) and pro-
vide enhanced services

Leveraging tribal networks to
create marketing and pro- duction
co-ops that aggregate produce to
gain economies of scope and
scale

Selling to large insti-
tutional consumers and
selling
directly to retailers

Quality image improves because
Image[2]/Reputation
of improved communication
with stakeholders?
Monetary[2] Adopting more modern vegetable cropping
methods to drive down costs; innovation to increase value improves income
Time and Effort[2] Process efficiency means less time and effort
has to be expanded on production of
products and reduced waste. Psycho-Logical[2] Enhancing food safety and
cleanliness

Repositioning in value
chains, etc.?

1: Morris et al. (2011)
2: Kotler and Keller (2006)
3: Vargo and Lusch (2004)

6. Method

6.1. The case study

This paper presents the early findings from an ongoing field study of entrepreneurship within the agribusiness sector in PNG. The U.S. Central Intelligence Agency's 2010 Fact book (www.cia.gov) estimates that PNG's per-capita income is in the lowest quartile globally, with a skewed income distribution as illustrated by a Gini index of 50.9, similar to several sub-Saharan nations such as Niger and Zambia. Approximately 36 percent of the population lives below a self-reported poverty line. Many people in Papua New Guinea exist in desperate poverty that has 82 percent of the population working in agriculture but generating only 21 percent of GDP (Coppel, 2004; Birch et al., 2009). Tribalism, lack of public infrastructure, public safety concerns, very inefficient food production and marketing and lack of education all contribute to PNG's food security problems.

The case study presented here was conducted by a project team from the Tasmanian Institute of Agricultural Research (TIAR) and Papua New Guinea's Fresh Produce Development Agency and National Agricultural Research Institute, and funded by the Australian Center for International Agricultural Research (ACIAR) in 2008 and 2009. Study methods included interviews, site visits, value chain analysis and group discussions.

Agricultural production in PNG is predominantly carried out by subsistence farmers using very traditional methods. Family subsistence needs are largely met by the household's production on its own land, and so the family is not compelled to rely on regular sales to obtain daily necessities (Benediktsson, 1998; Worinu, 2007). However, the issue of food security in PNG, as in other LDCs, is emerging as the population continues to rapidly increase and become more urbanized, and therefore, much more dependent on the purchase of food. For the impoverished market segment, this creates food security issues in terms of the risk of malnutrition.

Commodity supply chains traditionally operated in a perfectly competitive market structure characterized by many buyers and sellers exchanging a largely homogenous product with no vertical marketing coordination throughout the channel (in contrast to the highly coordinated vertical marketing systems that have emerged in specialty and organic food markets where the culture is one of "selling through" the other supply chain members in a mutually beneficial arrangement and that tend to create a monopolist competitive market structure). In the case of the field study, no vertical coordination between food producers and distributors existed prior to the value chain intervention.

In the case of PNG's food supply chain, few farmers used innovation to improve the consistency of supply or the quality of their produce because economic or social incentives were few. This perpetuated poverty for subsistence farmers (Vermeulen and Cotula, 2010) and, combined with the cost of accessing education and health services, drove significant internal migration from rural areas to major urban centres (Bourke and Harwood, 2009). In particular, this caused social and environmental problems in the peri-urban areas around the capital, Port Moresby. The PNG Fresh Produce Development Agency (FPDA) conducted the only major study of fresh vegetable supply to Port Moresby and estimated the shortfall in vegetable production could be as high as 80,000 tons per annum (Liripu, 2008).

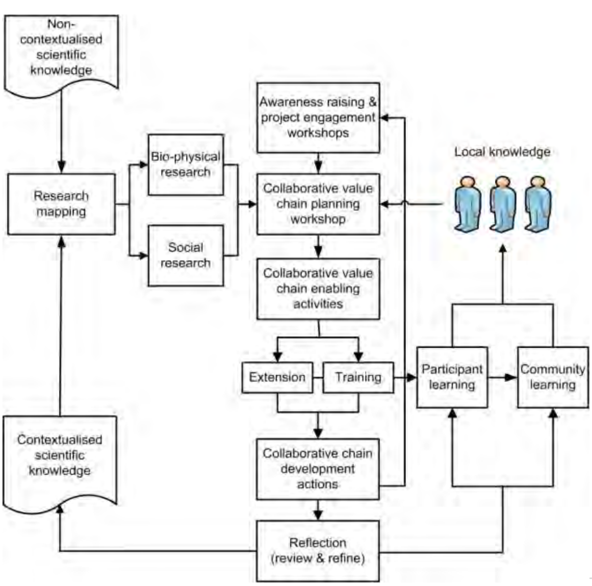
6.2. Research methods

Knoppen and Christiaanse (2007) argue that multidisciplinary approaches are necessary to provide improved explanations for the dynamic, complex interactions involved in the appropriation, coordination and adaptation processes in supply chain operations. This has prompted many international development agencies to use a systems approach to help overcome the complexity of efficient and effective food production and distribution in LDCs. Hence, ACIAR adopted a multidisciplinary approach to the development of value chains in PNG based upon entrepreneurial, sustainable, low-input horticultural production and management principles. This project's objective was to provide food security for Port Moresby while providing income opportunities for subsistence farmers.

Data were collected on the physical flows, communication flows and relationships from observations (to map the "means" of innovation and material flows), and semi-structured and focus group interviews using convergent/divergent interview techniques with a wide range of value chain participants, including the market buyers. Data were analyzed using qualitative content and thematic analysis, aided by the computer application NVivo (Version 8) to identify themes. This formed the basis for the development of potential "value chain innovations," which were validated with value chain participants. Figure 2 illustrates the rapid value chain research and development method used to explore the existing but uncoordinated vertical marketing system.

Source: derived from Chambers and Spriggs (2009).

Fig. 2. A rapid value chain research and development method.



Source: derived from Chambers and Spriggs (2009)

The iterative and ongoing processes captured in Fig. 2 and used in the study's rapid value chain research and development method consists of a five stage model: (1) situating the marketing system; (2) channel member and community focus groups; (3) creating and implementing an action plan; (4) reflection and improvement; and (5) participant and community learning.

Stage 1 — Background research on the marketing system
Mapping the physical movement of vegetable products from production to the consumer, as well as socio-economic mapping of the individuals and businesses, involved the social, cultural, political and economics rules governing the behavior of actors in the uncoordinated vertical markets of PNG.

Stage 2 — The channel member and community focus group workshops
Step 1: A women's only workshop was conducted to identify their capacities and problems in the marketing system from their perspective.
Step 2: Conducting the main workshop will involve the representatives of all the stakeholders in the fresh produce marketing system (farmers, collectors, wholesalers, transporters and retailers). This workshop will be constructed to encourage collaborative discussion of problems and strategies, ending with an action plan for change. It involved:

. Seeking agreement on objectives based on the preliminary research. When participants are in agreement about the objectives, divergent issues and concerns may be dealt with because there is a common goal.
. Divergent phase

. Participants are asked to suspend judgements and to listen openly and actively to other people's issues, problems and ideas and to creatively tackle problems;
. Information of relevance to participants is shared from the mapping research done prior to the workshop;
. Building trust, based upon understanding the viewpoints and problems of other members of the marketing system, by establishing conversations between the growers, transporters, supermarket managers and wholesalers; and
. A convergent phase during which plans for the actions are conducted to improve the vegetable marketing system.

Stage 3 — Implementation of the action agenda
Decisions of the workshop are being documented by

. Capturing the process and outcomes in reports circulated to community leaders for communication to the workshop participants;
. Ensuring the action plan is coordinated by designated stakeholders;
. Following up on an agreed date to review implementation of the action plan; and
. Forming a steering committee of stakeholders, nominated by all stakeholders at the workshop, to ensure the action plans determined by the workshop participants are carried out. This reinforces ownership of problem solving is in the hands of those most affected rather than the research team per se.

Stage 4 — Reflection and improvement
This stage reflects the iterative process of acting, learning and changing practices. In particular, it demonstrates the three interacting domains of

- Research and sharing that research;
- Capacity building to develop awareness, skills and the ability to achieve the important goals; and
- Achieving practical outcomes through people working together.

This process was achieved by the appointment of a representative steering committee to monitor the project. The reflexive process involves regular progress reporting to the steering committee and annual reporting to the stakeholder and donor agencies. This reflects on experiences and actions taken, recommends improvements to those actions and develops the next phase of research and development.

Stage 5 — Participant and community learning
The participants discuss their experiences and the actions proposed to improve processes and practices. Where the value chain analysis identified a lack of context-specific scientific knowledge resulting in the establishment of bio-physical research trials (e.g., suitable crop varieties or low-input soil management systems), the results feed into this process of participant and community learning through community reporting processes and extension activities such as field days, training courses and demonstration plots. As the cycle is completed, the enhanced local knowledge and context-specific scientific knowledge developed contributes to the next iteration of planning and action to improve the efficiency and effectiveness of the food value chain.

7. Findings and Value Chain Problems

7.1. The types of markets

This study found six distinct categories of food markets in PNG. Main market outlets for fresh produce were the informal roadside and local markets (Type 1); distant informal markets in major urban centres (Type 2); community entrepreneurs who acted as "aggregators" (Type 3); commercial wholesalers (Type 4); formal markets (Type 5), such as those run by local government; and direct to the institutional markets, such as hospitals, hotels, and mines (Type 6) (Birch et al., 2009).

7.2. Poor infrastructure for marketing

The road, telecommunications and finance systems in regional PNG presented major constraints on the vegetable marketing system. The country did not have a national, inter-connected road system and non-arterial roads are very poorly maintained because of the terrain and climate. Although cell phone telecommunications were improving, the lack of Internet services outside major urban centres and patchy cell phone reception meant that only the most basic marketing information was available. Finally, the banking system did not operate outside of the major towns, greatly constraining economic development.

7.3. Lack of economies of scale and coordination in marketing

Small farmers generally transported bags of vegetables to markets on public buses and then sold their produce around the various outlets. Prices received were highly variable partly because of the variability of supply and demand, but also as a result of the post-harvest deterioration caused by damage during transport and rough handling of the product. In addition, frequent harassment and intimidation of the farmers occurred at the markets.

7.4. Poor marketing channel inter-relationships

The channel can be conceptualized as a series of linked markets in which price was the only means of communication between buyer and seller; the relationships involved were transactional and short-term with price only-based coordination; there was no trust, commitment or management of supply. In PNG, all parties regularly engaged in opportunistic, exploitative behavior that invited reciprocal behavior, thus reinforcing the pattern. In particular, farmers were subjected to frequent harassment and therefore, they often sold their produce to the first buyer to avoid further conflict and danger.

7.5. Transformation of the value chain through the entrepreneurship method

A more efficient and effective approach to enhancing food security was the strategic innovation of creating a more interrelated vertical marketing system in which quality and quantity were more coordinated throughout the value chain. This preferred marketing system was based on an improved low-input, more environmentally sustainable production system producing a flow of higher quality vegetables into Port Moresby. The model being implemented in PNG uses three forms of corporate entrepreneurship to create value: (1) product innovation achieved through a better understanding of market and consumer preferences; (2) process innovation through radically improved farming production methods; and (3) business process innovation through changing how produce is distributed and marketed.

The entrepreneurial method allowed the major problems within the value chain to be reframed as opportunities. The present study's consumer and producer focus group discussions suggested customers were willing to pay more for higher quality, safer produce that meets their preferences. This information was used to redesign the vegetable production process to deliver produce that more closely conforms to the market demand. More advanced farming technologies were introduced to enhance production efficiencies. In addition, the "means" of a tribal social structure in PNG was leveraged through effectual reasoning — considering who I am and who I know — to create small "vegetable production cooperatives" where farmers from the same tribe would "pool" their produce to create some bargaining power with respect to price and terms. In addition, this pooled marketing process generated both economies of scale and scope, allowing the tribe to forward contract directly with retailer.

Business model reconfiguration is being accomplished by leveraging the tribal co-op model, reducing the cost of produce transport, transactions and marketing by accumulating produce from the entire tribe and spreading the costs (and risk) among more families. One concern business model innovation addressed was safety — often in the past the farmer's wife was responsible for transporting the produce to market and then selling it; typically selling to the first buyer who made an offer because of physical dangers in both travel and marketing. The reconfigured value chain allowed the risk to be ameliorated by minimizing the exposure to transport or the market by any single farmer.

The revitalized value chain is being redesigned to be a vertical marketing system with contracts linking the wholesalers and larger institutions (such as government agencies, hospitals, hotels and mines) to the farmer marketing cooperative, which accumulated the outputs of many small farmers and then marketed the produce as a single economic entity. Vegetables are brought from remote farms and villages to designated collection points where small, all-terrain vehicles with refrigerated boxes regularly collect produce. The price the farmer received is based upon weight and quality. The produce is pre-graded by the cooperative using a simple visual grading system. The produce is then transported out to a major arterial road and loaded onto a larger refrigerated vehicle for transport to a single contracting market outlet. This specialist freight service maintained product quality and often backhauled farm inputs and consumer goods for the villagers, reducing their need to travel to Port Moresby. The use of a trading account enabled farm inputs and consumer goods to be paid for by the proceeds of vegetable sales, thus avoiding the need for large cash payments. In some instances, cooperatives establish their own "retail stores." This approach is most effective in remote, isolated areas where travel to market is costly, difficult and infrequent.

The very tentative success of this model is dependent on all chain participants acting in a trustworthy manner with the intent to develop long term partnerships and collaboratively innovate or "co-innovate" to solve the chain's problems to efficiently and effectively meet consumer needs. The use of an entrepreneurial method underpinned by effectuation logic and implemented by the rapid value chain process forced the ACIAR team to consider who they were, what they were and who they knew could help as they approached this initiative. Affordable losses through the collaborative value chain planning workshops were established with an understanding that different partners might face very different consequences of a loss. The rapid value chain research approach also helped the ACIAR team develop new partners, resulting in additional generated new means. Contingencies were exploited by workshops and skill development training and a flexible approach to creating this new vertically coordinated value chain. For example, a particular focus was the training needed to improve the productivity and safety of women in vegetable marketing and encouraging young people to see a future in rural-based vegetable production businesses.

8. Conclusion

We hope this study stimulates a less bureaucratic and more entrepreneurial approach to international development projects in the international development community. The application of the entrepreneurial method and effectual logic is an attempt to enhance the food security for the poor of a LDC, in this case PNG, and offers an alternative framework for future international development projects. The entrepreneurial method leverages the powerful tools of corporate entrepreneurship, rapid value chain analysis (in this case) and effectual logic to move toward more effectively and efficiently increase food security in a LDC.

Three populations of interest exist in many international development projects: (1) the individuals; (2) the organizations that comprise the value chain; and (3) society. Metrics to measure value in all three contexts could be based on the conceptual work of (1) Kotler and Keller (2006) to estimate the total value of the product for the ultimate consumer; (2) Hunt and Morgan's (1995, 1997) resource advantage theory to capture efficiency and effectiveness of the organizational members of the agribusiness value chain; and (3) Taguchi's (1987) social loss perspective of quality and the World Business Council for Sustainable Development's (World Business Council for Sustainable Development, 2000) eco-efficiency framework (Isaksson et al., 2011).

The WBCSD's eco-efficiency framework uses zero waste as the ideal outcome, and then considers product redesign, process reengineering, market repositioning and the beneficial reuse of the waste stream by revaluing by-products as mechanisms for decreasing the waste stream. Although Taguchi's (1987) social loss perspective of quality simply states that quality products cause no loss to society, its simplicity is its power. Social loss is measured by the negative externalities resulting from the production, pro- curement, use and disposition of a product, which, in Taguchi's framework, must be internalized and offset to create positive outcomes. In Taguchi's framework, these positive offsets could include benefits to society such as (1) better nutrition; (2) management and business development; (3) enhanced health; or (4) something as simple as financial ben- efits to the poor because of lower priced produce. Table 3 summarizes the items that could be potentially used to measure value before and after the value chain CE initiatives for each population.

Food security, like many other prevalent human problems, may be most effectively addressed by a more entrepreneurial approach, reframing the problem as an opportunity for some to appropriate value while helping meet basic human needs. As the world slips once again into economic turmoil, governments will not have adequate resources to address all of the critical needs of an ever-expanding population. Entrepreneurship may be one potential solution for international development agencies to consider.

Can the entrepreneurial method solve all of the world's problems–most definitely not!

Can food security for the global poor be enhanced through the application of the entre- preneurial method–maybe in some situations? The entrepreneurial method offers an alternative logic to how an issue is conceptualized. For example, recent work by Sheth (2011) on marketing in emerging markets suggests there are many phenomena that can be reframed into exploitable economic opportunities that will foster growth in emerging markets and help the global poor. Likewise, when Schramm (2010) suggests that "economic reconstruction must be rethought" he is suggesting we include entrepreneurship as one way to attempt to better the "economic lives of the poor" (Banerjee and Duflo, 2007). The purpose of this paper was to use a case study to illustrate how an alternative

Table 3. Items used to operationalize the impact of an entrepreneurial method on value chain performance in PNG case study.

Population	Metric (Changes because of impact of CE on value chain initiatives)
Organization	Is resource efficiency increasing relative to competition increasing?[1] Is market position relative to competition increasing?[1] Is economic performance relative to competition increasing?[1] Are relative resource costs diminished?[1] Has quality (in terms of variance) increased?[3] Has relative market position been strengthened?[1] Has relative financial performance increased?[1] Has stakeholder satisfaction increased?[4]
Consumers	Has assortment &/or selection &/or quantity available improved?[5] Has quality in terms of fitness for use, nutrition, taste, or freshness increased? Has price decreased?[5] Has product availability improved?[5] Has distribution and marketing improved?[5]
Society	Has malnutrition decreased? Have jobs and human capabilities been increased?[2] Have negative environmental or social consequences of the value chain been diminished due to the innovations?[2, 4] Has society incurred any loss due to the externalities of the innovations?[3] Are there positive externalities or spill-over effects, including increased levels of education, participation in commerce or new business formation?

1: Hunt and Morgan (1995, 1997)
2: World Business Council for Sustainable Development (2000)
3: Taguchi (1987)
4: Isaksson et al. (2011)
5: Kotler and Keller (2006)

logic–the entrepreneurial method–can be applied to the problems of the poor–in this case to address food security issues in the developing world. It is hoped this study will stimulate additional research into how the power of entrepreneurship and effectuation might be applied to other issues facing the global poor.

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Contributions to ACIAR Monographs

Impact of training on horticultural practice adoption by women smallholders in the Central Province, Papua New Guinea

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Abstract

Subsistence food production is the most important part of Papua New Guinea agriculture, providing most of the food consumed in the country with an estimated 83% of food energy and 76% of protein. Women play a significant and crucial role in agricultural development in fields including, main crop production, live-stock production, horticulture, post-harvesting operations and fishing. Women in the horticulture industry in the Central Province of Papua New Guinea are no exception. Hence, in an attempt to increase the supply of vegetables into the Port Moresby markets to meet the increasing demands for these crops, women and daughters in the horticulture industry should be equipped with the required knowledge and skills to contribute to the production of vegetables. In line with this, the objectives of this research were (i) to identify the training needs of women farmers in the horticulture industry at village levels in Central Province through a needs analysis workshop; (ii) to determine the adoption and implementation of techniques presented during training; and (iii) to obtain feedback from women farmers in regards to the suitability of the training delivered. The main training needs were identified as Farm Production (crop management and irrigation), Marketing (product readiness and negotiating price) and Business Skills (banking and book-keeping). Post training evaluation using survey questionnaires, interviews and focus group discussion showed that the training was effective in improving their basic business skills, farm production skills and knowledge, as well as marketing opportunities.

Keywords: Adoption, Central Province, implementation, horticulture, training needs, women farmers

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Introduction

The National Agriculture Research Institute (NARI) is collaborating with the Tasmanian Institute of Agriculture, University of Tasmania and the Australian Institute for Sustainable Communities, University of Canberra, on a project *Increasing Vegetable Production in Central Province, Papua New Guinea to Supply Port Moresby Markets (ACIAR SMCN/2008/008)*. Local partners include the Fresh Produce Development Agency, Pacific Adventist University, Green Fresh and the Central Provincial Government of Papua New Guinea. One of the project's objectives is to establish more efficient, effective and sustainable vegetable value chains (focal chains) in order to provide improved economic returns expressed as profitability and household income security for chain participants.

Apart from scientific and capacity impact, social impact is also a major focus of this project. In order to enhance urban/regional equity and address some of the gender inequities in the production and marketing of vegetables the project has provided knowledge, skills and opportunity for small-holder families and an enhanced role for women in vegetable production and marketing. In addition, the development of more sustainable farm businesses with improved educational and occupational opportunities should improve the retention of young people in productive and profitable rural communities. With respect to horticultural training, it is posited that extension methods are often based on post-industrial methods deriving from the expert-novice model. Often new technologies are introduced in large meetings based on talk rather than even 'show and tell'. There is little or no follow-up in the field by village extension workers to assist implementation and adoption of new knowledge, skills and attitudes (Kayrooz, Chambers and Spriggs, 2006; Palaniappan, et al, 2011) nor is there an appreciation of gendered traditional roles affecting how smallholder farming is conducted (Leach, Sumner, and Waldman, 2008; McKnight, 1993).

In February 2011, group interviews were carried out in the villages of Rigo-Koiari and Bautama in the Central Province of Papua New Guinea (PNG) with men and women to determine what crops they produced. Villagers spoke about their crops, what they were proud of and what they hoped to do in the future. Once of the implications of group interviews was a realization that horticultural, business and market training for women and girls, men and boys was needed to realize expressed dreams. Before this training could occur, a training needs analysis had to be conducted and it was decided that a *Women and their Daughters* workshop should be held in September 2011 in the first instance and a pictorial training needs assessment trialed. The reasoning behind the development of a pictorial training needs assessment was the low level of literacy, especially amongst women, and that if a traditional pen and paper test was used, it would be time consuming and labor intensive because of the need to use Tok Pisin or Motu translators in the field. A workshop framework called a Collaborative Problem Solving Methodology (CPSM) was applied that had been used previously in the Highlands of PNG, Cambodia and Vietnam and shown to be particularly robust across cultural groups and in multi-cultural groups. Criteria were developed to guide the selection of women, including a range of ages and willingness to share training with other women (and men). The outcome was 29 women and their daughters from the villages of Rigo-Koiari and Bautama attending a two day consultative workshop. Following that workshop, an action committee comprising of project partners in consultation with a steering committee comprising of women leaders of the Rigo-Koiari and Bautama women groups got together to plan the training and logistics. The horticulture training was conducted in May 2012 according to the women's horticultural training priorities that were identified in the workshop. Participants of the training were women vegetable smallholder farmers from Rigo-Koiari and Bautama.

Materials and method

Needs analysis workshop

Women's training needs were identified in a needs analysis workshop in September 2011 using a Collaborative Problem Solving Method (CPSM). This method is based on a two day workshop using *Divergent* and *Convergent* thinking activities (Spriggs and Chambers, 2005; Chambers and Spriggs, 2006). On the first day, participants were asked to say why they came to the workshop and what their expectations were. They were then presented with cards showing pictures of major horticultural tasks along the value chain, which were identified during previous visits to the villages of these women, as well as pictures of activities related to business that may have been mentioned but were not portrayed e.g. micro-credit, opening a bank account; drawing up a seasonal calendar and/or business plan. Participants sat together in a circle of up to five members from the same village with a facilitator and with photo-cards scattered in the middle. The facilitator explained to the participants that the cards were meant to depict women performing different tasks. The participants discussed the cards, explaining to each other and to the facilitator what the different tasks were showing. The facilitator then asked the participants to divide the cards into three groups - tasks which were most difficult to perform; tasks which were easiest to perform and tasks that were in between difficult and easy. The facilitator kept track of the discussion, noting when consensus was reached, or not easily reached, and the minority opinions. Participants then turned their focus to the problematic tasks, discussing the obstacles and resources available to them for overcoming impediments. The facilitator then asked if training was needed for the most difficult tasks. The facilitator then posted pictures of the most difficult and quite difficult tasks onto butcher's paper so that other groups could see them and compare what each group came up with. The workshop facilitator recorded and compiled what the participants training needs were. This ended the first day. On the second day, participants had to make decisions or judgments about training priorities, which meant reflecting on the displayed pictures of very difficult and quite difficult tasks. Overwhelmingly, their training needs were identified as Farm Production (crop management and irrigation), Marketing (product readiness and negotiating price) and Business Skills (banking and book-keeping). A steering or communication group representing workshop participants was set-up to monitor the Action Plan on training priorities.

Pre-test, Post-test and Post post-test evaluations

Based on the training priorities identified in the workshop, training was conducted in May 2012. Pre- and post-test information about horticultural practices was collected before and after the training session from the 28 female horticulture farmers who attended the training from three different areas of the Central Province: Rigo/Koiari and Bautama Villages. Survey data was supplemented by observations, focus group discussions and interviews.

In March 2013, a longitudinal post post-test to determine participants' perceptions of adoption of training knowledge, skills and attitudes was carried out. At the same time staff from NARI observed horticultural practice in each village to see if training had been implemented. Evaluation of training over time has not been evident in the literature on the training of women smallholders in PNG, especially a period as long as ten months after training. Yet such an evaluation is essential to improving and reframing ways to enhance the smallholder business acumen of both women and men (Pamphilon and Hardy, 2006).

Data analysis

Data from 28 participants was entered and tabulated into excel spread sheets, analyzed by tallying and is presented in tables and pie graphs.

Results

Table 1: Pre-test evaluation on soil management knowledge before training

Pre-test on soil management knowledge before training		
Pre-test survey responses	**N=28**	**Responses in percentage (%)**
1. The methods used to manage soil in the gardens are:		
a) Mulching with dry banana stems, corn leaf etc.	18	43
b) Applying organic composts	7	17
c) Weeding	0	0
d) Applying fertilizers	1	2
e) Others: slash & burn/fallowing	16	38
2. The methods of soil management were learnt through:		
a) Parents	23	64
b) Relatives/friends	4	11
c) Formal training from Agriculture Extension Officers	8	22
d) Others: read posters	1	1
3. Are you able to follow these methods?		
a) Yes	28	100
b) No	0	0
4. Are there any other methods you know about soil management?		
a) Yes	24	86
b) No	4	14
4.1 If yes, the other methods of soil management known are:		
a) Slash and burn	3	15
b) Soil erosion techniques	1	5
c) Fallow/crop rotation	3	15
d) Others: drainage/applying food peelings	13	65

Interpretation: Before any training on soil management was given to the farmers, we wanted to find out what knowledge they had about soil management and the methods they used at home as soil management practices. The responses (Table 1) indicated that mulching with dry banana stems and corn leaf was the most practiced among the farmers, followed by other techniques which include slash and burn and fallowing. Applying organic composts such as food peelings was identified as the third most used soil management practices among the farmers. Most of these methods of soil management were learnt from the farmers' parents and formal training from agricultural extension officers. When further asked if they were able to follow these methods taught to them by their parents, all farmers positively responded adding that these are current practices.

Table 2: Post-test evaluation on soil management knowledge after training

Post-test on soil management knowledge after training		
Post-test survey responses	**N=28**	**Responses in percentage (%)**
1. Are there any other new methods you know about soil management?		
a) Yes	28	100
b) No	0	0
2. Other soil management methods learnt are:		
a) Fallowing	3	5
b) Green Manuring/Crop cover	12	19
c) Drainage	13	20
d)Crop rotation	13	21
e) Mulching	20	32
f) Applying fertilizer	2	3
3. These new soil management methods were learnt through:		
a) Parents	2	7
b) Relatives/friends	0	0
c) Attending this training	28	93
d) Others	0	0
4. Are you able to follow these methods		
a) Yes	27	71
b) No	1	29
5. Are there any challenges in following these methods?		
a) Yes	20	71
b) No	8	29
5.1 If yes, the challenges are:		
a) Finance/funding for implements needed to try out the new method	19	61
b) Convincing family, relatives or friends in trying out new methods.	3	10
c) Lack of support from family, relatives or friends.	9	29
d) Others	0	0

Interpretation: After the training, the post-test was conducted to find out if the participants did learn some new things. All participants positively agreed to having learnt new methods of soil management. These new methods learnt were mulching, crop rotation, drainage, green manuring and crop cover. Fallowing and using fertilizers were the least mentioned, as these were practices familiar to the farmers. Ninety-three percent of the farmers stated that these new methods were learnt by attending the training while the rest were already taught to them by their parents. When asked if they were able to follow these new methods learnt, 71% responded positively but the same number admitted to seeing challenges in following the methods. The biggest challenges identified were: finance/funding for implements needed to try out the new method (61%) and lack of support from family, relatives or friends.

Table 3: Pre-test survey on irrigation knowledge before training

Pre-test on irrigation knowledge before training		
Pre-test survey responses	**N=28**	**Responses in percentage (%)**
1. Methods that these women used to irrigate their gardens are:		
a) Irrigation system	1	3
b) Carrying buckets, containers, drums etc.	16	54
c) Using water pump to pump water	7	23
d) Do not irrigate food crop garden	6	20
e) Others	0	0
2. The methods of irrigation were learnt through:		
a) Parents	20	67
b) Relatives/friends	4	13
c) Formal training from Agriculture Extension Officers	6	20
d) Others	0	0
3. Are you able to follow these methods?		
a) Yes	28	100
b) No	0	0
4. Are there any other methods you know about irrigation?		
a) Yes	16	57
b) No	12	43
4.1 If yes, the other irrigation methods known are:		
a) Other Irrigation systems	8	50
b) Water pump	5	31
c) All of the above	2	13
d) Others	1	6

Interpretation: Common methods (Table 3) used to irrigate gardens were carrying buckets, containers or drums of water (54%); other farmers said they use water pumps as a source of water for their crops. In contrast, there are also farmers who do not irrigate their food gardens at all, but rather depend on rain. Most of the farmers stated that these knowledge and methods of irrigation currently used were learnt from their parents (67%). Others were taught by agriculture extension officers while the rest were taught by relatives and friends (13%). When farmers were asked if they knew of other irrigation methods, 57% responded positively with 31% of them knowing about using a water pump.

Table 4: Post-test survey on irrigation knowledge after training

Post-test on irrigation knowledge after training		
Post-test survey responses	**N=28**	**Responses in percentage (%)**
1. Are there any other new methods you know about irrigation?		
a) No	0	0
b) Yes	28	100
2. These new methods of irrigation was learnt through:		
a) Parents	0	0
b) Relatives/friends	0	0
c) Attending this training	28	100
d) Others	0	0
3. Are you able to follow this method?		
a) Yes	19	68
b) No	9	32
4. Are there any challenges in following the method?		
a) Yes	24	86
b) No	4	14
4.1 The challenges in implementing these new methods are:		
a) Finance/funds to purchase materials for irrigation	17	55
b) Attitude of community in trying out new methods	6	19
c) Road infrastructure	6	19
d) Lack of support from family, relatives or friends.	2	7
4.2 There are no challenges because:		
a) Financially secured	0	0
b) Support from family, relatives or friends	4	100
c) Others	0	0

Interpretation: After the topic of irrigation was taught to the women farmers, they were asked if they had learnt other new methods about irrigation; all farmers (100%) responded positively and said this new knowledge was learnt through attending the training. Sixty-eight percent of the farmers stated that they were able to follow new methods while 32% of the farmers said they couldn't. Eighty-six percent of the farmers stated that there were challenges in following this method while 14% didn't see any challenges in following this new irrigation method. The challenges were identified as finance/funding for the purchase of irrigation materials and equipment (55%), negative attitude of community in trying out new irrigation methods, with another 19% of the farmers stating that having bad road infrastructure was another challenge in trying out the drip irrigation.

Table 5: Pre-test survey on pests and disease knowledge before training

Pre-test on pests and disease knowledge before training		
Pre-test survey responses	**N=28**	**Responses in percentage (%)**
The main plants that compete in the main crop gardens are weeds such as:		
a) Nut grass	1	86
b) Kunai grass	1	3
c) Elephant grass	2	7
d) Others such as Milk weed, mimosa etc.	0	0
e) All of the above	25	86
The management practices used to manage weeds in the gardens are:		
a) Hand weeding	28	100
b) Spray with herbicides	0	0
c) Do nothing	0	0
The pests that damages crops in the gardens are:		
a) Lady bugs	2	5
b) Caterpillars (green/brown/black)	12	31
c) Grasshoppers (small/big)	3	8
d) Beetles	2	5
e) All of the above	13	33
f) Others: rats/birds	7	18
The practices used to manage insect pests in the gardens are:		
a) Pick them out by hand	7	25
b) Use pesticide	3	11
c) Do both A & B	16	57
d) Others: belief that weeding helps to keep the insect pests away.	2	7
Diseases observed in the gardens are:		
a) Plants dying from wilting	11	22
b) Plants changes colour	13	27
c) Fruits immature ripening	2	2
d) Leaves curling	1	4
e) Others: white spots/rotting before ripening/stunted plants/black spots	22	45
The practices used to manage diseased crops in the gardens are:		
a) Does nothing because she doesn't know how to manage diseased crops	10	36
b) Culling and destroying of affected plants	5	18
c) Spraying of fungicides/bactericides	7	25
d) Others: sterilize soil before nursery/apply wood ashes on infected crop area	6	21

Interpretation: Most farmers (86%) stated that the main plants that compete in the main crop gardens are weeds such as nut grass, kunai grass/signal grass and others. The most common management practice is done by hand weeding. Insect pests that damage crops in the gardens and as observed by the farmers were mainly a combination of lady bugs, caterpillars (green/brown /black), grasshoppers and beetles. In terms of management of insect pests, it was found that most of the farmers (57%) tend to scout and manually pick off the insects as well as using pesticides to rid the insect pests. Twenty-five percent of the farmers tend to only do scouting and manually picking off the insect pests. Diseases found to be observed in the gardens were: white spot, rotting before ripening, stunted plants and black spots (45%). Plants changing color (27%) was next followed by plants dying from wilting (22%). Practices used to manage diseased crops in the gardens varied. Some women did nothing out of lack of knowledge (36%); some treated diseased crops by spraying fungicides/bactericides (25%), while 21% sterilize the soil and apply wood ash on infected crop areas. Finally, 18% of the farmers cull and destroy disease affected crops.

Table 6: Post-test survey on pests and disease knowledge after training

Post-test on pests and disease knowledge after training		
Post-test survey responses	**N=28**	**Responses in percentage (%)**
1. Are there any other weeds/pests/disease you know that affects your garden?		
a) Yes	21	75
b) No	7	25
2. Other weeds/pests/diseases that affects the crops in the gardens are:		
a) Beneficial/harmful weeds	2	8
b) Disease caused by fungi/bacteria	3	13
c) Sucking/chewing/cutting insects	2	8
d) All of the above	17	71
3. I know that these weeds/pests/disease affects the crops in the gardens through:		
a) Parents	8	15
b) Relatives/friends	0	0
c) Attending this training	28	53
d) Others: seeing occurrence in the gardens/experiencing it on crops	17	32
4. Are you able to follow these methods?		
a) Yes	28	100
b) No	0	0
5. The methods used to manage weeds/pests/diseases are:		
a) Manually weeding	10	24
b) Using PDP for insect pests	2	5
c) Culling diseased crops	4	10
d) Spraying chemicals for insect pests/disease	7	17
e) All of the above	18	44
6. Are you able to follow these methods?		
a) Yes	27	96
b) No	1	4
7. The challenges in following these management methods are:		
a) Finance/funding for implements needed to try out the new method	22	50
b) Convincing family, relatives or friends in trying out new methods.	4	9
c) Lack of support from family, relatives or friends.	16	36
d) Others: attitude of community/land disputes	2	5

Interpretation: After the training on the topic of pests and disease management, most farmers stated that apart from those observed in the gardens, they now know that there are also other weeds, pests and diseases that affect crops. These other weeds, pests and diseases that affect crops in their gardens were learned about in training (51%) and were then observed by 71% of the farmers. They were a combination of beneficial and harmful weeds, disease caused by bacteria and fungi and sucking, chewing and cutting insects. Asked if they were able to follow the methods taught on how to manage the weed, pests and diseases, 100% responded positively by manually weeding, spraying appropriate chemicals for pests/diseases, culling diseased crops, using Plant Derived Pesticides - PDP - taught in the training for insect pests. Though 100% of the farmers responded positively to using the methods learnt, 96% said there will be challenges in following these methods. The challenges likely to be faced are: finance/funding for equipment, materials and consumables needed to try out the new methods; lack of support from family, relatives or friends in trying out new methods, and the negative attitude of community in accepting new methods.

Table 7: Adoption and implementation of crop management practices and irrigation based on the post post-evaluation (March 2013)

Training	Adoption	Partially	No adoption
Soil management practices	68%	16%	16%
Irrigation	26%	5%	69%
Weed management	90%	5%	5%
Insect pests management	90%	5%	5%
Disease management	84%	16%	0%

Interpretation: In terms of horticultural production and management, the majority of women have been able to apply their training. However, in irrigation 69% of women have not been able to apply new techniques. When asked why, most women said that newer techniques (such as drip irrigation) were too expensive and furrow irrigation could only work if you had ready access to water. However, one woman had borrowed money for a tank and pumps and was starting to use it for irrigation. In terms of impact on yield, quality and price, the majority of women (75% – 80%) said that their changed practices through training had improved these things, except that they had spent more money on their gardens where chemical were used to control pests and diseases or improved irrigation technology was purchased.

Discussion

Adoption and implementation

The horticulture industry in the Central Province is in its infancy. Farmers from that province who supply the Port Moresby markets are smallholders. Women in particular play an important role in the production of these vegetables, thus women and daughters in the horticulture industry had to be equipped with the required knowledge and skills to contribute to the production of vegetables. At the same time, they have to contribute to the economy sustainably and benefit their household income and food security. Sobha (2001) emphasized this by saying that training and technologies information had to be provided to farm women to improve their skills, level of decision making and effective participation. All pre-test results on soil management, irrigation and pests and disease management clearly illustrated these women farmers had little knowledge of improved husbandry practice and they did not understand the importance and reasons behind their traditional vegetable husbandry practices. In contrast, the post-test results revealed that they had broadened their knowledge of new and improved practices. The post post-test shows a considerable impact as these women farmers were able to adopt and implement these new skills and knowledge gained from the training. The horticulture training topics - soil management, irrigation and pests and disease management - were entirely based on what these women farmers identified as their training needs and priorities. This training has proven to have met the needs of the participants as they have all agreed that the training met their expectations. The women of the Rigo-Koiari area are now engaged in a contract with a supermarket chain in Port Moresby where they supply vegetables on a weekly basis. Women from Kerekadi decided that their best way forward was to cooperate by pooling their gardens and rotating one of them for improved soil management and production. This strengthens what Majhi and Patra (1996) suggested in their paper saying that a 'special training programme should be conducted to develop the scientific orientation, entrepreneurial abilities and working knowledge of farmwomen on agricultural activities. Padmanabhan (2001) emphasized the need for empowerment of rural women in agriculture through effective training and extension services.

Lessons learnt from the training

This training brought together two women's groups from different ways of livelihood. Rigo-Koiari women came from a well-established cooperative, while Bautama women were individual smallholders. Follow-up interviews have shown that most of the women appreciated the importance of these farming activities after learning the reasons behind them. Their practice is now reflective rather than unreflective. Obviously, the comprehension level of the participants in the training was not the same and small group learning may be the better way to proceed in future, allowing for individual capacities. Open group discussions also proved to be helpful. This training has enhanced these farmers' skills and knowledge.

However, vegetable husbandry is a very practical concept. Hence, in future horticulture training where crop management or vegetable husbandry practices are involved, follow-up observations of applied horticultural practice in the field and reinforcing knowledge and skills learned during training must be arranged and faithfully conducted by the trainers and extension workers, otherwise there is no maintenance program and change is less likely.

Conclusion

The horticulture training for smallholder vegetable women farmers of Central Province has had a considerable impact and some adoption resulting in changed horticultural and business practices. The women perceived that the application of training had improved production and lowered costs in terms of soil preparation and management of pests and diseases. They also claimed that adoption of training skills and knowledge had led to improved prices at the markets. This needs to be tested through observation and walking the chain with a group of women. Long term evaluation is essential to determine the extent and rate of adoption of training and changes to horticulture practices. Nonetheless, women were enthusiastic about their training and their ability to implement new knowledge and skills and men in their villages are now demanding similar training based on their priorities in horticulture, business and marketing.

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Comparing training preference outcomes by gender in the Central Province of PNG

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Abstract
This paper highlights the findings on the similarities and differences in training needs for men and women horticulture farmers in PNG. It is estimated that in PNG, women contribute 80 per cent of their time to horticulture production compared with men. However it is difficult to calculate the exact contribution of men and women to horticulture production as they do not work in isolation. So, understanding that men and women work jointly and women contributing more hours to horticulture production in PNG assumptions were made that there could be differences in preferences in regards to the training needs. A mother and daughter's workshop was conducted to identify training needs for 32 participants from two communities; Rigo-Koiari and Bautama in Central Province, PNG September 2011. Followed by this, a father and son's workshop was conducted for 21 participants from three communities; Rigo-Koiari, Sogeri and Bautama in Central Province, PNG September 2012. Both workshops were conducted with participants representing Central Province, PNG, at the same venue, Pacific Advent University, and a very similar methodology of collaborative problem solving was followed in regards to identification of training needs. Our results demonstrate that the training needs at Rigo-Koiari are at another level of management than those at Bautama, where basic horticultural and crop management needs are of priority in the women's workshop and there was no difference amongst the mature men from Bautama and Rigo /Sogeri in their training priorities in the men's workshop.

Keywords: training needs, collaborative problem solving methodology, divergent thinking, convergent thinking

Introduction

Papua New Guinean society is not yet industrialised, with 82 per cent of citizens are engaging in agriculture for a living, which provides income and employment opportunities to the predominantly rural populace. Most of these people obtain a large proportion of their domestic food requirements from the use of customary land, which is held by the community or village rather than individuals – the notion of land as a tradable commodity is largely absent from PNG society. As the society of PNG is generally patrilineal, women are placed in an inferior position in decision-making, particularly with regard to money, while effectively promoting male dominance.
Customary land tenure is concerned with networks of kin and the obligations of clan and community. As long as society is constructed within the framework of kinship, external interventions must be careful to maintain the balance of men's and women's roles in the household and in resource management (Gustafsson, 2004). Women are substantially involved in food production, and many are also engaged in the marketing of fresh produce, particularly in the local informal markets. They face considerable operational and social constraints with the lack of appropriate transport and other facilities, harassment and bullying in the marketplace, and have difficulty in retaining sufficient income for family purposes (Spriggs & Chambers, 2007).

For these reasons, a project on "Increasing vegetable production in Central Province, Papua New Guinea, for Port Moresby markets commenced from 2009. The project aimed to improve vegetable production through conducting field experiments in selected vegetables and by jointly establishing value chains to meet consumer needs. The project aimed to improve vegetable production in Central Province by actively engaging all actors of the society men, women and youth. In order to engage women, men and youth a training needs workshop was organized separately for older mothers and daughters/daughters in law and older men and sons/sons in law. A separate workshop was conducted for women and men in consultation with the PNG stakeholders to facilitate women's participation as women are continued to be placed in an inferior position in spite of contributing 80 per cent of their time to horticulture production compared with men (Chambers, 2012) . However it is difficult to calculate the exact contribution of men and women to horticulture production as they do not work in isolation (Cheryl, 2011). So, understanding that men and women work jointly and women contributing more hours to horticulture production in PNG assumptions were made that there could be differences in preferences in regards to the training needs.

A mother and daughter's workshop was conducted to identify training needs for 32 participants from two communities; Rigo-Koiari and Bautama in Central Province, PNG in September 2011. Followed by this, a father and son's workshop was conducted for 21 participants from three communities; Rigo-Koiari, Sogeri and Bautama in Central Province, PNG in September 2012. Both workshops were conducted with participants representing Central Province, PNG, at the same venue, Pacific Advent University, and a very similar methodology of collaborative problem solving was followed in regards to identification of training needs.

Methodology

Collaborative problem solving methodology (CPSM) draws on understandings of groups of individuals to resolve an issue where an obvious solution does not exist. CPSM as a workshop method, was first developed by Chambers, Spriggs and Kayrooz for the Australian Institute for Sustainable Communities at the University of Canberra, deriving from the processes of Value Management (Spriggs and Chambers 2004; Kayrooz, Chambers and Spriggs, 2006). The major elements for collaborative problem solving methodology are shared conception of the problem and shared understanding of the solution. The workshop is designed in two parts: the first provides relevant information, checks for assumptions, states what is given about the situation and facilitates **divergent** thinking, i.e. brainstorming issues and coming up with creative ideas; the second, **convergent** thinking is where judgements are made about possible ideas and solutions proposed, often as part of an action plan. . This methodology was chosen as the framework to design the training needs workshop for both men and women as an obvious solution (i.e. package of training) does not exist to support improvement in vegetable production by smallholder farmers for the following major reasons:

(i) production and yields are declining as a result of soil fertility decline;

(ii) the high price and shortage of fertiliser and seed result in increase of pest and disease due to sub-optimal agronomic practices;

(iii) a shortage of labour and unsatisfactory security discourages smallholder farmers to produce and market vegetables;

(iv) smallholder farmers lack information relating to markets and marketing of fresh produce and the influence of post-harvest quality losses, transport and road conditions (Spriggs & Chambers, 2007; Wilson & Hehona, 2008). These reasons reflect the complexity of the problem and it is obvious that a readily available solution to it does not exist.

Also, collaborative solving methodology allowed for a shared conception of the problem amongst men and women smallholder farmers in their respective workshops with staff from research and advisory stakeholders, Fresh Produce Development Agency, National Agricultural Research Institute, Pacific Advent University and an Australian research team from the Tasmanian Institute of Agriculture and

University of Canberra. The challenge of CPSM is that it demands effective communication skills. This is often done in developing countries by working in cross-sectoral groups across the value chain or in an organisation, thereby sharing issues in common and solutions that might work for various actors e.g. in a typical value chain, farmers, wholesalers, transport workers, supermarket managers, and so forth would be represented. However, in this context, although the focus was on the horticultural value chain, only smallholders were selected because it was about their training needs. Additionally, small group work was based on *place* (i.e. in this case on village or clan) because that was very relevant to PNG culture and society and therefore context was essential (OECD, 2010), as were appropriate media for eliciting training needs and priorities. The low level of literacy meant that the smallholders may not be able to communicate effectively in writing amongst themselves or with staff of the research and advisory stakeholders. This challenge was overcome by using a pictorial method of assessment used in gaining information in low literacy and cross cultural settings (Catalani & Minkler, 2010; Keremane & McKay, 2011). Posters were used to identify training needs for categories of horticultural production activities (soil preparation, planting, irrigation and crop management), marketing activities (harvesting, packaging and marketing,) and business activities (banking, book keeping and transport) during the divergent phase.

The convergence activity was planned on the second day so that the participants representing different villages by the time exchanged views and communicated freely and was willing to sit as groups irrespective of not belonging to the same village. After identifying very difficult, difficult and easy tasks, on the first day women and men participants in their respective workshops on the second day were asked to form subgroups based on their age as older and younger groups to prioritise training needs with stars indicating first, second and third priorities.

Participants in the two training needs analysis workshops, one for women conducted in September 2011 and another for men, conducted in September 2012 were selected using the following criteria:

- previous training of some kind
- active involvement in horticulture and/or keen to develop their production
- members of a women's or men’s agricultural organization or association
- commitment to sharing their learning with others
- a mix of ages i.e. mothers and daughters/daughters in law and fathers and sons/sons in law.

Participants in the two workshops, women and men were asked to sit in small village based groups according to the village from which they came. In mother and daughter’s workshop, 32 participants were seated in 4 small groups (3 village groups representing Rigo-Koiari and one village group representing Bautama). In a father and son’s workshop 21 participants were seated in 4 small groups (2 village groups representing Rigo-Koiari, 1 village group representing Sogeri and 1 village group representing Bautama).

Results and Discussion

The training needs for categories of horticultural production activities, marketing activities and business activities was identified during the divergent phase using pictorial technique in each of the women’s and men’s workshops, and a shared understanding of the training needs was identified by divergence on the first day amongst the small village based groups.

Table 1 presents the similarities and differences in training needs identified by women and men, and is followed by a commentary on each of the groups of activities (H = horticultural production, M = Markets and marketing, B = Business activities)

Table 3 Similarities and differences in training needs amongst women and men smallholders (H = Horticultural production activities, M = markets and marketing, B = business activities). The shaded cells represent difference in group perception

Tasks	Women	Men	Gender difference in training needs	Implications for training based on gender attributed tasks
Soil preparation (H1)	Easy Task	Very difficult task	Difference observed	Men's task
Planting (H2)	Easy Task	Quite difficult task	Difference observed	Men's task
Irrigation (H3)	Very difficult task	Very difficult task	Similarity observed	Both men and women's task
Crop management (H4)	Very difficult to quite difficult task	Very difficult task	Similarity observed	Both men and women's task
Harvesting (M1)	Easy task to quite difficult task	Easy task	Difference observed	Women's task
Packaging (M2)	Quite difficult to Easy	Quite difficult to Easy	Similarity observed	Both men and women's task
Marketing (M3)	Very difficult to Quite difficult task	Quite difficult task	Difference observed	Both men and women's task
Banking (B1)	Easy task	Easy task	Similarity observed	Both men and women's task
Book keeping (B2)	Easy task	Very difficult to quite difficult	Difference observed	Both men and women's task
Transport (B3)	Very difficult task	Very difficult to quite difficult task	Similarity observed	Both men and women's task

1.1 Training needs for categories of horticultural production activities

Similarities and differences in training needs for categories of horticulture production activities between men and women is attributable to the respective established roles of men and women in agriculture tasks.

Soil preparation (H1) – Soil preparation was agreed to be a difficult task by all men's groups which is different to the women's response, the difference in ranking by men and women is attributable to the respective established roles of men and women in agriculture tasks. Soil preparation is the role of men, so women did not classify the task as difficult. The majority of the men mentioned that they are in need of good ploughing equipment to prepare the land.

Planting (H2) is considered quite difficult. Men considered planting to be difficult, and related their experience to the group of activities before, during and after the physical activity of placing seeds in the soil. For instance, some experienced buying eggplant seeds that were labelled pink eggplants, whereas only some plants yielded pink eggplant fruits, while many of them yielded white fruit which were unmarketable. Some also asserted that seeds were very expensive and decided to save the seeds after harvest and tried replanting. The replanted seeds did not do well as the mother plants were hybrids, meaning the next generation of seed were either non-viable or produced very uneven stands and poor yield. Consequently, the group emphasized that they need crop varieties that can be regenerated by retaining seed from their fields.

Irrigation (H3) was agreed to be a difficult task by both women and men. The difficulty was because both women and men had to carry water in cans to their gardens, the distance of their garden from the river and the area to water contributing to the level of difficulty reported. Men stated that they had to carry 20 litre water cans and found this a significant burden.

Crop management (H4) - All men's village based groups agreed that crop management was a very difficult task which is similar to the women's response, where some members of each village group assessed crop management as a very difficult task. It is interesting to note that although women mentioned that men had attended training on crop management practices like application of chemicals, the majority of the men mentioned that crop management was a difficult task.

It can be concluded that horticulture production activities like soil preparation and planting are attributable to men and irrigation and crop management are attributable to both men and women. This implied that irrigation and crop management techniques that might suit both genders need to be considered during training.

Training needs for categories of marketing activities

Similarities and differences in training needs for categories of marketing activities between men and women is attributable to the respective established roles of men and women in marketing tasks.

Harvesting (M1) is considered as an easy task by majority of the men's village based groups. In the women's village based groups, two groups considered easy agreeing with the men's group and 2 groups considered quite difficult. The 2 women's village based groups considered the task quite difficult because they lacked experience in growing crops like cucumber and did not know when to harvest to meet consumer preference.

Packaging (M2) is considered to be quite difficult to easy task by both men and women. Women's village based groups stated that it was considered difficult as appropriate packaging for vegetables like capsicum and bok choi is very different and it is hard to maintain quality as it needs to be transported to a longer distance from the field before getting it to the transport site. However men's group considered easy stated that they had some resources to address their difficulties, such as own vehicles for transport or weaving cane baskets to improve packaging.

Marketing (M3) is considered as a difficult task to a quite a difficult task by both men and women. The opportunistic behaviour of men and women by taking a small volume of produce to the open market does not guarantee them a good price. The men's groups supplying to super markets stated that they are working to meet the supermarket demand in spite of the limitations mentioned in the above section 3.1. The women's village based groups agreed that the reason marketing being very difficult was that it was hard to find a space to sell their produce as the market is dominated by Highlanders. One of the women village based groups also mentioned that they had no say on the price as it was graded by the middle men at the market and the price was fixed.

It can be concluded that marketing activities like harvesting is attributable to women and packaging and marketing are attributable to both men and women, and confirms that both genders need to be considered in value chain building and packaging techniques.

Training needs for categories of business activities

Similarities and differences in training needs for categories of business activities between men and women is attributable to the respective established roles of men and women in business tasks.

Banking (B1) – All men and women village based groups considered the task easy as they had previously assumed that this task was difficult to achieve. It is interesting that both women and men considered that it might be difficult to achieve, but had found it otherwise.

Book keeping (B2) – Three women village based groups reported that they had prior training in book keeping and one village based group did not have prior training in this activity. Through collaborative problem solving methodology, a solution was derived through communication and consensus. The women village based groups that received training agreed to deliver training to those women who did not have the opportunity to attend training on book keeping and so the task was categorised as an easy task. The men's village based groups reported that book keeping was very difficult as they did not have the knowledge on book keeping and men's village based groups who reported that book keeping was difficult stated lack of time to maintain records.

Transport (B3) – All men's village groups agreed that transport was a difficult task (2 groups considered it as very difficult and 2 groups as quite difficult), which agrees with the women's response where all village groups agreed that transport was a very difficult task. Men agreed that they did not have reliable transport and had to depend on public motor vehicles (PMVs). If the PMVs arrive late then they get to the market very late and they had to pay 5 to 10 kina to keep their produce secured in the market, this additional cost being a drain on the value of their crops.

It can be concluded that concerns about business activities like banking, book keeping and transport are held by both women and men. This also confirms that both genders need to be considered in delivering business management training, though some specific tailoring of training to needs of men and women may be needed.

Training needs priorities by older and younger women and men

Convergent thinking is where judgements are made about possible ideas and solutions proposed, often as part of an action plan. After identifying very difficult, difficult and easy tasks, on the first day women and men participants in their respective workshops on the second day were asked to form subgroups based on their age as older and younger groups to prioritise training needs with stars indicating first, second and third priorities.

Table 2 presents training needs priorities established by older and younger women and men representing their village with the Roman numerals indicating the priority ranking.

The older mothers of Bautama village identified and ranked their highest training need as crop management, followed by banking, irrigation and planting. The youth of Bautama showed similarity in the preference and ranking of training needs. In addition to the training needs identified by older mothers, they also identified the importance of marketing a shown in the table 2 below.

The older mothers of Rigo-Koiari village had identified similar training needs in crop management, although their highest ranking was for book-keeping, followed by harvesting, soil preparation, marketing and packaging. Youth put their highest emphasis on soil preparation, crop management and irrigation and were therefore quite different than their older mothers in prioritizing compared with Bautama women. It transpired that some older mothers had received training in soil preparation, packaging, irrigation and marketing, but other younger women were not aware of this and vice-versa for banking, harvesting and marketing training for youth. The point was made about the importance of sharing the knowledge in the community between older and younger mothers.

In the men's, workshop, both the mature men and youth groups ranked their training priorities as Banking, Bookkeeping and Crop Management. The youth group identified planting as one of their priorities which was not identified by the mature men's group.

In terms of improving transport it was pointed out to the group that our project could not improve roads or transport per se and after further discussion it transpired that the group were asking for skills enabling them to lobby local, provincial and national authorities - skills identified for the Rigo group were submission writing, negotiation skills, and cooperative management.

The two villages were quite different in terms of their priority training needs for both older and younger mothers. It appears that the training needs at Rigo-Koiari are at another level of management than those at Bautama, where basic horticultural and crop management needs are of priority. However there was no difference amongst the mature men from Bautama and Rigo /Sogeri in their training priorities.

Conclusion

This paper highlights the findings on the similarities and differences in training needs for men and women horticulture farmers in PNG. Our results demonstrate that that horticulture production activity like soil preparation and planting are undertaken by men and irrigation and crop management are undertaken by both men and women. In regards to marketing activities, it can be concluded that harvesting is mostly done by women and packaging and marketing by both men and women. In the case of business activities it can be concluded that banking, book keeping and transport are undertaken by both women and men. This implied that irrigation and crop management techniques that might suit both genders need to be considered during training. This also confirms that both genders need to be considered in value chain building, packaging techniques and business management trainings. The training needs priorities established shows significant difference between older mothers and fathers compared to youth (Daughters/Daughters in Law and Sons/ Sons in Law). Our results demonstrate that the training needs at Rigo-Koiari are at higher level of management than those at Bautama, where basic horticultural and crop management needs are of priority in the women's workshop, but there were no differences amongst the mature men from Bautama and Rigo /Sogeri in their training priorities.

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Authors sincerely acknowledge women and men smallholders for their effort in participating in the workshops.

Table 4 Table 2 Training needs priorities established by older and younger women and men representing their village with the Roman numerals indicating the priority ranking .

Women participants	Bautama	Rigo-Koiari
Older Mothers	Crop Management (H4) (I)	Book keeping (B2) (I)
	Banking (B1) (II)	Harvesting (M1) (II)
	Irrigation (H3) (III)	Soil Preparation (H1), Crop Management (H4) (III)
	Planting (H2) (IV)	Irrigation (H3) (IV)
		Marketing (M3) (V)
		Packaging (M2) (VI)
Youth (ie Daughters/Daughters in Law	Crop Management (H4) (I)	Soil preparation (H1), Crop Management (H4) , Irrigation (H3) (I)
	Banking (B1) (II)	Book keeping (B2) (II)
	Planting (H2), Marketing (M3) (III)	Irrigation (H3) (III)
		Harvesting (M1) (IV)
		Packaging (M2) (V)
		Banking (B1) (VI)
		Marketing (M3) (VII)
Men participants	Bautama (Group 1 & 4)	Rigo & Sogeri (Group 2 & 3)
Older Fathers	Soil Preparation (H1) (I)	Soil Preparation (H1) (I)
	Book keeping (B2) (II)	Book keeping (B2) (II)
	Transport (B3) (III)	Transport (B3) (III)
	Crop Management (H4) (IV)	Crop Management (H4) (IV)
Youth (ie Sons/ Sons in Law)	Majority participants were from Bautama	
	Banking (B1) (I)	
	Crop Management (H4) (II)	
	Book keeping (B2) (III)	
	Transport (B3) (IV)	
	Soil Preparation (H1) (V)	
	Planting (H2) (VI)	

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Comparing training preference outcomes by gender in the Central Province of PNG

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Refereed Conferences

High yielding, quality cabbages and the challenges of production in the high altitude area of Central Province, Papua New Guinea: An approach to increasing the supply of temperate vegetables in to the Port Moresby markets

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Tapini District represents the cooler (temperature maxima 23-19°C, minima 12-9°C), higher altitude (1100-1800 masl) area of Central Province, Papua New Guinea (PNG), a tropical country just south of the Equator. Tapini district has potential for vegetable production to supply the increasing demand for temperate vegetables in Port Moresby arising from a substantial ex-patriot population and an emerging middle class. However, being located in a remote part of the Province, it still faces many challenges. The productivity of six cabbage varieties was assessed in field experiments during 2012 and 2013 to determine high yielding, high quality and, pest and disease tolerant varieties in the high altitude environment of Tapini. The findings suggest that KY Cross, Tropical Delight and Eureka varieties appeared to have the most promising yield, quality and, pest and disease tolerance. However these and other varieties of other vegetable crops need to be evaluated further at additional high altitude locations over a longer time frame under varying management practices to develop recommendations on varietal choice and appropriate cropping practices. The importance of off-farm constraints eg input supply chain and output value chain functioning and performance to production and economic outcomes for the local population was highlighted.

Key words: Cabbage, geographical and marketing constraints, high altitude, pest and disease tolerance, yield, quality.

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Assessment of Agricultural Land Capability Using GIS and Radar Imagery, Central Province, Papua New Guinea

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Abstract

Accurate and reliable spatial data on soil types is very limited in Papua New Guinea. The only regional digital dataset available is the Papua New Guinea Resource Information System (PNGRIS). This dataset is a highly extrapolated modelled GIS dataset which provides only a coarse and broad interpolation of probable soils which does not provide realistic on ground soil representation.

Using a 10 m Digital Elevation Model (DEM) derived from GEOSAR Radar data a four class Topographic Position Index was generated using Land Facet Tools Extension for ArcGIS (Jenness *et. al* 2011). This extension divided the topography into Ridges, Upper Slopes, Gentle Slopes and Valleys. Using this classification "Lower Slopes" of less than and equal to 10^{o} were selected as potential suitable sites for intensified arable agriculture. Slopes above 10^{o} gradient are more susceptible to rill and sheet erosion due to the intense high precipitation events experienced during the wet season.

This broad topographic based classification was further constrained by the bedrock geology underling the previously identified lower slopes. The soils best suited to intensive agricultural production were identified as those areas underlain by intermediate or mafic rocks e.g. basalt, gabbro and other igneous rocks high in ferro-magnesium minerals and iron oxides and their derivatives which provide the potential for the development of more productive and sustainable agricultural soils.

This broad first pass classification identified 41,533 hectares of land for potential agricultural expansion within the Rigo District in the coastal lowlands and foothills centred about the town of Kwikila some two hours by road southeast of the capital Port Moresby. Of the 41,533 ha identified some 10,632 ha is identified within PNGRIS as being prone to waterlogging and inundation of varying duration and severity. Most observed current agriculture land also falls within this first pass classification.

The coastal lowlands and adjacent elevated areas are known to have highly variable topography, including coastal plains, steep escarpments and dissected uplands/plateaux. Soils are also variable, with substantial areas of the coastal lowlands susceptible to inundation and steeper slopes overlain by shallow soils being susceptible to erosion (Bleeker 1983, Hanson *et al* 2001). For expansion of agriculture in Central Province, more detailed understanding of the location of suitable soils and their topographic limitations is needed. Historically, this would have been achieved through soil surveys, however, modern tools of GIS and radar imaging provide for rapid assessment of land capability for particular purposes. This assessment can be followed by 'ground truthing' and coupled with existing knowledge from, for example, field trials of crops and field data on soils, to assist in final assessment and decision making regarding agricultural development. This paper reports on the assessment of land capability in one potential area for agricultural development in Papua New Guinea, the Rigo district to the south east of Port Moresby.

Clearly, there are significant areas of land available for agricultural development in Rigo district, and by extrapolation, other areas of Central Province and beyond. However, for effective development, appropriate agronomic practices will need to be developed; these being part of other work being conducted by the authors and other colleagues. Land tenure issues notwithstanding these data will assist the sustainable agricultural development process in PNG and increase employment and business prospects for local farmer cooperatives.

We recommend using high resolution radar generated topographic coverage's in combination with soil parent material classification based on the mapped bedrock lithology as a base to generate more reliable land suitability maps and show national and local government development bodies, aid agencies and the village farmer cooperatives the areas available for land use intensification and sustainable national agricultural development. The maps would then be combined with other local data to provide a sound basis for development decisions and to guide agronomic practice.

Soil types and land use potential in Central Province, Papua New Guinea

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Abstract
Knowledge of soil morphology and chemical fertility at key agricultural research and demonstrations sites is fundamental to the development and extension of agricultural production systems. Developing countries are often challenged by incomplete and/or sparse spatial data that does not capture the variability in soil type, fertility and other key limitations to productive and sustainable use. While it is not possible to overcome all land use limitations in a short term project, a strategic approach that targets areas that have potential for intensive agricultural development can be used to best focus limited resources. This approach has been used in Central Province of Papua New Guinea. This province consists of lowland and elevated areas with vastly differing soil types and land use limitations. Here we report on profile characteristics and soil fertility of potentially productive soil and site combinations identified at research stations and from organised farming cooperatives in the district. The data show some of the wide diversity in soil physical and chemical characteristics in the province. The implications of these soil data for agricultural development and productivity are discussed.

Over all in PNG the understanding of the quality of soil resources is fundamental to development of sustainable agricultural production systems. In many developing countries, soil resources are described at an aggregated level, as in Bleeker (1983) and Hanson *et al*. (2001) for Papua New Guinea (PNG), but this is usually inadequate for decision making on cropping practices for long term sustainability. In this study, existing information on soils and land capability in Central Province PNG has been further supported by profile examinations of soils identified as having potential for sustainable agricultural development. Soil types in PNG are highly variable due to the landscape being affected by active geological processes, significant climatic gradients and variable topographic features in a high relief terrain. Land capability and land use potential is also highly variable (Hanson *et al.* 2001). This paper reports on profile characteristics and chemical fertility of soils identified as having potential for intensified vegetable production in coastal and elevated regions of Central Province, and identifies practices needed for sustainable production.

We found the variation in chemical soil fertility means that assessment of soil fertility and thus the need for fertiliser inputs or other soil and crop management strategies will be needed on a site-specific basis. We also found soil physical conditions were variable, however, the overriding interpretation is that careful management will be needed to maintain favourable conditions at all sites, though some are more susceptible to degradation than others.

Local capacity building through transformational learning – PNG Case Study

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ABSTRACT TEXT

Small farmers in Papua New Guinea (PNG) have long practiced subsistence farming that involves simple, labour intensive technologies using limited capital and few purchased inputs, and continue to do so due to poor transport infrastructure and lack of market information. Consequently, productivity, income and return on labour have been low leading to poverty and food insecurity.

In the work reported here, the traditional approach of improving farm income by increasing production and productivity solely through technical capacity building of small farmers was not followed. Instead a mixed method approach was used by establishing value chains, and engaging actors in the chain involved in production, processing, transport, marketing and consumption. The value chain development approach aimed at overcoming challenges, identifying and facilitating opportunities for small farmers, supported by training of smallholders to enhance their capacity to participate.

The challenges that small farmers faced were identified in a training needs workshop, using visual ethnographic techniques. Specific training needs were identified as horticulture production, business management and marketing. Small farmers from the Central Province were trained to improve their capability to capitalize opportunities in the value chain. This paper focuses on transformational learning theory and methods that contributes to instrumental (skills and knowledge) and communicative understanding about values and beliefs) learning, and how it was applied in the socio-economic context of PNG.

Improved vegetable production systems for community cooperatives in the Central Province, Papua New Guinea

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Abstract: We compared the performance of three vegetable production systems using one variety each of tomato *'Money Maker'* and capsicum *'New Ace'* in two hot and seasonally dry lowland locations of Central Province, Papua New Guinea. The three systems used were Traditional farmer's practice (TFP), improved production systems (IPS) and commercial high input practice (CHIP). TFP was based on traditional techniques using local knowledge and system descriptions from other earlier work; IPS supplemented the traditional practice with low cost technologies and practices expected to produce high returns and; CHIP employed techniques and technologies likely to be obtainable by few farmers due to high fixed and working capital requirements and other barriers.

In the traditional system pest and disease infestation were high, and responsible for lower fruit quality and yield than In IPS and CHIP. IPS produced crop yield and quality comparable to or better than that of CHIP, indicating that the use of additional low cost technologies and practices in the TFP may enable higher production and create opportunities for smallholder farmers to increase their disposable cash income. The results are discussed in context of the Improved Practice vegetable production system being adopted by smallholder farmers and community cooperatives in the Central Province, Papua New Guinea, and how these improved systems should be able to contribute to vegetable supplies for major local markets, especially Port Moresby.

Keywords: Adoptable, best practice, Central Province, commercial practice, community cooperatives, Papua New Guinea, production systems, smallholder farmers, traditional practice, vegetables

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Labour Costs are an issue in agriculture in a developing country too

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ABSTRACT

Labour cost in Papua New Guinea (PNG) is an important factor that is usually ignored by smallholder farmers in calculating the general cost of production. Typically, most labour in the villages of smallholder farmers is through family labour. A production costs survey was done in order to determine labour and other costs for smallholder farmers in producing vegetables. On site surveys were conducted with forms filled by the farmers from project sites. The study was conducted over three cropping seasons in Rigo, Central Province. Twenty active vegetable farmers were involved in the study. Usually, labour on smallholder farms in PNG is unpaid. The study identified that production costs are important in smallholder farming. Unit production cost of vegetables were between PNGK0.50 and K12.00. The labour cost for the crops surveyed varied slightly from crop to crop, and ranged from K2.00 to K6.00 per kg of (watermelon, Capsicum, Tomato and French bean). Labour costs are relatively high, and if fully recovered in the market would place PNG vegetables at a competitive disadvantage. Variable costs and fixed cost were also determined, allowing target (breakeven) prices to be calculated, and thus whether an offered price is acceptable to be determined. Farming, inevitably, will become increasingly competitive, and knowing the cost of production is an important tool in planning, forecasting, and decision-making in farming.

Key Words: production cost, labour, smallholder farmers

AN INTEGRATED APPROACH TO A VEGETABLE RESEARCH, DEVELOPMENT, EXTENSION AND TRAINING PROJECT IN A DEVELOPING COUNTRY, PAPUA NEW GUINEA

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ABSTRACT

Vegetables are a major part of the diet in Papua New Guinea (PNG), and demand for temperate vegetables is growing from the emerging middle class and increasing expatriate population. In 2010 we began a number of research, development, extension and training activities (RDE&T) aimed at increasing the capacity of smallholders near Port Moresby to meet this demand. Rapid value chain analysis (RVCA) and appreciative enquiry (AI) methodologies were used to identify priority activities. Initially, qualitative interview, observational and other data were gathered from smallholders, staff of RDE&T bodies and some businesses to gain understanding of their needs and the desired outcomes from RDE&T. This approach revealed priorities for production and resource management research the locations for such research, and activities to improve value chain performance. AI also revealed socio-cultural constraints and needs for training of participants in the value chain, in particular training of youth and women in production and marketing activities. Production research concentrating on resource assessment, adaptation and performance of selected temperate vegetables, and on performance of systems of production ranging from low input (traditional) to high input were undertaken over three years in contrasting topographic environments in Central Province. Training to meet identified needs of key demographic groups (women and their daughters, men and their sons) was designed and implemented through workshops linked to other project activities. This paper describes the processes used in designing this project and discusses how they can be applied in scoping, designing and implementing any RDE&T project in a developing country.

Key Words: project design, project implementation, resources, socio-cultural

Soil morphological and chemical characteristics of key research and demonstration sites of the Central Province, Papua New Guinea

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Abstract
Knowledge of soil morphology and chemical fertility at key agricultural research and demonstrations sites is fundamental to the development and extension of agricultural production systems. Developing countries are often challenged by incomplete and/or sparse spatial data that does not capture the variability in soil type, fertility and other key limitations to productive and sustainable use. While it is not possible to overcome all land use limitations in a short term project, a strategic approach that targets areas that have potential for intensive agricultural development can be used to best focus limited resources. This approach has been used in Central Province of Papua New Guinea. This province consists of lowland and elevated areas with vastly differing soil types and land use limitations. Here we report on profile characteristics and soil fertility of potentially productive soil and site combinations identified at research stations and from organised farming cooperatives in the district. The data show some of the wide diversity in soil physical and chemical characteristics in the province. The implications of these soil data for agricultural development and productivity are discussed.

Introduction
Understanding of the quality of soil resources is fundamental to development of sustainable agricultural production systems. In many developing countries, soil resources are described at an aggregated level, as in Bleeker (1983) and Hanson *et al*. (2001) for Papua New Guinea (PNG), but this is usually inadequate for decision making on cropping practices for long term sustainability. In this study, existing information on soils and land capability in Central Province PNG has been further supported by profile examinations of soils identified as having potential for sustainable agricultural development. Soil types in PNG are highly variable due to the landscape being affected by active geological processes, significant climatic gradients and variable topographic features in a high relief terrain. Land capability and land use potential is also highly variable (Hanson *et al.* 2001). This paper reports on profile characteristics and chemical fertility of soils identified as having potential for intensified vegetable production in coastal and elevated regions of Central Province, and identifies practices needed for sustainable production.

Materials and Methods
Soils with potential for agricultural development were identified in the coastal lowlands (National Agricultural Research Institute [NARI] at Laloki, Pacific Adventist University at Koiari Park and farmer cooperatives near Kwikila in Rigo district) and in the more elevated areas of the Sogeri Plateau and Tapini. Soil pits were dug at all sites to at least 1 m depth (or by soil auger) and soil profile morphological characteristics were described and soil horizons sampled. Standard chemical analyses were undertaken by NARI Chemistry Laboratory using analytical procedures outlined in Rayment and Higginson (1992).

Results
Summaries of soil profile descriptions are provided in Table 1 and these data show considerable variation in physical characteristics of profiles, with impeded drainage or high water-tables indicated by the presence of mottling (Mo) and manganese nodules (Mn) at differing depths in several soils. Texture class is dominated by

clays (LC – MC) and clay loams (CL) which are commonly silty (Z). Soil structure is moderate to strong in most upper profiles. The presence of carbonate in lower horizons of the Koiari Park and Rigo soils indicates high base status and low leaching regimes.

Table 1: Profile characteristics for selected soils in the Central Province of PNG

Laloki	**Koiari Park**	**Rigo 1**	**Rigo 2**	**Sogeri**	**Tapini**
Alluvial Dermosol	**Colluvial Vertosol**	**Colluvial Vertosol**	**Alluvial Vertosol**	**Colluvial Ferrosol**	**Colluvial Dermosol**
~40 m ASL	**~50 m ASL**	**~80 m ASL**	**~85 m ASL**	**~400 m ASL**	**~900 m ASL**
Imperfect Drainage	Imperfect Drainage	Well drained	Moderately well Drained	Imperfectly drained	Moderately well drained
A11 0 – 5 cm 10YR 4/2, ZCL M-PO	**A11** 0 – 10 cm 10YR 2/1, MC, S-PO, F, C, G	**A11** 0 – 5 cm 10YR 2/1, ZLC, S-PO, F, A	**A11** 0 – cm 10YR 2/1, ZLC, S-PO, W	**A1** 0 – 10 cm 7.5YR 3/3, LC, S-PO, F	**A11** 0 – 15 cm 7YR 2.5/1, ZCL, M-PO, W, MG
A12 5 – 12 cm 10YR 4/2, ZLC, M-PO	**A12** 10 – 25 cm 10YR 2/1,MC, S-PO, VF, C, F-MG, G	**A12** 5 – 25 cm 10YR 2/1, ZLMC, S-PO, F, D	**A12** 5 – 20 cm 10YR 2/1, ZLMC, S-PO, W	**A3** 10 – 25 cm 7.5YR 4/3, FSLC, S-PO, F, Mn, G	**A12** 15 – 25 cm 7.5YR 3/1, ZCL, M-PO, W, MG
B11 12 – 30 cm 10YR 4/3, ZLC, M-PR+M,	**B21g** 25 – 40 cm 10YR 4/1, LMC, M-AB, F, Mo, O, G	**A13** 25 – 45 cm 10YR 2/1, ZLMC, M-PO, VF, G	**B1** 20 – 35 cm 10YR 3/1, ZMC, MS, F	**B1** 25 – 35 cm 7.5YR 4/4, SCL, M-PO, F, Mn,	AB. 25 – 35 cm 5YR 3/2, ZLC, M-AB, W, CG
B12 30 – 50 cm 10YR 4/3, ZLC, S-PO+GR, Mo, G	**B22g** 40-60cm, 2.5Y 5/2, LMC, W-AB, F, Mo, S	**B21** 45 – 65 cm 10YR 3/2, LMC, M-PO, VF, CO_3, D	**B21** 35 – 50 cm 10YR 3/2, ZMC, MS, VF	**B21** 35 – 50 cm SCL, MS+M-AB, F, Mo, Mn, D	**B21** 35 – 45 cm 5YR 4/4, ZLC M-AB, W, MG
B21 50 – 75 cm 10YR 4/2, ZMC, S-PO+AB, Mo, G	**C1g** 60 – 80 cm 2.5 Y 5/2 , MC, MS, F, CO_3	**B22** 65 – 90 cm 2.5 Y 3/1, MC, MS, VF, CO_3, FG, D	**B22** 50 – 65 cm 2.5Y 3/2, ZMC, MS, VF	**B22** 50 – 85 cm 7.5YR 5/2, SLC, MS+W-AB, F, Mo, Mn, D	**B22** 45 – 65 cm 10YR 5/6, ZL,MC, M-AB, W, MG
B22 75 – 95 cm 10YR 4/2, ZLC, Mo,	**C2g** 80 – 95 cm 2.5Y6/2, MC, MS, F, Mo CO_3	**B23** 90 – 110 cm 2.5Y 3/1, MC, MS, F, CO_3, FG	**B23** 65 – 80 cm 2.5Y 3/1, ZMC, MS, VF	**B3** 85 – 120 cm 7.5YR 5/6, SLC, MS, F, Mo, Mn	**B23** 65 – 80 cm 10YR 5/6, ZMC, M-AB, W, MG
B31 95 – 105 cm ZLC	**C3g** 95 – 115cm 5Y7/8, MC, MS, F, Mo, CO_3		**BC** 80 – 95 cm ZMC, MS, VF		**B24** 80 – 100 cm 10YR 5/6, ZMC, W-AB, MG
B32 105 – 110 cm+ ZLC					**B25** 100 – 110 cm 10YR 5/6, ZMC W-AB, MG, Mo

Soil order from Isbell (2002)
Texture: CL = clay loam, LC = light clay, MC = medium clay note Z in front = silty, S = sandy, FS = fine sandy, L= light
Structure: PO = polyhedral, PR = prismatic, AB = angular blocky, M = massive
Gravel: FG = fine, MG = medium, CG = coarse,
Moist Strength: W = weak, F = firm, VF = very firm
Mottles, Nodules and Cutans: Mo = mottles, CO_3 = carbonate nodules, O = Organic cutans, Mn = manganese nodules
Boundaries: Clear unless shown as A = abrupt, G = gradational or D = diffuse boundary.

Fig. 1 provides selected analytical data for the profiles described and they show considerable variation in soil chemical characteristics. The three Vertosols (Mafic soils) at Koiari Park, Rigo1 and Rigo 2 are high in exchangeable Mg, CEC and C/N, but are generally low in P. However most profiles have high exchangeable Ca and moderate to high exchangeable Mg levels. Overall total N values are low (mostly <0.2%). All the soils have relatively high pH, except at Sogeri where the profile appears more leached. Available P as measured by the Olsen test ranges from low in the sesquioxide rich soil at Sogeri, to relatively high at the government research stations of Laloki and Tapini.

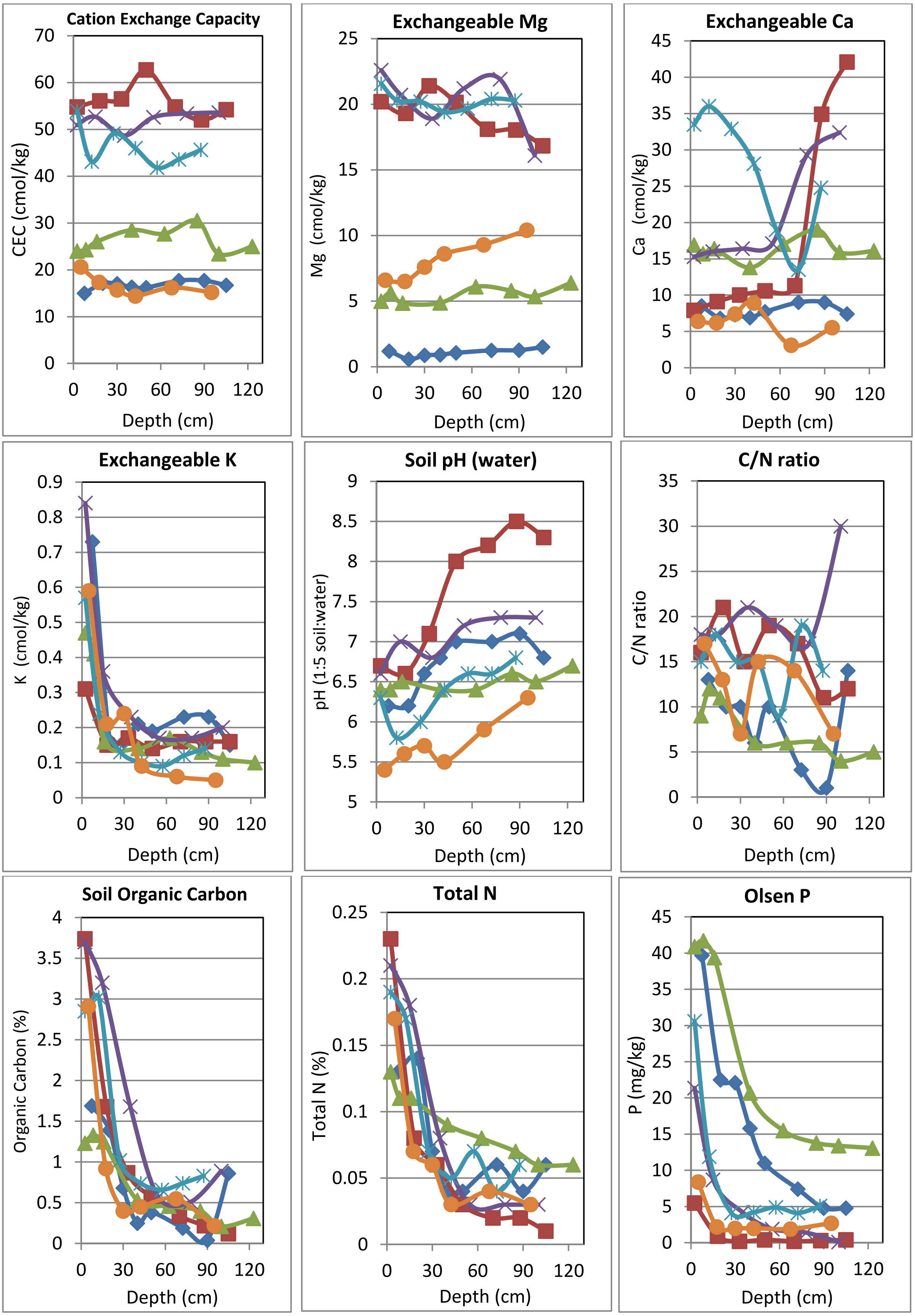

Fig 1 Cation exchange capacity (CEC), Exchangeable Ca, Mg, K, Soil pH, C/N ratio, Soil Organic Carbon, Total N and Olsen P. Sogeri (orange circles), Tapini (dark blue – diamonds), Laloki (green triangles), Koiari Park (red squares), Rigo 1 (purple x) and Rigo 2 (light blue *).

Total N and organic C concentrations are variable with values at Koiari Park and Rigo 1 and 2 (all Vertosols) being higher than at other sites. Both measures decline rapidly in the B and C horizons. C/N ratios are highly variable (ca 5 – 20), with some quite high (>16, above which immobilisation of N is likely). Exchangeable K values are low at Koiari Park and moderate to high at all other sites. Extractable P and exchangeable K, organic C and total N were concentrated in the upper profile, though significant concentrations of P were present in the upper layers of the B horizon at Laloki and Tapini. In the three Vertosols (Koiari Park, Rigo 1 and Rigo 2) exchangeable Ca increased markedly in the lower profile associated with the presence of $CaCO_3$ segregations.

Discussion

Profile physical conditions were variable, however, the overriding interpretation is that careful management will be needed to maintain favourable conditions at all sites, though some are more susceptible to degradation than others. Specifically, the mottling and manganese we observed suggests periodic water logging which may inhibit production during the wet season, while irrigation would be needed during the dry season. Weak moist soil strength, clayey textures and massive structure suggests that care will be needed in the use of machinery, where available, to minimise the risk of compaction, while high dry soil strength is likely to make soil cultivation when dry impractical. Thus, there is likely to be a narrow 'window' when soil conditions are suitable for use of machinery without degrading the soil.

The variation in chemical soil fertility means that assessment of soil fertility and thus the need for fertiliser inputs or other soil and crop management strategies will be needed on a site-specific basis.

To assist soil N and P economy at least, strategies to retain soil organic carbon will be essential. Management of the unfavourable C/ N ratios will require additional inputs of N from either organic (imported organic matter, compost, manures), biological (legumes) or fertiliser sources. Although regular burning of fields may in part be the cause of these high C/N ratios. How this is best addressed will depend on the local availability of suitable materials and crop rotations that are acceptable and profitable. Low to medium concentrations of extractable K can only be addressed by inputs of K in imported organic matter, ash or chemical fertilisers. An unfavourable Ca/Mg ratio (<1) has already been expressed as blossom end rot (Ca deficiency) of tomatoes at Koiari Park.

Land supply in Central Province for agricultural development should include analyses of soils to identify suitable and economically viable sites; the most suitable are likely to be in alluvial areas and toe slopes in mafic terrains with easy access to water for irrigation in the dry season.

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Using GIS and radar imagery for assessment of Land Capability for arable agriculture in Rigo District, Central Province, Papua New Guinea

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Abstract
Accurate and reliable spatial data on soil types is very limited in Papua New Guinea. The only regional digital dataset available is the Papua New Guinea Resource Information System (PNGRIS). This dataset is an highly extrapolated modelled GIS dataset which provides only a coarse and broad interpolation of probable soils which does not provide realistic on ground soil representation.

Using a 10 m Digital Elevation Model (DEM) derived from GEOSAR Radar data a four class Topographic Position Index was generated using Land Facet Tools Extension for ArcGIS (Jenness *et. al* 2011). This extension divided the topography into Ridges, Upper Slopes, Gentle Slopes and Valleys. Using this classification "Lower Slopes" of less than and equal to 10^o were selected as potential suitable sites for intensified arable agriculture. Slopes above 10^o gradient are more susceptible to rill and sheet erosion due to the intense high precipitation events experienced during the wet season.

This broad topographic based classification was further constrained by the bedrock geology underling the previously identified lower slopes. The soils best suited to intensive agricultural production were identified as those areas underlain by intermediate or mafic rocks e.g. basalt, gabbro and other igneous rocks high in ferro-magnesium minerals and iron oxides and their derivatives which provide the potential for the development of more productive and sustainable agricultural soils.

This broad first pass classification identified 41,533 hectares of land for potential agricultural expansion within the Rigo District in the coastal lowlands and foothills centred about the town of Kwikila some two hours by road southeast of the capital Port Moresby. Of the 41,533 ha identified some 10,632 ha is identified within PNGRIS as being prone to waterlogging and inundation of varying duration and severity. Most observed current agriculture land also falls within this first pass classification.

Introduction
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The coastal lowlands and adjacent elevated areas are known to have highly variable topography, including coastal plains, steep escarpments and dissected uplands/plateaux. Soils are also variable, with substantial areas of the coastal lowlands susceptible to inundation and steeper slopes overlain by shallow soils being susceptible to erosion (Bleeker 1983, Hanson *et al* 2001). For expansion of agriculture in Central Province, more detailed understanding of the location of suitable soils and their topographic limitations is needed. Historically, this would have been achieved through soil surveys, however, modern tools of GIS and radar imaging provide for rapid assessment of land capability for particular purposes. This assessment can be followed by 'ground truthing' and coupled with existing knowledge from, for example, field trials of crops and field data on soils, to assist in final assessment and decision making regarding agricultural development. This paper reports on the assessment of land capability in one potential area for agricultural development in Papua New Guinea, the Rigo district to the south east of Port Moresby.

Methodology
Papua New Guinea Resource Information System (PNGRIS) data were initially analysed and considered to be an over extrapolation of the natural resource data sets available. Consequently, P-band GeoSAR radar elevation

data, X-band GeoSAR Magnitude Radar Imagery, Regional Scale Geological Data and field observations of soils coupled with data from crop trial plots were used as primary data sources for the study.

X-band and P-band radar data is collected concurrently from each side of a survey aircraft at an elevation between 10,000 and 12,500 metres. The X-band wavelength penetrates clouds and reflects from tree canopy to deliver surface model data in forested areas and accurate terrain elevation in open areas. The P-band wavelength penetrates both clouds and tree canopy to deliver terrain elevation and surface feature extraction in forested areas. These characteristics make GeoSAR ideal for mapping large areas of mixed land cover particularly in Tropical areas such as Papua New Guinea (Williams and Jenkins 2009). The regional scale geological data provides the only credible bedrock information available for the selected study areas.

Tiled P-band radar surface points which penetrate all but the densest vegetation provide a high resolution model of the terrain. The points were provided by the Defence Imagery and Geospatial Organisation as ASCII point data with spacing of 2.5 metres, and were gridded to a mosaic of 10 m Digital Elevation Model (DEM) surfaces using the ArcGIS "3D Analyst" extension. This data provides a more accurate and higher resolution representation of the local topography than the publically available 30 and 90 metre Shuttle Radar Topography Mission (SRTM) data for the study area.

Using the 10 m DEM derived from the GeoSAR Radar data a four class Topographic Position Index (TPI) was generated using Land Facet Tools Extension for ArcGIS (Jenness *et al* 2011). This extension divided the topography into Ridges, Upper Slopes, Gentle Slopes and Valleys. Using this classification "Lower Slopes" of less than and equal to 10^{o} were selected as potential suitable sites for intensified agriculture.

This broad topographic classification was further constrained by the lithology or soil parent material underling the previously identified lower slopes. The area's deemed most suitable for intensified agricultural production were identified as those areas underlain by intermediate or mafic rocks or derived alluvium and colluvium which provide for deeper and base rich soil parent materials. Thus their derivative soils generally provide the potential for the more productive and sustainable agricultural lands. Limited numbers of soil profiles were described and soil types noted in road cuttings and gardens in the district.

Results

This broad first pass classification identified 41,533 ha of land for potential agricultural expansion within the Rigo district. The land was underlain by a wide range of parent material/bedrock, though most were of volcanic origin dominated by gabbro and basalt and a significant area of transported materials (9,899 ha, see Table 1 and Figure 1).

Table 1 Geological bedrock and associated areas of land assessed as suitable for agricultural development in Rigo district, Papua New Guinea

Geological Bedrock	Area (Ha)
Basalt and andesite pyroclastics, lava and volcanic sandstone.	3,955
Basalt and andesite pyroclastics and minor lava.	924
Basalt and andesitic agglomerate, minor tuff; tuffaceous sandstone and volcanic conglomerate.	725
Basalt and minor andesite agglomerate and tuff, partly reworked	312
Basalt and pillow lava with gabbro and dolerite intrusives (dykes), minor calcilutite	381
Gabbro, diorite, dolerite, basalt and other acid differentiates.	25,285
Gravel, sand, silt, mud, clay: alluvium and beach deposits downslope and adjacent to mafic and intermediate bedrock	9,899
Massive green mafic schist derived from basalt, dolerite, gabbro, volcanic sediment; and minor calcareous and felsic schist or phyllite.	52
Total	**41,533**

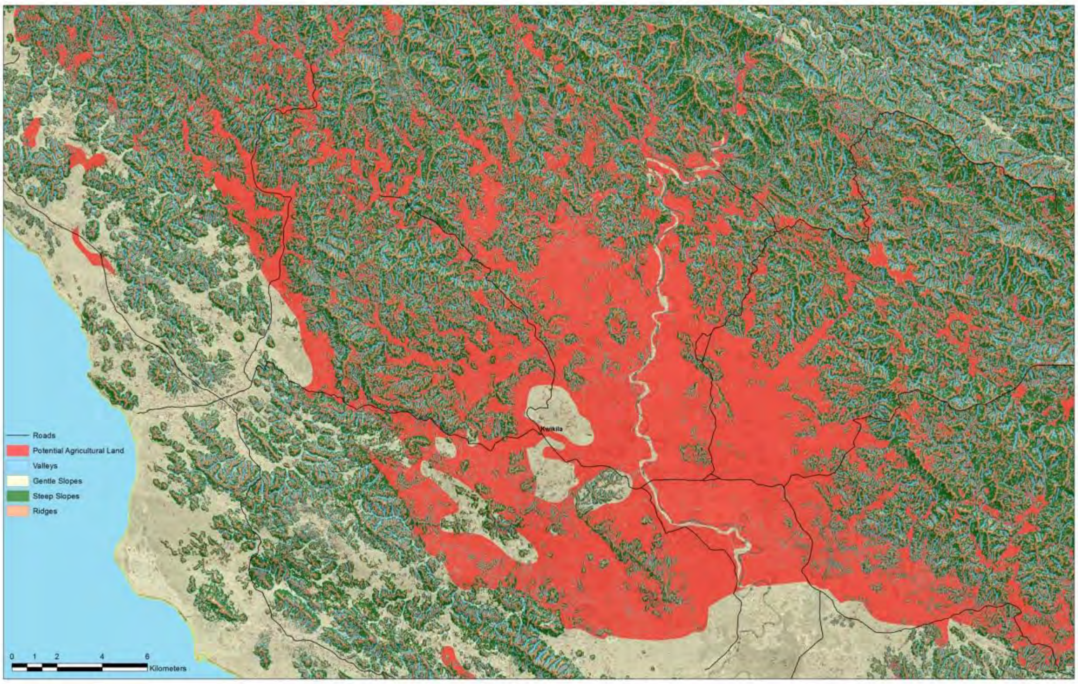

Figure 1 Potential suitable Agricultural Land (areas in red) in the Rigo Province PNG

The majority of this land is centred on the town of Kwikila some two hours by road south east from Port Moresby. Of the 41,533 ha identified some 10,632 ha is listed within PNGRIS as being prone to waterlogging and inundation of varying duration and severity (Table 2). Of the 10,632 ha susceptible to inundation 2,920 ha (Inundation types 1, 2 and 5 would probably be excluded from agricultural use).

Table 2 Areas of land subject to inundation in Rigo district

Inundation Type	Area (Ha)
1. Long term inundation	2,843
2. Near permanent inundation	6
3. Periodic brief flooding	3,909
4. Seasonal inundation	3,607
5. Tidal flooding	71
Total	**10,632**

Discussion

The GIS data and radar imagery has been combined to produce informative maps that can be used to prioritise areas for agricultural development. They have clearly identified potential areas, and by relaxing or tightening the constraints set when using the radar imagery, the area of potentially useable land would increase or decrease. For example, if the allowable slope was reduced to say, 7º for agricultural systems in which soil cover was limited between crops and during cropping while canopy cover was limited, therefore increasing the erosion risk, the area of suitable land would inevitably decrease. Conversely, if the assessment was being made for land uses involving perennial pastures, forestry and fruit trees the allowable slope limits could be increased, resulting in larger areas of potentially useful land being identified.

The present analysis has shown an extensive area of potentially useful land between elevated areas and many small, narrow areas of potentially useful land in nearby valleys and small areas in elevated areas. When combined with ground based observations along roads and in village gardens augmented with limited examination of augured soil profiles, the approach of using GIS and radar imagery is proving a very useful tool for assessment of land capability. Our team has also applied this approach in several other areas in Central Province, with similarly useful output, again with initial validation from ground based observations and soil data. Nevertheless, the approach must be complemented with other information, such as the data on inundation, to gain a more accurate assessment of land capability and guide development and agronomic decisions on crops to be grown and practices used on specific sites.

Clearly, there are significant areas of land available for agricultural development in Rigo district, and by extrapolation, other areas of Central Province and beyond. However, for effective development, appropriate agronomic practices will need to be developed; these being part of other work being conducted by the authors and other colleagues. Land tenure issues notwithstanding these data will assist the sustainable agricultural development process in PNG and increase employment and business prospects for local farmer cooperatives.

Conclusions

We recommend using high resolution radar generated topographic coverage's in combination with soil parent material classification based on the mapped bedrock lithology as a base to generate more reliable land suitability maps and show national and local government development bodies, aid agencies and the village farmer cooperatives the areas available for land use intensification and sustainable national agricultural development. The maps would then be combined with other local data to provide a sound basis for development decisions and to guide agronomic practice.

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Implications of soil morphological and chemical characteristics in the highlands of Central Province, Papua New Guinea for sustainable vegetable production.

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Soil morphological and chemical characteristics determine the productive capacity and sustainability of land use. In Papua New Guinea (PNG), increasing production of temperate vegetables is needed to supply growing city population of Port Moresby (PoM) due to rural to urban migration, increasing expatriate populations, an emerging middle class and changes to food preferences in response to the recent mining and oil boom in PNG. Preliminary investigations show that soils of the cooler, moderate to high rainfall highland areas of Central Province are suitable for vegetable production. The major soils (andisols and ferrosols), have suitable structure, but have multiple nutrient deficiencies and are at risk of erosion. Initial studies of production of some several varieties of broccoli, cabbage, carrots and capsicum during 2011-12 at Sogeri (altitude 650 masl, temperature - maximum 27-30 °C, minimum 16–19 °C) and Tapini (altitude 1100 -1800 masl, temperature - maximum 19-23°C, minimum 9-12°C) produced acceptable yields of vegetables of high quality, for example broccoli - 2 300-6 000 kg/ha, cabbage 10 000-19 000kg/ha and carrot 900-1 200kg/ha for Tapini. and capsicum 5 000-6 700kg/ha, provided nutrient deficiencies were corrected. This work is being expanded and repeated in 2012-13, supported by detailed soil analyses. Production under low, medium and high input systems is being evaluated to provide information on soil and crop management practices that enhance sustainability. The findings are being used in development and extension activities to support sustainable expansion of vegetable production on contrasting soils in favourable temperature and rainfall environments.

Implications of soil morphological and chemical characteristics in the highlands of Central Province, Papua New Guinea for sustainable vegetable production

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Introduction

Soil morphological and chemical characteristics determine the productive capacity and sustainability of land use. 'Increasing production of temperate vegetables is needed to supply the growing city of Port Moresby. Tapini (Goilala Plateau, ~1200m ASL) and Sogeri (~600m ASL) have cooler environmental conditions than coastal lowland areas near Port Moresby'. Tapini and Sogeri areas could produce more vegetables for Port Moresby, especially if soil limitations can be overcome.

Fig 1: Papua New Guinea – Central Province – Tapini and Sogeri on the regional map.

Soil morphology of Tapini & Sogeri

Fig 2: Moderately well drained permeable soil profile, 30cm of topsoil, silty clay sized particles, soft when moist but firm when dry.

Fig 3: Somewhat degraded and compacted Red Ferrosol, moderate drainage with silt/clay sized particles, sandy clay substrates formed from alluvium of mafic origin.

'Soil structure fair to favourable'; 'impeded drainage in some areas, e.g. Sogeri' to moderately drained soils in Tapini. Texture class is dominated by silty clays particles in Tapini and Sogeri, Sogeri having more sandy clay substrates present.

Soil chemical characteristics of Tapini & Sogeri

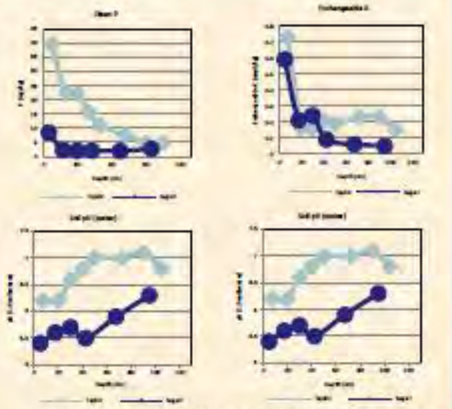

Fig 4: Cation exchange capacity (CEC), Exchangeable Mg, K, Soil pH, Soil Organic Carbon and Olsen P.

Exchangeable K concentrated in surface, low at depth > 30cm'; 'Olsen P high at Tapini, low to very low at Sogeri, 'pH lower at Sogeri than at Tapini'; 'Cation Exchange Capacity (CEC) moderate at both sites'.

The Sogeri site was fertilized using fertilizer (NPK & Urea), however, no fertilizer was applied to the comparatively fertile Tapini site.

Vegetable Production Potential of Tapini & Sogeri

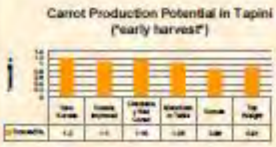

Fig 5: Potential production yield – Carrots, Cabbage and Broccoli at Tapini and Capsicum at Sogeri.

'Good quality vegetables can be produced at Tapini'; 'This was first year's results, carrots affected by *immature harvest* so yields comparatively low'; 'Candidate varieties for further evaluation identified e.g. 'Eureka, KK Cross, KY Cross Cabbage', Southern Comet, Southern Star Broccoli' and Giant Bell Capsicum in Sogeri.

Conclusion

This research shows that satisfactory yields of high quality vegetable can be produced , once soil limitations are corrected and sound crop management practices are applied in Tapini and Sogeri areas of the highlands of Central Province, Papua New Guinea.

Acknowledgment

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Future vegetable farming in Papua New Guinea – responding to resource constraints and population in a developing country: a case study

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Keywords: climate, soil resources, socio-economic, value chain analysis

Introduction

The population of Papua New Guinea (PNG) is growing at approximately 2.1% per year (CIA 2009) increasing the demand for food. Internal migration to peri-urban areas of the national capital Port Moresby (PoM), increased demand from an expanding middle class and expatriate mining and gas industry professionals are compounding food demands in PoM. Highland regions e.g. Eastern Highlands Province (EHP) grow a range of vegetables, but distance from PoM, and poor transport infrastructure and services constrain consistency of supply of quality vegetables. Seasonally dry coastal lowlands and cooler highlands (Sogeri Plateau, Goilala District), in Central Province (CP) nearer PoM have the potential to increase production and improve reliability of supply. In 2008, about 50,000 tonnes of PoM's 141,000 tonne/yr fresh produce came from peri-urban gardens (FPDA 2008) on soils which are rocky, erodible, drought prone and difficult to irrigate (Bleeker 1975) and unlikely to sustain production for these reasons an lack of security of land tenure. Vegetables are also produced in several alluvial flood plains and on the Sogeri Plateau. Markets are dominated by root and leafy vegetables, broccoli and zucchini. Quality is variable and retail prices unstable, and marketing is mostly through informal and direct (supplier to end user or supermarket) markets. Supply has not meet PoM demand (FPDA 2008; Worinu 2007), so this study was initiated to identify constraints to and opportunities for improving vegetable supplies to PoM markets.

Material and Methods

Field visits to farms and research institutes, interviews of individual farmers, groups of farmers, and agricultural research, development and extension officers, meetings with commercial providers in EHP and CP, and market operators and retailers in PoM were undertaken during May 2009 and July 2009 to determine farm characteristics and practices, land management, recent developments in vegetable production in EHP and opportunities for improvement in vegetable production and delivery to consumers from EHP and CP. Data were analysed using a rapid value chain analysis (Collins and Dunne 2008). Climatic (temperature, rainfall and soil water) limitations were assessed as in Hackett (1988) using climatic data for PoM, (35 years of data), and Goroka (EHP, 9 years of data to 2007), otherwise qualitative survey and literature sources were used. Land resources were assessed by soil profile assessment at key sites and GIS mapping (Doyle et al 2010).

Results and Discussion

Biophysical considerations in designing future farming systems

Climatic characteristics and limitations vary considerably (Table 1) mostly due to altitude and topographic influences (rain shadow of Owen Stanley Ranges), the principal constraints being temperature and water supply (excess or deficit). Rainfall increases to the east in the CP lowlands improving land use suitability (Bleeker 1983), though irrigation will be needed for dry season production and enhanced drainage necessary during the wet season throughout CP lowlands. The range of suitable temperate vegetables is constrained by temperature, though spring onions, white radish, bulb onions and shallot are grown near PoM. Soils and landscape are highly variable, and with their physical and chemical limitations, only soils most suitable for vegetables are recommended (Table 2). Land potential on the dissected Sogeri Plateau is high, while in the Goilala district soils are poor and potential low (Hanson et al., 2001). Most alluvial soils are likely to have good structure and high natural fertility but both would be expected to decline once cultivated. Land management techniques range from low-input practices such as long bush fallows and burning, to high input techniques including legume rotations, composting, mounding, drainage, soil retention barriers, mechanised tillage and irrigation.

Socio-economic considerations in designing future farming systems

Shifting cultivation is practised widely, with shortened rotations increasing the risk of land degradation. Crop options chosen reflect socio-cultural norms and market opportunities, with individual farmers or groups of farmers (e.g. cooperatives in the Goroka district (EHP) and Rigo and Goilala (CP)) selecting crops expected to provide the best return. Limited availability and expense of inputs such as suitable cultivars, fertilisers and agricultural chemicals and simple, inexpensive and portable irrigation infrastructure can compromise production. Transport and marketing infrastructure and market performance (Bonney et al, these proceedings) combine with size and scale of enterprises, seasonality of production, land tenure and land management to constrain income and financial capacity, and thus the ability to improve overall system performance. The challenge, then, is to identify aspects of the system that can be improved in environmentally sustainable, economically feasible and culturally appropriate ways.

What might future farming systems be like?

Future farming systems in PNG will be substantially determined by topographic, climatic and soil features and socio-cultural conditions. By aggregation of production from small holdings and group purchase of equipment and inputs, some benefits of economies of scale can be achieved. Land tenure may impede development of larger enterprises, so 'permanent settlement' farming with substantial fixed infrastructure may be unlikely in the short term. Innovative financial packages and formalisation of cooperative arrangements will support transformation of production to a more commercial approach. However, these developments can only realise their potential with support of enhanced infrastructure – especially transport and cool chain facilities. Challenges in agronomic practices will be met by optimisation of use of local resources and strategic purchased inputs which are likely to remain expensive and not readily available. Retention of organic matter as a nutrient source and for soil structural purposes will be a key component. Fertilisers and legume N will be required. Nutrient efficient crops should be grown if possible. A key long term challenge will be providing continuity of supply to markets by utilising a range of agro-ecological environments, with appropriate cultivars and planned production schedules developed by cooperatives in collaboration with off farm participants in the value chain. A diversity of crops and associated rotations will help minimise risk and optimise land management and continuity of income through the year.

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Table 1. Climatic characteristics and constraints in Central and Eastern Highlands Provinces

Location and altitude	Rainfall (mm)	Wet season	Mean max temp (ºC)	Mean min temp (ºC)	Main climatic constraints
Port Moresby 44m (Weather station)	899	Dec-Apr (61%)	31.4-32.5	22.4-23.7	High temperature (for C3 plants) Excess water (Dec-April) Water stress (May-Nov)
Goroka (EHP) 1587m (Weather station)	1722	Sept-May	25.5-27.5	14.9-16.2	Mild water stress (June-Aug)
Goilala District (CP) ~1000m (at Tapini AP)	2200 - 3200	~Sept - May	Highly variable, related to altitude		Water stress (~June-Aug) Low temperature, occasional frost Cloud cover
Sogeri Plateau 500-1000m	2200 - 3500	Few data, expect temperatures to be between Port Moresby and Goroka temperatures, with only minor climatic limitations			

Sources: Hanson et al (2001), PNG National Weather Service (2009), Goilala District (2011)

Table 2. Soil characteristics and constraints in Eastern Highlands and Central Provinces

District	Principal soils	Physical limitations	Fertility limitations
EHP	Andisol	Slope, erosion risk	Low pH, CEC, P, K, B, high C:N ratio, some areas low Zn, Mo, Cu, Mn
CP Lowlands	Alluvial	Inundation Impeded drainage	Maintaining soil fertility Organic matter loss
	Skeletal soils	Slope, erosion risk, low water holding capacity	Multiple deficiencies
Goilala	Ferrosols, Andisols	Slope, erosion risk	Multiple deficiencies
Sogeri	Ferrosols	Slope, erosion risk	Low pH, multiple deficiencies, acid soil toxicity

Sources: Birch *et al* 2009, Hanson *et al* 2001, Radcliffe and Kanua 1998

Using value chain systems modelling to develop more sustainable cool temperate vegetable marketing systems in a transitional economy: a case study in PNG

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Keywords: co-innovation, transitional economies

Introduction

Agriculture is important to Papua New Guinea (PNG) accounting for 21 per cent of GDP and 17 per cent of total exports (Coppel, 2004). Production is predominantly carried out by smallholders working 'customary land' using subsistence agriculture methods. Family subsistence needs are still largely met by the household's production on its own land and so they are not compelled to rely on regular sales to obtain daily necessities (Benediktsson, 1998, Worinu, 2007). Supply chains generally operate with spot market forms of governance (Gereffi and Frederick, 2009) characterised by short term, opportunistic, sometimes exploitative and even violent behaviours. Thus, there are few incentives for smallholders to improve consistency of supply or the quality of their vegetables to markets outside their local area. This perpetuates poverty and disempowerment of smallholders (Vermeulen and Cotula, 2010) and, if they aspire to change their situation, the cost of accessing education and health services drives significant internal migration to major urban centres (Bourke and Harwood, 2009). In particular, this has caused social and environmental problems in the peri-urban areas around the capital, Port Moresby. The PNG Fresh Produce Development Agency (FPDA) conducted the only major study of fresh vegetable supply to Port Moresby and estimated that there is a shortfall in vegetable production that could be as high as 80,000 tonnes per annum (Liripu, 2008). The recent resources boom has exacerbated this shortfall and imports increasingly substitute for local production reducing the benefit of the boom to PNG. Central Province has the physical and climatic potential to meet much of Port Moresby's demand for food however, finding sustainable models of agrifood production compatible with the complex socio-economic and infra-structural constraints on commercial-scale production will be necessary if this is to occur.

Material and Methods

Marketing supply chains are frequently regarded as 'systems' (Bäckstrand, 2007) whilst Knoppen and Christiaanse (2007) argue that multidisciplinary approaches are necessary to provide improved explanations for the dynamic, complex interactions involved in the appropriation, coordination and adaptation processes in supply chain operation. This has prompted many international development agencies to use systems approaches such as Participatory Action Research (PAR) (Reason and Bradbury, 2001) to overcome the 'wicked problems' of agrifood production in transitional economies. Hence, this project adopted a multidisciplinary approach to the development of efficient and effective value chains in Central Province, PNG based on sustainable, low input horticultural production and value chain management principles to meet the growing demand for fresh vegetables in Port Moresby. The research methods were based on a participatory action learning cycle 'with' rather than 'on' the participant smallholders (Heron and Reason, 2001). An initial 'scoping study' used Rapid Value Chain Analysis to identify the focal vegetables, participating communities and the priority constraints on production and marketing. Then, following Bonney et al (2007) data were collected on the material flows, communication flows and relationships from observation ('walking the chain' to map the material flows) , semi-structured and group interviews using convergent/divergent interview techniques with a wide range of chain participants. As it was not possible for consumer value attributes of the focal vegetables to be investigated directly with consumers, retail and institutional buyers were interviewed. Data were analysed using qualitative content and thematic analysis, aided by the computer application NVivo (Version 8) to identify the themes. This formed the basis for the development of current and future state models and identification of the potential 'chain improvements' which were validated with chain participants.

Results and Discussion

The biophysical constraints to developing the vegetable production system have been dealt with by Birch et al (2011), in these proceedings, however, it is sufficient to note that they are important contributors to the highly variable quality, quantity and consistency of vegetable produce being 'pushed' into the marketing system. Therefore, this paper will focus on addressing the marketing system constraints identified in the current state model.

The types of markets
The main market outlets for fresh produce are the informal roadside and local markets (Type 1), distant informal markets in major urban centres (Type 2), community entrepreneurs who act as 'aggregators" (Type 3), commercial wholesalers (Type 4), the formal markets (Type 5) such as those run by local government and direct to the institutional markets such as hospitals, hotels and mines (Type 6) (Birch et al., 2009).

Poor infrastructure for marketing
The road, telecommunications and finance systems in regional PNG present major constraints on the vegetable marketing system. The country does not have a national, inter-connected road system and non-arterial roads are very poorly maintained due to the terrain and climate. Whilst cell phone telecommunications are improving rapidly, the lack of internet services outside the major urban centres and patchy cell phone reception mean that only the most basic marketing information is possible, even if it were available. Finally, the banking system does not operate outside of the major towns and, with the prevailing lack of law and order, the use of cash is not advisable.

Lack of economies of scale and coordination in marketing
Smallholders generally transport several fifty kilogram bags of vegetables to markets on public motor vehicles and then hawk their produce around the various outlets until a satisfactory price is obtained. Prices received are highly variable partly due to the variability of supply and demand but also as a result of the mixed passenger freight transport causing some post-harvest deterioration in already highly variable quality of produce. In addition, costs are higher than a specialised freight service, considerable time is wasted and frequent harassment and intimidation is experienced.

Poor chain relationships
In the current system, the relationships involved are transactional, short-term with price-based incentives and no trust, commitment or coordination of supply. All parties regularly engage in opportunistic, exploitative behaviour that invites reciprocal behaviour thus reinforcing the behaviour. In particular, women are subjected to frequent harassment and the outcome is that smallholders often sell their produce to the first buyer to avoid further conflict.

A preferred production and marketing model
The preferred, future state model is based on an improved low input, more environmentally sustainable production system producing a more consistent flow of higher quality vegetables into Port Moresby (Birch et al (2011) these proceedings). The model being implemented is based on contract between a Type 4 or 6 market outlet and a smallholder cooperative which allows smallholder farmers to drop in and out of production as motivation or social obligations dictate whilst still maintaining the overall contracted output. Vegetables will be brought from remote farms and villages in the area to designated pickup points where a small, all-terrain vehicle with refrigerated box will regularly collect produce. The transaction will be on the basis of weight and grading.

The produce will be pre-graded by the cooperative using a simple visual grading system, weighed and the grading checked and receipted into the freight contractor's vehicle. The produce will then be transported out to a major arterial road and loaded onto a larger refrigerated vehicle for transport to a single contracting market outlet. This specialist freight service will be efficient and maintain the cool chain and, where possible, 'front-load' trade goods for the villagers thus avoiding the need for them to frequently travel to Port Moresby. The use of a trading account will enable the trade goods to be paid for by the proceeds of vegetable sales thus avoiding the need for cash payments. In some instances, cooperatives may establish their own 'trading stores' or identify a member of their cooperative willing to start one as their own business. This approach will be particularly helpful in remote, isolated areas where travel to the capital is difficult and infrequent.

This model is dependent on all the chain participants acting in a trustworthy manner with an intent to develop long term partnerships and collaboratively innovate or 'co-innovate' to solve the chain's problems in efficiently and effectively addressing consumer and customer needs in the chain. This will require understanding the informational and skill needs of the participants and the delivery of targeted, just-in-time training. A particular focus will be the training needed to improve the productivity of women in vegetable marketing and encouraging young people to see a future in rural-based vegetable production businesses.

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Agronomic research to support the development of vegetable value chains in Papua New Guinea

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Keywords: Papua New Guinea, value chains, tropical vegetable systems

Introduction

PNG villagers are skilled gardeners and in most years families are able to grow ample food, sourcing 83% of their energy needs and 76% of their protein requirements from their gardens (Bourke and Allen, 2009). Despite this, as pointed out by Bourke and Allen (2009), roughly one sixth of the population lives in severe poverty, 94% of these in rural areas. These communities have limited opportunities to generate cash income and the resulting inability to purchase extra sources of protein combined with poor access to health and education, results in high infant mortality rates and short life spans. The antithesis of this is the large market demand for fresh fruit and vegetables of western origin, driven by the increase of middle class and expatriate segments of the population in Port Moresby and other urban centre's. This section of the population has a disposable cash income, but is unable to purchase their preferred choice of western vegetables due to production shortages. While in one sense it is preferable to encourage the utilization of the many local food plants available, the demand for western vegetables presents a significant opportunity for the rural poor to generate disposable income. Attainment of this objective requires the establishment of value chains to supply the fresh vegetables between local rural communities and high volume clients.

The production and supply of produce to customers in a market is complex, and requires the development of sophisticated value chains that are both efficient and profitable. A corner stone in the development of a vegetable value chain is the consistent production and delivery of both the volume and quality of the product required by the customer. In turn, the consistent supply of high quality produce at the contracted volume depends on the integrity of the agricultural system, from both biophysical and strategic planning perspectives. While physically sustaining the chain, consistent supply of quality produce also builds the level of trust between its participants. Earlier research has identified some core biophysical restraints to the production of western vegetables in the area surrounding Port Moresby. Of most importance are irrigation during the dry season, affordable high performance plant varieties, adequate land preparation, soil fertility and pest management (Birch et al., 2009). This paper describes our approach towards the development of low input, higher yielding sustainable production systems to support the establishment of value chains between village cooperatives and wholesale clients in the Port Moresby region.

Approach

While the area surrounding the National Capital District, in which Port Moresby is located, is referred to as the lowlands, the physical geography ranges from undulating land close to sea level to deeply dissected mountains exceeding 2000m in provinces near Port Moresby. Most western vegetables currently grown in local gardens close to sea level are those considered tolerant to heat, such as tomatoes, capsicum, watermelon and beans. In complement to this, the lapse rate of temperature associated with the slopes of the Owen Stanley Range provides an opportunity to grow cool-temperate vegetables. To support the development of the value chain, the vegetables chosen for this project were required to be desired by the market, considered acceptable to the farmers, and suited to the climate. To ensure this, we used Participatory Action Research (Bradbury and Reason, 2001) during the planning phase of the value chain to select vegetable species that met these criteria (Bonney et al.; these proceedings). The crop species chosen by this method included tomato (*Solanum lycopersicum*), capsicum (*Capsicum annuum* L.), carrot (*Daucus carota* subsp. *sativus*), cauliflower (*Brassica oleraceae* var. *botrytis*), broccoli (*Brassica oleraceae* var. *italica*), ball cabbage (*Brassica oleraceae* var. *capitata*) and French beans (*Phaseolus vulgaris*).

During the planning and consultation phase of this project, it was determined that most major limitations raised by Birch et al. (2009) could be addressed through variety and agricultural systems trials.
There is one major retail outlet through which vegetable seed is purchased in Port Moresby, and the varieties

carried by this merchant range from inexpensive open pollinated lines to expensive hybrids. For some species such as tomato, there are also local land races in circulation (pers. com. Rosa Kambuou). Varieties used in the value chain should be those most suited to the local environment and if possible inexpensive and open pollinated. Open pollinated varieties are considered superior as these allow poor farmers to grow and select their own seed, while hybrids are expensive and do not have a strong record of performance in PNG. In collaboration with local scientists and agronomists, 4-7 varieties of each species were selected for evaluation at different altitudes on the basis of availability, reputation with farmers, varietal adaptation and the relative volumes sold by the merchant (Table 1). Evaluation of the treatments will be participatory, involving both formal technical assessments by project staff and subjective assessments by farmers to assess morphological and agronomic differences, disease resistance and yield.

Table 1. Crops, varieties, trial location and altitude selected in 2011 variety trials.

Crop	Varieties	Locations
Tomato	Tropic Boy, Summer Star, Grosse Lisse, Roma, Money Maker, Tough Boy	Laloki[A] PAU[B] Sogeri[C]
Capsicum	Giant Bell, Yolo Wonder, Yellow, California Wonder, SRC-CF 6	Laloki PAU
French bean	Climbing Stringless Blue Lake, Dwarf Gourmet's Delight, Contender, Dwarf Snap bean, Stringless	Laloki PAU
Cabbage	Sweet Eureka, Racer Drumhead, Tropical Delight, Cophenhagen Market, KK Cross, KY Cross, KK Improved	Sogeri Tapini[D]
Carrot	New Kuroda, Manchester Table, Top Weight, Kuroda, Improved Kuroda, Chantenay Red Cored	Sogeri Tapini
Broccoli	Southern Comet, Green King, Summer King, Shogun, Southern Star, Green Beret, Prominence	Tapini

[A] 29m, [B]37m, [C]467m, [D]1058m

Traditional agricultural systems are typically slash and burn, with limited nutritional amendments and little or no irrigation, and these systems are currently incapable of meeting the demands of the value chains being established. In collaboration with local agronomists and research staff, systems trials have been established at Laloki, Sogeri and Tapini to compare 'Traditional Practice', with a low cost 'Improved Practice', and a 'High Input' (High Output) system based on Australian agricultural practices. Each system treatment considered the management of fallow and rotation, the management of soil fertility, irrigation, physical soil management, bedding practices and pest control (Table 2). The 'Traditional Practice' treatment was based on the common features of local systems described in the Mapping Agricultural Systems Project (MASP) (Bourke et al., 1993). As there is variation between the traditional systems used in each locality, with essentially each garden within a system being unique, this treatment incorporated the predominant practices. Loosely based on the local systems described by the MASP, the ethos of the 'Improved Practice' system was to improve yields while minimizing capital expenditure, with most gains expected to be generated through new knowledge and the improved use of existing resources. Consequently, this treatment emphasized the use of affordable micro-irrigation technology (AMIT;(Anon., 2011)), organic soil amendments, and plant based pesticides (Table 2). The 'High Input' system was primarily based on Australian agricultural practices while retaining local practices where possible. Thus, this treatment was geared towards maximum yield with a lower return per unit input, and requires a significant investment in fertiliser, irrigation, pesticides and related infrastructure.

Evaluation of the systems trials will again be undertaken from both a technical and participatory perspective. Assessments will include yield, quality and a gross margin analysis for each system. These field studies commenced in June 2011 at Laloki, Sogeri and Tapini, and have been implemented by local project staff to complement the socioeconomic and value chain research (Bonney et al, 2011, these proceedings) that guided the selection of crops, sites and topics researched. The expected outcome of this research is the incorporation of recommendations from the trial work into the value chain by its participants. While the primary focus of this information will be the grower cooperatives, this information will also be provided to other participants, such as transport operators, wholesalers and retailers, as value chains are strengthened though the exchange of peripheral information affecting the entire chain. The success of this implementation will then be reassessed through value chain analysis, and the cycle of research and review repeated until the project terminates in December 2013.

Table 2. Descriptions of the 'Traditional Practice', 'Improved Practice' and 'High Input' treatments used in the agricultural systems trials.

	Traditional Practice	**Improved Practice**	**High Input**
Fallow / rotation	Fresh ground in 1st year, followed by short grass fallow following season. Land prepared by slash and burn.	Fresh ground in 1st year, followed by short fallow of Piper (*Piper aduncum)* and a leguminous cover crop.	Grasses and other plants sprayed with glyphosate and mechanically incorporated. Crops rotated with green manure as fallow.
Maintenance of soil fertility	No amendments	Compost applied to under beds; split application of 100 kg/ ha NPK (12:12:17)	Soil testing to assess nutritional status, followed by application of NPK (12:12:17) at the recovery rate for the crop species.
Irrigation	Irrigated using watering cans when necessary, drainage used where required.	Gravity fed micro-drip irrigation system. Rainfall supplemented to 25-30 mm per week, or as needed. Dried Kunai grass used a mulch to retain moisture and cool soil.	Gravity fed micro-drip irrigation system. Rainfall supplemented to 25-30 mm per week, or as needed. Dried Kunai grass used a mulch to retain moisture and cool soil.
Physical soil management	Hand tillage	Tractor tilling on flat ground, hand preparation on steep slopes.	Tractor tilling on flat ground, hand preparation on steep slopes.
Bedding practice	Plant on ridges of long beds, 10-40 cm high.	Plant on ridges of long beds, 10-40 cm high.	Long flat topped beds created using tillage equipment.
Pest control	Manual control of insects, weeds pulled or hoed. No fungal control.	Kunai grass mulch to suppress weeds, and removed using a Dutch Hoe. Regular crop scouting for insects, with control by Neem oil (azadirachtin), *Derris* dust (rotenone), soap (1%) or chilli solutions. Fungal control with Neem oil, milk or bi-carbonate of soda.	Weed seedlings sprayed 1 day prior to emergence or transplanting. Weeds controlled using glyphosate. Mancozeb applied as a preventative fungicide and where feasible, fungal disease controlled using chlorothalonil. Insects controlled with lambda cyhalothrin, bifenthrin, *Derris dust or* omidacloprid

Conclusion

This paper has described an approach using agronomic trials to support the development of vegetable value chains in a society struggling with both cultural and economic transition. It emphasises the need to engage the entire value chain, specifically growers, and to seek improvement of the existing subsistence system through change that makes minimal transformation to existing practices while achieving a high return on low cost improvements.

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Building social resilience through understanding capacities of smallholder farming in Papua New Guinea

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Keywords: smallholder farmers, appreciative inquiry, rapid supply chain appraisal, community

Introduction

The Papua New Guinea economy is in transition to a semi-commercial/commercial farming system. However, the majority of the population of PNG practice subsistence farming (Mopafi 2004). To accommodate change, understanding the capacity of farming communities to adapt and be socially resilient is essential (Adger 2000). We are implementing a project to increase vegetable production in Central Province (CP) for Port Moresby (PoM) markets (ACIAR 2010, Birch et al 2009) in partnership with Fresh Produce Development Agency (FPDA), National Agriculture Research Institute (NARI), Pacific Adventist University (PAU), Central Province Administration (CPA) and Greenfresh (GF), of PNG. Here, we discuss strengths and weakness of smallholder farming in several locations in CP in terms of adaptation to change and social resilience.

Methods

To gauge capacity for change and social resilience, we used the Appreciative Inquiry (AI) framework (Cooperrider et al 2003) and Rapid Supply Chain Appraisal (RSCA, Collins and Dunne, 2008). These elicit current vegetable farming realities and ideas for change within communities or contexts. Use of AI engages the community, builds trust among members and encourages sharing of knowledge (Raymond 2006). The method is cyclic and has four layers - - the 4-Ds: Discovery, Dream, Design and Destiny. During initial interviews, we used the first two – Discovery and Dream – and asked participants to name the best and most problematic things about vegetable growing and to envision the future (Table 1). In a follow-up workshop with participants (often run on gendered lines), Dreams provide the entry point for exploring Design, which encourages thinking about strategies to improve vegetable growing and Destiny, which encourages them to implement actions and provide feedback to the community (Watkins and Mohr 2001). This paper reports on the Discovery and Dream components undertaken with smallholder farmers in several locations in CP, chosen because of(i) need to enhance socio-economic conditions (Birch et al, 2009) (ii) potential to improve vegetable production identified in consultation with the stakeholders and small farmers; and (iii) climatic conditions favourable to increase vegetable production for PoM. Thus, Bautama (Hiri district), Rigo–Koiari (Rigo district), (lowland areas SE of PoM) and Tapini (Goilala district, Highlands NW of PoM) were chosen. A collaborative approach to cross-cultural research is an important value underpinning AI/RSCA methodology, and . was evaluated by our PNG partners for cultural appropriateness. We then decided to use focus groups instead of individual interviews, and constructed focus group questions (Table 1) with our PNG partners facilitating development of their research skills (Reason and Bradbury 2008).

Smallholder participants (men, women and young people) were contacted by FPDA to confirm their availability. Focus groups of men and women were conducted separately at each locality, in groups of 4 to 15, allowing both men and women to present their views. Questions were asked by Australian and PNG researchers in English and a local language e.g. Tok Pisin, Motu. Responses were recorded by the interviewer in English and accuracy was confirmed. A reflection process was included to ensure arrangements for and execution of interviews remained appropriate (Reason and Bradbury 2008), and to explore reasons for any differences among data from each interviewer.

Results and Discussion

As AI focuses on community strengths (Watkins and Mohr 2001; David and Michel 2004), it provides information on building the capacity of smallholder farmers and mitigating their vulnerability during social and economic change. However, negative institutional arrangements and structural issues may emerge and have to be explored by for example RSCA. Both strengths and weaknesses will influence processes of capacity building and adaptation to change. Key words repeated around growing and marketing of vegetables (themes) were identified but not ranked at this stage. Positive themes were around food security, family labour and farming commitment, negative were clustered around inputs, transport, markets, services and socio-cultural constraints.

Strengths that favour the community capacity to adapt to change and resilience

(i) Food Security of farmers who grow food for the family and relatives, with surplus produce sold to meet family expenses e.g. school fees, and to improve diet through purchase of rice, meat, tea and sugar (also reported earlier for PNG in Mueller et al. 2001).

(ii) Family members (including children) labour contribute to farming, with women playing a vital role in selling produce in the market for cash to spend on family needs. This confirms reliance on family labour over costly hired labour. However, the disadvantage is the potential for delays in work due to absenteeism for social commitments or illness (Allen 1996).

(iii) Desire of participants including majority of youth to remain in farming – confirms that small scale farming with cash crops can be an attractive alternative to migrating to the cities, with youths wishing to expand their farms rather than migrating. However, concern that urban migration was reducing the farming workforce had been found in an earlier study (Birch et al 2009), and could be regarded as a weakness or even threat.

Weakness that constrain community capacity to adapt to change and resilience

(i) Limited availability an ,cost of inputs and knowledge gaps constraining production – in particular that most available vegetable seeds were not developed for local environments so crops did not perform well, lack of irrigation infrastructure necessitating laborious hand watering, lack of tools for soil preparation and limited knowledge of pest and disease control.

(ii) Poor access to markets, transport and support services and distance from research and extension services are major constraints that weaken linkages and limit resilience (Mopafi 2004).

(iii) Socio cultural constraints such as lack of individual land ownership, the absence of trust, inequality for women in production and marketing, intensive management of labour and the high priority of cultural obligations (Mopafi 2004) may also to constrain cropping decisions and compromise production and community unity, and thereby resilience.

(iv) Post harvest constrains include difficulties in selling small amounts of surplus produce, lack of storage facilities, difficulties with cash and lack of knowledge about post-harvest preservation and packaging.

The strengths of subsistence farming predominantly relate to on-farm activity, perhaps founded in long established socio-cultural norms, while the weaknesses relate largely to inadequacy and unreliability of off-farm services with the exception of inadequacy of knowledge of technical and marketing aspects. The last mentioned needs to be addressed through extension and education, while the off-farm weaknesses can only be addressed through major redesign of the systems involved. On-farm strengths will be enhanced by overcoming on- and off- farm weaknesses to improve the comparative economic strength of rural and urban communities.

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Table 1: Matrix of AI and RSCA

Appreciative Inquiry (AI) Process		Rapid Supply Chain Appraisal (Collins & Dunne, 2008)			
		Value creation	**Product**	**Communication**	**Chain governance**
Discovery (The best of what is...)	1. What has worked well for you in growing crops in your village? 2. What have been your successes in marketing horticultural products?	• What are you most proud of in growing crops? • What do buyers see as being different or good about your produce?	• What is it that has worked well for you in growing crops in your village? • What has worked well for you in marketing crops in your village?	• Who was responsible? (Identification of the leader) • How did you know what to produce? • How did the group make the decisions?	• What has been the greatest achievement of the cooperative since it was formed? • What made this possible? What happened to achieve success? • Why did this work so well?

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Dream **(What might be…)**	3. What dreams (ideas) do you have for the future, given your successes in horticulture?	• How might you get the best prices?	• What might your produce look like when you harvested it? • What might your produce look like when it arrived at the buyers?	• How might you find out what the buyers wanted? • How might you find out what the transporters wanted? • How might you make sure that everybody in your group knew what to do?	• How might you make sure (motivation) everyone in the family/village/cooperative did what they needed to do for everyone to be more successful?

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The Role of Soil Organic Matter in Temperate Vegetable Value Chains in Central Province, Papua New Guinea: a short review

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Keywords: compost, climate, soil type, shifting and continuous cultivation, nutrient recycling

Abstract

This paper reviews available literature on vegetable production systems in Papua New Guinea (PNG), including the role of composted organic matter in sustaining the practice of shifting cultivation. The implications for commercial temperate vegetable production in Central Province (CP), PNG, are discussed, taking into consideration the similarities and differences between CP and the traditional highland vegetable production regions.

INTRODUCTION

Agriculture in PNG has traditionally been practised on small holdings to produce staple foods such as sweet potato, taro and banana. Shifting cultivation, where land is cropped for periods of one or two years interspersed with several years of regrowth of natural vegetation, is common (Sem,1996; Sillitoe, 1998; Hartemink, 2004). However, PNG is a large and diverse country, and a range of both traditional and recently introduced production systems exist, including extended cropping over several years, perennial plantations, and even hydroponic production. With population growth over 2% per year (CIA, 2011) demand for food is increasing. Near the capital, Port Moresby (PoM), this is compounded by internal migration from rural regions to peri-urban areas and by the increasing demands of the expanding middle class and mining and gas developments for more diverse foods such as cool temperate vegetables (FPDA, 2009). To try to help meet this demand a project began in 2010 to establish viable value chains for the production of temperate vegetables in CP, near PoM (Fig. 1). Sustainable, profitable production of the required volume and quality is the foundation of such chains. However, the capacity of traditional smallholders to consistently deliver these requisites is low and, in particular, they lack the financial resources and resilience to manage risks associated with high input production systems. Thus, the management of soil fertility through organic matter is a fundamental part of viable value chains that enable greater indigenous benefit from the resources boom.

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This review briefly considers the potential role of soil organic matter in underpinning value chains by examining how soil organic matter has been managed in traditional systems and by considering the implications of translating or adapting such practices to temperate vegetable production in CP.

ORGANIC MATTER IN PNG SOILS

Organic matter (OM) is widely accepted as a vital component of a healthy soil physical, chemical and biological condition (Dick and Gregorich, 2004) and its concentration in soil is the net result of biomass production and decomposition (Greenland and Nye, 1959). Of the five major soil-forming factors (climate, parent material, time, organisms and topography; Jenny, 1941) climate is possibly the strongest determinant of soil OM concentration because of its major influence on plant production and on the activity of decomposing organisms; rainfall being positively and temperature negatively correlated with OM concentration (Spain et al., 1983). In tropical and semi-tropical environments, temperature and rainfall are generally greater than they are at higher latitudes, and evidence from Australia suggests that tropical conditions, particularly the higher temperatures, result in lower soil OM concentrations (Spain et al., 1983).

Situated between the equator and 12^{o}S, PNG lies in the tropics, but its soils somewhat confound the conventional view of tropical regions because of the country's relatively young and still active landscape, and significantly cooler climate in its highland areas (Bleeker, 1983). OM concentrations greater than 10% are common in surface soils under native vegetation, particularly in the highlands (Bleeker, 1983; Sillitoe and Shiel, 1999). Many PNG soils are much less weathered than the Oxisols (Soil Survey Staff, 2006) and Ultisols of tropical Africa and South America (Sillitoe, 1998), and retain some permanent surface charge (Bleeker and Sageman, 1990). They include Alfisols, Entisols and Inceptisols which are estimated by Bleeker (1983) to cover over 40% of PNG's land mass, and 60% by Hartemink (2004). These soils, compared to Oxisols and Ultisols, are therefore less dependent on OM as a source of CEC. Indeed, some Inceptisols developed on volcanic ash preserve OM from decomposition and show a negative relationship between OM and CEC (Bailey et al., 2008). This is thought to be due to the complexing of OM by allophane, a mineral present in volcanic ash, which reduces the specific surface area of the allophane and blocks some negative charge on the humus (Bartoli et al., 2007). PNG does have highly weathered soils, including Oxisols at Sogeri in Central Province and Ultisols in Western and West and East Sepik Provinces (Bleeker, 1983), but they are not widely represented. Reports of OM in lowland soils are few, but the higher temperature would be expected to give lower concentrations than in the highlands. This is borne out by data from Hartemink et al. (2000) from a sandy, alluvial Entisol at Lae (65 m altitude) in Morobe Province, which had only 2.4% organic carbon in the top 23 cm.

ORGANIC MATTER MANAGEMENT IN PNG CROPPING SYSTEMS

Shifting cultivation has been the system of agriculture traditionally practiced in PNG, and can include continual movement to new areas after one or two years of cultivation or a more systematic rotation between plots within a limited overall area (Bleeker, 1983; Manu and Halavatau, 1995). Fallow periods, during which the land is usually allowed to return to natural vegetation, extend from a few years to more than a decade, depending on available land. One of the main benefits of shifting cultivation in tropical environments is the recovery of soil OM and associated nutrient reserves during the fallow period, for it is by depleting this pool that nutrients are supplied for the cropping phase. For example, at Kerevat in the lowlands of East New Britain Province, (Bourke, 1980; cited by Bleeker, 1983) soil OM halved after 16 years of continuous cropping with sweet potato, taro and peanuts or cowpeas.

The fallow is generally considered to recover and recycle nutrients more than generate new stocks (Hartemink, 2004), but as increasing population pressure has led to

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shorter fallows (Szott and Palm, 1996), attempts have been made in some areas to introduce leguminous and other shrubs into this phase rather than rely on grasses such as *Imperata cylindrica* (kunai grass) which is a common invader after cropping ceases. In Morobe Province, Hartemink (2004) found that after a one year fallow, the leguminous shrub *Gliricidia sepium* held greater stocks of carbon, nitrogen, phosphorus, calcium and magnesium than either a non-leguminous shrub *Piper aduncum*, or kunai grass. Overall, *Piper* was the preferred fallow because it returned greater amounts of nutrients to the soil, rather than *Gliricidia,* which sequestered a large proportion into woody tissues. The greater return of potassium by *Piper* (200 kg/ha compared with 100 kg/ha for the other species) was of particular importance because of the high K demand of the root and tuber crops grown in the cropping phase by the local farmers.

In PNG, staple foods like sweet potato are widely grown in soil mounds or raised beds (Sillitoe, 1998; Fig. 2a), but the mounds take different forms in different districts. Some mounds are large (40-120 cm in height, 100-400 cm in diameter) and made by covering heaps of dried grass and compost with 20-30 cm of soil, while others are smaller and contain no added organic material (Waddell, 1972). Oral history credits Tuingi, an Engan man, with developing the first composted mounds for sweet potato cropping with the aim of increasing tuber yields for a 'mapu yae' feast. The practice then spread to areas outside Enga Province (Weissner and Tumu 1998). Hence, these special composted mounds became known more popularly as Engan mounds. Other food crops are often planted with sweet potato including corn, brassicas (e.g. cabbage, kale, rape, mustard), beans, peas, and highlands pitpit (*Setaria palmifolia*) as illustrated in Fig. 2b.

While shifting cultivation is widespread, some Southern Highlands farmers on volcanic ash soils (Andepts) were observed to keep gardens with large mounds containing embedded compost under cultivation for more than 10 years with only occasional, brief grass fallows (Sillitoe, 1998). Soil organic carbon was maintained above 10% throughout the cultivation period, aided presumably by complexing of soil OM with the mineral allophane (Bailey et al., 2008). In this situation, the compost, because of its concentration in the centre of the mounds, appeared to have minimal soil contact and consequent nutrient immobilisation but its nutrients are still directly accessible to crop roots. Increasing rates of compost have been shown to give a linear increase in sweet potato yields of a similar order to equivalent rates of inorganic fertiliser (Floyd et al., 1988), while Kapal et al. (2010) showed that, compared to burning or mulching, the composting of organic matter in mounds improved sweet potato yields. The reasons for the response to composting and mounding are thought to include increased soil depth and the establishment of soil physical conditions conducive to both tuber development and OM mineralisation, and less favourable for diseases including tuber rots (Sillitoe, 1998).

Evidence for yield decline under shifting cultivation in PNG is largely anecdotal (Bailey et al., 2008) and there is further anecdotal evidence (Sillitoe 1998) that yield decline is not universal. In the latter case, farmers in the Southern Highlands were able to sustain production by moving to a virtual sweet potato monoculture after an initial year or two of more diverse cropping. While soil fertility and OM declined with time, sweet potato appeared able to continue to produce with the regular addition of composted regrowth grasses (estimated at 20-40 t/ha fresh weight, equivalent to an estimated 3-6 t/ha dry matter) between successive crops. The potassium recycled in this way, and the ability of sweet potato to scavenge for soil phosphorus, were considered key attributes of the system's resilience (Sillitoe, 1998). While the nitrogen recycled at these rates of compost is modest (30-60 kg N/ha at 1% N in dry matter), Hartemink et al. (2000) found that sweet potato cv. Markham did not respond to more than 100 kg N/ha as ammonium sulphate, indicating that recycled N may be able to meet most of the crop's requirement.

TEMPERATE VEGETABLE PRODUCTION IN CENTRAL PROVINCE

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The literature reviewed thus far is weighted towards the main vegetable production regions in the PNG highlands and to sweet potato, the staple crop in those areas. Our project aims to increase temperate vegetable production for commercial markets in CP, near PoM. Here the soils are not formed on volcanic ash but consist of other Inceptisols as well as Vertisols in the coastal lowlands (<200 m), and Oxisols at Sogeri (400-600 m) and Tapini (1100m). Other than the Oxisols, these soils are not as strongly structured and are less well drained than many in the highlands, particularly the volcanic ash soils. In addition, being mostly at lower altitude, temperatures are higher in CP than in the highlands, and rainfall is less (about 1000 mm), with a more distinct dry season (Bleeker, 1983). Finally, unlike sweet potato, temperate vegetables are not efficient phosphorus scavengers and would be expected to respond strongly to inorganic P fertiliser.

Mounding is practiced in CP, particularly in those higher areas where sweet potato is a dominant or sub-dominant staple, or in those lowland areas where highlanders have settled and brought sweet potato with them (Bourke 1985). However, composting does not seem to be common, with burning the preferred way to deal with fallow regrowth. This represents a loss of carbon and nitrogen from the soil and presents our project with an opportunity to try to capture these losses for the benefit of our temperate vegetable production systems. The lower rainfall in CP means there will be relatively less vegetative regrowth during the fallow period and so less organic inputs at the time of land preparation. Combining this fact with the knowledge that temperate vegetables are relatively inefficient nutrient scavengers, especially for phosphorus, leads us to the conclusion that some NPK inorganic fertiliser will be needed if the volumes and quality of produce required by the market are to be supplied. Given that we also aim to produce our vegetables in the dry season to minimise the impact of pests and diseases, irrigation will also be needed, especially in the lowlands. This has previously been recommended for lowland onion production (Wiles 2000). Some system intensification thus appears inevitable. However, we believe only modest intensification is needed to meet market goals, and just as importantly, that modest changes are those most likely to be adopted. With this in mind, we aim to compare three production systems in our forthcoming field work: 1) a typical low-input system based on production practices described in the Mapping Agricultural Systems Project (MASP), a survey of land and agricultural systems and practices in various PNG districts (Allen et al., 2002); 2) a best practice low-input system based on MASP but modified to incorporate low-cost practices that offer a high return on investment in a system that requires minimal capital expenditure; and 3) a high-input/high-output system resembling that used by developed countries.

Up to five cultivars of a range of temperate vegetables including tomato (*Solanum lycopersicum)*, capsicum (*Capsicum annuum* var. *Annuum)*, broccoli (*Brassica oleracea var. Italica*), headed cabbage (*Brassica oleracea var.* C*apitata* L.), carrot (*Daucus carota* L.) and French bean (*Phaseolus vulgaris* L.) will be grown at low altitude (50 m, max. 32–30°C; min. 23–19°C); mid altitude (400 m, max. 30–27°C; min. 19–16°C); and high altitude (1100-1800 m, max 23-19°C, min. 12-9°C). The land systems defined by MASP relevant to the selected areas (Allen et al., 2002) can be broadly characterised by fallow and rotational practices, maintenance of soil fertility, irrigation, physical soil management and bedding practices. All rely heavily on fallow to maintain soil organic matter, and very little irrigation is undertaken. Consequently, it is our view that the low-input best-practice system used to support value chain development should focus on the incorporation of organic matter as compost and mulch (Fig. 3), the inclusion of *Piper* and leguminous species during fallow, supplementation with low rates of synthetic fertiliser, and the implementation of low-cost micro-irrigation systems.

CONCLUSION

Translating knowledge about traditional vegetable production in the PNG highlands to viable temperate vegetable production in Central Province is challenging because of significant differences in climate, soils and crop species. Nevertheless, it is very likely that

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maximising additions of organic matter to soil will be a key part of sustainable production systems that are low-cost but which offer sufficient returns to be attractive to farmers.

ACKNOWLEDGEMENT

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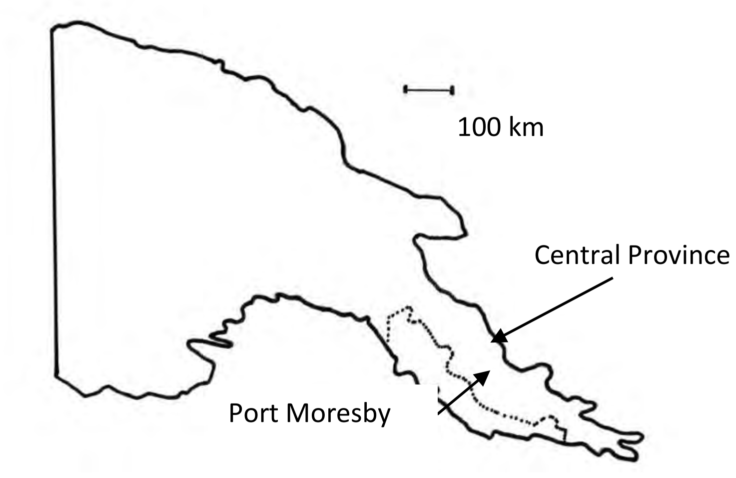

Fig 1. Map of mainland Papua New Guinea showing Central Province.

Fig. 2a. A vegetable garden near Mt Hagen on the road to Taloma (PNG Highlands) with sweet potato planted on large mounds of soil containing embedded organic matter.

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Fig. 2b. Sweet potato intercropped with vegetables on an Engan mound (photo courtesy of Issac Taraken).

Fig. 3. Mulched taro plot at Boze, Western Province (photo courtesy of James Ernest).

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Implications of soil resources for vegetable crop options and agronomic practice for sustainable production – a comparison of Eastern Highlands and Central Provinces, Papua New Guinea

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Abstract
Soil resources of the Eastern Highlands Province and Central Province of Papua New Guinea are outlined, with particular emphasis on the implications of their characteristics for agronomic practice and soil management under conditions of increasing demand for food because of population increase. Implications for crop options are also examined. Key areas of irrigation and drainage, acid soil infertility, organic matter based farming and nutrient management, with particular emphasis on nitrogen, phosphorus and potassium supply and availability in soils, are examined in a sustainability context. Cation balance, micronutrient and sulphur supply are also considered. The risk of soil degradation is examined briefly, and the need to select appropriate sites for sustainable intensive production highlighted.

Key Words
Sustainable, vegetables, soil resources, soil management

Introduction

Soil resources and climatic conditions interact strongly influence crop options and agronomic practices. This interaction is particularly important in developing countries where purchased chemical inputs are usually scarce and expensive, and often inaccessible to local producers because of cost. Value chain analysis also provides guidance to areas where production of food crops is favoured by socio-economic and marketing factors and infrastructure, subject to the availability of suitable biophysical resources, especially soils. Soils of the Eastern Highlands and Central Province of Papua New Guinea (PNG) are highly variable, as discussed in a companion paper (Doyle et al 2010) – this paper concentrates on those with the greatest agricultural potential, and examines the implications of soil characteristics and limitations for crop options and agronomic practices, within the constraints of a developing country. Climatic limitations are a relatively minor constraint in the PNG highlands, with adequate rainfall in most months, and moderate maximum and minimum temperatures throughout the year (Table 1). The main climatic constraint is likely to be excessive rainfall causing excess runoff and perched water tables. The coastal lowland areas lie in the seasonally dry tropics, and tend to have excessive rainfall from November to April and dry conditions for the balance of the year, with a tendency for improved distribution towards the east. Temperatures are high throughout the year (Table 1).

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Table 1. Mean monthly rainfall (mm) and maximum and minimum temperatures (°C) at Goroka (Eastern Highlands Province) and Port Moresby (Central Province, coastal lowlands area), Papua New Guinea.

	Jan	*Feb*	*Mar*	*Apr*	*May*	*June*	*July*	*Aug*	*Sept*	*Oct*	*Nov*	*Dec*	*Total*
(a) Goroka													
Rain	*153.4*	*214.5*	*272.2*	*175.7*	*151.9*	*43.8*	*70.4*	*49.2*	*150.1*	*132.1*	*145.4*	*163.8*	*1722.5*
Max	*26.7*	*26.5*	*26.5*	*26.9*	*26.3*	*26.1*	*25.6*	*26*	*26.2*	*27.0*	*27.0*	*27.5*	-
Min	*15.5*	*16.2*	*16.2*	*15.7*	*15.4*	*15.1*	*14.9*	*14.9*	*15.6*	*15.4*	*15.7*	*16.1*	-
(b) Port Moresby													
Rain	*192.2*	*140.6*	*189.8*	*105.2*	*56.2*	*21.6*	*13.8*	*12.0*	*14.4*	*15.2*	*40.0*	*47.8*	*848.8*
Max	*32.1*	*31.6*	*31.4*	*31.3*	*31.0*	*30.3*	*29.9*	*30.3*	*31.0*	*32.0*	*32.5*	*32.4*	-
Min	*23.7*	*23.5*	*23.4*	*23.5*	*23.5*	*23.1*	*22.4*	*22.6*	*23.2*	*23.5*	*23.6*	*23.7*	-

Source:PNG National Weather Service (2009)

Summary of Soil Resources Characteristics

The Eastern Highland Province (EHP) of PNG is characterised by areas of recent volcanic and associated geomorphic activity, giving rise steep slopes and deep incision of the landscape which often constrains access and increases the risk of land degradation. The most intensively used arable soils are the Andisols which are oxy-hydroxide rich, fine textured soils with variable drainage characteristics formed from volcanic ash. They have high levels of organic matter, but low chemical fertility and acidic soil reaction trends. The exchange complex is dominated by aluminium with low levels of all exchange cations but with potassium particularly limiting. The soil acidity and high iron oxide levels mean P fixation is an issue (Bleeker 1983, Harding and Hombunaka 1998, Radcliffe and Kanua 1998,). Other nutrient deficiencies include boron, zinc, molybdenum, copper and manganese (Radcliffe and Kanua 1998, Harding and Hombunaka 1998).

In Central Province the highly dissected Sogeri Plateau forms an elevated area inland from Port Moresby which is accessible by road. Here the dominant soils used for agriculture are well structured, deep Oxisols. However steep slopes in this deeply incised landscape mean a high soil erosion risk exists across much of the area. Hanson et al (2001) indicate high land potential in this area, despite the likelihood of acid soil infertility, strong P fixation and other nutrient deficiencies similar to those in EHP.

In the peri-urban areas near Port Moresby, National Capital District (within Central Province), landforms vary from steeply sloping hills and mountains, with shallow soils of low natural fertility derived from siliceous sedimentary rocks to alluvial valleys associated with numerous streams flowing southward from the Owen Stanley Ranges. The alluvial soils are typically deep, dark, and fine textured being derived from mixed felsic and mafic parent materials.

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Implications for Crop Options and Agronomic Practices

Crop Options

Because of limitations of availability and cost of fertilisers, crop selection must consider the adaptation of indigenous and exotic crops to soil fertility limitations. This implies, for example that crops that efficiently extract P from low availability sources in highly P fixing soils, for example sweet potatoes, peanuts and soybeans should be preferred over introduced temperate crops. The low availability of K in many highland soils constrains yield of many crops, particularly the high K requiring crops such as sweet potatoes. However, there are dietary, financial and social factors that impinge on crop selection, sweet potatoes being a staple crop of social significance to PNG peoples, while social change and dietary preference favours temperate vegetables such as Brassicas for urban markets. These latter crops require high levels of fertility, including specific requirements for boron and molybdenum, and therefore require either purchased inputs or new land in which to be grown. The latter option remains available while land supplies are non-limiting, but with increasing population placing pressure on land resources, cannot continue indefinitely. Clearly, areas of production of high nutrient demand crops will need to be carefully selected, but carry the risk of nutrient exploitation, followed by reduced productivity and lack of sustainability of production and the soil resource. Soil nutrient constraints will limit cropping options and require increasingly sophisticated rotations and increased nutrient inputs from local and imported sources. Further, soil limitations will be a major determinant of expansion of crop production to meet the needs of increasing urban populations in Port Moresby and other cities of PNG.

Drainage and Irrigation Options

In the Eastern Highlands, the topsoils are generally well structured with good drainage. However some subsoils are more limiting with occurrence of impeding clayey layers, causing permanent and seasonal gleying, perched water tables and formation of iron and manganese segregations, nodules and pans. They indicate that artificial drainage will be necessary for long term production in the lower lying and flatter parts of the high rainfall environments. In the coastal lowland areas, high ground water tables and seasonal flooding will limit crop options and season of production. On the slopes around Port Moresby, irrigation is necessary because of limited soil depth and poor water holding capacity. Currently, migrant highlanders occupy this land without security, and use reticulated (urban) water for irrigation, an unsustainable situation.

Options for Managing Acid Soil Infertility

Lack of financial capacity to import ground limestone or dolomite means approaches to soil pH adjustment used in developed countries are not viable. Amelioration of soil pH in the Andisols and Oxisols in the Highlands and Sogeri, utilising limestone in uplift areas of the Owen Stanley Ranges is possible. Local processing to suitable particle size may be viable in the longer term, however, preparation of burnt lime using crop residues as the heat source in small kilns and taking advantage of the cultural importance of fire may offer a way forward (Bailey et al 2008). Though not expected to be a widespread limitation in the alluvial areas, soil acidity is likely to constrain production on the slopes around Port Moresby, and combined with erosion risk on these soils, severely constrain their long term use. Amelioration of soil pH in these sloping areas is unlikely to be considered given the lack of security of tenure of migrant settlers.

Organic Matter Based Farming

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The moderate to high levels of organic matter measured in the topsoils of the highlands soils (Bailey et al 2008) suggests nitrogen supply from well managed minearlisation should be sufficient for most crops. However, high C:N ratios may limit N supply, particularly during periods of high crop demand. Also, and the adequacy of N supply and other nutrients partly sourced from organic matter (e.g. sulphur) may not be sustainable as rotations are intensified in response to increased food demand (Bourke 2001). The current practises of burning most crop residues reduces the plant nutrient pool, and leads to degradation of soil structure, adversely affecting crop production and land resource conservation. Further, increasing population pressure is forcing production onto poorer soils with lower organic matter levels and weaker structure, placing these at risk further degradation. These problems are already evident in some of the more intensively farmed areas e.g. Sogeri Plateau and peri urban hillsides near Port Moresby. By contrast, the river valleys of the coastal lowlands are less intensively used for vegetable production, and offer opportunities for increased and sustainable production.

Nutrient Management Options

Regardless of location in the highlands or coastal lowlands, increased production with shortened rotations will bring new nutrient management challenges and intensify existing limitations. Of the macronutrients, shortened rotations will render nitrogen constraints more widespread and severe, and place increased demands on all other nutrients through crop uptake and removal in harvested product. Consequently, purchased nitrogen, either as fertiliser or imported organic matter (mulch or compost from other cropped or non-cropped areas) or rotations including legumes will be required. Importantly, additional N entering the system is likely to further acidify already acid soils, creating demand for liming materials.

Phosphorus supply represents a major challenge, because of P fixation by several major agricultural soils, inadequate current soil supply, and high cost of P fertilisers. There are also no sources of phosphate rock for fertiliser manufacture (Fixen 2009). Importing plant material from non-crop areas and return of domestic waste, and if available, industrial by-products could assist but are unlikely to meet the needs for soil P especially on highly fixing soils. Thus, in the short term at least, production of P efficient crops e.g. peanuts and perhaps mycorrhizal crops on highly fixing sites and high P demand and P inefficient crops e.g. tomatoes, brassicas on comparatively P fertile sites in lowland alluvial areas emerge as the preferred strategies, provided market conditions allow. In the longer term, though, there appears no alternative to purchased P fertiliser.

K supply in many Highland soils is inherently low (Bleeker 1983), and long term production of high K demand crops such as sweet potatoes has exacerbated the situation. Importing organic matter and burning it to release K or using it as mulch (Bailey et al 2008) can provide some K, but simply transfers K from one location to another. Return of domestic and other waste may also provide some K. However, the amounts returned are likely to be small compared to total need and with limited reserves of slowly available K in soils of the

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highlands, the importation of K fertiliser seems inevitable. Alluvial soils are better supplied, so K application may not be needed for some time.

Calcium and magnesium supplies are low in acidic volcanic soils with low CEC in the Highlands, but be less limiting in alluvial coastal soils. Though not currently recognised as a significant production limitation, intensification and intensification of rotation cycles is likely to result in deficiencies, expressed, for instance as blossom end rot in tomatoes (Ca deficiency). Raising soil pH as outlined earlier would also reduce the risk of metal, especially aluminium, toxicities, while enhancing solubility of micronutrients such as molybdenum. The challenge, in the PNG context, is to provide liming materials at an affordable price.

Inherent sulphur supply in tropical soils depends on the ability of the profile to retain sulphur through adsorption. This in turn depends on parent material. Soils developed on basic parent material will have a greater sulphate adsorption capacity, particularly at depth, than soils developed on acid igneous rocks or sediments (Barrow 1978). This sulphur is much less strongly adsorbed than phosphorus or molybdenum (Barrow 1978), and is therefore relatively available to plants. The capacity of soils to sorb sulphur also increases with annual rainfall because higher rainfall increases weathering and makes soils more acid. As cropping intensifies, depletion of inherent sulphur will occur, and continued supply in the topsoil will depend on inputs of either organic matter or S-containing fertilisers.

Of the micronutrients, boron and molybdenum are most widely recognised as deficient in the highlands of PNG (Bleeker 1983, Bailey et al 2008), but little if any information is available for the coastal lowlands. Raising soil pH can improve molybdenum solubility, otherwise supply of molybdenum as a seed dressing or fertiliser will be required. There is little option but to supply boron as fertiliser to crops that are susceptible to boron deficiency e.g. brassicas, for production to continue in current locations. Alternatively, their production could be increased in more favourable sites in the Highlands or Lowlands, provided market and infrastructure conditions allowed.

Soil Degradation and its Control.

Soil erosion in the regions studied is limited by the small patchwork nature of the production gardens. Even on steep slopes; the cover upslope, well maintained field drains, good soil structure and short slope lengths all combine to limit erosion risk. However the increasing pressure to expand the areas of production, and in particular the drive to grow on poorer more weakly structured soils, notably in the peri urban setting, represents a major soil erosion risk. There is a need to better select intensive production regions to protect the peri urban environment, harness the better regional resources (soil, water, people) and ensure a sustainable and consistent food supply chain.

Conclusion

Suitable soil resources for sustainable vegetable production are available in EHP and CP of PNG. However, limitations of chemical fertility, topographic position and in some locations soil depth will limit crop options and long term sustainability of production. Key areas of

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irrigation and drainage, acid soil infertility, organic matter based farming and nutrient management, with particular emphasis on nitrogen, phosphorus and potassium supply and availability in soils will require solutions that are affordable for local producers and sustainable. In the longer term, cation balance, micronutrient and sulphur supply are expected to become increasingly limiting and require similar solutions. The risk of soil degradation is a significant production limitation in elevated areas, emphasising the need to select appropriate sites for sustainable intensive production.

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Increasing food security for Port Moresby, PNG – issues of land suitability, technology, tenure, and tribalism

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Abstract

We visited the Central Province of PNG and examined and reviewed the soil, land and water resources within one day by road of Port of Moresby (PoM). We reviewed infrastructure development projects for roads, mineral and gas developments and telecommunications networks. We examined the climatic conditions for vegetable production and we undertook “rapid value chain analysis” of the vegetable industry at regional and national level.

The work was undertaken to guide where agricultural development ought to be directed to feed the expanding population in PoM and associated mining developments. The poor transport networks between the highlands regions and Port Moresby vegetable production needs to become more localised to satisfy growing demand.

We discovered highly suitable soils in alluvial valleys with decreasing irrigation demand moving east from PoM. We discovered arable red soils in the Sogeri highlands but erosion and fertility are issues that limit increased use. We found the soils in the PoM peri-urban area are steep, shallow and of low fertility and thus need high irrigation and nutrient inputs and are prone to erosion.

Arable soils with irrigation water exist in the Province but this is not the only limitation to increasing vegetable production. Tribal, gender, market, technological and infrastructural issues need to be solved in unison with the low/traditional input natural resource management solutions. The best option for agricultural development appears to be in the eastern river valleys of the province for which improved road, telecommunication and power infrastructure is being put in place or is planned.
Key Words
PNG, population, sustainable, alluvial soils, soil drainage, markets

Introduction

In developing countries with low agrochemical inputs soil type and topography together with climatic conditions strongly influence crop options and agronomic practices. In PNG the lack of a national road system prevents the timely transport of vegetables produced in the fertile high rainfall Andisols of the highlands to the largest market, Port of Moresby (PoM). Instead, the route to the PoM market is by either sea, which is slow, or air, which is expensive even for high value, low volume products. This encourages the migration of provincial people to the urban fringes of the major centres to produce food on the slopes around PoM for this expanding market. This in turn contributes to both social problems and the over-exploitation of peri-urban soils, water and land for vegetable production. Poor land management of the commonly steep slopes and sensitive soils result in land degradation, erosion and stream

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siltation (Figure 1b). Further, vegetable production in such areas frequently relies on already stretched urban water resources.

Finally, the inability of many smallholders to obtain finance using customary land as collateral also restricts the development of sustainable primary production (The Land Summit Coordinating Committee 2005). Matching tenure to land suitability in combination with appropriate technology is critical to the future of PoM's vegetable supply security.

Soil and land resources of Central Province

Three key systems were examined; 1) Ferrosols of the dissected Sogeri plateau north of PoM, 2) Rudosls and Tenosols of the peri urban slopes of PoM and 3) Dermosols and Vertosols of the alluvial valleys east of PoM.

Soil of the dissected Sogeri plateau

The land potential on the dissected Sogeri Plateau is listed as very high by Hanson *et al*. (2001). The region is linked to PoM by a good road which runs to the start of the Kokoda Track. Some improved land management practices from the highlands of PNG such as small terraces for gardens have been adopted at Sogeri. The soils are well structured deep Ferrosols, the limitationss of variable and steep slope angle with the potential for soil erosion being very high in many places. These soils are likely to be very highly P fixing and acidic which will require both nutrient and erosion management for increased production (Figure 1a).

Soils of the peri urban slopes

One of the key issues in the immediate vicinity of the city is the intensive production on the moderate to steep slopes with associated issues of soil erosion and drought (Figure 1b). There is thus a significant potential for soil nutrient decline in the shallow soils developed from siliceous sedimentary rocks.

Figure 1 (a) Gardens on steep and moderate slopes on the dissected Sogeri plateau. The soils are deep, well-structured Ferrosols but the erosion risks without well designed soil conservation measures are significant. Soil acidity and associated Al and Mn toxicity and P

fixation are also issues. (b) Peri-urban production on shallow rocky soils on sedimentary rocks. These soils are nutrient deficient, erosion prone and require hand irrigation often from urban water supplies.

Alluvial soils

To the south-east of PoM, field inspections revealed areas of soils with desirable physical characteristics (well drained) on stream levees, but areas of impeded drainage and perched water tables further from streams (back plains). The former offer potential for wet season production, while the latter would require improved drainage for wet season production and irrigation for dry season production.

Larger river valleys northeast and east of PoM were field checked including the Laloki River floodplain and first river terrace, the Kemp Welsh Valley and the flood plains of rivers entering Cloudy Bay (Figure 2a and b). Soil auger borings and stream sections indicated the presence of many pockets of deep alluvial soils of medium to fine texture derived from mixed alluvium. The parent materials being basic volcanic materials and various sedimentary rocks. These materials are likely to have a high natural fertility though soil fertility loss and structure decline appear to be increasing where rotations have been long and intensive (Pacific Adventist University, pers comm. See Figure 2).

Figure 2 (a) Deep, moderately structured, medium textured alluvial soils under very intensive use at Pacific Adventist University, adjacent to the Lakoki River. These soils are becoming structurally degraded and nutrient levels are very low and require amendments. (b) Deep, well structured, fine textured alluvial soils with high native fertility at Cloudy Bay Central Province.

The Kemp Welsh Valley and flood plains of rivers entering Cloudy Bay have many discontinuous areas of deep medium to fine textured alluvial soils. The better drained soils are on stream levees, with impeded drainage and perched water tables some distance from streams. Rainfall increases eastwards and thus these valleys will have a lower irrigation demand. This is supported by higher land use potential indicated in the map produced by Bleeker (1975, see Figure 3).

Nevertheless, where mechanised agriculture has made intensive use of alluvial soils e.g. at Pacific Adventist University on the Laloki River, structural degradation and declines in soil nutrient concentrations have occurred. There is no doubt that similar trends will emerge in other alluvial areas, even without burning of crop residue, once crop production and intensive land use are introduced or expanded. It will be essential to design and implement systems that are conservative of organic matter in the lowlands; therefore indigenous, improved or alternative soil management systems need to be tested in partnership with farmers and NGOs to ensure adoption of more sustainable systems (Hanson et al., 2001).

Climatic conditions of Central Province

PoM lies in the rain shadow of the Owen Stanley Ranges, and therefore receives less rain (899 mm) than the nearby highlands, for example Goroka (1722 mm). PoM rainfall is highly seasonal, being concentrated in December to April. However rainfall increases in the eastern parts of the Central Province and this increase improves the mapped land use suitability significantly, especially in alluvial valleys (Bleeker, 1975 and 1983, see Figure 3). Temperatures are high at PoM, with monthly mean maxima of 31.4 to 32.5 degrees Centigrade and mean monthly minima of 22.4 to 23.7 degrees Centigrade.

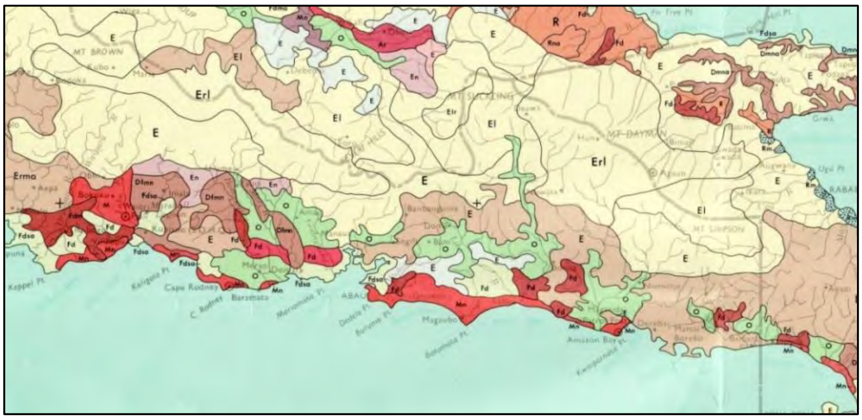

Figure 3 Land use limitations map of the eastern part of the Central Province indicating areas of land with "O – No Land Use Limitations" (Bleeker 1973).

Both water supply and high temperature stress can be expected to limit plant growth during the 'dry' season, sharing characteristics with coastal and sub-coastal areas of north-western Australia (Bureau of Meteorology 2009), particularly as evaporation exceeds rainfall by a factor of 1.5 to 2.2 (Hall 1984). Soil water is limiting in all months except January to April, and is severely limiting from June to November (Soil Water Index <0.2 on a 0 to 1.0 scale). These values may not be directly applicable to vegetable crops for specific edaphic reasons, but give a clear indication of both temperature and water limitations. Irrigation from either underground water or purpose built dams will need to be considered for dry season production, as will careful selection of plants to minimise the impact of temperature stress. However this irrigation demand will greatly decrease in the eastern parts on the province as is indicated by the increase in land use potential.

Excess water is likely to limit production during the wet season (December to April), necessitating enhanced drainage in low lying areas. However, on stream levees, internal drainage is unlikely to limit production during the wet season, while away from stream levees, enhanced surface and internal drainage will be required. Even then wet season production is unlikely to be possible except for areas bordering the levees because of the likelihood of regular inundation, while dry season production would require irrigation.

Conclusions

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The lack of capacity to develop greater sustainably supply chains in PNG due to a combination of poor transport and telecommunications infrastructure and the land tenure systems mean development of more localised suitable production areas is required. We have identified the alluvial valleys in the eastern most parts of the Central Province as having the greatest potential for increase production. This is because they provide the best combination of soil, water, climate and infrastructure. The recent development of cooperative and government grants at the local level represent a real chance of successful agricultural development.

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Evaluation of capsicum varieties in low & mid altitude areas in Central Province, Papua New Guinea

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Abstract
A preliminary investigation was carried out to assess the productivity of several varieties of capsicum in different agro-ecological zones of Central Province. Field experiments were conducted from June to November 2011 to determine high yielding varieties in low and mid altitude areas of Central Province. In the low dry land conditions six varieties of sweet pepper (capsicum) were evaluated at Laloki (altitude 30 masl; 9° 22.37′ S and 147° 15.18′ E; temperature- max 32–30 °C and min 23–19 °C.) and in the mid altitude area of Sogeri (altitude 650 masl, Temperature - max 30–27 °C and min 19–16 °C), where only four varieties of capsicum was evaluated as compared to six varieties evaluated in Laloki. Initial findings suggest that SRC-CF 5, SRC CF 6 and Giant Bell appeared to be most promising in terms of their yield and productivity in the low altitude area. Giant Bell variety also proved promising with a significant difference in yield among the other three varieties tested in the mid altitude conditions of Central Province. However these varieties need to be evaluated further at additional locations under varying management practices to develop recommendations on varietal choice and appropriate cropping practices.

Key Words: Varieties, capsicum, growth, yield and quality, pest and disease infestation

Introduction

Sweet pepper or Capsicum (Capsicum annum var. Frutescens) are eaten raw in salads, but more commonly cooked, fired or processed together with other foods. They are consumed in such quantity per serving that they constitute a real table vegetable contributing to the nutritional value of the meal. Sweet pepper is a warm and dry season crop. It germinates well at a temperature of 20oC -30oC and grows well around 25o. FAO statistics estimate world production of capsicum peppers in 2001 at 21.3 million t from a harvested area of 1.6 million ha (average yield 13.4 t/ha); China is the largest producer with 10 million t, followed by Mexico (1.9 million t) and Turkey (1.5 million t). India is probably erroneously represented with only 50,000 t. Production in tropical Africa is estimated at 1 million t, with Nigeria (715,000 t from 90,000 ha) and Ghana (270,000 t from 75,000 ha) as the largest producers.

However, capsicum is a newly introduced vegetable crop in Papua New Guinea (PNG) and it is currently grown on a very small scale in the country for home consumption and the local markets. With the rapid population growth, estimated at 2.1% pa (CIA 2009), increasing migration from rural to peri-urban areas and the expansion of the gas and mining industry is increasing the demand for higher value food products in PNG. This is particularly so in large and expanding urban areas such as Port Moresby. Population changes are also causing changes in food preferences including greater emphasis on temperate vegetables. Thus there is a need to provide a range of high quality temperate vegetables to the market and also diversify the source of vegetables for continuity of supply hence, capsicum or sweet pepper is one of those identified vegetable crops. Now that there are a number of new varieties

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(cultivars) available to producers, information on fruit yield and quality as well as resistance or tolerance levels to pests and diseases is particularly desirable for the local industry within Central Province to improve production to supply the Port Moresby Markets.

Hence, this preliminary variety evaluation trial was conducted in two different agroecological zones of Central Province at Laloki (altitude 30 masl; 9° 22.37′ S and 147° 15.18′ E; temperature- max 32–30 °C and min 23–19 °C.) and in the mid altitude area of Sogeri (altitude 650 masl, Temperature - max 30–27 °C and min 19–16 °C), sought to look at yield and fruit quality as well as resistance or tolerance levels to pests and diseases on four established capsicum lines from commercial seed company while the other three cultivars were open pollinated lines from AVRDC, World Vegetable Centre. In addition to this, determine which variety did well in low and mid altitude conditions of the Central Province for growers to grow and provide the Port Moresby vegetable markets.

Materials and methods

Site of Study

The trials were conducted at the National Agricultural Research Institute, Southern Regional Centre Laloki (altitude 30 masl; 9° 22.37′ S and 147° 15.18′ E; temperature- max 32–30 °C and min 23–19 °C.) in hot dry lowlands conditions and nearby cooler highlands condition in the mid altitude area of Sogeri National High School (altitude 650 masl, Temperature – max 30–27 °C and min 19–16 °C). Six varieties of capsicum were evaluated at Laloki while four varieties were evaluated at Sogeri (Table 1). All capsicum varieties were purchased from Brian Bell & Co. Ltd (Port Moresby) except for three varieties (SRC-CF 4, SRC-CF 5 and SRC-CF 6; open pollinated) which were brought in from AVRDC World Vegetable Centre,Taiwan.

Crop management

Normal nursery and crop husbandry practices were applied in the nursery before transplanting into the field. Seedbed preparation was done by a tractor before transplanting took place. The beds were ploughed, then harrowed and finally rotor-tilled a few days before planting. Surface micro drip irrigation was applied on a daily basis until last harvest. Weeds were mostly controlled by hand weeding. Recommended cultural and plant protection measures were applied to raise the crops.

Parameters of data collection and statistical analysis

Experimental treatments were laid out in a Randomized Complete Block Design with 3 replications in both sites. Sweet pepper seedlings for Laloki site were transplanted on the 29th September 2011 at 0.4m x 0.60m spacing in 2.4m row lengths hence each plot accommodating 3 rows and 6 plants/ row. All 6 varieties were planted in a total area of 13.8m x 8.2m. Sweet pepper seedlings for Sogeri site were transplanted on 25th October 2011. Same plant spacing was applied; however total area planted for four entries was 6.8m x 9.8m.

Seedlings were placed 8-10cm deep into a flat seedbed.

Data was collected on yield and yield attributes. Further, a scale of 1-5 was used to score pests and disease infestation on the crop (1= no infestation; 5= 100% infestation). Sweet pepper varieties were harvested four times from November 25th, December 02nd, 09th and

16th2011 at Laloki while varieties for Sogeri site was harvested 5 times from December 14th, 21st 2011 and 28th, January 4th and 11th 2012. The significance difference among the varietal plots was determined at 5% Least Significance Difference (LSD) and ANOVA by using Statistix Version 8.

Results and Discussion

All varieties had similar growth and development stages and reached flowering, fruit set and picking stages almost at the same durations (Table 2) irrespective of altitudes. Variety California Wonder was severely affected by pests and diseases in both sites while other varieties experienced little or moderate infestation (Table 3). All varieties were infested by common sweet pepper pests (army worm, leaf minor, fruit fly) and diseases (bacterial wilt and black leaf moulds). Fruit size for most of the lines evaluated was predominantly large and medium. Variety SRC-CF 4 was the only smallest fruit in size (Table 4). Fruit shape varied from oblate (SRC-CF 4) to conical (SRC-CF 5) while the rest of the varieties were bell shaped. Colours also ranged from green/red (SRC-CF 4, 5 and Giant Bell), California Wonder and Yollo were green while Yolo Wonder was green/yellow with the only yellow colour variety being SRC-CF 6 (Table 4). Varieties SRC-CF 5 (8641 kg/ha) and Giant Bell (8021 kg/ha) out yielded all other varieties at Laloki and California Wonder (4936 kg/ha) produced lowest yield at this site (Table 5) while other varieties were intermediate in their yields. This is clearly influenced by the number of flowers per cluster with the number of fruits set and their prolific fresh weights (Table 5). Though other varieties (SRC-CF 6, Yolo Wonder, California Wonder and Yollo) showed a high number of flowers per cluster (Table 5), most flowers were aborted due to high temperature during the dry season period (November to December, 2011). This result is in confirmation with Marcellis (2004) findings where he states that heating for short periods showed that flowers/fruits were the most susceptible to abortion.

At mid-altitude (Sogeri) however, varieties Giant Bell, Yolo Wonder and Yollo were almost similar in yields producing 6416 – 6790 kg/ha fresh fruits, whereas California Wonder yielded the lowest (541 kg/ha). The variations in fruit yield might be due to the influence of the growing temperature, associated traits like number of flowers per cluster of a plant. Peet et al. (2002) confirmed this by saying the reduction of fruit set under moderately elevator temperature stress was mostly due to a reduction in pollen release and viability in plants. Furthermore, Wien (1989)confirms this result in his findings indicating that the inhibitory effect of high temperature should be considered during the flowering period. Pepper, like some other fruit vegetables, shows a cyclic growth pattern where periods of high fruit set and slow fruit growth alternate with periods of low fruit set and rapid fruit growth (Kato and Tanaka, 1971; Marcelis, 1992).

Pests and diseases are a major part of biological factors that causes yield loss in capsicum. Variety California Wonder yielded the lowest in both sites because results clearly indicated that this variety was mostly affected by pests and disease (Table 3). Sorensen (2005) reported that over 40 pest species of insect and mites including aphides, whiteflies, fruit borers, cutworms, plant bug, mites and other minor pests are common pests that cause direct damage to fruits, leaves and flowers of capsicum.

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Comparing overall yield performance of all varieties at two locations, it is very interesting to see almost comparable or higher yield levels of open pollinated (OP) varieties SRC CF 4, 5, and 6 to those of hybrid varieties that are being imported and sold in Papua New Guinea (Table 5). It may be mentioned that varieties SRC CF 4, 5, and 6 were obtained from AVRDC; their seeds multiplied at Laloki and are being tested in the trial. OP plants are varieties that are capable of producing seeds that will produce seedlings just like the parent plant while hybrid seeds are created by plant breeders by cross breeding two compatible types of plants (Lee, 2010) whereas these varieties evaluated were said to be high yielding.

Conclusion

This preliminary study revealed that varieties SRC-CF 5 (open pollinated) and Giant Bell were the highest yielding varieties with less pests and disease infestation and high quality fruits in both the low and mid altitude areas of Central Province, Papua New Guinea. Thus, these varieties are promising for capsicum growers in Central Province to supply the Port Moresby markets. However, further evaluation of these open pollinated varieties and established lines are needed to arrive at conclusive recommendations.

Acknowledgement

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List of tables

Table 1: Varieties of capsicum crop for variety evaluation at different sites.

No. of varieties	Varieties	Location
6	(1) Giant Bell (2) Yolo Wonder (3) California Wonder (4) SRC-CF 4 (5) SRC-CF5 (6) SRC-CF 6	Laloki
4	(1) Giant Bell (2) Yolo Wonder (3) California Wonder (4) Yollo	Sogeri

Table 2: Crop phenology and growth parameters of capsicum varieties

Varieties	[1]Average of three replications		
	Days to emergence	*Days to flowering	Days to fruit set
SRC-CF 4	15	59	66
SRC-CF 5	15	56	63
SRC-CF 6	15	54	61
Giant Bell	15	58	65
Yolo Wonder	17	59	65
California Wonder	15	59	65
Yollo	15	59	65

[1]Average of three replications and five plants randomly sampled per variety per replication from both sites (Laloki and Sogeri)

*Days to flowering after transplanting

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Table 3: Pests and disease infestation of capsicum varieties in two sites

Varieties	†Pests infestation		†Disease infestation	
	[1]Laloki	[2]Sogeri	[1]Laloki	[2]Sogeri
SRC-CF 4	3.00[a]	*NG	4.00[a]	*NG
SRC-CF 5	2.00[a]	*NG	2.00[b]	*NG
SRC-CF 6	3.00[a]	*NG	2.00[b]	*NG
Giant Bell	3.00[a]	3.33[a]	2.00[b]	2.0[a]
Yolo Wonder	3.00[a]	3.33[a]	2.00[b]	2.0[a]
California Wonder	3.00[a]	4.00[a]	2.00[b]	4.0[a]
Yollo	*NG	3.00[a]	*NG	2.0[a]
Grand mean	**2.833**	**3.41**	**2.33**	**2.5**
CV	**41.26**	**25.81**	**44.95**	**41.63**

[1]Laloki - There are 2 groups (A and B) in which the means are not significantly different from one another.

[2] Sogeri - There are no significant pairwise difference among the means.

† Pests and diseases rated on a scale of 1-5 (0-no infestation, 5-maximum infestation)

*NG = Not grown in that site

Table 4: Fruit size, fruit shape and colour of capsicum varieties

Varieties	**Fruit shape**[1]	**Fruit colour**[1]	**Fruit size**[1 & 2]
SRC-CF 4	Oblate	Green/red	Small
SRC-CF 5	Conical	Green/red	Large
SRC-CF 6	Bell	Yellow	Medium
Giant Bell	Bell	Green/red	Large
Yolo Wonder	Bell	Green/yellow	Medium
California Wonder	Bell	Green	Medium
Yollo	Bell	Green	Medium

[1]Average of three replications and five fruits randomly sampled per variety per replication from both sites (Laloki and Sogeri).

[2]Fruit sizing data: Large >60g; Medium 55-60g; Small <50g

Table 5: Yield and yield attributes of sweet pepper varieties

Varieties	No. of cluster/plant		No. of flowers/ cluster		No. of fruits/ cluster		Fresh wt./fruit (g)		Fresh fruit yield (kg/ha)	
	[1]Laloki	[2]Sogeri	[1]Laloki	[2]Sogeri	[1]Laloki	[2]Sogeri	[1]Laloki	[2]Sogeri	[1]Laloki	[2]Sogeri
SRC-CF 4	7.23^{c}	*NG	5.00^{cd}	*NG	5.17^{a}	*NG	49.33^{c}	*NG	6170.3^{d}	*NG
SRC-CF 5	12.46^{a}	*NG	5.76^{b}	*NG	4.64^{b}	*NG	65.00^{a}	*NG	8641.0^{a}	*NG
SRC-CF 6	9.16^{b}	*NG	7.73^{a}	*NG	3.52^{c}	*NG	60.00^{b}	*NG	7527.3^{c}	*NG
Giant Bell	8.36^{bc}	8.23^{b}	4.96^{d}	4.93^{a}	4.02^{b}	3.40^{c}	64.00^{a}	60.33^{a}	8021.3^{b}	6790.3^{a}
Yolo Wonder	7.80^{c}	7.63^{c}	5.66^{bc}	5.26^{a}	3.21^{bc}	4.63^{a}	60.33^{b}	58.00^{ab}	7218.0^{c}	6416.0^{b}
California Wonder	9.30^{b}	9.33^{a}	5.30^{bcd}	5.30^{a}	3.93^{c}	3.16^{c}	60.00^{b}	55.33^{b}	4936.3^{e}	5491.3^{c}
Yollo	*NG	6.40^{d}	*NG	5.20^{a}	*NG	4.30^{b}	*NG	60.00^{a}	*NG	6663.3^{a}
Grand mean	**9.05**	**7.90**	**5.73**	**5.17**	**4.07**	**3.87**	**59.77**	**58.41**	**7085.7**	**6340.3**
CV	**7.36**	**2.31**	**6.47**	**3.85**	**9.40**	**3.55**	**1.69**	**2.63**	**2.56**	**1.88**

[1]Laloki Means within the column followed by different letters are significantly different at $P<0.05$ LSD

[2]Sogeri Means within the column followed by different letters are significantly different at $P<0.05$ LSD

*NG = Not grown in that site

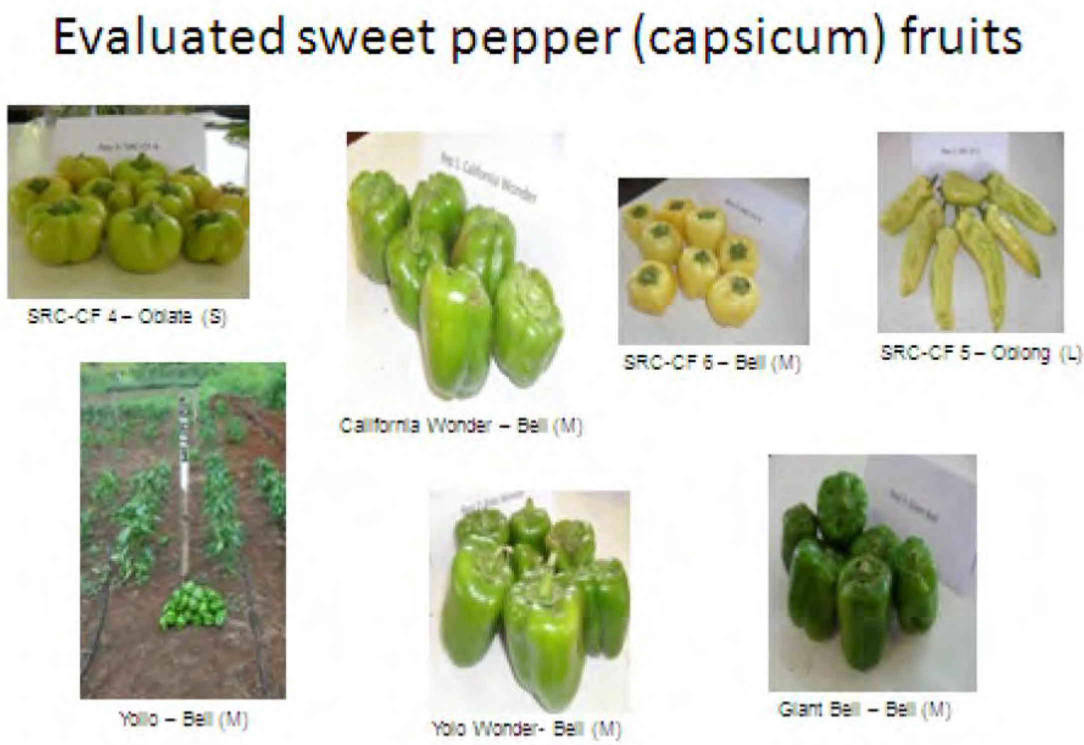

Figure 1: Seven Capsicum Varieties Evaluated at Laloki and Sogeri

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Initial Field Evaluation of Six Exotic Tomato, *(L. esculentum)*, cultivars in Pacific Adventist University: An approach to towards improving vegetable production in Central Province to supply Port Moresby markets

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Abstract

Tomato (*Lycopersicum. esculentum*) is an important vegetable crop grown worldwide and there is an urgent need to improve its production to meet the increasing demand of people in Port Moresby (PoM) market, Papua New Guinea (PNG). In this study the ability of growth and yield of six different varieties of tomato were investigated at Pacific Adventist University Farm, Central Province of Papua New Guinea during June-September 2011. A total of six different tomato cultivars were evaluated for growth and yield performances. The statistical analysis of the results showed a significant effect ($p<0.05$, LSD) on the yield, growth and cutworms damage on the six cultivars. The Money maker, Summer star, KY Grace and Gross Leese cultivars produced a significant effect ($p<0.05$, LSD) on crop growth and yield than other cultivars. Blossom end rot and tomato fruit worm infestations adversely affected yield particularly in Roma and Beef Steak cultivars during the fruit maturation phase. Evidences of yield loss due to these biological factors have provided added challenges in addressing the urgent need for suitable tomato cultivars in Central Province to supply PoM markets. Furthermore, we are still conducting more research on evaluation of vegetable varieties and identifying the insect-pest-disease infestation this year, 2012 at PAU and National Agriculture Research Institute (NARI).

Key words: tomato cultivars, BER, Fruit worms, abiotic and biotic factors

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Introduction

Failure to crop adaptation of exotic vegetable species due to adverse climate change and increase pressure of pest and disease is a major food crop production issue in Papua New Guinea (PNG) and worldwide. The ability of investigating the potential genetic cultivars that are tolerant to both biotic and abiotic factors is at crucial state to alleviate and improve food crop production. Tomato, *L. esculentum* (Miller), is an important vegetable crop that is grown in temperate and tropical regions of world. It is one of the important highly value adding vegetable crop which has a high significant nutritional values to improve food security in developing countries. It has potential minerals and vitamins for human nutrition and to help them to generate income and creates employment in rural and urban areas in the world (Villarreal, 1980). Most of the tomato varieties recently been introduced are not evaluated in the local conditions before farmers use them. The cultivars available germplasms offshore need more emphasis for field evaluation before they are displayed on the seed dealers' shelfs. . Increasing the knowledge of field evaluation of exotic tomato cultivars may be good guides to select potential varieties for farmers to improve and increase their production.

The advance in production and technology of tomato seeds and plants, have produced many new early maturing germplasms are made available by the commercial seed catalog offshore. These has improved the quality of propagation materials and increased the yield performances of the individual cultivars. In PNG, cultivar evaluations to increase crop yield and improve economic potential for local farmers deserve research attention. The different varieties of tomato in local conditions of PNG need to be more thoroughly investigated under commercial production regime. In PoM, there is an agent need to improve tomato production particularly in the Central Province (CP) to supply PoM markets. However, production of tomato to supply PoM markets is constraints by many factors and the locality and variety selection are some of the major factors. Central Province is the best locality because the quality and quantity of the products that reach the customers or markets are highly valued and accepted by the buyers.

Tomato has a potential to positively contribute towards alleviating of poverty and improvement of food security by improving its yield and quality in PNG. However, to improve tomato production, there have to be thorough evaluations conducted on the importation of different cultivars made available from germplasms offshore. Therefore, this investigation was carried out on six selected tomato cultivars to (1) evaluate the development and yield performances and (2) determine the cultivar resistant on potential insect pests in Central Province of PNG.

Materials and Methods

The study was carried out in Pacific Adventist University farm (S09º24.309' E147º16.343) in hot dry lowland conditions of Central Province, PNG. The research funds were procured by the Australian Centre for International Agriculture Research (ACIAR) in partnership with the Tasmania Institute of Agricultural (TIA) on the vegetable value chain in PNG. This experiment was conducted in early July and the observations and data were collected in August – September, 2011. There were six different cultivars (Money Maker, Beef Steak, Summer Star, Gross Reese, Roma and

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KY Grace) evaluated in the field conditions. The experiment was designed in randomized complete block (RCB). Each plot size was 2.5 m x 3 m or 7.5 m^2 replicated three times with a total of fifteen plants subjected plot. The transplanting to the field was conducted when the seedlings had 5 true leaves after 54 days in the screen house. The planting density was 60 cm within plants and 75 cm between rows in the field plots.

Plot management were considered from the date of sowing in the field. An estimate of 120 kg/ha of NPK was used in the field as a side dressing during the transplanting operation and 95 kg/ha for UREA, half of it during the transplanting and half of it was applied 15 DAP. The irrigation practices were considered when the plants were planted in the field condition for facilitation of plants establishment up to the time of full plant establishments, until floral stage where when the plants were in watered with cans. The plants were irrigated twice per day (6 am and 5 pm); however, variations of irrigation were due to rainfall and other abiotic factors. Hand weeding was done as per the emergence of the weeds. Plant protection was part of the field evaluations where cultural and chemical control measures were considered at when infestation was beyond threshold level.

The growth parameters such as plant height, fruit numbers, and canopy width of the crops were determined during the study. The parameters were measured by elastic taper measures. The yield parameters were measured after 120 DAP. Statistical analysis by using Statistix 8.0 and the degree of significant differences among treatment means were tested using the LSD test at 5% probability level (Steel and Torrie, 1980; SAS Institute 1992).

Results and Discussion

The growth and yield evaluations of the different cultivars of tomatoes are presented in Tab. 1. Statistical analysis indicated that were significant differences ($P<0.05$, LSD) among the growth parameters of selected tomato varieties. Money maker and KY grace growth developments were faster ($P=0.1172$, $CV=13.97$, $DF=2, 5$) whereas Roma cultivars variety. Furthermore, the primary branches showed non-significance differences ($P>0.05$). The secondary developments showed that , KY Grace, Roma and Money maker produced more significant secondary branches ($P=0.0465$, $CV=20.37$, $DF=2, 5$) whereas the Summer Star cultivar produces < secondary branches. Comparison on the means of tertiary branch numbers showed that there was significant difference ($P=0.0196$, $CV=18.12$, $DF=2, 5$) among the different varieties. The assessments on the canopy width showed significant differences ($P=0.227$, $CV=16.53$, $DF=2, 5$) among the different varieties. Money maker variety produced wider canopy compared to the other cultivars. Roma and Beef steak produced lower canopy width. The increase in the tertiary branches results in wider canopy sizes. The statistical comparison on fruit length and diameter of six different tomato cultivars showed significant differences ($P<0.05$, LSD) among the cultivars (Fig. 1).The fruit length analysis detected that all means were comparable among the varieties. Money maker and Summer star produced significant ($P<0.0912$, $F=2.62$, $CV=25.30$, $DF=2, 5$) fruit length compared to other cultivars. Other the other hand, width of the fruits sizes showed that Money maker, Summer star and Beef steak provided significant (P=0.0496, F=3.34, CV=18.12, DF=2, 5) fruit diameters compared to other cultivars.

The total means of the fruit numbers produced differences (P<0.05, LSD) among different varieties. Comparisons on total fruit numbers showed that Money maker produced significant number of fruits whereas Gross leese had the least number of fruits. Money maker yielded more marketable fruit than other varieties. The lower marketable fruit numbers were observed in Roma and Beef steak. Roma had high unmarketable fruit weight. Money maker, Summer star, Beef steak and KY Grace were intermediate, but were not significant different from Roma. Gross leese had low fruit weights but was not significantly different from Money maker, Summer star, Beef steak and KY Grace. Furthermore, investigations on marketable fruit weight showed that Money maker and Gross leese had higher marketable fruit weight compared to Summer star and KY Grace which produced intermediate marketable fruit weights. Beef steak and Roma produced significantly lower marketable fruit weights. The assessment on the unmarketable fruit weight showed that there was no significant difference determined among the entire trailed varieties.

The root lengths had no differences (P=0.0180, CV=16.85, DF=2, 5) among the different varieties. The results determined that different varieties of tomato plants were not much influenced by their root lengths. Many tomato field evaluations have been undertaken in many environments as a way to increase crop productivity (Gubis, 2003; Chaerani, 2006). Most of the findings have shown significant (p<0.05, LSD) adaptation and yield performances. Superior adaptability of a crop genotype against biotic and abiotic stresses along with improve yield and quality are essential for wider acceptability. Genetic, agronomic and physiological characteristics play a vital role in this regard. Large phenotypic variations on the measured characters for the phenological development were observed among the 6 varieties used in this experiment. Relative differences in performances among varieties are realistic and can be used to identify the best performing varieties. Yield is a complex quantitative character which depends on yield contributing characters. Number of fruits per plant was the most important trait towards yield contribution. The variations among the estimates vary because of different alleles that present and the frequency of the occurrences of this allele. Variety selection helps minimize lycopene production and minimize genotypic variations in tomato varieties.

Tomatoes, wherever grown, are hosts of wide variety of insect pests. Between 100 and 200 species are reported to attack tomatoes worldwide (Lange and Bronson, 1981). The evaluation of the presence of insect pests and diseases also determine the quality and yield of crops. Roma had higher reduced yield due to higher presence of BER and incidence of Fruitworm, *H. armigera* in the fruit development and maturation stage. BER on the cultivars showed significant differences (P<0.05, LSD) among the cultivars. Roma cultivars results showed susceptibility to BER which caused ~100% yield loss on the fruit maturation stage. The other cultivars had no significant symptoms of BER. The evidence of this findings were closely related to Bar-Tal *et al* (2001a) that incidence of BER for tomato fruits harvested was due to BER 65% of the total yield was not marketable. So far, most studies done on BER and it reported that it occurred as a result of low calcium levels in fruit distal due to competition for Ca uptake with other mineral nutrients in the soil.

Fruitworm was one of the main contributing factors towards the yield of tomato fruits in PAU experimental sites. They bore in the early and late maturing fruits thus result in the yield loss and quality. Investigation on the incidence and crop loss showed significant differences among the cultivars. The cultivars that were more susceptible to fruitworm infestation were Roma cultivars. Intermediate results were obtained from Beef Steak, KY Grace, Summer Star and Gross Leese. Money maker alone showed less yield loss because of its mechanisms of early fruit maturation traits. Among the insect pests, the polyphagous tomato fruitworm (*H. armigera*) is one of the most destructive, causing yield losses as high as ~70% due to fruit boring (Bar-Tal et al., 2001a).

Acknowledgements

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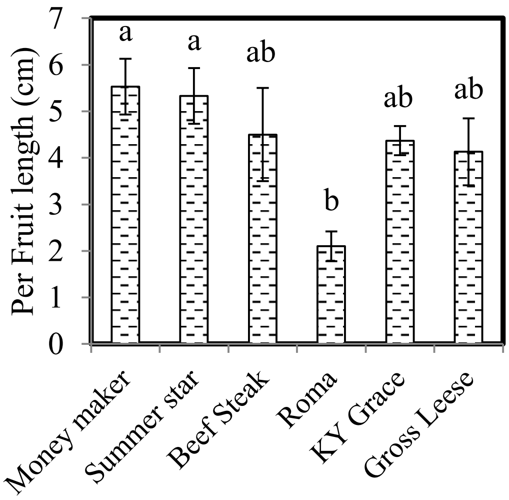

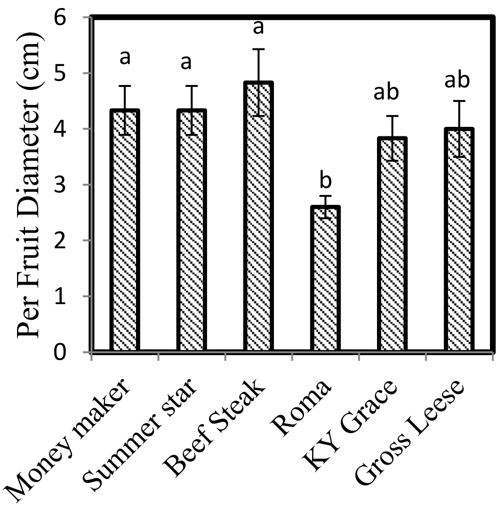

Fig 1. Means±SEM of different tomato variety fruit diameter and fruit lengths (cm) produced at the end of the harvests. The bars present the means of fruit lengths and error bars present the SEM. The different letters above the error bars are the LSD at significant level (P<0.05).

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Table 1. The total means† ± SEM of the following growth parameters of six tomato varieties evaluated in PAU dry lowland conditions in Central Province, 2011.

Variety Name	Plant height (cm)	Means P,S and T branch numbers per plant			Canopy width (cm)	Root length (cm)
		Primary branches	Secondary branches	Tertiary branches		
Money-maker	137±6.7a	5.3±1.5a	15.0±2.3bc	47.3±2.3a	59.10±3.4a	29.0±2.1a
Summer Star	113±16.3ab	4.9±0.29a	13.7±2.7c	36.7±1.5ab	49.2±3.3ab	30.5±2.2a
Beef Steak	111.3±5.1ab	6.0±1.0a	20.0±1.0abc	36.0±8.4ab	42.0±1.5b	37.3±2.7a
Roma	97.7±1.9b	4.3±0.3a	21.7±1.5ab	36.0±4.0ab	44.0±6.1b	26.0±0.2a
KY Grace	132.7±2.3a	5.0±1.15a	24.7±4.1a	28.3±4.1bc	50.0±7.2ab	24.7±2.2a
Gross Leese	116±14.7ab	5.0±0.0a	20.7±3.7abc	20.7±2.3c	47.0±6.1ab	20.0±0.7a

† Means of 3 replications for different varieties sampled were 5 plants per plot. Means ± SEM within the column followed by different letters (a, b, c and d) are significantly different at P<0.05, LSD.

Table 2. Table shows six tomato cultivars growth (cm) and yield (kg/ha) (means ± SEM) evaluated at PAU dry lowland conditions in Central Province , 12/09/11. The table shows the amount of fruits produced by per plants and characterized marketable yield (kg/plant) and nonmarketable yield (kg/plant) compared among cultivars.

Variety Name	**Number of fruits per plant**			**Weight of fruits per Plant**	
	∑ Marketable and nonmarketable fruits/plant	Number of Marketable Fruits/plant	Number of Unmarketable fruits/plant	Marketable Yield per plant (kg/plant)	Unmarketable Yield per plant (kg/plant)
Money maker	14.0±0.6a	8.0 ±0.6a	6.0±0.57ab	0.39±0.07a	0.11±0.02a
Summer Star	11.3±2.3ab	4.3±0.33b	7.0±2.6ab	0.24±0.05ab	0.18±0.05a
Beef Steak	9.7±0.5abc	2.8±1.33c	4.7±0.8ab	0.17±0.07b	0.42±0.33a
Roma	9.3±1.8abc	0.0±0.00c	8.7±1.0a	0.12±0.03b	0.32±0.04a
KY Grace	8.7±1.5bc	5.0±0.57b	4.3±1.3ab	0.17±0.02ab	0.19±0.03a
Gross Leese	6.0±1.8c	4.67±0.88b	4.0±1.0b	0.38±0.10a	0.22±0.03a

Means of 3 replication of five plants per plot were assessed individually for the six different varieties of tomato plants. All statistical means ± SEM within the column followed by different letters are significantly different at P<0.05. All the statistical means were separated using the LSD <0.05 levels.

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Table 3. Means ± SEM insect pests and diseases incidences on the cultivars of tomato in Pacific Adventist University plots.

Cultivars	Sample size (N)	Fruit worm incidences per plant	Blossom end rot	
			Incidences per plant	Yield loss (%)
Money maker	10	0.67±0.66 b	2.00±0.57 c	19.13±3.91 c
Summer Star	10	1.33±0.33 b	4.33±1.45 bc	32.48±16.42 bc
Beef Steak	10	1.33±0.66 a	4.67±0.67 b	74.4±25.5 ab
Roma	10	8.00±1.15 b	8.67±0.33 a	100.0±0.00 a
KY Grace	10	1.33±0.66 a	2.66±0.33 bc	51.26± 7.5 bc
Gross Leese	10	1.33±0.33 b	3.00±0.57 bc	37.74±2.25 ab

All statistical means ± SEM within the column followed by different letters are significantly different at P<0.05. All the statistical means were separated using the LSD test.

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Title	Vegetable project to guide production under current and future climates.
Theme	Farming Systems
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Key search words	Climate change, vegetables, population, value chain analysis, land suitability

Production of vegetables and other foods in Papua New Guinea (PNG) needs to increase substantially to meet the food needs of a rapidly increasing population, with an emerging middle class and increasing expatriate population associated with resource development projects (natural gas, mining) leading to expectations of greater diversity in food availability. Vegetables are a traditional food source, however, heavy reliance on carbohydrate-rich sweet potato and banana as staple foods has resulted in some malnutrition. We have recently commenced a research project designed to increase vegetable supplies, specifically for Port Moresby. However it is expected that technologies and practices that emerge from the project will be applicabile in PNG and nearby Island States, as commercial food production increases to meet the needs of urban populations. Pressure on land resources is also increasing, meaning sustainable production practices are required to address land degradation while meeting the needs of intensification of production. PNG has a wide range of agro ecological zones, from temperate highland regions with reliable near year round rainfall, to seasonally dry tropical lowlands, providing the opportunity for continuity of supply of a diversity of temperate and tropical crops. Climate change is expected to result in temperature changes of around 2o C in tropical areas by the mid to late 21st century, increased frequency of severe weather effects, and in the islands of the south west Pacific, variable effects on total and seasonality of rainfall (Bates et al. 2008, Nurse and Sem 2001). Thus, agro ecological zones in PNG could change, but with complex orographic influences of highly variable topography, local changes in temperature and rainfall are likely to be highly variable.

Our project addresses vegetable production in lowland, mid-elevation and highland agro ecological zones with a range of temperature and rainfall conditions, and will therefore increase understanding of food production in PNG under current and future climates with warmer temperatures requiring greater care in selection of production sites. We are undertaking a broad scale assessment of land suitability and infrastructure availability using PNGIS data. Our next step will be to undertake a more detailed regional study of candidate areas for vegetable production in Central Province to provide the basis for detailed production oriented research. We are using a Value Chain Analysis approach to identify vegetables to be used in the project, and through the systems analysis approach embedded in it, identify key constraints and researchable topics. Findings to date indicate that the focus of ongoing research will be the adaptation of existing socio-cultural, production and marketing practices to improve low input production and achieve a critical mass of coordinated supply based on retailer/consumer value attributes. The project will complement the development of climate change adaptation strategies in Australia, which has a wider range of agro-ecological zones, albeit largely due to latitude rather than, as in PNG, elevation. Thus, while addressing the immediate challenge of meeting food needs of current and anticipated populations in PNG, our project will provide information that will be useful in adapting to future climates. Future, warmer climates may constrain areas in which production of some crops e.g., temperate vegetables, and/or result in changes in production practices e.g., time of planting, cultivars

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used, irrigation frequency in response to shifts in seasonal characteristics and water supplies being needed.

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Small Scale Vegetable Gardens to Local Markets – A Case Study from PNG

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Abstract

Improved farm productivity and household income security through overcoming production, transport and marketing constraints is vital to improved profit sharing and strengthening their favourable attributes along the value chain, and thus improving the socio-economic status of small holder producers of vegetables in Central Province of PNG. Vegetable production is the major source of income for small scale farmers, and plays a significant role in meeting family expenses including food, children's education and medical expenses. Over 80% of farmers practice subsistence farming with low input. However there are many challenges during the process of growing vegetables in their gardens and selling them at local or more distant markets eg Port Moresby. An action research framework was followed using semi-structured interviews during the initial phases of a project to increase vegetable production in Central Province to identify the socio-economic constraints and the strengths affecting production and profitability. The most salient socio-economic constraints to emerge were limited availability of tools and equipment, irrigation infrastructure (capital finance), appropriate varieties, lack of training in agronomic practice (eg irrigation) and post harvest handling and packaging. Off-farm constraints of poor road and transport infrastructure constrain timely delivery of quality produce. Despite the socio economic constraints, strengths identified were good price for vegetables, cooperative approach, pragmatic relationships and interest in farming. These findings have assisted in focussing research activities at production level and along the value chain, and in providing guidance to initiatives outside the scope of the project, for instance, establishment of marketing infrastructure.

Key Words: Value Chain, Socio-economic constraints, Semi-structured interviews

Acknowledgement: The financial support of the Australian Centre for International Agricultural Research is acknowledged.

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Industry Journals

Published on line – Farming Matters Website

Theme: Farming Matters - What is the potential contribution of localized food production to the overall sustainability of food systems?

Title: Strengthening Local Vegetable production in Papua New Guinea using value chain analysis

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Improvements in vegetable production, transport and marketing are important to the well being of small holder farmers in Papua New Guinea, and opportunities for strengthening the industry and enhancing performance can be achieved by use of value chain analysis.

Local vegetable production in Papua New Guinea

Farming, and especially vegetable production, plays an important role in the lives of small holders using communally or customary land. It plays multiple roles of fulfilling basic needs, maintaining and strengthening the social fabric and providing nutritious food for the community. Although the basic needs of the family are usually met by selling produce at the local market, farming is more than family business in Papua New Guinea. It provides food security and economic incentives in rural communities. Often, though, produce available for sale is only the excess to family needs in what is mostly subsistence farming. Importantly, poverty in rural and urban communities and inequality of opportunity remain challenges in Papua New Guinea (PNG), and undermine the progress of the nation.

Food production largely relies on family and relatives of the clan or village for labor using very simple tools such as bush knives, grass knives, spades and knapsacks. There is minimal capital investment on communally owned or customary lands because of lack of security of title. Land and labor productivity is low as farmers face many environmental and socio-economic challenges in growing crops. In spite of being less productive than more intensively managed commercial farming, subsistence farming remains the predominant system in PNG, perhaps because it serves as a social safety net. However Yale (2006) warns that it will be wrong to assume that subsistence farming will support the growing population, currently expanding at about 2.1% per year.

Challenges in food production in PNG

Quality and limited shelf life of produce is of concern. This may be explained by deficiencies in one or more components of the post harvest system e.g. inadequate transport, storage and handling systems, as well as factors adversely affecting crops prior to harvest, including adverse weather conditions (particularly high temperature and excessive rainfall), pest incidence and sub-optimal crop management practices. Also, that farmers do not deliver quality produce consistently can be related to dysfunctional value chains. Further, for many years wantok ties, which are duties and obligations to help the kins speaking the same language, has provided insulation against individual vulnerabilities (Monsell-Davis 1993). This in turn discouraged others from working hard and seeking to improve their produce, as the benefit had to be shared with those who were not contributing equitably. Wantok and family systems are being challenged by the pressure for change, and are causing urban poverty in Papua New Guinea (Storey 2010). Nevertheless, the social change has yet to translate into improved farming practices and consistent delivery of high quality produce by individual farmers or farmer groups. However, encouraging signs are emerging, with, for example, the formation of farming cooperatives and the entry of entrepreneurs in, for example, transport.

Relationship between farmers, wholesalers, transporters and consumers

Most small farmers have opportunistic relationships with input suppliers, transporters, wholesalers and consumers. This means that there is no firm relationship between the farmers input suppliers, transporters, wholesalers and consumer. Although many wholesalers encourage locally grown produce, smallholder farmers arrive at the wholesalers and often find that their produce does not match quality standards required or are confronted by an oversupply of the same produce. As a result their produce is rejected, received at a low price, or the farmers choose to sell elsewhere. Basically, the farmers have little or no real influence on the price they receive, yet they continue to absorb production, marketing and transport risks and costs.

Most farmers believe that they are not offered a fair share of the retail price and many ultimately sell their produce directly to consumers in markets or free standing stalls. Small farmers and women may be harassed at local markets causing them to sell at a low price because of lack of bargaining power. At local markets, small farmers need to sell their produce by evening so they reduce the price to clear it by the end of the trading day. Consequently, small growers face a number of challenges and uncertainties that discourage them from improve farming and

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marketing practices. Nevertheless, the local markets serve as a food source for the urban poor and provide some cash income to meet family needs of smallholder farmers.

Improving local food production by value chain enhancement

A project on "Increasing Vegetable Production in Central Province, Papua New Guinea to Supply Port Moresby Markets" funded by the Australian Centre for International Agricultural Research and led by the Tasmanian Institute of Agricultural Research is identifying and addressing vegetable supply chain priorities in Central Province of PNG. It aims to provide small farmer communities with production options and marketing skills so they can take advantage of the opportunity to improve their socioeconomic position in a sustainable manner in an economy that is expanding due to mineral and gas development projects.

An integral part of the project was a value chain workshop for the stakeholders held at Pacific Advent University, Port Moresby. The value chain workshop was designed to assist stakeholders to develop skills to improve the performance of the value chain through enhancing relationships among the chain participants (or actors) - farmers, transporters, wholesalers and consumers. The ultimate aim is the development of viable, functional value chains that provide satisfactory returns to all participants in them.

The workshop was attended by 30 participants including District Administrators of Central Province, and staff of Fresh Produce Development Agency (FPDA), National Agricultural Research Institute (NARI) and Pacific Advent University (PAU). The concepts of supply chain and value chain were presented to the group. Participants discussed the following topics:

Expectations of consumers and suppliers;

Attributes of the produce; and

Challenges that needs to be addressed.

The participants were divided into three groups with participants from different organizations in each, and all engaged with the topics enthusiastically. The workshop revealed that the customers preferred the suppliers to provide a regular supply of high quality produce at reasonable price. Suppliers expected customers to provide feed back on the produce, and also that customers should be willing to pay better price for fresh produce and had other desirable quality characteristics. Lack of access to markets was also identified among challenges that were of socioeconomic, socio-cultural and political origin.

Access to market

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In order to create access to markets, negotiations have begun among the farmers in several regions near Port Moresby for instance in Rigo-Koiari and Bautama. A meeting of small farmers, transporters and wholesalers to complement the meeting of organizations and institutions was facilitated by the Project team to gain agreement on crops to be grown, quantities produced and frequency of supply. Arrangements for transport and the basis of price determination were negotiated between the wholesalers and producers as part of this process. Quality requirements were outlined for each crop with verification and monitoring being done by comparing photographs with standards developed by FPDA.

Next Steps in Implementation of the Project

The project has now moved into the next phase of implementation. In this, an appropriate selection from the agreed crops list (tomato, capsicum, carrot, cauliflower, broccoli, ball cabbage and French beans) will be grown under experimental and semi commercial (demonstration) conditions in five locations in Central Province, with the support of NARI, FPDA and PAU. Associated with this field work, enhanced transport and storage infrastructure is being provided by entrepreneurs and a commercial partner in the project, Greenfresh, to develop improved value chains into Port Moresby. Quality assessments are being further developed by FPDA.

The project is a ‘cyclic’ project, and on completion of the work currently in progress, progress will be assessed using value chain analysis and other tools that gain information on system performance, changes made if necessary for the next year, and the cycle repeated until the project terminates in December 2013.

Acknowledgement: The financial support of the Australian Centre for International Agricultural Research is acknowledged.

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Telephone: Ph:+61 7 5460 1105 Simple tools like bush knives at the local shop in Port Moresby

Photograph by Dr. Gomathy Palaniappan

Quality maintained at one of the Supermarkets in Port Moresby

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Photograph by Dr. Gomathy Palaniappan

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Workshops

VALUE CHAINS AND MARKETING

Increasing vegetable production in Central Province, Papua New Guinea (PNG) to supply Port Moresby markets

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Key Words: value chains, socio-economic research.

Take home messages

- *Population increase, development and urbanization in PNG are increasing food demand.*
- *Current production areas are constrained by resource limitations infrastructure inadequacy and inconsistency of supply and quality, which mean prices are variable.*
- *Value Chain Analysis an effective tool for focusing research and marketing activities.*
- *Substantial progress since January 2010: value chain analysis, initial land assessment, and socio-economic research advanced, field experimentation at five sites commenced.*

Introduction

PNG's population is increasing at about 2.1% per year, compounded in Port Moresby (PoM) by internal migration and an expanding middle class; thus increasing demand for food. Highland regions (e.g. Eastern Highlands) produce vegetables, but distance and poor infrastructure and services constrain supply of quality vegetables. Seasonally dry lowlands and cooler highlands (Sogeri Plateau, Goilala District) in Central Province (CP) nearer PoM have the potential to improve reliability of supply.

Objectives

The project aims to establish two examples of efficient and sustainable vegetable value chains in CP. These will allow identification of suitable resources and evaluate, implement and extend, resource management and agronomic practices for increased yield, quality and reliability of vegetable supply.

What has been done

Value chain analysis and initial socio-economic research have progressed substantially. Data from these will be used to guide field experiments and product marketing strategies. Field trials commenced in May 2011 in the Goilala, Rigo and Sogeri districts and two sites in Laloki, near PoM.

Outcomes to date

Detailed data has been collected on the socio-economic characteristics and operation of value chains from current and potential vegetable production regions. From this, strategies to improve performance of value chains have been identified. Socio-economic research has identified knowledge, skill, finance and infrastructure constraints to production and marketing of vegetables. Very good collaboration with Australian and PNG partners has been established.

Discussion

Project outcomes are being used to inform future activities, and have guided site selection and design for field experiments commencing in 2011.

Funding and project duration

Australian Centre for International Agricultural Research

- Jan 2010 – Dec 2013

Technology transfer and publications

- Eight conference papers and four media articles.

Additional collaborators

- Drs G. Palaniappan, M. Boersma, A. Gracie (TIAR)
- Prof B Chambers (University of Canberra)
- National Agricultural Research Institute, Laloki, PNG
- Fresh Produce Development Agency, Goroka, PNG
- Central Province Administration, Port Moresby, PNG
- Pacific Adventist University, Port Moresby, PNG
- Green Fresh Produce, Port Moresby, PNG

Irrigation of vegetables, Pacific Adventist University, PNG

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Chain members' perception of vegetable value chains in Papua New Guinea (PNG)

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Key Words: value chain, subsistence farmers

Take home messages

- *Farmers' view – need information about the quality, quantity and price of the produce to meet the market requirements*
- *Transporters' view – need regular supply and good road conditions*
- *Whole sellers' view – need fewer larger suppliers of quality of produce with right maturity*
- *Consumers' view- need freshness, quality of produce, regular supply and reasonable prices*

Introduction

Vegetable crops are traditional staple foods in PNG. However, production and yields have declined, adversely affecting diet and economic wellbeing. This highlights long-standing concerns about adequacy of Port Moresby's fresh food supplies. Importation of Australian rice, fruit and vegetables symbolises a continuing dependence on Australia and is detrimental to PNG's economy.

Objectives

To obtain an overview of vegetable value chain systems from perspective of participants (farmers, transporters, wholesalers and consumers) and develop research capacity in Australia and PNG.

Methods

The Rapid Supply Chain Appraisal Methodology (RSCA) was used to investigate smallholder vegetable production systems. This included gaining an initial industry perspective and understanding the chain dynamics through mapping the chain.

Results

Subsistence smallholder farmers are focused on family food provision, with small surpluses for sale in informal markets. Commercial smallholders produce a limited number of crops for supermarkets, kai bars and institutions. Information flow among value chain participants is limited, due to inadequacy of telecommunications and problematic business relationships.

Discussion

The current organisation of production and marketing results in a compromised system, with problematic flow of low quality products. Also, there is no objective understanding of consumer expectations, and the governance subsystem (the 'relationships') is almost non-existent, although it may be more prevalent amongst the commercial smallholder channels.

Funding and project duration

Australian Centre for International Agricultural Research

- Jan 2010 – Dec 2013

Technology transfer and publications

- Six papers in international conferences and two in national conferences;
- Four media articles.

Additional collaborators

- Drs M. Boersma, A. Gracie, R. Doyle, L. Sparrow (TIAR)
- National Agricultural Research Institute, Laloki, PNG
- Fresh Produce Development Agency, Goroka, PNG
- Central Province Administration, Port Moresby, PNG
- Pacific Adventist University, Port Moresby, PNG
- Green Fresh Produce, Port Moresby, PNG

Subsistence small holder farmers near Port Moresby

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Training Manual

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FARMER'S TRAINING MANUAL

INTRODUCTION TO BASIC CROP PRODUCTION, POST HARVEST AND FINANCIAL MANAGEMENT PRACTICES IN THE CENTRAL PROVINCE OF PAPUA NEW GUINEA

P. Seta-Waken, R. Malie, P. Utama, G. Palaniappan and B.C. Chambers

Editors C. J. Birch and B Chambers

SMALLHOLDER FARMER'S TRAINING.

For

VEGETABLE FARMERS FROM PRODUCTION SITES OF THE LOW, MID AND HIGH ALTITUDE AREAS IN CENTRAL PROVINCE

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Project Identification: SMCN/2008/008 Increasing Vegetable Production in Central Province, Papua New Guinea to Supply Port Moresby Markets

NARI Southern Regional Centre, Laloki, Central Province,

Papua New Guinea

Acknowledgements.

This manual is derived from the Training Needs Analysis Workshops conducted in 2011, 2012 and 2013 for farmers in Rigo/Koiari, Hiri, Sogeri and Tapini districts by staff of NARI, FPDA, PAU and Project Team Members from Australia, and the contribution of the many participants in those workshops is acknowkedged. We would paricularly like to sincerely thank Central Province women, men and youth for their generous sharing of traditional knowledge and skills in the training workshops.

Also, the financial assistance of the Australian Centre for International Agricultural Research is gratefully acknowledged, as without the support provided the production of this manual would not have been possible.

Table of Contents

Introduction

This manual arises from a series of training workshops conducted by the National Agriculture Research Institute, Southern Regional Centre (NARI – SRC) in conjunction with Fresh Produce Development Agency (FPDA) and the Pacific Adventist University(PAU) as partners in this ACIAR funded Vegetable Project for the Central Province.

Women and Men Smallholders from low, medium and high altitude regions in the Central Province of PNG participated in joint and gender separated workshops conducted from 2011 to 2013. The first was a Training Needs Analysis workshop and the second a Training Workshop on the Value Chain. In the first set of workshops, participants were shown a series of pictures from a typical value chain (from soil preparation and planting to harvest and sales) and first asked in small village based groups to talk about them in terms of their competencies and capacities to undertake such activities. These responses were then shared with the whole group and then women ranked in order of priority their training needs by village, older mothers and fathers and youth. In the second set of workshops, men and women were then separately recalled for requested training by district. The training needs identified were able to be categorised as Farm Production (soil management, crop protection and irrigation), Post-Harvest (product readiness, postharvest and negotiating price) and Business Skills (banking and book-keeping). NARI SRC- Laloki was nominated to provide training especially on Farm Production needs and FPDA, Southern Region conducted training in Post-Harvest and Business Skills.

The notes in this manual capture basic information and are meant to be used in conjunction with the Trainer's own experience and as negotiated in context with specific groups of farmers.

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Section 1 Basic Farm Production Training

Introduction

Basic Farm Production Training is the first of a series of training activities conducted by the National Agriculture Research Institute, Southern Regional Centre in conjunction with Fresh Produce Development Agency and the Pacific Adventist University as partners in an ACIAR funded Vegetable Project for the Central Province.

The notes in the first three topics provide information on farm production techniques especially on basic soil management techniques, an introduction to simple irrigation techniques such as the drip irrigation system and finally information on crop protection. Therefore, these notes are very brief and will need to be expanded by the Trainer's personal knowledge and experiences in vegetable farming.

Training Objectives

By the end of this training, farmers will be able to:

1) Identify soil management practices and appreciate the importance of soil management.
2) Understand some new irrigation technologies and how they can adopt it in their current farming practices.
3) Identify common weeds, pests and diseases of vegetables and understand some management practices.
4) Understand how to make their own Plant Derived Pesticides and appreciate resources in their surroundings that are available to use.
5) Understand the importance of safety when using chemicals for application in their farms.

Topic 1 Basic Soil Management Practices

Objectives

By the end of this topic, you should be able to:

1. Know what soil management is;
2. Identify ways to properly manage your soil; and
3. Appreciate these soil management practices to maintain soil fertility.

Introduction

A soil can lose its ability to support plant growth if it is not looked after (*managed*) properly. This may happen through landslides, flooding and erosion. Soil management means using it wisely so that it can support plant growth.

Soil management practices

Soil management practices include the following:

Mulching

What is mulching?

- Covering of the surface of the bed prepared for planting vegetables with dry grass, leaves, saw dust and food peelings.

Photos 1-4: Mulching materials (L to R) Sawdust, food peelings, leaves and a grass mulched crop

Why is mulching good?

- Mulching helps to:
  (1) Hold back water and keep crops cool during the dry season.
  (2) Minimize weed growth.
  (3) Preventing soil erosion by reducing the impact of raindrops on the soil surface and runoff.
  (4) Improve soil fertility and structure.

Photos 5-8: Mulching is good (L-R) hold back water (Photo 5) and control weeds and soil erosion (Photos 5-8).

Types of mulches

Mulches can be divided into two types:

1. **Organic mulches-** The most common ingredients of organic mulches are dry grass, leaves and saw-dust and crop by-products like peanut shells, coffee hulls, rice hulls, coconut husks and corn cobs.

Photos 9-11: Types of organic mulches

2. **Artificial mulches** - These include polyethylene plastics, fibreglass and aluminium foil, sand, stones and gravel.

Photos 12-14: Types of artificial mulches – light coloured plastic (L), black plactic © and ????? ®

Crop rotation

What is crop rotation?

Crop rotation is the process whereby a first crop (e.g. peanuts) planted on the land is followed by planting a different crop (e.g. cabbage) on the same land after harvesting the first crop. The diagram below shows an example of crop rotation.

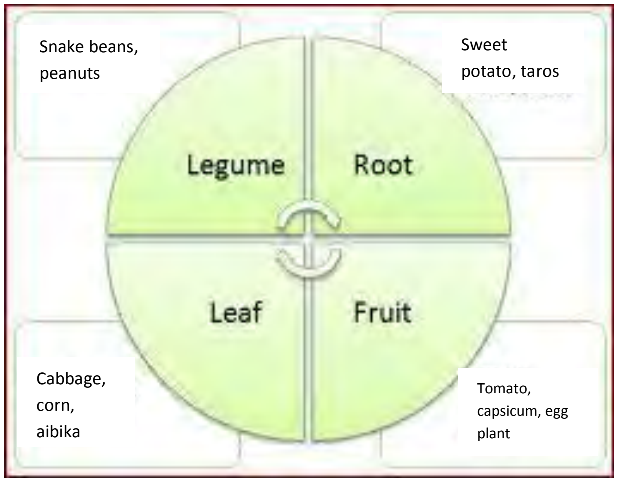

Figure 1.1: An example of crop rotation. The non- legume crops (corn, aibika and cabbage) will use up nitrogen in the soil while legume crops (peanut and snake bean) will add nitrogen to the soil. After harvesting, the non-legume crops will be rotated as shown by the arrows and the cycle continues.

Why is crop rotation good?

Crop rotation is good because:

(1) It avoids disease attack on crops in the previous plot.
(2) It adds nitrogen in the soil by growing legume crops.
(3) Prevention of soil erosion by growing dense - foliaged or vined - crops such as snake beans.
(4) Varieties of crops are grown for farmer's use.


Photos 15-16: Examples of crops able to be grown in rotation

Cover cropping

What is cover cropping?

Cover cropping is when the bare soil surface is protected by a cover of certain legume plants. An example is growing legume plants such as *Pueraria or Centrosema* in a plantation of coconut, cocoa, oil palm and rubber. The cover crops should be better established before these plantation crops are mature.

Photos 17-18: Pueraria- legume plants

Photos 19-20: Centrosema- legume plants

Why is cover cropping good?

Like green manuring, cover crops help to:

1. Reduce weed growth,
2. Conserve soil moisture,
3. Add nitrogen into the soil,
4. Improve soil organic matter content and soil structure; and
5. Prevent soil erosion.

Land fallow

What is land fallow?

Land fallow is when the land is rested from cropping for a certain period of time. In the past the fallow period used to be 10 to 25 years. Today, these periods in some areas are only 3 to 5 years as a result of land pressures due to increases in population.

Photos 21-24: Land fallow practices –intensive production – little if any fallow (Top left) and (top right), weedy fallow (Bottom left) and diagram of rotation (bottom right)

Why is land fallow good?

Land fallow helps to restore:

1. Organic matter content of the soil;
2. Soil fertility;
3. Soil structure; and also
4. Reduces or prevents soil erosion.

Activity 1

1. Think back to your village garden.
    a. Write down 6 types of crops grown.

    b. For each crop tell us if they are mulched and if so with what type of material.

    c. For each crop, what rotation system is used? For example if sweet potato is grown, what is the next crop grown in the same garden?

    d. Is your land left to fallow? How long do you normally fallow your land?

Methods of fertilizer application

There are 4 methods of applying fertilizers to crops.

Broadcasting Method

The fertilizer is held by the hand or machine and is evenly distributed over the soil surface and then carefully mixed into the soil. This method is easy to use but usually the crops may not utilize fertilizer as it may be out of reach of the roots of the crops. Also the fertilizer is usually applied before the crops are planted and if it rains heavily some loss of the fertilizer may occur by leaching.

Photos 25-26: Broadcasting fertilizers in the field

Placement of fertilizer

The fertilizer is placed as a band to the side of the seedlings, about 10cm from vegetables such as cabbages, tomatoes and capsicum. If seeds are planted the fertilizer is placed in the planting holes then covered with some soil before seeds are added. The placement method is good because fertilizer is given directly to individual plants. However, it requires more time and excess (too much applied) fertilizer may kill the crops.

Photos 27-28: Placing fertilizers to plants

Foliar (leaf) application

Some fertilizers can be mixed in water and sprayed with machinery (manual or motorized sprayers) onto the leaves of growing crops. This has to be done carefully as too much fertilizer used will injure plants.

Photos 29-30: Foliar application

Fertigation method

In this method the fertilizer is mixed in a tank and a motorized pump is used to pump the fertilizer via an irrigation pipe or fixed irrigation sprayers/sprinklers onto the soil at the base of the crop. Fertilizer can also be mixed in a bucket with water and applied using a watering can.


Photos 31-32: Fertigation methods – by watering can (L) and in trickle irrigation (R)

When can you apply fertilizer?

Fertilizers can be applied:

1. Before planting (*pre-planting* or *pre-emergence*);
2. At planting; and
3. During the growth stages of a crop (*post- planting* or *post-emergence*).

The timing depends on types of crops and fertilizers.

Activity 2

2. Think back to your village garden/farm. Do you use fertilizers? Fill in the table.

Name of crop	Is fertilizer applied?	What type of fertilizer is used?

3. When (time) do you apply fertilizer?
4. What method do you use to apply fertilizer?

Manuring Techniques

What is Manure?

Manure is the waste materials from animals or plants that are added to the soil to improve soil fertility. Manure is used as organic fertilizer that contributes to the soil fertility by adding organic matter and nutrients.

Advantages and disadvantages of manuring

There are good sides and also bad sides of using manure. Table 1.1 below summaries the good and bad of using manure.

Table 1.1: Advantages and disadvantages of manuring

Advantages	Disadvantages
• Increases the content of soil organic matter and nutrients • Improvement in the plant nutrition. • Improvement of soil structure • Increase in crop yield	• Labour intensive • Longer time to see the result • Odour/ smell and heat can harm

Types of Manure

There are three main types of manure that are commonly used.

1. Green or plant manure
2. Farmyard or animal manure
3. Tea or liquid manure



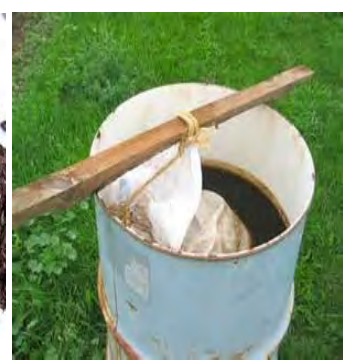

Photo 33: Green manure **Photo 34: Animal manure** **Photo: 35: ‘Tea’ or Liquid manure**

Green or plant manure

What is a Green or Plant manure?

Green manuring is the process of growing legume plants such as muccuna or mung bean into well prepared soil until they are leafy.Two (2) months after sowing (20cm to 30cm tall) they are ploughed into the soil, because when they are very young, their tissues are very soft resulting in them rotting and decaying very fast.

Green manure plays similar roles like the cover crop; however, it has a shorter period of time for preparation.



Photos 36-38: Green manuring

Why is green manuring good?

To improve the soil:

1. organic matter content;
2. fertility;
3. structure; and also to
4. prevent erosion; and
5. Conserve soil moisture.

Most green manure crops are legumes such as muccuna, pueraria and mung bean, etc.

Farm yard or animal manure

What is animal manure?

Animal manure refers to the waste such as dung and urine from the animals. Most common manures used are from poultry droppings, pig or cattle dung that are used in the form of solid manure directly applied to the soil about two (2) weeks before planting. Note that manure must not be applied fresh to the base of your crop because as it decomposes it produces heat that may burn and harm your crop.

Animal manure is very useful manure for improving soil fertility. Most animal manures are applied in solids so it can also be referred to as solid manure. The rate of decomposition of the manure depends entirely on the type of animal waste or dung used.

Effectiveness of the manure results on the time and application methods used, and of course the type of manure used. Uniform application of manure must be done two (2) weeks prior to planting as it will be in a solid form. However, if it exceeds for more than two (2) weeks after application then the soil is likely to lose nutrients through soil erosion or leaching. To avoid losing the nutrients if you are not planting soon after the manure application, then plant legumes so that the nutrients are absorbed by the cover crop. Application is either by broadcasting or side dressing.

One of the main disadvantages of animal manure is the contamination of water through leaching or run off from the soil surface.


Photo 39: Chicken manure


Photo 40: Cattle dung


Photo 41: Goat manure

'Tea' or liquid manure

'Tea' or liquid manure is derived from the two main sources of manure. Depending on the source used, 'tea' or liquid manure is labeled. For instance, if you are to use animal or farmyard manure it is called **animal 'tea' manure**. However, if you are to use plant manure, it is referred to as **plant 'tea' manure.**

Steps in preparing 'tea' manure

The steps in preparing the animal and plant 'tea' manure are the same. However, there are slight differences in the storage period. Animal manure 'tea' will last longer than the plant manure tea.

Materials and steps needed for animal and plant 'tea'

Table 1.2: Materials for animal and plant tea

Animal manure	Plant manure
1. Pig, chicken, goat, sheep, cow dung etc. 2. Sack or stock feed bag (50kg) 3. Clean water 4. 200 liter (44 gallon) drum, plastic containers or buckets (10/15L) 5. A stick or wooden timber 6. Big stone for weight	1. Green leaves- soft, hairy & leguminous 2. Wood ash 3. Sack or empty stock feed bag (50kg) 4. Clean water 5. 44 gallon drum, plastic containers or buckets (10/15L) 6. A stick or wooden timber 7. Big stone for weight

Table 1.3: Steps in making Animal and Plant 'tea' Manure

Animal Manure	Plant Manure
1. Collect or gather dried animal manure. 2. Fill the manure into the sack or stock feed bag. 3. Place a good size stone into the bag filled with manure to hold weight purposely to prevent the bag floating. 4. Make hole at the top part of the bag and insert a stick or timber to hold the bag up right when place into the drum. 5. Fill water up halfway of the drum or plastic container. 6. Lift the bag filled with manure and place it into the drum filled with water and cover it with a lid, cloth or fly wire. 7. Using a stick, stir the 'tea' daily. 8. The 'tea' should ready for application after 7 days.	1. Gather the three(3) types of green leaves: Soft – cassava Hairy – pumpkin Leguminous – gliriceadia shade tree, luceana etc. 2. Chop them up into fine pieces. 3. Fill the bag with the chopped leaves. 4. Add wood ash for minerals, it also acts as pest repellent and shake thoroughly. 5. Add in the stone to as weight to avoid the bag from floating. 6. Fill the drum/container halfway with clean water. 7. Place the bag of manure into the drum filled with water and cover the drum/ container with a lid, cloth or fly wire. 8. Stir every morning. 9. The 'tea' should be ready for application after 7 days.

Illustration of making Animal 'Tea' manure and Plant 'Tea' manure

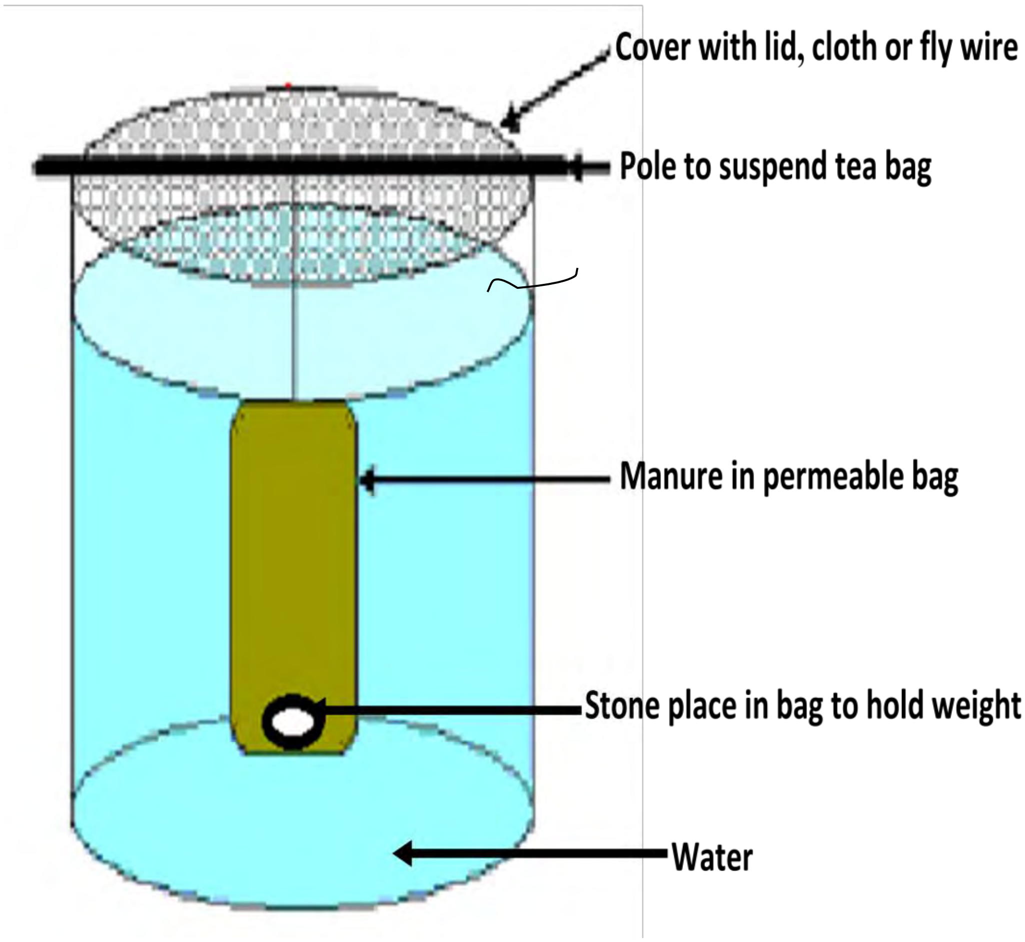

Figure 1.2: Making animal or plant 'tea' manure

Another way of making plant 'tea'

Source: Forthway, UK, 2010

Figure 1.3: Making plant 'tea'

Application

Application is done by diluting the manure with equal amount of water and is applied using a watering can or small tins to apply at the side of the plant. Avoid application during rainy season to prevent the leaching process.

Advantages and disadvantages of plant manure

Table 1.4: List of advantages and disadvantages of plant manure

Advantages	Disadvantages
1. Supplies major and minor nutrients 2. Taken up quickly as it is in the liquid form 3. It can be stored longer period. 4. Cheap 5. Takes shorter period of time to be ready	1. Labor intensive 2. Not applicable during rainy season 3. Can burn plants if applied directly on the surface of the leaves. 4. Stored for a shorter period

Composting

What is Compost?

Compost is the mixture of organic matter which is decomposed and used as organic fertilizer for improving soil fertility.

Organic matter includes dry leaves, green grass clippings or food peelings and animal manure. Dry leaves produce carbon for heat energy, green clipping, food peelings, animal manure provide nitrogen and micro-organisms to help break down the organic matter (the decaying process). The process of composting acts as the soil conditioner, fertilizer, adds humus and can also act as a pesticide. It is very rich in major and minor nutrients needed by plants for healthy growth. Compost will also require water and oxygen for the living organisms helping in the decomposition process.

Advantages and Disadvantages of using compost

Table 1.5: List of advantages and disadvantages of composting

Advantages	Disadvantages
1. Waste products are made use of properly and recycled. **2. Adds nutrients and recondition the soil. E.g.: soil structure improvement.** **3. Cheap** **4. Helps to clean up contaminated soil.** **5. Kills plant diseases and pest in the soil.**	**1. Produces odour smell** **2. Attracts pests such as rodents and other insects** **3. Labour intensive** 4. **Time consuming**

Types of Compost

There are two compost types that farmers may prefer to make and use.

1. 18 to 30 days compost
2. 3 months compost

18-30 days compost

Materials and steps needed for 18-30 days compost

Table 1.6: Materials needed to make 18-30 days compost

18 to 30 day compost materials
1. Sticks or bamboo to build a stockade with its shelter. 2. Kunai grass, sago leaves or plastic sheet for the roof. 3. Dry leaves, green grass clippings and fresh animal manure. 4. Sack bags or banana leaves to cover the compost. 5. Ropes or tie wire for tying edges of the stockade.

Table 1.7: Steps in making 18-30 day's compost

18 to 30 days compost making steps
1. Build a 1m (L) x 1m (W) x 1m (height) stockade and allow a similar sized area to turn the manure. 2. Chop dry leaves and green leaves together. 3. Thoroughly mix the chopped leaves with fresh animal manure. 4. Combine the mixture and pile to make a heap up to 1m high. 5. Cover the heap with the sack bag or banana leaves. 6. After 3 to 4 days turn the heap and continue to turn after every 2 days. 7. In 18 to 30 days the compost should be ready for use.

Three months compost

Materials and steps needed for 3 months compost

Table 1.8: Materials needed to make 3 months composts

3 months compost materials
1. Sticks or bamboo to build a stockade with its shelter. 2. Kunai grass, sago leaves or plastic sheet for the roof. 3. Dry leaves, green grass clippings and fresh animal manure. 4. Sack bags or dry banana leaves to cover the compost. 5. Ropes or tie wire for tying edges of the stockade. 6. Green manures like legumes.

Table 1.9: Steps in making 3 months compost

3 months compost making steps
<u>First stage: Making a heap.</u> **1. Build a 2.5m (L) x 2m (W) x 1.5m (height) stockade and allow a similar area size to turn the manure.** **2. Chop dry leaves and green leaves together and make a layer about 15cm thick.** **3. Sprinkle a thin layer of animal manure about 2cm on top of the first layer.** **4. Add a second layer of plant materials, preferably green manures.** **5. Sprinkle wood ash or charcoal dust on top of the green manure.** **6. Each layer should be 30cm thick.** **7. If the weather is dry, sprinkle 4L of water to make the layer damp.** **8. Repeat the above steps until you have heap about 1.5m high.** **9. Cover the heap with 10cm top soil to minimise nutrient loss.** **<u>Second stage: Turning the compost.</u>** **1. Turn the heap using a fork after 1 month.** **2. Move the materials from the top and sides of the heap to the middle of the new heap.** **3. Turn the heap every two weeks until the compost becomes dark grey in colour.** **<u>Third stage: Monitoring Progress.</u>** **1. From 8 days onwards, push a stick in the middle of the heap and pull it out. If it feels hot this is a good sign that decomposition is occurring.** **2. The compost will be ready for use when it becomes 24hot and greyish in colour. This takes 3 months.**

Note: The only difference between these two composts is the time frame for the manure to be ready for use.

How to apply compost

Compost can be used in the following manner:

1. Broad casting – scattering of compost on to the soil surface prepared for planting.
2. Incorporate – dig up or plough compost into the soil before planting.
3. Side dressing – make a hole at the side of your plant, place your manure into the soil, mix and cover it.

Note that if you are not ready to use the compost immediately, store your compost in the shade or cover with 10cm of top soil to minimise nutrient loss.

Photo 42: Compost constructed using local bush materials

Source: Daily Green Post, 2000

Figure 1. 4: Interior structure of compost

Summary

Appropriate soil management practices should be used where possible to maintain high soil organic matter content to;

1. Protect the soil from erosion;
2. Provide nutrient to your soil using different manuring and composting techniques;
3. Improve the soil properties and structures that will benefit the soil, which in turn will;
4. Improve crop growth and bring better yield to the farmer!

Good soil management practices are:

1. Mulching;
2. Crop rotation;
3. Cover cropping;
4. Land fallow;
5. Manuring;
6. Fertilizer application;
7. Compost making and application.

Reference

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Topic 2 Simple Irrigation Techniques

Objectives

By the end of this topic you should be able to:

1. Identify different types of irrigation techniques;
2. Know about drip irrigation;
3. Appreciate and use the drip irrigation method in your various farm settings.

Introduction

Like people and animals, plants also need water forhealthy and normal growth. Many farmers rely only on the rainfall to water their crops. Water for irrigation is very important to successfully grow vegetables all year round even in dry periods without rain. The fertilisers and nutrients in the soil are absorbed into the plant along with the water through its roots in the soil for the plant to grow well and produce more.

Some vegetable require relatively more and frequent water than others. Example, cabbages requires more water than tomatoes, capsicums and watermelons that grow well in drier conditions. A form of irrigation system is a must to successfully grow our vegetables especially in the drier periods when there is no rain.

Types of Irrigation

The type of irrigation system depends on the size of the farm, the source of water (from a water-well, dam or river) and how much the farmer can afford.

1. Manual – the simplest but least efficient system is watering by hand using buckets and watering cans for irrigation. Water is fetched and applied to plants by hand.


Photos 1-2: Using watering cans to manually water food crop gardens

2. Canal or furrow – water pumped (using manual or motorised water pump) and stored in reservoir or tank which is then directed to flow into the open field between the furrows or ridges. You may need a water pump to draw water from water well or from a river.

Photos 3-4: Water canals/ furrows

3. Drip – water is pumped into a tank (a reservoir) and then delivered as drips to the plants' base through small and narrow tubes through gravity force. This system is effective when the tubes are not blocked by dirt or build-up of salts from the water.

Photos 5-6: Simple drip irrigation system in the field.

4. Overhead Sprinklers- this system requires sufficient pressure from the water-pump to force water to shoot out of the upright sprinklers as sprays as they rotate.

Photo 7: Overhead sprinklers

Drip irrigation

What is drip irrigation?

Drip irrigation or micro-irrigation is a method that allows a farmer to control the application of water and fertilizer by allowing water to drip slowly near the plant roots through a network of valves, pipes, tubing and emitters. However, drip irrigation is not applicable to all farms.

Photo 8: Drip emitter on a crop

Advantages of drip irrigation

1. Less water can be used
2. Lower operating pressure means low cost for fuel/petrol for pumping.
3. Water used well because plants can be supplied with water.
4. Water is applied directly to the plant root zone.
5. Reduced weeding
6. Reduced pests/disease infestation
7. Reduced soil erosion
8. Reduced labor




Photos 9-12: advantages of drip irrigation

Disadvantages of drip irrigation

1. Higher initial investment
2. Requires regular maintenance and high quality water
3. Tubes may be lifted by wind or moved.

Materials needed for a small drip irrigation system

1. Water source – The water for irrigation can come from wells, streams, ponds, tanks, rain, recycled water from wastewater treatment plants or other sources.
2. Tap
3. Filter
4. Valve
5. Sub Main
6. Laterals
7. Micro-drip
8. Connectors
9. Stoppers

Parts and fittings for a simple drip irrigation system

1. **Water source**

2. Tap
3. Filter

4. Tank

5. Valve

6. Submain (19mm)

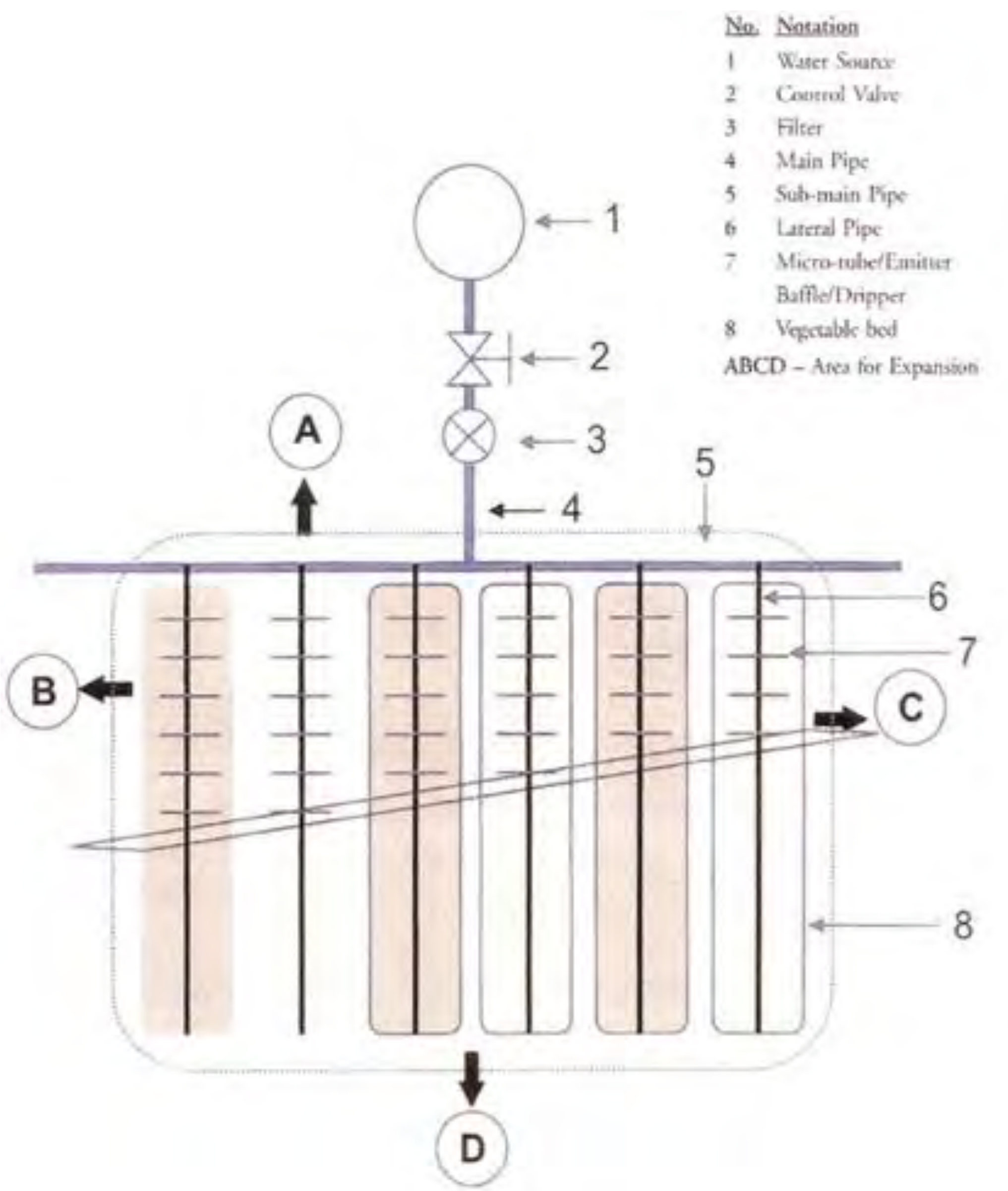
7. Laterals (16mm)

8. Connectors / elbows

9. Stoppers

Components of a drip irrigation system

A typical drip irrigation system has seven major components.



Source: IDEal Technical Manual, 2000

Figure 2.1: Main components of a simple drip irrigation system

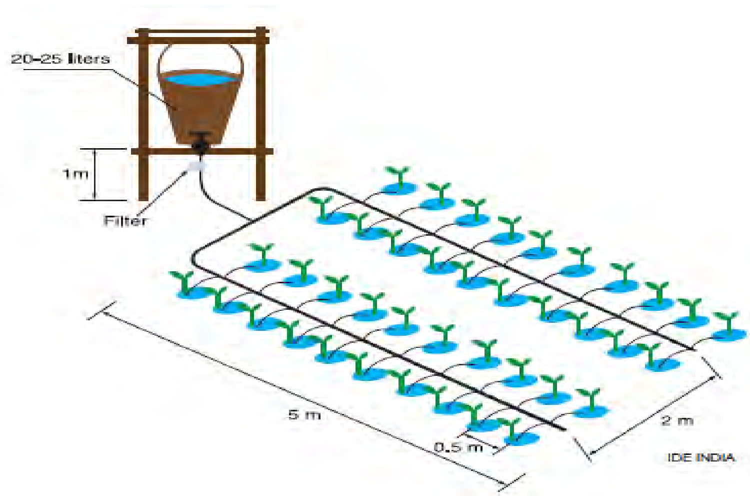
Simple drip irrigation systems

International Development Enterprises (IDE) in India has developed simple, affordable low-cost drip irrigation systems for smallholder vegetable growers. These systems include:

- Bucket Kit
- Family Nutrition Kit
- Drum Kit
- Customized System
- Combo Kit

Bucket Kit Features

- A pre-assembled kit to irrigate vegetables in home gardens.
- Has a 20-liter bucket with one or two rows of lateral drip lines 5 to 10 meters in length, depending on the space available.
- Can irrigate up to 20 square meters.
- Bucket can be hung from a tree or pole 1 meter hig



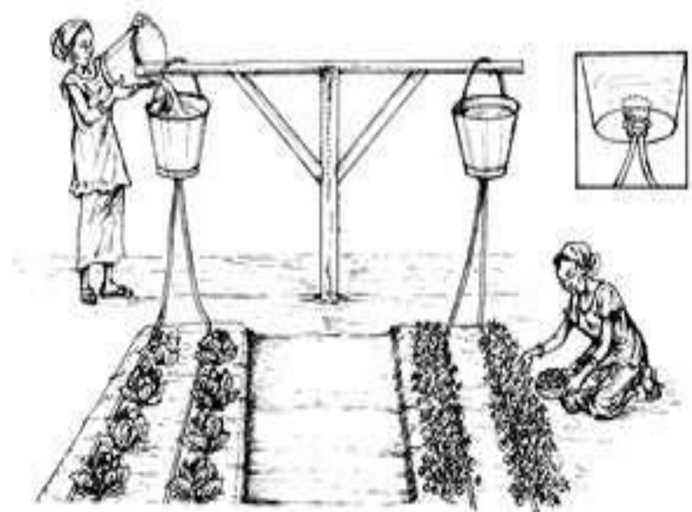


Fig 2.3: A simple bucket kit for irrigating a small vegetable garden.

Fig 2.2: A simple bucket kit for irrigating a small vegetable garden plot of approximately 20m².

Photos 13-14: Simple drip kit for irrigating a small vegetable garden plot.

Activity 1

1. We will now construct a simple micro-drip irrigation system in the demonstration site.

2. Try to think back to materials available in your area such as bamboos, the sizes that can be used and try to utilize those and make a simple irrigation kit system using the examples given in this topic.

Summary

Apart from proper soil management and crop protection practices, water is also a very important factor for plant survival. There are a number of ways in which water is applied to our crops in the field. There are various simple irrigation techniques that can be used to in the farm. The types of irrigation systems depend on the size of the farm, the source of water and how much the farmer can afford.

The drip irrigation system is a simple easy to use irrigation system that allows a farmer to control the application of water and fertilizer by allowing water to drip slowly near the plant roots through a network of valves, pipes, tubing and emitters.

Simple drip irrigation kits such as the Bucket Kits will be available soon in Brian Bell Ltd for farmers purchase and use.

Reference

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Topic 3 Basic Crop Protection

Objectives

By the end of this topic you should be able to:

1. Describe which plants are called weeds;
2. Identify ways to control and mange weeds;
3. Know what an insect pest is;
4. Recognize which insects are pests to a particular crop;
5. Identify ways to control and manage insect pests;
6. Learn some Plant Derived Pesticide (PDP) techniques;
7. Define plant disease;
8. Describe symptoms of a plant disease;
9. Identify ways to control and manage plant diseases;
10. Appreciate the importance of safety when using chemicals in your farms.

Introduction

Crop Protection deals with the pests and weeds that cause crop losses and how they are managed to minimise these losses. There are 3 main agents that cause damages to our crops; Weeds; Insects and Plant diseases.

Weeds

What are weeds?

A weed is a plant that is growing in the wrong place.

For example, volunteer tomatoes, or beans become weeds if they grow in ground that has been planted with a crop of sweet potatoes. Weeds can interfere with cropping or grazing activities or block waterways and competefor nutrients in the soil resulting in low crop yields. Some examples of introduced weeds of economic importance to PNG are shown on the next page.




Nut grass **Siam Weed** **Micannia** **Milk weed**

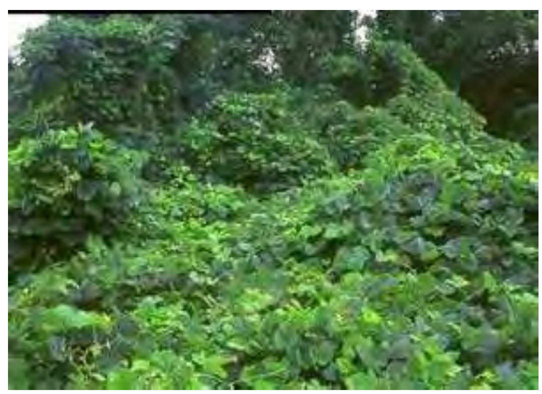
Photos 1-4: Some common weeds found in farmers field

The effects of weeds on crops

1. **Harmful effects of weeds:** Weeds directly compete with crops for light, nutrients and water and causing reduced crop yields. Some weeds can also act as hosts for insect pests and disease agents.


Photos 5-6: Weeds competing with crops

2. **Beneficial effects of weeds:** However, in abandoned land, weeds can also act as cover crops and help reduce soil erosion and add organic matter to the soils when they decompose. Some may also act as a source of food and may have medicinal properties.

Photos 7-8: Weeds acting as cover crops, reducing soil erosion

Ways to control weeds

Photo 9: Physical control

1. Physical Control

a. Hand weeding
b. Hoeing and cultivation
c. Mowing and slashing

2. Cultural Control

Cultural practices include:

1. Mulching
2. Cover cropping especially using leguminous crops also helps to reduce weed growth. Cover crops also help to improve soil fertility.

Photo 10: Cultural control

3. Chemical Control

Using chemicals:

- These chemicals are called herbicides.
- Herbicides are expensive and dangerous to use without proper equipment and training.
- Some herbicides kill the plant by contact with the plant surface and are called contact herbicides.
- Others can be applied to one part of the plant and they are then absorbed and distributed through the plant's vascular system to the whole plant. These, e.g. glyphosate or roundup are called translocated herbicides. However, care must be taken as these can also kill crop plants.
- Manufacturers therefore give strict instructions on the label of the containers as to how and when a particular herbicide can be applied and its potential danger to humans and animals and crops.
- Chemicals do result in a quick kill of weeds and may only be economic if used in large plantation crops such as cocoa, coffee, and oil palm.

Photos 11-12: Using chemicals to control weed

Insect Pests

What are insect pests?

Pests refer to mostly the 'bad' insects and their larvae which feed and damage food crops. They include:

1. Sucking insects such as aphids, stink bugs, plant hoppers and thrips.;
2. Chewing insects such as grasshoppers, caterpillars and beetles;
3. Leaf rollers such as aibika leaf roller and banana skippers.; and
4. Barrowing insects like taro beetles, sweet potato weevils and red banded caterpillars.

Photo 13: Symptoms of sucking insects

Photo 14: Chewing insects - caterpillar

Photo 15: Barrowing insects- weevils

Ways to control insect pests

a) **Physical Control**
   - Do hand picking and killing them. Possible for small garden only. Best time to hand pick insects are early in the mornings on a weekly basis when the sun is not too high.

Photo 16: Physical control

b) **Cultural control**
   - Cultural Control involves**:**
     - Crop Rotation
     - Planting of repellent crops in the vegetable garden
     - Planting resistant crop varieties.

Photo 17: Cultural control

c) **Biological Control**
   - Biological control encourages the use of other natural living organisms (e.g. insects, birds) to control/kill other 'bad' insects. The 'good insects' are called parasites / parasitoids or predators) and include spiders, praying mantis

Photo 18: Biological control

and lady bird beetles which feed on other 'bad' insects that destroys our crops.

d) **Chemical Control**

- Using of organic or inorganic pesticides to kill the bad insect pests attacking our vegetables.

Photo 19: Chemical control

I. **Organic pesticides**

- Organic pesticides are naturally derived pesticides made from plants like:
  - Derris (poison roots)
  - Tobacco leaf and stalk
  - Neem leaves, bark & seeds
  - Marigold leaves and stem
  - Chili fruits
  - Pawpaw leaves

Photo 20: Organic control

Note: Refer to the PDP section on using Chili and Neem seeds by NARI.

II. **Inorganic pesticides**

- These are pesticides that are produced using chemicals. They are very effective but can be harmful to the environment and are very costly. There are strict safety measures to follow to avoid poisoning yourself, others and polluting the environment.

- It is best not to use inorganic pesticides in your home garden unless you are sure and know how to safely handle the chemicals and correctly mixing and applying the chemicals to your crops. This is because they are usually poisonous to humans. However, it is useful on commercial scale farming. Examples of insecticides & their mixing rates sold in agricultural supply stores in PNG include:

Chemicals	**How to use**			
	Plant	**Pest**	**Rate**	**How to apply**
Confidor	Capsicum Tomato Zucchinis Melons Eggplants	Green peach aphid	Mix 1 sachet in 5 litres of water	Spray thoroughly at first sign of pests. Ensure undersides of leaves are sprayed.
Karate	Capsicum Tomato Zucchinis Melons	*Heliothis-amigera* *Earias vitella* *Spodoptera sylepta derogara*	400-500mls/ha or 10 mls in10 litres of water	

	Eggplants	Tubermoth, aphids		

Note: Application of these chemicals requires knapsack sprayers. The application rates defer from chemical to chemical. On every chemical container there should be labels and instruction guides given on the rate for mixing and application (e.g. 10mls into 10L water) and how to apply them.

Activity 1

1. Below are some photos of different pests. Do you see some of these pests in your gardens? If yes, what crops do they attack?


Tomato Hornworm


Corn Earworm


Brown Sting bug


Pumpkin Beetles


Cane Toad


Capsicum Maggots


Giant African Snail

Plant diseases

What is plant disease?

If a plant is not growing well or looks sick compared to a normal healthy plant, it is diseased. We can usually see with our eyes some of the symptoms that plants are not growing well.

Photos 21-23: Symptoms of sick plants

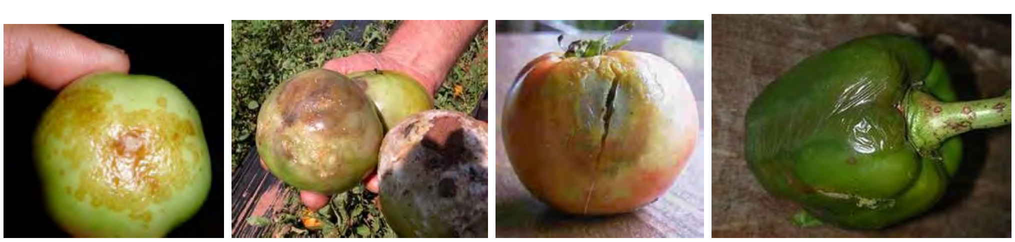
What causes plant disease?

Most plant diseases are caused by:

1. **Fungi -** Fungi cause plant tissue to rot, spots on the flowers, leaves and stem.

Photos 24-26: Symptoms of diseases caused by fungi

2. **Bacteria -** Bacteria diseases are similar but often the only difference is, it gives off an awful smell.



Photos 27-30: Symptoms of diseases caused by bacteria

3. **Virus –** Virus **di**seases have symptoms very similar to some nutrient deficiencies.


Photos 31-32: Symptoms of disease caused by virus- Mosaic virus I tomatoes

Common diseases in crops

Photo 33: Tobacco plant showing wilting symptoms

Wilt diseases

The symptoms of wilting are shown by the leaves. The leaves are no longer erect but are drooping downwards and are limp. Wilt may be caused by not enough water in the plant but the plant recovers as soon as water is applied given to the soil and taken up by the roots. But if the plant does not recover from the wilting even though there is enough water given it means that the wilting is caused by a disease.

We can test this further by slicing the plant stem. If the tissue is sliced along the stem length which is called the vascular tissue (which allows water to move from the roots to the leaves) shows a brown streak running along the length; if the tissues are sliced across the stem, the vascular system appears as a brown ring. This browning shows that the wilt is due to a blockage of the vascular system and the disease is known as *vascular wilt disease*. Vascular wilt diseases are usually caused by pathogenic fungi or bacteria.

Leaf blight

The symptoms of leaf blight start from the appearance of tiny brown spots of dead tissue on the green leaves. These enlarge and merge together until the whole leaf is dead. Under good environmental conditions the disease can spread from one plant to another plant until the entire crop is affected. If the disease starts when plants are young it is called *Early leaf blight*, but if it occurs later when plants are flowering or producing fruit, it is called *late blight*. Leaf blight disease is common on tomatoes, capsicum, potato crops and taro. Leaf blight disease is caused by pathogenic fungi.


Photos 34-35: Early and late symptoms of leaf blight on tomato (left) and pumpkin leaves (right).

Leaf spots

Sometimes there may be a number of different types of leaf spots on a plant. Some may be regular or round and small; others may be irregular, and others are where the diseased brown dead tissues drop off leaving a hole. More than one disease may occur on the same plant caused by pathogenic fungi (or bacteria).

Photo 36: Leaf spots on tomato leaves.

Activity 2

1. Take a walk in the garden and see if any tomatoes are showing signs of wilt. Scrape the top layer of soil and test if the soil is moist or dry.

   If the soil is moist then remove a wilted plant and take a knife and cut open the stem, horizontally and longitudinally and examine to see if you see any signs of vascular browning.

2. Examine the leaves for brown spots. If the spots are brown with concentric rings that look like a target board of darts - it is called *target spot* and this is indicative of early blight disease.

3. Take a walk amongst some taro plants growing in the field. Examine both young and old leaves. Note if young leaves have any circular brown spots on them. Now examine older leaves and see whether there are huge areas of brown spots or dead tissue due to the merging of a number of dead leaf spots. Examine the under surface of the leaves and check whether there is any white ring around the border of the leaf spot. If so, this is Taro leaf blight disease. It is best to observe this in the early morning.
   a. Symptoms observed……………………………………………………………...
   b. Number of plants affected………………………………………………………..

Ways to control disease

There are three common controls that can be used.

1. **Cultural control**
    - Using disease –free planting materials i.e. healthy seeds or cuttings obtained from a healthy crop.
    - Good hygiene, i.e. removing and destroying infected material, e.g. cocoa pods with black pod disease by burning; destroying crop residues after the crop is harvested.
    - Crop rotation by planting different host crops after the first crop is harvested i.e. beans after sweet potato. Also avoid too close spacing when planting corn, peanuts, and taro.
    - Planting cultivars which are resistant to disease– e.g. new taro and potato varieties with tolerance to Leaf blight.
2. **Physical control**
    - Preventing excess water e.g. use glass –house or drip irrigation.
    - Farm quarantine – stop unnecessary movement of people animal, machines in and out of the farm.
3. **Chemical control**
    - There are chemicals that can be used to control diseases caused by micro-organisms such as fungi. These are called fungicides. However these are also costly and require care in using the right chemical for the right disease. When using chemicals, care must be taken and directions followed on the label of the chemicals.
    - Use of a fungicide, such as a copper based fungicide or *Mancozeb* (Table 3.1shows details for an example of use of *Mancozeb)*
    - Managing insect pests such as aphids which transmit plant viruses

Table 3.1 Examole of recommendations for use of *Mancozeb*)

Chemicals	**How to use**			
	Plant	**Disease**	**Rate**	**How to apply**
Mancozeb	Tomato	Early blight Late blight Leaf mould Grey leaf spot Grey mould	40g/16L Knapsack o**r** **50g/20**L knapsack	Spray at first appearance of the foliage disease. Spray at 7-10 day intervals. Continue into the picking season to obtain best results against leaf mould.

Activity 3

1. Do you use any of these practices in your gardens/farms to control diseases? If so, describe what you do?

[5]Safety instructions for the use of chemicals

Selection of suitable pesticides and herbicides

- Use only those pesticides recommended by the Department of Primary Industry or NARI.
- Read the instruction on label. Follow precautions exactly.
- Do not use more pesticides than is recommended. Do not mix more pesticide than you will use in one day.

Safe storage of chemicals

Store chemicals in a safe place where they cannot be reached by children or domestic animals. Do not store chemicals in the same room as food or drink.

- Always keep the pesticide in a original container. Never use other containers such as beer or lolly-water (soft drink) bottles. Check the containers regularly to make sure that they are not leaking.
- Only buy as much pesticide as you will use in a few months, so that you do not need to store it for too long.
- Do not use empty insecticide containers for storing or carrying food or drink.

Safety during spraying operations

- Make sure that the right protective clothing and equipment is available.
- When spraying wear the appropriate protective clothing.
- When windy, do not spray near children or other people, animals or prepared food.
- Never suck or blow blocked nozzles with your mouth
- Do not fill pesticide in knapsack sprayers over the full level mark.
- Do not eat, drink or smoke while handling or applying the pesticide
- Do not eat, drink or smoke until you have washed and changed your clothes.
- After you have finished spraying, wash the spray and then yourself and clothes.
- If you feel sick after using a pesticide, go and see a doctor immediately. Make sure to tell him the exact name of the chemical used.

[5] Acknowledge the Crop Protection Team: The National Agricultural Research Institute, Papua New Guinea

Disposal of chemicals
- Do not empty spare chemicals or wash the sprayer near a drinking water supply.
- Destroy or dispose all empty chemical containers safely.

Time of harvest
- Observe the recommended waiting period between the last spray then you can harvest your crop.

[6]Tok lukaut long marasin bilong sprei long gaden

Makim ol gutpela marasin
- Usim ol marasin ol didman tokim yu long em tasol.
- Ridim gut ol toksave i stap long botol. Bihainim gut ol dispel toksave.
- Yu mas bihainim stret toksave bilong didiman long hamas marasin bilong usim. You mas mixim o skelim inap marasin long yusim long wanpela taim tasol.

Gutpela wei bilong karim na lukautim ol marasin
- Putim ol marasin long hap we’e ol pikinini, pik na dok ino inap long kisim. Yu no ken putim marasin long ples yu save putim kaikai.
- Olgeta taim tu mas lusim marasin istap long tin o botol bilong em yet. Yu noken usim ol narapela botol o tin na coke botol. Lukluk na sekim ol tin nogut ol lik na kapsait.
- Baim inap marasin long usim long sotpela taim tasol, olsem bai yu no inap putim long haus longpela taim.
- Ino ken kapsaitim ol pinis marasin botol o tin long kaikai o wara.

Gutpela wei blong sprei
- Yu mas igat spre pam na ol samting bilong skelim marasin na karamapim skin bilong yu.
- Yu mas tingting gut na karamapim gut skin bilong yu taim yu laik holim na usim strongpela marasin stret long botol.
- Taim yu spre, yu mas putim ol samting long karamapim skin bilong yu.
- Noken spreim ol marasin klostu long ol pikinini o man na pig o dok o kaikai.
- Yu no ken winim maus bilong spre pam taim em i pas.
- Yu no ken pulumapim tumas spre pam.
- Yu no ken kaikai, simuk o dring long taim yu spreim marasin.
- Yu no ken kaikai, dring o simuk pastaim long yu waswas na senisim ol klos
- Bihain yu pinis spre, yu mas wasim spre pam, klos bilong yu na yu yet.
- Sapos yu pilim sik bihain long yu usim marasin, go na lukim dokta hariap tru. Yu mas tokim em stret nem bilong dispela marasin yu bin usim.

Gutpela wei blong toromoi pipia marasin
- Ino ken kapsaitim hap marasin o wasim spre pam klostu long wara bilong dring.
- Bagarapim o brukim na planim long graun ol marasin botol i pinis long en.

Wanem emi gutpela taim bilong kamautim kaikai bihain long spreim marasin
- Yu no ken rausim ol kaikai long garden inap long taim ol i makim long toksave long botol marasin.

[6] Acknowledge the Crop Protection Team: The National Agricultural Research Institute, Papua New Guinea

Safety gear for using chemicals

Nose masks

Safety glasses

Gloves

Overalls

Safety boots/ gum boots

Clean water and soap

[7]How to make home-made pesticides

What are home-made pesticides?

There are a number of native and widespread plants that have substances in their leaves, roots or wood which protect them from being eaten by insects. Home-made pesticides can be produced from these plants without expensive equipment. We call them *plant derived pesticides* or **PDPs.** Most PDPs are not as dangerous to people as commercial pesticides, and can be used without expensive protective clothing.

Photo 37: Ripe chilli pods

Equipment & materials

Materials needed:

· 1 medium size plastic bucket (~10L)
· Rubber gloves
· Wooden hammer/strong stick
· Plastic kitchen strainer
· Stick for straining
· Sprayer
· Clean water (preferably rain water)
· Piece of soap
· Chilli pods — 350g fresh or 70g dry pods or 1 tin-fish can of dry pods
· Neem seeds — 100g neem seed kernels or 120 dry seeds

Photo 38: Ripe neem pods

Making Chilli PDP

Steps in making chilli PDP are:

i. Put chilli pods into bucket.
ii. With a mallet or gloved hand pound or squeeze pods to a fine paste.
iii. Add one litre water (3 soft drink cans 330 ml in size) and rub mixture of pods and water between gloved hands.
iv. Add four teaspoons (20g) of soap flakes.
v. Leave mixture in bucket overnight or for one day.
vi. Pour liquid into sprayer through a strainer to remove dirt and large particles.
vii. Add water to make up to the knapsack carrying capacity.
viii. The liquid is now ready to spray the crops.

Photo 39: Young neem pods

[7] Acknowledge the Crop Protection Team: The National Agricultural Research Institute, Papua New Guinea

Making Neem PDP

Steps in making Neem seed kernel extract PDP

i. Take 100g/120 neem seed kernels.
ii. Grind or mesh the seeds to a fine paste.
iii. Pour 1 litre of water into a bucket and add paste.
iv. Stir the water and neem seed paste with gloved hands.
v. Cover and allow settling overnight or for 12hours.
vi. Pour liquid into a knapsack sprayer through a strainer to remove dirt and large particles.
vii. Add four teaspoons (20g) of soap flakes.
viii. Add water to make up to carrying capacity of knapsack sprayer.
ix. Liquid is now ready to spray crops.

Pesticide plants

PDPs	Scientific name	Region	Plant part used	Type of plant
Derris	*Derris elliptica*	Wet lowlands, below 600m	Roots, squeezed	Climbing plant
Neem	*Azadirachata indica*	Dry lowlands, e.g. Markham Valley or Central Province	Seeds, ground	Big tree
Chilli	*Capsicum frutescens*	Lowlands & highlands	fruits, mashed or powdered	Small cultivated
Pyrethrum	*Tanacetum cinerariaefolium*	High altitudes, above 2200m, e.g. Enga, Western or Southern Highlands	Dried flowers	Cultivated

Plants from which pesticides can be made

Photo 40: Neem flower & leaves

Photo 41: Pyrethrum flower

Photo 42: Derris tree

Photo 43: Derris bark

Photo 44: Derris roots

Summary

Weeds grow in any environment. They are found in gardens, pastures, in water, on trees and in all environments. Weeds compete with crops for water, nutrients and sunlight resulting from loss of yield. Weeds can be controlled by physical, cultural, mechanical, chemical (herbicides) and biological control.

Pests refer to mostly the bad insects and their larvae which feed and damage our vegetables. Insect pests can be controlled by physical, cultural, biological, organic and inorganic pesticides.

Plant diseases are hard to see or recognize at an early stage until the crop has been affected. Observing the visible symptoms indicate there is a plant disease problem. To control crop diseases, some of these include good cultural practices, physical control and using chemicals.

Safety when using chemicals for any farm use is very important. Chemicals must be safely stored away to avoid children from touching them. Wearing safety equipment is also very important when preparing to apply chemicals such as pesticides, herbicides or fungicides on crops. Being safe and taking note of safety regulations during chemical applications is also very important.

Plant derived pesticides (PDP) use is economical and safe for the environment and farmer use. Farmers are able to use resources in their surroundings to make PDPs to use on their crops to control insect pests safely.

Reference

Making your own Plant Derived Pesticides. Extension Series No. National Agricultural Research Institute. Papua New Guinea

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Plant disease images: http://en.wikipedia.org/wiki/plant disease_images

Crop pests images: http://en.wikipedia.org/wiki/crop pests_images

Section 2 Post Harvest Training

Introduction

Section 2 of this training focuses on Post Harvest knowledge and skills and delivered by Fresh Produce Development Agency staff. On many occasions, considerable proportions of the produce never reaches the consumer, incurring significant loss to farmers. The topics in this section will cover the important aspects of Post-Harvest practices that can minimize loss during the chain from farmer to consumer.

The topic illustrations simply show what Post-Harvest management practices look like and what the level of maturity is for:

- Commercial value and physiological value according to different market requirements,
- Indicators of maturity
- Time to Harvest
- Tools to use for harvesting fruit, vegetable or root crops
- Harvesting techniques depending on the type of crop yields
- Field handling covers, Selection and Grading, Sorting and Trimming
- Packaging- waxed cartons or cane baskets
- Storing of the produce in the right place
- Transportation

Topic 4 Post Harvest

Objectives

By the end of this topic you should be able to understand how to:

1. Reduce losses between harvest and consumption;
3. Extend the storage life of fruits and vegetables; and
2. Retain quality of fruits and vegetables;

Introduction

Post-harvest is the stage from harvesting of the produce to reaching the end consumer. In this stage the produce is harvested, washed, graded, packed and transported and handled by many people like the grower, transporter, wholesaler, retailer and the consumer for business.

Harvesting of the produce at the right maturity stage is important for longer shelf life. Harvesting immature fruits and vegetables would also affect the postharvest life of vegetables. To increase the shelf life of the produce, farmers need to void wastage and improve the quality.

Harvesting can be done either manually or mechanically. If improper harvesting and transporting methods are used, this will result in wounds, bruises and cuts on fruits and vegetables. The wounds provide entry for micro-organisms that reduce quality and also create openings for greater water loss particularly in leafy vegetables.

Photo 1: 5 months old bulb onions **Photo 2: Staked pumpkins ready for harvest**

Activity 1

1. Discuss in small groups the differences between super markets and wet markets.

Market requirement for maturity

There are two types of maturity that are relevant to market requirements.

1. Physiological maturity is the stage when the produce (fruit/flower/leaves) becomes fully developed; Examples: Over ripe tomatoes cracking and flowers forming on pak choi as shown below.

Photo 3-4: Overgrown pak choi flowering and over ripe tomatoes cracking

Note: Retail shops and wholesalers won't go for this kind of maturity as shelf life is short.

2. Commercial maturity is the stage when the produce is ready for market. This can occur before physiological maturity. Example: Tomatoes and English cabbage as shown below.

Picture 4-5: English cabbage and tomato at right level of commercial maturity for the market

Activity 2

1. Walk through your garden and identify and differentiate between levels of immaturity and maturity of crops e.g. youngest to oldest crops. List down the differences in a table

Harvest management practices

For proper harvest management practices, attention must be paid to maturity stage of produce, harvesting techniques, harvesting containers, harvesting tools, packaging and transport.

Maturity stage of produce

The right maturity stage of produce can be determined by indicators such as size, shape, and colour, size of pods filled, appearance and texture.

Produce harvested early may not have flavour and may not ripen, whereas produce harvested late may be too ripe and be fibrous (Bautista and Mabesa, 1977). Examples; Lettuce and capsicum at the right maturity stage, ready for harvest as seen in these pictures.

Picture 6: Lettuce ready for harvest

Picture 7: Capsicum ready for harvest

Harvesting techniques

The five main harvesting techniques are:

1. Harvest on the coolest part of the day – early hours of the morning or late in the afternoons are the best times to harvest.
2. Avoid harvesting produce that is wet from dew or rain. Wet produce will overheat when not ventilated and could be damaged.
3. Separate produce that are unfit for human consumption from high quality produce.

4. Always use clean equipment's and containers when harvesting.
5. Harvested produce must be put under shade to keep as cool as possible and protect from water loss until transport is available.

Harvesting tools for different crops

There are different harvesting techniques used for different crops.

1. Root and tuber crops include sweet potato, yam and cassava - Digging sticks and forks can be used to remove the soil. When digging, the stick or fork should be placed far from the root to loosen the soil and lever the tuber out of the soil.

Picture 8: Using a fork to harvest sweet potato

2. Vegetables including cabbages and broccoli - The use of short sharp knives for cutting stems and trimming in the field should be encouraged. Outer layer of leaves should be kept to protect product for the market.

Picture 9: Using sharp knife to harvest cabbage

3. Fruits including mangoes and pawpaw- Depending on the fruit trees, you will require picking poles for mango fruits or oranges . This kind of tool will prevent fruits falling to the ground.

Picture 10: Picking poles for harvesting mangoes

4. Bulb - Bulbs should be removed by hand from the ground.

Picture 11: Harvesting bulb onions with hands

Field Handling

1. Trimming - This process involves removing leaves, stems and other plant parts that are not required by the market from the produce .

Picture 12: Trimming cabbages ready for sale

2. Cleaning – Cleaning is done to remove dirt, dust, insects or visible parts infested by insects prior to being marketed.

Photo 13: Washing off radish to clean off dirt

3. Curing - This is a process where produce like root tubers and bulbs are kept in high temperature and humidity to extend shelf. Curing hardens the skin of the produce and is effective in reducing decay and water loss during storage or transit. Curing is done in the field or in curing rooms.

Picture 14: Curing bulb onions

4. Sorting - Sorting is done to remove damaged, bruised, and diseased; pest infested and deformed produce from the good produce.

Picture 15: Sorting out mangoes for the market

5. Grading - Grading involves sorting produce into uniform sizes, length, color and firmness for better market price.

Picture 16: Grading of vegetables for better market price

Packing

Packaging is done to assemble the produce in convenient units for transportation, marketing and distribution (Hassan 2010). Packing must be done to protect the produce during handling and transport. Choosing the right packing materials for the produce is important to avoid bruising and damage due, for example, to an increase in humidity. Natural materials like bamboo baskets and jute sacks can be used, as they are usually cost effective. But there can be disadvantages like lacking rigidity during transport. Plastic crates can be used for rigid transport, but they can be expensive.

Packing the right quantity in bags or cartons to prevent mechanical damage is important. If produce is packed loosely there are chances of vibration that can cause bruises. If produce is packed too tightly bruising can occur due to compression (Grierson, 1987).

Photo 17: Potato packed in bags

Photo 18: Capsicums packed in waxed cartons

Photo 19: Using plastic crates to pack corn

Pre cooling

Between harvest and consumption, it is important to have the produce at a cooler temperature to increase s life of the produce. By keeping the produce at cooler temperatures, it avoids loss of water from produce that could lead to wilting and shriveling.

To keep the temperatures low, harvest at early hours of the morning. Keep produce under shade after harvest and during transport. If possible, transport in refrigerated vans.

Picture 20: Precooling of vegetables

Storage

Vegetables may be stored temporarily for reasons such as awaiting transport to markets. In order to maintain quality before sale and consumption the produce must be stored in a cool store room. The storage life of vegetables is greatly extended by maintaining low temperatures in the storage place.

Vegetables should be cooled as soon as possible after harvest and then stored at the appropriate temperature.

Picture 21: Storage of vegetables for the market

Transportation

Several factors reduce quality during transportation;

- Bruising –this is caused by vibration of vegetables during transportation and rough handling during loading and unloading.
- Rough handling - when produce is handled repeatedly.
- High transit temperature (especially in the field, if not cooled immediately), poor or no packaging and bad roads.

Photo 22: Poor handling of round cabbage causing produce damage

Summary

To have quality produce, management of produce should be maintained from harvesting to the consumer by following a series of post-harvest practices:

- Harvest produce at the right maturity stage.
- Harvest produce using right equipment to minimize mechanical damage.
- Trim the produce to meet consumer needs.
- Clean the produce to remove dirt, dust and parts damaged by insect pests.
- Sort the produce and remove damaged, bruised, diseased, pest infested and deformed produce for better price.
- Pack the produce in right packing material and right quantity for handling.
- Keep the produce under shade or at cooler temperature after harvest.
- Store the produce at a cool place.
- Transport the produce avoiding damages due to temperature or bruising.

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Section 3 Basic Financial Management Training

Introduction

Basic Financial Management Training is provided by staff from FPDA. Improving rural vegetable farmers' financial management is fundamental to the success of any rural household. This is possible through awareness and training on money management and showing the rural farmers what money is, how to make money grow, how to save better for future circumstances and where to source credits for farm expansions. Credits are necessary if intended for good cause such as starting a business or making money work for farming families without unduly burdening the farming families. The skills of money management can be practiced when the rural farming families are literate in finances.

Financial management is very important if farmers are going to be profitable and expand their business operations. Money is a key resource for any business and it has to be managed well for the betterment of the farming household. Without proper money management it is possible that a business will fail.

The objectives of this section are to enhance farmers' capacity in money management. The section aims to increase farmers' knowledge on:

1. Record Keeping. This topic will show farmers the different types of records and the importance of keeping detailed records of all farm operations, both financial and physical;

2. Budgeting - Farmers will learn techniques on how to budget better and to follow their budget;

3. Savings - Farmers will learn why they should save, how to save and where to save;

4. Loans - Farmers should know why they need loans and make informed decisions if loans are necessary. They also need to know how they can access loans and what is involved in repayment.

These topics should guide the farmers to making informed decisions so they can better plan and manage their finances, thus improving farm business and their livelihoods.

Topic 5 Record Keeping

Objectives

By the end of this topic, you should:

1. Know the importance of keeping records;
2. Know the different types of records used;
3. Know how to keep records of income & expense;
4. Know how to keep records of farm physical operations.

Introduction

Record keeping is very important both in farm business and in farming households. In farm business it is very important that proper records are kept as a basis of meeting legal requirements and for effective management decision. Financial records and physical records of farm operations can also aid a farmer with loan applications.

Clear, adequate, accessible and relevant records provide the basis for both of these functions. To stay in control of money, it is usually necessary to write down what has been received and spent. Memory is not good enough for proper analysis. It is a common problem for most rural households, who treat income as disposable when it may be needed to meet business needs. Others have problem controlling the sale of goods on credit – that is when goods are delivered to a buyer, the buyer to pay at a later date.

Keeping a cash book to record income and costs (expenses) is helpful. A cash book will easily inform the farmer of past income and expenses which the farmer will use to make informed decisions for the present and also to use for cash flow budgeting for the future.

What sort of records should be kept?

1. **Financial records** include cash receipts and payments associated with all aspects of the farm business, including operating income and expenses and non – operating items such loans and payments of interest or tax. Capital contributions or withdrawals by owners will also be included.

2. **Non-financial records** will provide information that supports, explains and provides context for financial records. These could include a separate set of records for;

   1. Suppliers
   2. Customers
   3. Labour
   4. Staff time allocations to different activities
   5. Records of environmental conditions eg weather
   6. Physical production activity records such as use and maintenance records for plant and equipment
   7. Stock inventories
   8. Volumes of production, cropping records such as cultivation, planting dates, ,planting rates, fertilizer and chemical types and application rates, crop yields, crop quality.

Cash Recording

Cash recording is the recording of all cash transactions based on the use of a cashbook. All cash transactions fall into two categories, **Receipts** and **Payments**. You can have two separate books or one book with two sections.

Receipts

Cheques or money received in payment for the sale of goods, fruits and vegetables or livestock.

Payments

Payment includes details of payments for goods and services encountered by the farming household.

Cash Book

Develop a cash book to keep records of all cash income received from farm operations and all expenses paid to service providers and goods.

The Cash Book should include part (A) Cash Income and Part (B) Cash Payments

A) **Cash Income**
Date: Record the date of Income
Particulars: Record details such as sources of income and its purposes and quantity of produce.
Amount received: Record the total amount received from the sale of goods. Table 5.1 shows an example of record for cash income from sales of farm produce.

B) **Cash Payments**
Date: The date the transactions occurred.
Particulars: Record details of who the payment was made to and for what purpose.
Amount paid: Every payment, whether by cash, cheque or deductions is entered here. Table 5.2 shows an example of record for cash payments made.

The recording of cash income and payments depend on an individual. It requires self–discipline and commitment to record regularly. Cash records are required for cash flow statements or budgets. All the cash records of receipts and payments in the cash books are then transferred to developing a cash flow statement or budget monthly, quarterly, half yearly or annually for planning purposes.

C) **Non-financial records**

The third set of records that should be kept are non-financial records, such as production operations. Examples for a nursery and field operations are shown in Table 5.3 (A, B)

Table 5.1: An example of a 'Household Cash Income Record Sheet'

Month:	**July 2013**	**Incomes**							
Date	**Details**	**Total Kina**	**Vegetable (Kina)**	**Yams**	**Fish**	**Poultry**	**Cooked food**	**Trade store**	**Others**
1/7/13	Sale of 1 bag aibika	70.00	70.00						
5/7/13	Sale of 1 bag pumpkin	100.00	100.00						
8/7/13	Sale of cooked food (scone balls)	30.00					50.00		
9/7/13	Sale of cooked food (scone balls)	30.00					30.00		
12/7/13	1. sale of 2 bags (50 kg bags) of pakchoi 2. sale of 1 bag yam	400.00 300.00	400.00	300.00					
14/7/13	1. sale of 1 bag pakchoi 2. sale of 10 chickens sold @ K30.00 each	200.00 300.00	200.00			300.00			
15/7/13	1. sale of 6 chickens @ K30.00 each	180.00				180.00			
16/7/13	1. sale of 8 chickens @ K30.00 each 2. sale of cooked food (scone balls)	240.00 46.00				240.00	46.00		
17/7/13	1. sale of 12 chickens @ K30.00 each	360.00				360.00			
17/7/13	2. Gift from son in the city	200.00							200.00
18/7/13	1. sale of 4 chickens @ K30.00 each 2. sale of 1 bag aibika	120.00 67.00	67.00			120.00			
20/7/13	1. sale of cooked food	40.00					40.00		
25/7/13	1. Sale of 1 bag pakchoi	200.00	200.00						
Total for Month		**2683.00**	**1037.00**	**300.00**	**0.00**	**1200.00**	**166.00**	**0.00**	**200.00**
Previous total brought forward		**860.00**	**540.00**	**0.00**	**0.00**	**0.00**	**120.00**	**0.00**	**0.00**
Cumulative total carried forward		**3743.00**	**1577.00**	**300.00**	**0.00**	**1200.00**	**186.00**	**0.00**	**0.00**

Table 5. 2: An example of 'Household Cash Payments Record Sheet'

Month	**July 2013**	**Payments**												
Date	**Particulars**	**Total**	**Production cost**	**Marketing cost**	**Food items**	**Hygiene accessories**	**Education**	**Clothes**	**Communica tions**	**Medical fees**	**Alcohol, cigarette**	**Customs**	**Wantok**	**Livestock**
1/7/13	1. transport cost & gate fee	10.00		10										
	2. purchase of food items	50.00			50.0 0									
	3. school expense	5.00					5.00							
	4. flex cards	5.00							5.00					
2/7/13	1. food	10.00			10.0 0									
	2. education	5.00					5.00							
	3.wantok	20.00											20.00	
	4.customs	50.00										50.00		
4/7/13	1. education	5.00					5.00							
7/7/13	1. Transport & gate fee	10.00		10.00										
	2. food	30.00			30.0 0									
	3. education	5.00					5.00							
	4.flex	5.00							5.00					
Total for month		**210**	0	20	90	0	20	0	10	0	0	50	20.00	
Previous total brought down		**350**	50	40	130	20	40	50	20	0	0	0	0	
Cumulative total carried forward		**560**	50	60	220	20	60	50	30	0	0	50	20	

Table 5.3 An example of a non-financial record: '(A)Nursery and (B) Field Operations Records'

A) Nursery operations for 1 year

Cropping Code	Date seed sown /planted	No. of seeds or trays sown	Date seed germinated	No. of seeds or % germinated	Nursery medium used	Other comments & observations

……

B) Field operations for 1 year

Crop planted	Area planted	Date of planting	No. of seedlings or trays planted	Fertilizer application date & rate	Fungicide application date & rate	Insecticide application date & rate	Other comments & observations

Summary

Key points to remember:

- Keeping records of all farm operations, as both financial and physical records will provide guidance and insights for the farmer to use when making sound management decisions.
- Keep records of money received through sales of farm produce and a separate record for payments made on a daily basis.
- Keep both records of household income and expenses and farm income and expenses.
- Physical records are equally as important as financial records.

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Topic 6 Cash Account Budgeting

Objectives

By the end of this topic, you should be able to:

1. Understand what a budget is;
2. Appreciate the importance of a budget;
3. Create your own budgets.

Introduction

Budgeting is a very fundamental function in finance and money. This topic will show you what a budget is, why it is important to budget and how you can create your own budget. Budgets come with goals to achieve which will help in good financial management.

What is budgeting?

Budgeting is planning income and expenses in a period which acts as a guide for individuals, families and businesses to make better informed decisions about their finances. To change the way you handle money is to budget.

A good plan on how to use income will help you build wealth. A person who budgets will have control over their finances which will allow them to make financial decisions at the very beginning. When you budget well you will be able to reach your financial goals more quickly and avoid or minimize debt. Pproper budgeting doesn't require that you spend less, however it will help you make more effective financial decisions.

Why is budgeting important?

Budgeting is important because it helps you control what your money will do for you. By assigning each Kina to a category e.g.vegetable farm budget, you are controlling where your money goes and what it does. This will help you to begin to reach your financial goals.

Budgeting can be both done in business settings and personal settings.

Vegetable Farm Budget

In a vegetable farm budget, farmers will plan how they will use their available finances for farming expenses. A good budgeting technique is doing a budget on a crop base that is suitable to farmers' locality. This budgeting process is normally done at the end of the year for the next year, or beginning of a crop production cycle, whatever period is suitable to the farmers.

There are two categories of cost in vegetable business that are critical to cash flow. These are growing and marketing costs. There are other costs – called overhead costs – like depreciation (loss of value) of machinery, but these are not considered in this topic.

Growing costs are all costs that are required in producing vegetables. This includes cost of seeds and planting materials, labor cost in land preparation and transplanting or planting, weeding and pest and disease management. Central Province and other areas with similar climate are prone to drought during the dry season, therefore irrigation is very important and vegetable farmers need to cost this out.

The second part of the cost of vegetable farm business is the **marketing cost**. Marketing costs cover all the costs involved in taking the produce from the farm site to where the consumers are. The cost of marketing vegetables to distant markets in the cities such as Port Moresby includes harvesting and packaging, transport, communication, handling, market commissions, gate fees and spoilage cost.

Table 6.1 An example of 'Vegetable Farm Income and Expense Budget'

Crop: Tomato (crop spacing is 90cm x 50cm)
Area: 2500m^2. 4000 plants planted in this area.

Income (6 tonnes or 6000kg @ K3.00/kg	**K18,000.00**
Expense	
Seeds (500g)	K250.00
Nursery practices (soil sterilization, composting watering and general husbandry practices)	K 150.00
Land preparation (slashing, ploughing, harrowing @ K0.50/m^2 for 2500m^2)	K1250.00
Transplanting or planting (10 men for 30 hours @ K3.00/hr)	K900.00
Stalking (10 men for 40 hours @ K3.00/hr)	K1200.00
Weeding (10 men for 30 hours @ K3.00 /hr)	K900.00
Pest & disease control	K180.00
Irrigation (Hire of water pump and fuel)	K450.00
Harvesting (10 men for 20 hours @ K3.00/hr)	K600.00
Sorting, grading & packing (5 men for 20 hours @ K3.00/hr)	K300.00
Packing Box (300 boxes @ K5/box)	K1500.00
Transport Cost (300 boxes @ K5/box)	K1500.00
Markets fees & commissions	K700.00
Communication cost	K100.00
TOTAL COST	**K9,980.00**
Gross Income: (Income – Expense)	**K8,020.00**

Personal Budget

In personal budgeting, individuals of each household who are the main money managers can make a plan of their income related to living expenses. A well thought out plan of income against all household expanses will enable a person to have control over where he or she spends the income. A good budget will guide the individual to spend within what he or she has planned thus minimizing debt to achieve financial goals. The idea is to have a workable budget and to stick to it as much as possible.

Budgeting can be made easier if you list all expenses. This will help you keep track of the expenses and make you cut unnecessary expenses.

Figure 1-2: Create a budget for your self

How do I create a budget?

The simple steps below will show you how you can create your own budget.

Identify you goal

What are your financial goals? Do you have debts you need to pay off in order to minimize the debts you have? Are you dreaming of owning a car, sending your children to university or owning a business? This is the time you need to identify a goal. Without a goal, you will not achieve what you could in your future lives. Budgeting can be short term, medium term and long term. Short term goals can range from 1 month to 1 year, medium term from 1 year to 5 years and long term can be over 5 years.

SMART Goals

You should set SMART goals.

S - Specific – be specific about your goals.
M - Measurable – Is it measurable? Quantifying it is better than being vague.
A - Achievable – set a goal that you will achieve given the strengths that you have.
R - Relevant – be realistic and set real goals that you can achieve.
T - Time bound – set a time frame for your goal so you work towards achieving it.

Figure 3: Setting SMART goals will guide you to save better.

Budgeting can involve tough choices, but if you have set yourself smart goals, it will make budgeting a little less painful.

Example of a farmer setting a smart goal would be:
1. Short term goal: By the end of this year, I will save K1000.00 to visit my Dad
2. Medium term goal: By 2017, I will save K6000.00 to send my son to university
3. Long term goal: By 2020, I will save K30, 000 to buy a tractor.

When setting goals, it **is important that you set the time in which you want to realize your goal, what is it that you want and value of your goal so that this will guide you to achieve your goals.**

Where your money is going

Do you find yourself running out of money before you realize you have nothing left? Do you wonder how and where all of your money went? If you have no idea how all of your money disappeared, it is good to make a list of all your spending. Before you can manage your money, you have to know how you're spending it. Make a list of all expenses in a month to track. Get in the habit of recording your expenditures once a day.

Separate the expenses into three categories.

1 Fixed Needs – Necessary expenses that stay the same from month to month, e.g., rent, phone bill, school fees
2 Variable Needs – Necessary expenses that may vary from month to month, e.g., fuel, food
3 Wants – Non-essential expenses are items that are not very essential and ones which you can forgo e.g. parties, eating out, electronic items, new clothes.

Expenses categorized in such manner will make budgeting much easier where expenditure can be cut back in areas that are not necessary.

In the budget, include a monthly savings goal as an expense. It is much easier to save money if you've planned for it in your budget. And it's important, too: if you run into unforeseen expenses, you'll want to be able to pay them without going into debt. And even if nothing goes wrong, having some savings will help you follow your dreams in the future.

Where your income is coming from

Income is money that you receive through various money generating activities such as sale of farm produce, sale of fish, livestock, trade store goods or from salary if you are employed. A farmer receiving a loan can also be classed as income and income may also include gifts from families. It is better to list all the activities that give good income. An example of a table of income and what it is used for is included in Table 6.1. Table 6.2 shows an example of a budget – which puts values on each income and expense item, and shows how much money can be saved.

Table 6.1: An example of 'Rural Household Income & Expenses'

Money comes from (Income)	Money is used for (Expenses)
Income from sale of garden produce	Day to day household costs (food, clothes , ceremonies, school fees, gifts to church)
Income from sale of fish	Day to day farm costs (seeds, pesticides, labor etc.)
Income from customs (bride price)	Large one off household cost such as building or repair to house , big ceremonies, school fees etc.)
Income from loan	Buying a tractor
Gifts from families	Special treats or luxuries

Keeping track of your income will also help boost your morale, and you can look for opportunities in which income can be increased.

Activity 1

1. Make a list of all your expenses and income for a fortnight, month and year.
2. Create your own budget by using the budget format included or you can create your own
3. Set yourself smart goals. Goals will help you to stick to your budget.

Table 6. 2: An example of a budget from a Village Farmer

My Budget: ……………………………………………………………….

Date: ……………………………………………………………………….

INCOME (MONEY IN)

Description of Income	**Fortnightly**	**Monthly**	**Yearly**
Sale of garden produce	50.00	108.33	1300.00
Sale of fish	150.00	325.00	3900.00
Sale of livestock	50.00	108.33	1300.00
loan			
Gifts from wantok	20.00	43.33	520.00
Total Income	270.00	585.00	7020.00

SAVINGS = Total Income – Total Expenditure

Fortnightly Savings: ……………………….K54.00……

Monthly Savings: ……………………….K117.00………

Yearly Savings: …………………………….K1404.00……

EXPENDITURE (MONEY OUT)

ITEM	**Fortnightly**	**Monthly**	**Yearly**
Food	80.00	173.33	2080.00
Energy	5.00	10.83	130.00
Rent			
Clothes	5.00	10.83	130.00
Fuel			
Lunch	5.00	10.83	130.00
Bus Fare (transport)	10.00	21.67	260.00
Phone/flex	5.00	10.83	130.00
Cost of farm inputs	40.00	86.67	1040.00
Livestock			
Entertainment			
School lunch & cost	20.00	43.33	520.00
Wantok	5.00	10.83	130.00
Customary	10.00	21.67	260.00
Church	27.00	58.50	702.00
Unexpected costs			
Savings	54.00	117.00	1404.00
Others	4.00	6.50	104.00
TOTAL EXPENDITURE	**270.00**	**582.82**	**7020.00**

Cash Flow Budget

Cash flow budget is a valuable tool one can use to monitor cash coming into the household and going out through payments for goods and services. A person who keeps track of the cash flow is able to predict problems and take avoidance actions.

Table 6.3e below shows an example of a cash flow for the three first months of a year.

Table 6.3: HOUSEHOLD CASH FLOW STATEMENT for January to March 2013

Name of family: ………………………...Name of Village ……………………………………

Income	**January**	**February**	**March**	**Total**
IGA 1: Vegetables	200	140	200	540
IGA 2: Fruits	500			500
IGA 3: Root crops	230		300	530
IGA 4: Chicken	800	800	800	2400
IGA 5: Banana	150			150
Other income: gift from wantok		300		300
(A)TOTAL INCOME	1880	1240	1300	4420
Deduct				
Expenses (Money family used)				
1. Food	250	300	300	850
2. Soap & others	60	60	60	180
3. Electricity o kerosene	60	60	60	180
4. Transport cost	60	80	40	180
5. Clothes	20	200		220
6. School fess & other education costs	80	60	100	240
7. Beer, gambling, smoking & betel nut				
8. Other household goods	150			150
9. Building & renovating house				
10. Community obligations (bride price, funeral etc)	200		50	250
11. Church work (10% of total income)	188	124	130	442
12. Wantoks as gifts	50		50	100
13. Communication costs (flex cards & top ups)	30	30	30	90
14. Loan repayment	200	200	200	600
15. Savings (20% of total income)	376	248	260	884
(B) TOTAL EXPENSES	**1724**	**1362**	**1280**	**4366**
(A-B) MONEY LEFT surplus/(deficit)	156	(122)	20	54
OPENING BALANCE	210	366	244	210
NEW CLOSING BALANCE	**366**	**244**	**264**	**264**

Summary

Key points to remember:

- Make it your habit to record all expenses and income on a daily basis. This will help you to keep track of your expenses and to budget for the future.
- Have a SMART goal which can be a motivator for your savings.
- Include savings as an expense in your budget.
- Always remember that a cash flow budget will project to you the cost and income in a period of time, whether quarterly, half year or yearly.
- Categorise your expenses into fixed, variable and wants. Budget for the fixed and variable and try to save on the wants.

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Topic 7 Savings

Objectives

By the end of this topic, you should be able to:

1. Understand what saving is;
2. Know the importance of savings;
3. Know how to save better; and
4. Where to save your money.

Introduction

Rural farmers in the Central Province and other parts of PNG, need skills to guide them to save to realize their dreams. It will all start when farmers understand the need for savings for future expanses. Not only will they understand the need for savings, but make plans on how they will save and where exactly they are going to save. These are some of the areas that the farmers will be shown in this topic, which will inform them about plans for savings for future expansions of their farm or other bigger costs that are unaffordable now.

What is saving?

Saving is setting aside some percentage of your income for later use, especially for things you are unable to afford now or putting aside money for future use, such as sending your children to university, or wanting to buy a house or a car or even starting a business. In today's society, you will hear people talk about savings, but do they really save. Everyone knows it's smart to save money in the long run, but many of us still have difficulty doing it. Smart money-savers not only need to save but they also need to consider how to spend the money they *do* have, as well as how to maximize their income.

Figure 1-2: Save a portion of your income each time and you will be surprised how your money will lead to your destination.

Why do you need to save Money?

For many, they say life is short so live for the day. That can be true; however are you truly happy living for each day as it comes? Do you have enough to send your children to school, buy your dream car, or even have sufficient money at the time you need it if an unexpected thing happens, such as an illness that requires money for treatment? These are times you need extra cash that you have tucked away. Saving a little each time will ease your anxiety and your stress level during ‘rainy days’ (days when things don’t go to plan).

Activity 2

1. Write in your note books some of the reasons why you need to save.

Reasons for savings

How can you be a smart saver?

As mentioned earlier, many people will say save money now for the future, but do they really practice what they say. The steps below will show you how you can save better. To start thinking about savings, you need to set realistic SMART goals and keep all spending in check.

Figure 3: Savings that can ease your burden of worrying about tomorrow.

Pay yourself first. Before you spend or do anything with your income, the first thing you need to do is to pay yourself. As soon as your money lands in your hands, you need to find a way to pay yourself first. That is, saving some percentages of your income first in your savings account where you can’t get ready access to it. People who have paid jobs with regular fortnightly income should open a separate savings account and arrange for a direct automatic transfer of the amount nominated. This will ease the temptation of using all of the money.

For village farmers, and those who do not have regular fortnightly income, it is wise to stick to your budget. The percentage nominated for savings should be set aside for deposits into a savings account. Decide on a specific cash amount to manually deposit into a savings account each month and stick to your goal. In order to help you save better, try follow this simple rule and you will be surprised how easily it works.

Follow this simple rule when budgeting and saving:

1. **Save 20% of your income. This must be the first thing once you have cash in your hands.**
2. **10% of your income should be for church activities or other valued regular activity.**
3. **70% of your income should be used for other expenses.**

Figure 4: Open a savings account and save 20% of your income

Where can you save?

There are two options for rural village farmers to save;

1. Save with informal savings: **Informal savings** is saving money with small, unregulated savings options such as voluntarily saving at home in piggy banks, or carrying money around in bags or at home in secret places where other people cannot steal from.
2. Save with formal savings: **Formal savings** is saving money in bank accounts or through savings and loan societies which are regulated financial institutions.

Examples from each of the two are given together with their advantages and disadvantages in Tables 7.1 and 7.2 below.

Table 7.1: Some examples of formal and informal savings.

Examples of Formal savings	Examples of Informal Savings
• Savings account at a commercial Bank • Savings account in a micro bank • Savings in interest bearing deposits	• Penny box (Piggy banks) at home • Carrying in bilums and wallets • Hiding in the house under beds etc. in secret places • Giving to relatives or trusted person to keep safe

Table 7.2: Advantages and disadvantages of formal and informal savings

	Formal savings (Banks)	Informal savings
Advantages ☺	• Safe keeping • Accumulates interest • Easy access to loan against savings	• Easy access when required • No account opening requirements
Disadvantages ☹	• Not easily accessible • Account opening requirements that is not friendly for village farmers • Limited access to the banks	• Not safe to keep at home • No interest • No growth plan • No control over spending due to easy access

Where can savings be made?

By analyzing the advantages and disadvantages of formal and informal savings, you can see that it is better to save formally with banks. Savings in banks and other regulated financial institutions will give you the opportunity of earning interest on your money. Similarly, the money is kept safe in the banks than being at risk of theft and damage if kept at home.

Examples of some commercial banks in Papua New Guinea where savings can be made include the Bank of South Pacific (BSP), ANZ and Westpac. Micro-banks include Nationwide Microfinance, PNG Micro-finance and Women's Micro Bank . You need to shop around to identify a bank that gives good interest for your savings. All banks are different and a thorough assessment will guide you to save your money in the best place.

Other places that you can save money include savings and loan societies. If you are a member of any of these societies you can save. Also it is good to thoroughly study their products and requirements and go for the one that suits you most.

Some examples of PNG's financial institutions that farmers use to either save or borrow money.

Figure 5: Bank of South Pacific (Source: Bing image)

Figure 6: ANZ Bank has branches nationwide in major provincial centers. (Source: Bing Image)

Figure 7: National Development Bank provides loans to farmers and any other SME. It has branches nationwide (source: Bing Image)

Figure 8: Nationwide Microbank has branches in all provincial centers (Source: Bing Image)

Activity 3

1. Do some research and identify a bank that best suits your savings requirements.
2. Open a new savings account.
3. Start saving money by depositing 20% of your total income each fortnight or month.
4. Remember to stick to your goal!

Figure 9: open a savings account and save up to 20% of your income

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Summary

Key points to remember:

- Have a SMART goal to follow when saving.
- To achieve your savings goals, pay yourself first.
- 20% of your income should go to savings, 10 % for church, for example and 70% for other expenses.
- Make sure you shop around and identify saving options that best suit you.
- Remember to open a savings account and arrange for automatic deposit if you are receiving regular income.
- If you are self –employed and receiving cash, make sure to stick to your goal and deposit into your savings account every month.

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Save Your Money. www.wikihow.com/Budget_Save Your Money

Topic 8 Loans

Objectives

By the end of this topic, you should be able to:

1 Understand the difference between formal and informal credit;
2 Understand the different language (words) used by formal lenders;
3 Understand well the requirements of getting a loan; and
4 Calculate the repayments for a loan.

Introduction

This topic will give information on how you can make informed decisions when it comes to getting a loan. A loan can be risky if you do not have plans on how it can be used and repaid. In this topic, farmers will be introduced to what credit is. A loan is not a grant or gift; it comes with obligation for repayment which is tied with interest. Farmers who want to get loans should have plans on how to use the money so that it does not be a burden, but will generate income to finance the repayments. This topic will show farmers how to get the loan and where to get loans at interest rates that are lower. Loans can be obtained formally and informally also covered in this topic.

What is a loan?

A loan is money you receive from financial institutions or other people which you agree to pay back with interest at a later time, often consecutively until repayments are done. People borrow because they do not have enough money to afford the cost of goods and services they require at that time.

Why do you need a loan?

People get loan for various reasons. Some borrow to improve their income and improve livelihood, while others borrow for leisure or non-essentials goods – and that can make families worse off. Borrowing to improve farm outputs and income is a fair reason for borrowing because it is making families better off. Farmers who want to expand their farms but do not have sufficient money can obtain loans to finance their farm expansion.

Figure 1: Don't let loan be a burden to you but use it to generate more income

Do you really need a loan?

Before you decide to get a loan, you should firstly make plans on you how you will use the loan. Borrow money if the borrowing is going to be used to fund expenses that will earn more money in the future. Loans are not handouts. They are accompanied with obligations and responsibilities.

What are the requirements of getting a loan?

Different banks and financial institutions have different loan requirements and loan products to suit different needs. Most commercial banks would require some form of security before they will approve your loan. Banks will not just lend you money instantly. They will require you to make plans on how you will use the loan. Some of the plans they require will be your business plan and marketing plan including the cash flow projection of the farm project that you want to venture into. It is wise to research the various banks and financial institutions on the loan products they have and their requirements and only get loans from the banks with which you are most comfortable. Ask people who have obtained similar loans as you are seeking about the experiences they have. They might give you good information that can be helpful.

Requirements for a loan application

Here are some examples of information that lenders may ask for when you apply for a loan. Not all lenders require all these things.

- Records to show what income you have had in the past.
- Records to show past expenditure (receipts)
- Identification
- References of your character from an approved person
- A cash flow budget
- A business plan
- Security (collateral) or a deposit
- Approval from the appropriate authority to run your business (if necessary)
- Completed loan application form

How to keep records necessary for a loan application

Keep all the records of past income in a folder to use if you need to show how much income you have received and how much you have spent. Savings records are also useful to show a good savings habit and regular payments.

Examples include:

- Sales of produce sold to a store, a supermarket, processor
- Receipts for expenditure
- Wages records
- Savings passbook
- Bank statements

Keeping a cash book to record income and costs (expenses) is helpful. A cash book tells you what your income and costs have been in the past that can be helpful in estimating future income and costs for a cash flow budget.

Where can you get a loan?

There are two credit options available to village farmers. Loans can be obtained formally or informally. Tables 8.1 and 8.2 below will distinguish between formal and informal loans and their advantages and disadvantages.

Table 8.1: some examples of loans from the formal and informal sector

Examples of formal loans	Examples of informal loans
• Loan from a bank • Loan from savings and loan society • Loans from credit scheme(seed funding or district credit scheme)	• Money lenders • Loan from wantok (family members) • Obligations • Buying things on credit

Table 8.2: Advantages and disadvantages of formal and informal loans

	Formal credit	Informal credit
Advantages ☺	• Interest rates are much lower than the informal • Give higher loan amount, thousands of kinas for bigger projects.	• Easy access, no requirements
Disadvantages ☹	• Strict loan application requirements which often discourages small farmers • Have collaterals to obtain loans	• Interest rate are too high, over 40% on short term • Do not give bigger loans, especially over one thousand kina

Formal loan is borrowing from banks and recognized financial institutions. The credits given are not handouts and repayments must be done on set time periods. Penalty fees and account maintenance fee apply and the system will fail if you don't pay back the loans. Only use credit

- If you can repay the loans
- If the loan is used to improve your farm and livelihood
- If you understand the terms and conditions of formal credit.

All micro banks and some commercial banks in Papua New Guinea give credits to village farmers and people outside the formal employment or formal business sector. If you are thinking about getting a loan to expand your farm business, it is better to do research and find out from the various banks in PNG that give loans at a competitive rate and which suits your needs. In order to get a loan you need to firstly open a savings account with a financial institution that rewards you with good saving interest rate plus low interest for loans. The savings you have can be used as collateral against the loan.

Loan repayment

The exercise example on loan repayments will give you some understanding on how repayments are calculated on a flat interest rate.

For Example:

A vegetable farmer wants to take a loan to expand the vegetable farm to supply to a new market. The cost of expanding the vegetable farm is projected at K3000 as starting capital. Due to financial constraints, the farmer can't afford to expand, so wants to get a loan to fund the expansion.

The farmer then approaches a rural bank that gives loan to similar small farmers with similar cash flow budget, and provides the bank with a loan application for loan of K3000. The bank then approves his loan and he gets K3000 loan on a flat interest rate of 10% pa. The term of the loan is 3 years. Repayment will start after 3 months when he starts to sell his vegetables. The calculations below will show you how he repays the loan over 3 years.

What would be the repayment for this vegetable farmer?

- Principle amount = K3,000.00
- Term of the loan = 3 years = 36 months
- Flat interest per annum (year) = 10 % of K3,000.00 = K300.00
- Flat interest for the term of the loan = K300 x 3 years = K900.00
- Total to repay = Principal + flat interest = K3,000.00 + K900 = K3900.00
- Loan repayment per month = K3900.00 ÷ 36months = K108.33 per month

He would repay **K108.33** per month for **3years.**

Terms used in applying for loans

Some terms or words used when applying for loans are summarised in the table below.

Table 3: Terms used when applying for a loan.

Terms Used	**Meaning**
Interest	Extra amount paid on top of amount borrowed based on a % rate. Two types of interest used in loans i) Flat interest – interest is paid on the amount borrowed for the period of loan ii) Simple interest - interest is paid only on the amount of the loan that is still owed so the amount of interest reduces as the loan is repaid.
Interest rate	Interest is expressed as a percentage, usually per month or per year (annum).
Principal	The principal is the amount of money you borrow at the beginning. As well as paying interest you have to pay the principal back.
Loan repayments	Loan repayments are the total of interest and principal together. Repayments are usually divided into regular time periods.
Loan term	The loan term is the number of months or years that you take the loan for.
Fees	You will usually have to pay other charges for borrowing money, as well as interest. These other charges are called fees. There are different types of fees. Examples are loan fees, stamp duty, fees for using cheques, fees for withdrawing savings, and fees for late repayments.
Default penalties	You pay the lender more money if you don't make your repayments regularly. This is called a default penalty (or default fee).
Arrears	If you stop repaying loans, you would be in arrears.
Collateral (security)	Security is sometimes required as a requirement for loan in terms of assets (savings, deposits, land, house or vehicle.)
Grace period	Sometimes you don't have to start repaying the loan immediately after you take the principal. You might be allowed a 'grace period' until you have to start repaying.
Terms and conditions	The requirements you have to meet when borrowing the money from formal lenders.

Summary

Key points to remember:

- A loan is not a handout. It comes with obligations. Loans have to be repaid with interest.
- Only get loans if you are going to expand your farm or improve your families' livelihood. Loans to fund entertainment and leisure can make families worse off.
- Farmers are encouraged to get loan from banks and regulated financial institutions who have a lower interest rate compared to informal loans.
- Get information on the various loan products from different financial institutions before you decide to get a loan.
- Formal banks would normally have requirements that you will have to meet before they approve your loan. Remember to submit all their requirements together with the loan application when applying for loan.
- Keep necessary records such as savings records, receipts from sale of produce etc. for loan application
- Get yourself familiarized with the monthly repayment calculations and scheduled.

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Relevant Press Articles

Central farmers acquire new skills

The trainees and course facilitators after the graduation.

A GROUP of farmers from Central province attended a week's training at the National Agricultural Research Institute's (NARI) Laloki station, outside Port Moresby last week.

The training facilitated by NARI also received input from other project partners like the Tasmanian Institute of Agriculture, University of Canberra, Fresh Produce Development Agency and the Pacific Adventist University.

The Central Province Vegetable Project is an Australian Institute of International Agricultural Research (ACIAR) funded project started in 2009 by NARI.

An extension specialist from the Tasmanian Institute of Agriculture in Australia, Gomathy Palinappan, was also a trainer and observer in the course focusing on marketing and value chains in agricultural enterprises.

NARI studies have shown that soil and climate conditions at Rigo/Koiari low altitude, Sogeri/Koiari mid altitude and Tapini's high altitude were suited to grow quality vegetables in large quantities for the city market.

The 25 men were selected from Rigo/Koiari, Sogeri/Koiari and Tapini representing the lowlands, mid and high altitude parts of the province.

A similar training was conducted for women in Rigo/Koiari, Bautama and Sogeri in May last year while the women farmers from Goilala district are being trained this week. Their training and ends tomorrow, Aug 16. Barbara Chambers from the University of Canberra who is the overall women and youth coordinator of the project is here this week monitoring and evaluating the training.

The training is a follow up on the needs analysis workshop conducted last September and May this year by the Vegetable Project Team comprising staff from NARI and its partners.

NARI agronomist and training facilitator Philma Seta-Waken said results from research trials so far in the low altitude (Laloki), mid altitude (Sogeri) and high altitude (Tapini) show that there was a huge potential for growing vegetables in these three locations.

"I am confident that Central province can supply the demands for the Port Moresby markets but of course when there are proper road infrastructure, transport and cooling facilities and markets."

She said the availability of transport services, cooling facilities and markets would boost the morale of farmers to produce for both commercial purposes and also to provide nutritious food for their families."

The training included financial literacy, crop management, post-harvest and marketing. During the week's training, Nationwide Micro-Bank, Bank South Pacific and Brian Bell staff also made presentations on how they could assist in banking, farming equipment and seed supplies. Some of the farmers opened savings accounts with BSP Rural.

In addition, information was also provided by business houses such as the PAU Farm and Island Breeze Ltd on services that could be of help to the farmers. NARI principal scientist Rosa Kambuou told the participants that the knowledge they had acquired should be passed on to other villagers who might want to learn and adopt the skills. She also urged the farmers to form a network to share and exchange ideas in their work.

FPDA's Mark Worinu, who flew in from Goroka to attend the graduation, said the Central Province Vegetable Project was something new happening in an area where FPDA has had very little work done in.

The farmers have been urged also to make use of their knowledge and with the right transport and marketing facilities provided, the fresh produce brought in from the Highlands of PNG and even imports.

NARI agronomist and course facilitator Philmah Seta-Waken and Sebaa Baina of Rigo Koiari, one of the trainees who graduated.

Central DAL advisor Kila Gege speaking to one of the trainers Gomathy Palanappan of the Tasmanian Institute of Agriculture after the graduation ceremony at Laloki last Friday.

Project to continue

SOME time soon after independence two to three plane loads of fresh produce from the Goilala mountains were delivered to Port Moresby city daily.

Produce such as citrus fruits, and high altitude vegetables along with Arabica coffee made their way to the city markets and farmers in the Goilala district enjoyed a steady income for some time.

That was in the 1979, when agriculture and livestock functions in provinces were controlled by the Department of Agriculture and Livestock. With assistance from German development partner, GTZ Goilala farm produce were flown to the city markets daily.

However, when under the government's decentralisation process, these functions were transferred to the provincial government, a lack of funding became a real obstacle and flights by light aircraft from Tapini to Port Moresby became less and less frequent.

That was when farmers saw no incentive to produced large quantities for outside markets.

Central province's agriculture and livestock advisor Kila Gege was a young didiman then working at Tapini in the Goilala district and was part of the success in agricultural activity there.

Gege recounted his experiences to a group of vegetable farmers from Central province who completed a week's training at the National Research Institute's low land station at Laloki, outside Port Moresby last Friday.

The training was part of the Central Province Vegetable Farming Project started in 2009 by NARI with funding from the Australian Centre of International Agricultural Research (ACIAR).

The project winds down this year but due to the potential in the province, Gege gave an undertaking on behalf of his administration to continue it.

"We would like the project to continue. We have allocated money but need to identify what specific areas to fund," Gege said.

Gege also said that the Central province farmers had missed out on a golden opportunity to supply vegetables to the LNG Project which was already scaling down its construction-related activities.

He said the government had forgotten farmers in the allocation of business support grants for local entrepreneurs.

Goilala women farmers trained

WOMEN vegetable farmers from Goilala district of Central completed a week long training at the National Agriculture Research Institute (NARI) Southern Regional Centre at Laloki and graduated on Friday Aug 16.

This training of trainers was a follow up from the Central men's training completed earlier this month and is also the final for farmers in the target communities of an ACIAR funded Central Province Vegetable Project. The project is facilitated by NARI and its project partners Fresh Produce Development Agency, Pacific Adventist University and partners from Australia, Tasmanian Institute of Agriculture and the University of Canberra.

The women farmers were trained in basic financial literacy, crop management, post harvest and marketing techniques as these were the priority needs identified by them during a needs analysis workshop conducted in May this year.

These women farmers are from the high altitude environmental conditions in Central where they can grow temperate vegetables to supply the ever increasing population and demand in the Port Moresby markets.

The farmers had the opportunity to be introduced to several business houses like the Pacific Adventist University Farm and Island Breeze Ltd, a locally owned business aimed at helping farmers transport their vegetables and finding the markets for them in Port Moresby.

The farmers were also given the opportunity to open accounts with the Nationwide Microbank and BSP Rural as well as learn about some of services they provided to farmers and little business people. The Agriculture section from Brian Bell Ltd were also present to sell seeds, agricultural chemicals and tools to the farmers.

During the training, the farmers expressed that their environment was conducive for different vegetables and food crops to grow, however, a lack of roads, transportation and a cooling facilities were the biggest obstacles in the production of vegetables, and urged the proper authorities to hear their cries.

Farmers being introduced to the drip irrigation system and rope and washer pump during crop management

Veronica Briggs, a participant in the training said, "We the mothers and womenfolk in Goilala are hard working people, we can grow the vegetables to supply the market, but we have no proper services in our district to convince the Goilala people to go big in production."

Briggs said the women were very happy that they had attended this very informative has enhanced their k they would go back a women and men in th ties.

Rudd's parting praise for little-known seed group

By Australia Network political editor Catherine McGrath (from ABC News website)

Updated February 28, 2012

Photo: A field research officer works on an ACIAR-funded farm in Papua New Guinea. (ACIAR)

When former foreign minister Kevin Rudd spoke at his press conference after his defeat in the leadership ballot, he thanked family, key supporters and Government agencies he had worked with in his term.

He singled out for praise the little-known Australian Centre for International Agricultural Research (ACIAR).

So appreciative was the former foreign minister that his thanks to ACIAR came third in importance behind the Department of Foreign Affairs and Trade and AusAID, and in front of ASIS (Australian Secret Intelligence Service) and the Canberra Diplomatic Corps.

ACIAR is an organisation few Australians know and yet it is a significant statutory authority delivering aid in the form of field based agricultural research, leadership and project design.

The budget is $100 million a year but further funding comes from international partnerships.

Mr Rudd described the staff of ACIAR as "a great bunch of folks".

"They are probably amongst the foremost experts in agricultural science and seed productivity in dealing with poor and developing countries anywhere in the world," he said.

"So when I go somewhere, East Timor or the north of Africa and they can't get enough out of seed yield, we get those folks to go and do the work.

"They are a brilliant bunch."

FARMING TODAY

Celebrating women's contributions

By SENIORL ANZU

PAPUA New Guinea women's involvement in agricultural research has gained significance during International Women's Day last week.

The Australian Centre for International Agricultural Research (ACIAR) gathered a group of PNG's leading female agricultural researchers in Port Moresby to celebrate the important contribution of PNG's women agricultural researchers to empowering rural women to end hunger and poverty.

"Women play a key role in agriculture, one of PNG's most significant industries, supporting up to 85% of the population," says ACIAR.

"PNG has many talented women agricultural researchers who are delivering improvements in agricultural production and marketing."

Richard Marles (centre) and PNG women agriculture researchers in Port Moresby on International Women's Day last Thursday.

Among those in attendance were scientists and researchers of various research and development organisations such as the National Agricultural Research Institute, Coffee Industry Corporation, Fresh Produce Development Agency, New Britain Palm Oil and PNG Women in Agriculture. Many of them are partners in ACIAR projects.

Australia's Parliamentary Secretary for Foreign Affairs and Pacific Island Affairs, Richard Marles, met with them during their gathering.

Marles said that women make huge contributions and with better education, they can escape poverty.

"An educated girl can make more decisions for herself, has the potential to earn money, to choose when to get married and when to have children," Marles said.

"She will know more about nutrition, is more likely to seek vaccinations for her children and invest in her family and community.

"All of Australia's development programs in PNG place women at their centre, because we know that when we help girls and women fulfil their potential, their families and communities grow and prosper."

Mares said women in PNG play a critical role in agriculture and they need to take one step at a time to inspire girls to build the future for all women.

Meanwhile, the main strategy of ACIAR's program in PNG is to secure improved food supply and rural incomes for smallholder farmers. This is being achieved by increasing productivity and profitability of farming systems, including by developing breeding strategies, integrated pest, disease, weed and nutrient strategies, and through evaluating wider industrial opportunities for products.

The ACIAR programme is also examining the role and effectiveness of women's groups in rural industries, in terms of efficiency and equity in agricultural and marketing systems.

Philmah Seta, project scientist with ACIAR vegetable project at NARI Laloki, Central province.

Some of the participants of the research and development team with Prof Westby listening while NARI scientist Michael Dom explains the sweet potato silage process developed by NARI.

PNG and UK research institutions sign MOU

By JOSEPHINE YAGA

IMPROVING nutrition and incomes for the rural and urban poor is a common interest shared by many research institutions.

However, conducting and promoting development oriented agricultural research remains a challenge.

But collaboration between research institutes is imperative for research and development as it provides opportunities for knowledge sharing between organisations and enhances agricultural research and development.

With this common interest, the National Agricultural Research Institute's (NARI) director general, Dr Raghunath Ghodake and the United Kindom-based Natural Resource Institute's (NRI), director Prof Andrew Westby signed a memorandum of understanding recently in Lae, to collaborate and compliment each other's research efforts by jointly developing programs on the application of modern science and technology.

The two parties agreed to cooperate in:

- scientific research, training and development;
- administrative and technical support; and
- funding by jointly seeking support for collaborative research projects of mutual interests.

NRI is a specialised institute and school of the University of Greenwich.

Ghodake (left) and Andrew Westby signaling the new partnership with a handshake.

Recognised internationally as a multi-disciplinary centre for research, consultancy and education for the management of natural and human resources, it subscribes to the UN millennium development goals and works with partner organisations and funding bodies to achieve them.

Ghodake emphasised the dynamics of such collaborations and pledged NARI's commitment to NRI as a partner.

The signing of the MoU coincided with the conclusion of training on research and development, facilitated by the University of Technology at the Taraka campus.

About 100 participants and resource persons witnessed the MoU signing occasion held at NARI's Momase regional centre in Bubia, Lae.

UTAS helps out with vegie growing in PNG

Vegie chat: TIAR researchers Drs Al Gracie, Leigh Sparrow, Richard Doyle and Mark Boersma discuss the production and marketing of watermelons with smallholder families from the Rigo-Koiari Cooperative in Central Province, PNG.

'Ultimately, the project should improve the capacity of local institutions to undertake research, development and extension projects and improve the economic wellbeing of the local population.'

The Tasmanian Institute of Agricultural Research (TIAR) is taking a lead role in an international research project designed to increase vegetable production and improve profitability of small crop holders in Port Moresby, Papua New Guinea.

The collaborative project involves production and social research, undertaking a wide-ranging value chain analysis which identifies where significant improvements can be made in production, transport, marketing and retail activities.

TIAR vegetable centre leader, Associate Professor Colin Birch, said researchers were looking at a variety of crops suited to the region's farming areas and for markets in Port Moresby.

"The project's primary aim is improvement in the economic wellbeing of smallholders and participants in the value chain," Associate Professor Birch said.

"It also seeks to improve the quality and reliability in supplying vegetables for the consumer.

"Ultimately, the project should improve the capacity of local institutions to undertake research, development and extension projects and improve the economic wellbeing of the local population."

As part of the project, social research is also being carried out with a particular focus on the role of women and young people in vegetable production and marketing.

Now into its second year, the four-year project is a collaborative effort between seven TIAR researchers, the University of Canberra, and a number of PNG organisations including Central Province Administration, the National Agricultural Research Institute, the Fresh Produce Development Agency, the Pacific Adventist University and Green Fresh.

The project is being funded by the Australian Centre for International Agricultural Research.

UTAS Research to Reality, March 2012.

Sowing the seeds of improved vegetable production in PNG

Associate Professor Colin Birch, from the Tasmanian Institute of Agriculture (TIA), is leading a team of scientists that is developing new vegetable production and marketing systems in Papua New Guinea.

Papua New Guinea (PNG) has a rapidly expanding population and an emerging middle class, including a growing expatriate community in the capital, Port Moresby. Food needs are increasing and the emerging middle class is demanding a more westernised diet (including temperate vegetables such as broccoli, beans and onions).

This demand creates an opportunity for smallholders and villages to expand their income by broadening the range and supply of the higher-quality vegetables they grow, explained Associate Professor Colin Birch, from the Tasmanian Institute of Agriculture.

Assoc Prof Birch is leading a team of scientists that is developing new vegetable production and marketing systems in PNG.

"The project aims to improve the economic wellbeing of smallholders and participants in the value chain, and to improve the quality and reliability of the supply of vegetables for the consumer," Assoc Prof Birch said.

"The project is designing production – and marketing – systems for PNG, and selecting temperate vegetables that will grow well in climates that vary from hot, humid coastal regions to seasonally cooler regions of the highlands.

"We have also had to take into account other issues such as the role of women and young people in vegetable production and marketing. Other challenges include rough roads and lack of availability of refrigerated transport to get the vegetables to market, and quality deterioration in open markets."

The project has focused on inclusive research engaging PNG scientists and community members in producing and delivering high-quality vegetables.

"Field trials have been carried out in collaboration with a high school, cooperatives, Pacific Adventist University and the research farm of the National Agricultural Research Institute at Laloki," Assoc Prof Birch said.

"We are also developing the capacity of PNG researchers by encouraging them to undertake the field and value chain research and to co-author published papers from the project."

Ultimately, this project should improve the capacity of PNG institutions to undertake research, development and extension projects, improve availability of quality vegetables, and improve the economic wellbeing of smallholders, villages and other participants in the value chain.

The project has focused on inclusive research that has engaged PNG scientists and community members. A tomato variety trial is pictured on the left and, on the right, Philma Seta-Waken, Colin Birch, Dickson Benny and Richard Doyle describe a soil profile.

This four-year project, funded by the Australian Centre for International Agricultural Research, features collaboration between UTAS, the University of Canberra and several institutions in Papua New Guinea: National Agricultural Research Institute; Fresh Produce Development Agency; Pacific Adventist University; Central Province Administration and Green Fresh Ltd.

Simeon, L. 2012, Research News, p5 in HARINA, Newsletter of Pacific Adventist University, 29 (5) Pacific Adventist University, 2012.

Research News

By Dr Lalen Simeon

Pacific Adventist University is fortunate to collaborate with other universities and organisations in 3 big Research Projects. One of these projects is sponsored by Australia Centre in Agriculture Research (ACIAR). This project is aimed at increasing vegetable production in Central Province.

The collaborating research partners are the University of Tasmania (UT), University of Canberra (UC), The National Agriculture Research Institute (NARI), Fresh Produce Development Agency (FPDA), Central Province Government and Pacific Adventist University (PAU).

A lot has taken place since this project started in 2009. PAU has successfully completed the first scientific vegetable experiment under the leadership of Japhet Nivi (Lecture – School of Science and Technology) and Peter Sale (Current Farm Manager). The second scientific experiment will start early next month and the final experiment will be conducted next year, in 2013.

The focus of this research is to identify different varieties of vegetables that can grow well in low and high altitude in Central Province. There are four scientific experimental sites (Goilala, Sogeri, NARI and PAU). This study also aims to work with existing farmers all over Central Province.

Last year, PAU hosted a workshop for women farmers from Rigo Koiari and Bautama. This workshop helped the Researcher Partners identify the specific farming needs of the two different groups.

After much consultation, meetings and planning; a workshop was conducted for these ladies at NARI (14 - 18 May 2012).

Topics covered in this workshop were Budget and Finance which was conducted by Dr Lalen Simeon and an invited guest, Mrs Belinda Bayak Moses (ex-PAU student).

The lessons delivered were very basic because most participants had only completed the first stage of primary education. NARI and FPDA covered Agricultural topics such as, natural insecticide, harvesting techniques, post harvest, packaging, irrigation, Plant diseases and mulching.

During this training a group of women from Hiri decided to attend the workshop and at the end of the week they requested for extra help and wanted the Research Partners to work closely with them. They have realised that women farmers earn a lot of money and they want to be like that. They graduated with a specific Certificate on Friday (18 May 2012). This ceremony was attended by the AusAID representative – Ms Emily Flowers and other interested organisation.

Participants at Nari Research Centre

Similar workshop will be conducted for men and young boys starting this year. Our 3 staff, Peter Sale, Japhet Nivi and Dr Lalen, who are involved in this research project are working very hard and as a result every plans and work they have carried out so far has been quite successful and we thank God for his leading in this part PAU plays in this project.

Promising Vegetables for Central Province

Posted on March 21, 2012 by PNG-AGRINEWS

Promising vegetables for Central Province

by PNG-AGRINEWS March 21, 2012

Capsicum harvested in Sogeri

The potential for vegetable production in the Central province is yet to be fully recognised. An agronomic study shows that open pollinated vegetables like tomato, French bean and capsicum can grow well in the lowland areas where as in the high altitudes, scientists have noted encouraging performances by English cabbage, broccoli and carrots. For mid altitudes, capsicum is looking promising while evaluations for tomato and broccoli are still in progress.

These are some of the findings from the National Agricultural Research Institute (NARI) from agronomic trails under a collaborative vegetable project funded by the Australian Centre for International Agricultural Research (ACIAR). The trials were carried out in Laloki, Sogeri and Tapini, to evaluate the vegetables (tomato, capsicum, French bean, broccoli, English cabbage and carrots) in three altitudinal sites – low, mid and high – of the province.

Other collaborators are the Fresh Produce Development Agency, Pacific Adventist University, Central Province's Department of Agriculture and Livestock and Australia's Tasmanian Institute of Agriculture and the University of Canberra.

The project's objective is to increase vegetable productivity, diversify vegetables to farmers and consumer preference, enhance supply consistency, quality assurance; and guarantee two efficient and effective value chains and well-distributed benefits in the Central Province.

During a project review meeting last week at NARI Laloki outside Port Moresby, all partners presented their outcomes, achievements and challenges in this collaborative initiative. The two-day review was to:

- assess the outcomes, achievements and challenges of the project's first year of implementation,
- rechart the future activities including work plan for year 2012,
- plan for the Mid-term Review by external reviewers in November this year, and
- showcase the project to stakeholders, including network farmers, in the Central Province.

A production cost survey in the farmer's field, also done by NARI, showed that farmers' yields are below average and costs including man-days are above average. This study recommended more training for farmers with supply of improved vegetable seeds. Production cost is a component of the Value Chain Management aspect of the project.

The review meeting was attended by Project Leader Associate Professor Colin Birch, ACIAR Country Manager Emily Flowers, NARI Deputy Director General Dr Sergie Bang and representatives from partner organisations.

PNG-AGRINEWS | March 21, 2012 at 7:04 am | Categories: Uncategorized | URL: http://wp.me/p1wjsS-fm

PNG-AGRINEWS

Celebrating the contribution of PNG agricultural researchers

Posted on March 9, 2012 by PNG-AGRINEWS

Philmah Seta-Waken of NARI

To mark the International Women's Day, March 8 2012, the Australian Centre for International Agricultural Research (ACIAR) highlighted the important contribution of Papua New Guinea's women agricultural researchers to empowering rural women to end hunger and poverty.

Women play a key role in agriculture, one of PNG's most significant industries, supporting up to 85% of the population. PNG has many talented women agricultural researchers who are delivering improvements in agricultural production and marketing. Many work for the National Agricultural Research Institute (NARI), and other industry bodies, and are partners in ACIAR projects.

In Port Moresby yesterday, Australia's Parliamentary Secretary for Foreign Affairs and Pacific Island Affairs, Richard Marles, met with a group of PNG's leading female agricultural researchers.

"Had the opportunity to meet some outstanding women in the PNG agricultural sector at an International Women's Day photo exhibition supported by ACIAR today" Mr Marles tweeted.

A photo collection of women agricultural researchers, including many of the women Mr Marles met can be viewed on youtube: http://t.co/DMbEAFPw and on Flickr: http://t.co/t8jF3WB0 (high resolution can be supplied).

Mr Marles met with:

- Maria Linibi, founder, PNG Women in Agriculture
- Dr Norah Omot, Socio-economist, National Agricultural Research Institute (NARI)
- Annastasia Kawi, scientist in integrated pest and disease management, NARI
- Janet Pandi, senior livestock scientist, NARI Lae
- Gorethy Dipsen, landscape and biodiversity officer, New Britain Palm Oil, Ramu Agri Industries
- Susan May Inu, Coffee Industry Corporation
- Philmah Seta-Waken, agronomist, NARI Laloki
- Poela Utama, Fresh Produce Development Agency
- Birte Komolong, NARI Headquarters
- Amanda Mararuai, NARI Kila Kila
- Hilda Sim, Quality Manager at the NARI Kila Kila Soil and Plant Chemistry and Science Labs
- Janet Lipai, Head Chemist of Soil and Plant section NARI Kila Kila Soil and Plant Chemistry and Science Labs
- Angela Pora, NARI Kila Kila

Mr Marles media release: http://ministers.dfat.gov.au/marles/releases/2012/rm_mr_120308.html

The main strategy of ACIAR's program in PNG is to secure improved food supply and rural incomes for smallholder farmers. This is being achieved by increasing productivity and profitability of farming systems, including by developing breeding strategies, integrated pest, disease, weed and nutrient strategies, and through evaluating wider industrial opportunities for products. The ACIAR program is also examining the role and effectiveness of women's groups in rural industries, in terms of efficiency and equity in agricultural and marketing systems.

More information:

Emily Flowers, ACIAR PNG Country Manager: 0011 675 71286629, emily.flowers@aciar.gov.au
Mandy Gyles, ACIAR Public Affairs Officer: (0408) 332 374, mandy.gyles@aciar.gov.au

Seta-Waken, P. 2011. SRC feature vegetable farming in Mini field day at Laloki, p9 in NARI Niu Volume 14, Issue 4. Newsletter of the Papua New Guinea National Agriculture Research Institute, 2011.

SRC feature vegetable farming in Mini field day at Laloki

NARI Southern Regional Centre (SRC), Laloki hosted a mini field day on 23 November 2011, focusing on open pollinated vegetables such as tomato, capsicum, eggplant, yard long beans and various other beans with the theme, *"Saving your own vegetable seeds for sustainability and improved livelihood"*.

Farmers came from as far as Bereina, Hisiu, Rigo, Koiari, the peri-urban farmers from 8-Mile in NCD and those around the Laloki area attended the field day to see and learn about vegetable farming, which is a project funded by ACIAR.

Also present were visiting scientists from the Tasmania Institute of Agriculture Research (TIAR), a collaborative partner of the Vegetable Project along with local partners - PAU, FPDA and the Central Provincial Government. Agricultural Advisors from the Southern Region were also present to mingle with farmers and staff of SRC.

The Vegetable Team was fortunate to have industrial trainee students from UNRE's Oro and Vudal campuses who assisted in answering farmers' queries and supplying pamphlets of vegetable production and seed saving techniques from as low as 20t and show bags at K2 containing various information on vegetable production and seed saving techniques and eggplant and chilli seeds.

The programme began with a welcome speech by Professor Udai Pal, SRC Research Program Leader and coordinator of the Vegetable Project. This was followed by remarks by Dr. Richard Doyle, from TIAR.

The farmers were then shown the vegetable varietal demonstration plots of eggplant, capsicum, yard long beans, soybean, mung bean, French beans and okra whose seed lines were brought in from The World Vegetable Centre (AVRDC), in Taiwan. These varieties are being evaluated for their productivity, nutritional quality, and pest and disease resistance with the primary goal of making vegetable seeds available to farmers at affordable prices.

Another feature was comparing the benefits of three different production systems:
(1) Typical low input system based on the traditional farmers practice and knowledge;
(2) Best practice system, based on modified, improved technologies; and
(3) High input system based on commercialized farmers practice.

At the end of this trial, the best farming practice will be recommended to farmers to use to grow their best identified variety of vegetables.

Farmers braved the scorching sun to learn about these varietal demonstrations of different vegetables with many showing interest in the drip irrigation system.

As the main focus was on seed sustainability and improved livelihood, a demonstration of 'vegetable seed extraction techniques' of open pollinated seeds of tomato, capsicum and eggplant was conducted.

It was highlighted to farmers that they do not have to keep buying hybrid seeds but extract and save their own seeds for the next planting seasons. At the same time, they can be able to improve their family diet with the nutritious home grown vegetables and sell the surplus for their daily income.

- Philmah Seta-Waken

Gwabu, C and Benny, D. 2012. More training needed for efficient vegetable production, p8-9 in NARI Nius, Volume 15, Issue 1. Newsletter of the Papua New Guinea National Agriculture Research Institute, 2012.

More training needed for efficient vegetable production

A production cost survey in the Central Province shows that farmers are not efficient in the production of vegetables. This is evident in the low yields of all vegetables while man-day's are very high for most vegetables.

This was revealed by a progressive study undertaken by economics and value chain component of the ACIAR Vegetable Project implemented by NARI SRC, Laloki. The survey was conducted in November 2011 in selected vegetable farming areas namely Rigo-Koiari Cooperative Society (RKCS) located about 60 kilometres, and Bautama along the Magi High Way, about 30 kilometres, east of Port Moresby.

Of the 20 farmers interviewed, 100% grow vegetables compared to 60% who grow tuber crops. A farmer usually grows multiple vegetable crops. Out of the total, 15 farmers grow tomatoes and capsicums; two grow carrots and eggplant, nine - cabbages, 11 beans, 17 watermelons, while six grow zucchini.

Stanley Chapman (right), a vegetable farmer at Bautama participating in the survey

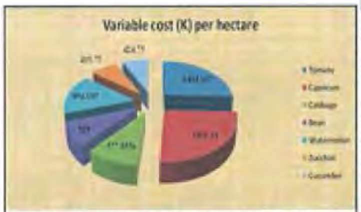

Figure 1. Variable cost for different vegetable crops

Variable cost per hectare

Excluding labour, variable cost per hectare (single use inputs such as fertilizers, insecticides, weedicides) ranges from about K400-K1500, which are quite low indicating minimal use of inputs (see figure above).

Man-days

With the exception of bean and zucchini, all other vegetable have man days of less than 100 but more than 50 (see the figure below).

Average Man days for each vegetable enterprise

In terms of contributions of man days by different production activities, weeding has been the highest followed by land preparations, for all the vegetables (ref to table below). Efficient method of controlling weeds is required by the farmers.

Table 1: Man-day contributed by different production activities

Farmers' yields are below average for all the crops, therefore systematic training in production is required. Against the costs (which excludes labour cost as labour is unpaid, provided by families), bean has the highest production cost (K11.80) per kg and lowest yield (2.56 kg) per man-day. Watermelon is the clear winner, with all 20 farmers surveyed grow it (see *Continued next page*

Table 1: Man-day contributed by different production activities

Vegetable	Land Preparation	Nursery	Planting	Weeding	Irrigation	Fertilizer & pesticides applications	Harvesting & Packing	Transportation to roadside
Tomato	11	10	11	18	7	4	10	4
Capsicum	23	14	14	21	8	5	13	5
Watermelon	17	7	13	17	6	4	10	5
Cabbage	23	13	15	31	5	3	6	4
Bean	57	8	48	14	9	10	3	6
Zucchini	35	31	31	47	15	9	12	9
EggPlant	26	21	15	22	4	5	7	3

From previous page

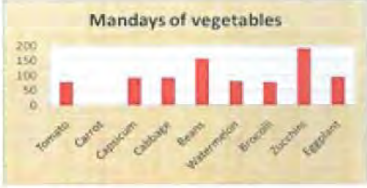

Figure 2. Man-days for different vegetable crops

Table 2: Costs, Yield, Man-days per hectare and unit production cost for different vegetables

	Total Cost (Kina/ha)	Yield (kg/ha)	Unit Production cost (Kina/kg)	Yield per man-day (kg)
Tomato	3624	584	6.21	7.20
Capsicum	6366	1436	4.46	35.40
Bean	4714	400	11.79	2.56
Watermelon	2836	4340	0.65	55.00
Zucchini	4836	1150	4.20	5.79

An avenue to address this is by training farmers to improve their productivity through improved cultivation, weed control, and simple plant protection measures among others. Farmers also need to be supplied seeds of improved vegetable varieties.

The survey was done purposely to collect all the costs from land preparation to harvesting and then to transportation to road side (farm gate) involving vegetable farmers both well established and those who are comparatively new. The survey is continuing and will include farmers from Sogeri, Hisiu and Tapini.

- Clifton Gwabu and Dickson Benny

Project staff packaging vegetable seeds for distribution. Photo: Barbara Tomi

POST COURIER 13TH MARCH 2012

agriculture

If you have a story to tell, call us on **309 1033**, or email **plevo@spp.com.pg**

Researchers remembered . .

By SENIORL ANZU

PAPUA New Guinea women's involvement in agricultural research has gained significance during International Women's Day last week. The Australian Centre for International Agricultural Research (ACIAR) gathered a group of PNG's leading female agricultural researchers in Port Moresby to celebrate the important contribution of PNG's women agricultural researchers to empowering rural women to end hunger and poverty.

"Women play a key role in agriculture, one of PNG's most significant industries, supporting up to 85% of the population," according to ACIAR.

"PNG has many talented women agricultural researchers who are delivering improvements in agricultural production and marketing."Among those in attendance were scientists and researchers of various research and development organisations such as the National Agricultural Research Institute, Coffee Industry Corporation, Fresh Produce

Agriculture. Many of them are partners in ACIAR projects.

Australia's Parliamentary Secretary for Foreign Affairs and Pacific Island Affairs, Richard Marles, met with them during their gathering.

Mr Marles highlighted that women and girls make huge contributions and with better education, they can escape poverty.

"An educated girl can make more decisions for herself, has the potential to earn money, to choose when to get married and when to have children," Mr Marles said.

"She will know more about nutrition, is more likely to seek vaccinations for her children and invest in her family and community.

"All of Australia's development programs in PNG place women at their centre, because we know that when we help girls and women fulfil their potential, their families and communities grow and prosper."

Mr Marles said women in PNG play a critical role in agriculture and they need to take one step at a time to inspire girls to build the future for all women.

Meanwhile, the main strategy

PHILMAH Seta, project scientist with ACIAR vegetable project at NARI Laloki, Central province. Picture courtesy of ACIAR

rural incomes for smallholder farmers. This is being achieved by increasing productivity and

strategies, integrated pest, disease, weed and nutrient strategies, and through evaluating wider industrial

the role and effectiveness of women's groups in rural industries, in terms of efficiency and equity

Women today……

Farmers improve crop management

By JAMES LARAKI

RURAL women farmers in the Central province are now better equipped to improve their vegetable production through improved crop management practices, thanks to a collaborative effort of the Pacific Adventist University (PAU), Fresh Produce Development Agency (FPDA), and the National Agricultural Research Institute (NARI).

To assist women farmers in the province, a week-long training was conducted at the NARI Southern Regional Research Centre - Laloki recently for selected women farmers representing various villages and communities of the Rigo/Koiari and Hiri districts.

The training organized under the Australian Centre for International Agricultural Research (ACIAR) funded project “increasing vegetable production in the Central Province to supply Port Moresby markets” was aimed at assisting the participants to improve their basic crop management and postharvest skills.

Ms Philmah Seta-Waken of the ACIAR vegetable project said the objective of the training was to help the women farmers to identify and appreciates the importance of soil management practices; learn about new irrigation techniques and their possible adaptation in their current farming practices; and identifies common weeds, pests and diseases which are essential elements to improve their production.

Ms Seta-Waken said the training was a result of recommendations from a need analysis workshop held last September which noted that women farmers in the province lack necessary skills in crop management and husbandry practices. She said the farmers; especially women in the Central province need the necessary skills to improve their vegetable and other crops to supply the Port Moresby markets.

The training attended by over 28 women farmers representing various communities in the province is part of the projects efforts to improving vegetable production to supply the ever increasing Port Moresby markets. It also part of NARI and the project partners’ efforts to empower women in sustainable in vegetable farming and other agriculture related activities. The project which is being implemented by NARI in collaboration with PAU and FPDA is expected to continue to provide training on various aspects of vegetable production including postharvest handling, pests and diseases, marketing and bookkeeping, and other crop husbandry practices with the aim improving vegetable production in other communities in the province.

Depending on the outcome and experience of the Central vegetable project, such trainings will be extended to other provinces in the country to promote sustainable vegetable production.

Brian Bell agriculture department staff demonstrating and displaying various products to participants, including a variety of vegetable seeds during the training.

Laraki, J. 2012. Central Women Learn Farm management. Farming Today. p28 in The National 14th June 2012 Issue. The National Newspaper of Papua New Guinea 2012.

FARMING TODAY

Central women learn farm management

By JAMES LARAKI

A GROUP of rural women farmers in the Central province is now better equipped to improve their vegetable production through improved crop management practices, thanks to a collaborative effort of the Pacific Adventist University (PAU), Fresh Produce Development Agency (FPDA), and the National Agricultural Research Institute (NARI).

Brian Bell display... Brian Bell agriculture department staff demonstrating and displaying various products to participants, including a variety of vegetable seeds during the training.

Graduation... Participants with their certificates during the closing ceremony of the training.

To assist women farmers in the province, a week-long training was conducted at the NARI Southern Regional Research Centre at Laloki recently for selected women farmers representing various villages and communities of the Rigo and Hiri districts.

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The project, which is being implemented by NARI in collaboration with PAU and FPDA, is expected to continue to provide training on various aspects of vegetable production including postharvest handling, pests and diseases, marketing and bookkeeping, and other crop husbandry practices with the aim improving vegetable production in other communities in the province.

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Seta-Waken, P. 2012. AVRDC seed on trial in Papua New Guinea, p8 in Fresh 13th January 2012 Issue. Newsletter of Asian Vegetable Research Development (AVRDC) – The World Vegetable Centre, Taiwan, 2012.

AVRDC seed on trial in Papua New Guinea

(top): Farmers view the demonstration plots. ***(right top):*** Drip irrigation in capsicum trial. ***(right bottom):*** **Philmah Seta-Waken** demonstrates tomato seed extraction. Farmers can reduce their production costs by saving seed of open-pollinated varieties for the next planting season.

The National Agriculture Research Institute-Southern Regional Centre (NARI-SRC) Vegetable Team hosted a mini-field day, "**Saving your own vegetable seeds for sustainability and improved livelihood,**" on 23 November 2011 at Laloki, Papua New Guinea to promote open-pollinated vegetables such as tomato, capsicum, eggplant, yard-long bean and other beans. AVRDC – The World Vegetable Center provided seed for the trials. A crowd of more than 50 farming stakeholders from peri-urban and rural communities far and near attended, of which about 30 were vegetable farmers.

Three visiting scientists from the **Tasmania Institute of Agriculture Research** (TIAR) joined the event. TIAR is a partner in the Vegetable Project funded by the **Australian Centre for International Agricultural Research** (ACIAR), which is jointly implemented with NARI at Laloki along with other project partners **Pacific Adventist University** PNG, **Fresh Produce Development Agency** PNG, and the **Central Province.** Regional agricultural advisors from the five provinces of the Southern Region mingled with farmers and NARI staff to learn about vegetables and seed saving techniques. Industrial trainee students from the **University of Natural Resources and Environment** PNG helped answer farmers' queries and distributed production pamphlets and seed of eggplant and chili.

Udai Pal, the Research Program Leader of NARI Southern Regional Centre, Laloki, and coordinator of the Vegetable Project, opened the field day. Project scientist **Philmah Seta-Waken** guided farmers through the vegetable evaluation trial plots for eggplant (7 varieties), capsicum (6), yard-long bean (8), vegetable soybean (8), mungbean (6), French beans (5) and okra (6). The varieties were evaluated for their productivity, nutritional quality, and disease and pest resistance, with the goal of making quality vegetable seeds available to local farmers at affordable prices. The trial also compared the benefits of three different production systems: 1) low input system based on traditional farmer's practice and knowledge; 2) best practice system based on modified, improved technologies, and 3) high input system based on commercial practice.

Farmers appreciated having the opportunity to evaluate the varieties. They also got a closer look at the drip microirrigation system used in the test plots, and examined an affordable, modified version of the system.

Seta-Waken then demonstrated seed extraction techniques for tomato, capsicum, and eggplant. "If farmers could successfully adopt these techniques, they will not need to keep buying hybrid seeds, as they can save their own seeds for the next planting seasons," she said. "At the same time, they can improve the family diet with nutritious vegetables, and sell the surplus for daily income."

– Philmah Seta-Waken

Seta-Waken, P. 2012. Promising vegetables for Central Province, p46 in The National 22nd March 2012 Issue. The National Newspaper of Papua New Guinea, 2012.

Promising vegetables for Central province

By PHILMAH SETA

THE potential for vegetable production in Central province is yet to be fully recognised.

An agronomic study showed that open pollinated vegetables such as tomato, French bean and capsicum can grow well in the lowland areas whereas in the high altitudes, scientists had noted encouraging performances by English cabbage, broccoli and carrots.

For mid altitudes, capsicum was looking promising while evaluations for tomato and broccoli were still in progress.

These were some of the findings from the National Agricultural Research Institute (NARI) from agronomic trails under a collaborative vegetable project funded by the Australian Centre for International Agricultural Research (ACIAR).

The trials were carried out in Laloki, Sogeri and Tapini, to evaluate the vegetables (tomato, capsicum, French bean, broccoli, English cabbage and carrots) in three altitudinal sites – low, mid and high – of the province.

Other collaborators are the Fresh Produce Development Agency, Pacific Adventist University, Central Province's Department of Agriculture and Livestock and Australia's Tasmanian Institute of Agriculture and the University of Canberra.

The project's objective was to increase vegetable productivity, diversify vegetables to farmers and consumer preference, enhance supply consistency, quality assurance, and guarantee two efficient and effective value chains and well-distributed benefits in the Central province.

During a project review meeting, the partners presented the results of their work.

Media Interviews

Birch, C. J. 2011 Media Interview – Radio Australia Pacific Beat PNG's Central Province aims to feed a booming capital. 27th September 2011 http://www.radioaustralia.net.au/pacbeat/201109/s3346276.htm

Birch, C. J. 2011 Interview– ABC Radio, Tasmanian Country Hour on 'Conservation Agriculture' and 'Vegetable Project in PNG' 27th September 2011. http://www.abc.net.au/rural/tas/content/2011/09/s3326935.htm

Birch, C. J., 2011. Progress with vegetable project in PNG, ABC Radio Northern Tasmania Interview, Broadcast 6th February 2011.

Birch, C. J. 2010. TIAR Vegetable Centre undertaking research in Papua New Guinea. ABC Radio Interview, October 2010.

Pamphlets and Extension Materials

Seta-Waken, P. 2011. Pamphlets and Toktok Series for Mini Field Day. NARI SRC. Laloki. Theme: "Producing and saving vegetable seeds for sustainable and improved livelihood". November, 2011. National Agriculture Research Institute.

List of pamphlets and booklets done for the Mini Field Day, November 2011

Pamphlets

1. Capsicum
2. Tomato
3. Eggplant
4. Yard-long Bean
5. Pakchoi

NARI TOKTOK SERIES: SAVING YOUR OWN SEEDS

1. Capsicum Seeds
2. Tomato Seeds
3. Eggplant Seeds
4. Yard-long Bean Seeds
5. Okra Seeds
6. Soybean Seeds

Note: NARI TOKTOK SERIES is a publication by NARI

Copies can be obtained from:
Southern Regional Centre—Laloki
P O Box 1828
Port Moresby
National Capital District

Telephone: 323 5511
Fax: 323 4733
Email: narilaloki@nari.org.pg

Capsicum

ACIAR Vegetable Project Team
NARI-SRC, Laloki
P O Box 1828
Port Moresby
National Capital District

Telephone: 323 5511
Fax: 323 4733

CAPSICUM

Nursery

- Fill seedling tray with fine rich soil.
- Sow 1 packet per seedling tray and cover gently with soil.
- Water seedlings every morning.
- Seedlings will be ready for prickling 1week after planting.

Prickling of seedlings

- Before prickling, thin out the seedlings to only one healthy plant.
- Transplant that healthy plant into a small poly cup.
- Water the seedlings soon after prickling.
- Place the seedlings outside the nursery for 14 days to harden.

Field transplanting

- Transplant seedlings to the field when the seedlings are at 4-5 leaf stage.
- Field must be well prepared before transplanting.
- Ensure that drains are dug around the field to remove excess water.
- Water the seedlings soon after transplanting.

Field Management

- **Irrigation**
    - Make sure crops are kept well watered every day.
- **Pest and disease**
    - To control against pest, use appropriate pesticides.
    - To control against disease use tolerant or resistant cultivars.
    - Good sanitation practices like timely removal and burning/burying of diseased plant parts is also the best way to control pest and disease.
    - When spraying it is important to spray under the leaves to protect them from bacterial and fungal infestation (the spraying movement should be like the letter "C").
    - Do not smoke when working in the garden to prevent the spread of Tobacco Mosaic Virus (TMV).
- **Fertilization**
    - At transplanting apply chicken manure & N-P-K-Mg @200kg/ha.
    - 1st side dress 1wk after transplanting—N-P-K-Mg@ 200kg/ha & Urea@150kg/ha.
    - 2nd side dressing 3wks after transplanting—N-P-K-Mg@ 200kg/ha & Urea@150kg/ha.
- **Harvesting**
    - Start harvesting about 60 days after transplanting (35-40 days from flowering), and continue on a weekly basis for 2 months.
    - Capsicum should be harvested when fruits reach full size and become firm, but before turning colour (unless they are intended for mature colour yellow, orange, or red).
    - Since stems of capsicum plants are very fragile, a knife should be used to harvest fruits.
    - Avoid mechanical transmission of viruses by dipping knives routinely in milk.

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- **Harvesting**
  - The first harvest is 60 to 70 days after transplanting depending on the desired maturity (green mature, breaker, full red) of the fruit and continues thereafter on a weekly basis for a period of one month.

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Tomato

ACIAR Vegetable Project Team:
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Tomato

Nursery

- Fill seedling tray with soil.
- Sow 1 packet per seedling tray and cover gently with soil.
- Water seedlings every morning.
- Seedlings are ready for prickling 1week after planting.

Prickling of seedlings

- Before prickling, thin out the seedlings to only one healthy plant.
- Transplant that healthy plant into a small poly cup.
- Water the seedlings soon after prickling.
- Place the seedlings outside the nursery for 14 days to harden.

Field transplanting

- Transplant seedlings to the field when the seedlings are at 4-5 leaf stage.
- Field must be well prepared before transplanting.
- Ensure that drains are dug around the field to remove excess water.
- Water the seedlings soon after transplanting.

Field Management

- **Mulching:**
  - Mulch with organic mulches (cut grasses) to control weeds and maintain enough soil moisture.
- **Irrigation**
  - Make sure crops are kept well watered every day.
- **Pest and disease**
  - To control against pest, use appropriate pesticides.
  - To control against disease use tolerant or resistant cultivars.
  - Good sanitation practices like timely removal and burning/burying of diseased plant parts is also the best way to control pest and disease.
  - When spraying it is important to spray under the leaves to protect them from bacterial and fungal infestation (the spraying movement should be like the letter "C").
  - Do not smoke when working in the garden to prevent the spread of Tobacco Mosaic Virus (TMV).
- **Fertilization**
  - At transplanting apply chicken manure & N-P-K-Mg @200kg/ha.
  - 1st side dress 1wk after transplanting—N-P-K-Mg@ 200kg/ha & Urea@150kg/ha.
  - 2nd side dressing 3wks after transplanting—N-P-K-Mg@ 200kg/ha & Urea@150kg/ha.
- **Staking**
  - Staking should be done 3 weeks after planting to support the tomato vines and to prevent them from touching the ground.
  - Staking also helps in easier management and aeration of the crop, thus, reducing the risk of infestation with diseases.
  - Staking materials that can be used are bamboo or wooden poles for the base, rope, wire or nylon string for tying the vines.

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- **Harvesting**
    - The first harvest is 60 to 70 days after transplanting depending on the desired maturity (soft or tender, deep purple) of the fruit and continues thereafter on a weekly basis for a period of one to two months.

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Egg plant

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Telephone: 323 5511
Fax: 323 4733

Egg plant

Nursery

- Fill seedling tray with soil.
- Sow 1 packet per seedling tray and cover with soil.
- Water seedlings every morning.
- Seedlings will be ready for prickling after 1 week of planting.

Prickling of seedlings

- Before prickling, thin out the seedlings to only one healthy plant.
- Transplant that healthy plant into a small poly cup.
- Water the seedlings soon after prickling.
- Place the seedlings outside the nursery for 14 days to harden.

Field transplanting

- Transplant seedlings to the field when the seedlings are at 4-5 leaf stage.
- Field must be well prepared before transplanting.
- Ensure that drains are dug around the field to remove excess water.

Field Management

- **Mulching**
    - Organic mulches (cut grasses) may be used to control weeds and maintain enough soil moisture.
- **Irrigation**
    - Make sure crops are kept well watered every day.
- **Pest and disease**
    - To control against pest, use appropriate pesticides.
    - To control against disease use tolerant or resistant cultivars.
    - Good sanitation like timely removal and burning/burying of diseased plant parts is also the best way to control pest and disease.
    - When spraying it is important to spray under the leaves to protect them from bacterial and fungal infestation (the spraying movement should correspond to the letter "C").
    - Do not smoke when working in the garden to prevent the spread of Tobacco Mosaic Virus (TMV).

Field Management

- **Fertilization**
    - At transplanting apply chicken manure & N-P-K-Mg @200kg/ha.
    - 1st side dress 1wk after transplanting—N-P-K-Mg@ 200kg/ha & Urea@150kg/ha.
    - 2nd side dressing 3wks after transplanting—N-P-K-Mg@ 200kg/ha & Urea@150kg/ha.

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Field management

- **Irrigation**
  Make sure crops must be kept well watered every day.

- **Pest and disease**
  - To control against pest use the appropriate pesticides.
  - Alternatives are botanical pesticides such as neem and pawpaw extracts.
  - To control against disease use tolerant or resistant cultivars.
  - Good sanitation such as timely removal and burning/ burying of diseased plant parts is also the best way to control pest and disease.

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Yard-long/Snake Bean

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Yard-long Bean

Direct seeding

- Apply basal fertilizer according to recommendation below
- Cover fertilizers with 2 cm soil before sowing 2-3 seeds per hill at 30.0 cm distance between hills. This will avoid burning of the germinating seedling
- Cover seeds with 2-3 cm soil after planting

Field management

- **Irrigation**
  - Make sure crops must be kept well watered every day
- **Pest and disease**
  - To control against pest use the appropriate pesticides
  - You can also use botanical pesticides such as neem (*Azadirachta indica*) and papaya (*Carica papaya*) extracts
  - To control against disease use tolerant or resistant cultivars
  - Good sanitation such as timely removal and burning/burying of diseased plant parts is also the best way to control pest and disease

- **Fertilization**
  - Basal application - chicken manure
  - 1st side dress 2wks after planting: Complete (14-14-14) - 10g
  - 2nd side dress 4wks after planting: Complete (14-14-14) - 10g on a need basis.

- **Staking**

  - Staking is done 2 weeks after sowing to support the vines and to prevent pods from touching the ground.
  - Staking also helps in easier management and aeration of the crop, thus, reducing the risk of infestation with diseases.
  - Staking materials that can be used are bamboo or wooden poles for the base, GI wire and nylon string for tying the vines.

- **Mulching**
  - Mulch with organic materials to control weeds and regulate soil moisture.

- **Harvesting**
  - Yard-long/snake beans can be harvested 45-65 days after plant emergence.
  - Green tender pods are harvested 7-10 days after flowering when seeds are partly developed.
  - Pods are picked at a 2-day interval to prolong the productive life of the crop.
  - Harvesting should be done early in the morning so as not to expose the pods to sunlight, thus, minimizing transpiration.

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- **Harvesting**
  - The first harvest is 35 to 50 days after transplanting .
  - Harvest when leaves are fresh and crisp before the outer leaves turn yellow.
- **Post-harvest handling**
  - Remove any dead or damaged leaves, trim the base and wash the plant.
  - Harvested Pak choi is at risk to wilting.

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Pak Choi

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Pak Choi

Nursery

- Fill seedling tray with soil.
- Sow 1 packet per seedling tray and cover gently with soil.
- Water seedlings every morning.
- Seedlings will be ready for prickling 1week after planting.

Prickling of seedlings

- Before prickling, thin out the seedlings to only one healthy plant.
- Transplant that healthy plant into a small poly cup.
- Water the seedlings soon after prickling.
- Place the seedlings outside the nursery for 14 days to harden.

Field transplanting

- Transplant seedlings 21 days after sowing.
- Provide some protection from the wind since young plants can be damaged easily in windy conditions.

Field Management

- **Mulching:**
  - Organic mulches (cut grasses) may be used to control weeds and maintain enough soil moisture.
- **Irrigation**
  - Pak choi is shallow-rooted and requires frequent watering.
  - Make sure crops are kept well watered every day.
- **Pest and disease**
  - To control against pest, use appropriate pesticides.
  - To control against disease, use tolerant or resistant cultivars.
  - Good sanitation practice like timely removal & burning/burying of diseased plant parts is also the best way to control pest and disease.
  - When spraying it is important to spray under the leaves to protect them from bacterial and fungal infestation (the spraying movement should be like to the letter "C").
  - Do not smoke when working in the garden to prevent the spread of Tobacco Mosaic Virus (TMV).

Field Management

- **Fertilization**
  - At transplanting apply chicken manure & N-P-K-Mg @200kg/ha.
  - 1st side dress 1wk after transplanting—N-P-K-Mg@ 200kg/ha & Urea@150kg/ha.
  - 2nd side dressing 3wks after transplanting—N-P-K-Mg@ 200kg/ha & Urea@150kg/ha.

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Southern Regional Centre – Laloki

MINI FIELD DAY

Theme: Produce and Save Vegetable Seeds for Sustainable Production and Improved Livelihood

CAPSICUM SEEDS

23rd November 2011

ACIAR Vegetable Project Team

Steps on extracting and saving Capsicum seeds

Step 1: **Harvest:** Select healthy, disease & insect free fully ripe fruits from healthy plants; store them under shed (cool & dry place ~25°C, 50% RH) for a week to allow any slightly immature fruits to ripen fully.

Step 2: **Extraction:** Cut each capsicum into half or open at the top and gently scoop out the seeds with a small knife into a small tray or container

1. Cut capsicum into half or open the top as show below

2. Gently scoop out the seeds with a small knife into tray or container

1

Save seeds, saves money

Step 3 **Washing: continue...**

5. Pour into clear bowl

6. Fill with water and stir, allow the content to settle

7. Pour out the immature seeds floating on the water surface

Note: Repeat this process until water is almost clean and clean seeds line the bottom of the container

3

Step 4: **Straining:** After thorough washing fill the container with water and stir, then allow the contents to settle. Pour out the immature seeds floating on the water's surface. Repeat this process until water is almost clear and clean seeds line the bottom of the container.

1. Pour clean seeds into a fine-mesh strainer

2. Pour on clean dry surface such as a tray, paper towel or newspaper

4

Step 5: **Drying & storage:** Pour these clean seeds into a fine-mesh strainer. Let the excess water drip out and place seeds onto a clean dry surface such as a tray, paper towel, or newspaper. Dry seeds under partial sunlight or shed for two to three days. After drying, store capsicum seeds in airtight container - manila envelopes (for small quantities), cloth or mesh bags, plastic containers, metal containers, foil envelopes or any other suitable container. Store seeds under dry and cool conditions in order to maintain seed viability.

1. Dry seeds under partial sunlight or shed

2. Store seeds under dry and cool conditions

5

Step 3: **Washing:** After all seeds have been scooped into the container, bring container to the tap and wash under running water. Using a fine-mesh strainer, wash seeds thoroughly under running water.

1. Extracted seeds in container

2. Wash seeds using running water

3. Pour seeds in fine strainer

4. Wash again with running water

2

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Southern Regional Centre – Laloki

MINI FIELD DAY

Theme: Produce and Save Vegetable Seeds for Sustainable Production and Improved Livelihood

EGG PLANT SEEDS

23rd November 2011

ACIAR Vegetable Project Team
Southern Regional Centre, Laloki, P O Box 1828,
Port Moresby, NCD

Steps on extracting and saving Eggplant seeds

Step 1: **Harvest:** Select healthy (disease & pest free), fully ripe fruits (color changed from violet/green to yellow) from healthy plants; store them at room temperature for 5 -7 days until they become soft

Step 2: **Extraction:** Cut each eggplant into half at its equator and gently scoop out the sheath containing the seeds with a small knife into a small tray or container

1. Cut into half

2. Scoop out sheth with Small knife

Step 3: **Fermenting:** After all seeds have been scooped out, put into the container if you have used a small tray. Loosely cover the container and leave in a warm place (25-30oC) to ferment for 1-2 days. (You can also add a little water to the contents before covering.)

Step 4: **Washing & straining:** After 1-2 days, a layer of mucilaginous sheath mixture will appear in the container. Fill the container with water and using a fine-mesh strainer, wash the mucilaginous with the seeds thoroughly under running water. Pour out the pulp and immature seeds floating on the water's surface. Repeat this process until water is almost clear and clean seeds line the bottom of the container

Wash using fine-mesh strainer under running water, pour out pulp and immature seeds floating on the surface

Step 4: **Drying & storage:** Pour these clean seeds into a fine-mesh strainer. Let the excess water drip out and place seeds onto a clean dry surface such as a tray, paper towel, or newspaper. Dry seeds out in the partial sun for 2-4 days. After drying, store eggplant seeds in airtight container - manila envelopes (for small quantities), cloth or mesh bags, plastic containers, metal containers, foil envelopes or any other suitable container. Store seeds under cool and dry conditions in order to maintain seed viavility.

Remove excess water, place seed on clean dry surface, dry seeds in partial sun for 2-4 days and store in airtight container

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MINI FIELD DAY

Theme: Produce and Save Vegetable Seeds for Sustainable Production and Improved Livelihood

YARDLONG BEAN SEEDS

23rd November 2011

ACIAR Vegetable Project Team
Southern Regional Centre, Laloki, P O Box 1828
Port Moresby, NCD

Steps on extracting and saving Okra seeds

Step 1: **Harvesting:** Harvest disease and pest free pods when they turn yellow (do not wait for completely dry pods). This is to avoid any damage due to sudden rain

Mature Yardlong beans

Step 2: **Drying the pods:** Tie pods in bundle and hang for drying under the sun for a couple of days until pods change color

1. Pods tied in bundle and hand for drying

2. Pods ready for threshing

1

Step 3: **Threshing & Drying:** Thresh seeds by gentle beating with sticks or by opening pods to avoid seed damage/ injuries and collect seeds into a small tray or container.

Pods opened to collect seeds and dry seeds under partial sunlight for 2-3 days

Step 4: **Drying & Storage**: Dry seeds under partial sunlight for 2-3 days. Store seeds in airtight container, manila envelopes (for small quantities), cloth or mesh bags, plastic containers, metal containers, foil envelopes or any other suitable container.

Store seeds in airtight container

2

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MINI FIELD DAY

Theme: Produce and Save Vegetable Seeds for Sustainable Production and Improved Livelihood

OKRA SEEDS

23rd November 2011

ACIAR Vegetable Project Team
Southern Regional Centre, Laloki, P O Box 1828,
Port Moresby, NCD

Steps on extracting and saving Okra seeds

Step 1: **Harvesting:** Select healthy pods as soon as they turn brown (do not wait for completely dry pods) from healthy plants. This is to avoid any damage due to sudden rain.

Select healthy pods and harvest

Step 2: **Drying**: Dry pods under partial sun for a few days until they turn golden brown.

Dry pods turn golden brown

1

Step 3: **Threshing:** Thresh seeds by gently opening pods to avoid loss due to breaking injuries into a small tray or container

Thresh seeds gently by opening pods and place in tray or container.

Step 4: **Drying & Storage:** Dry seeds for a week under partial shed. Store seeds in airtight container ,manila envelopes (for small quantities), cloth or mesh bags, plastic containers, metal containers, foil envelopes or any other suitable container.

1. Dry seeds for a week under partial shed
2. Store seeds in air tight container

2

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MINI FIELD DAY

Theme: Produce and Save Vegetable Seeds for Sustainable Production and Improved Livelihood

SOYBEAN SEEDS

23rd November 2011

ACIAR Vegetable Project Team
Southern Regional Centre, Laloki, P O Box 1828,
Port Moresby, NCD

Steps on extracting and saving Soy bean seeds

Step 1: **Harvesting:** Harvest pods as soon as they turn yellow/brown (do not wait for completely dry pods). This is to avoid any damage due to sudden rain (2-3 pickings required)

Pods ready for harvest

Step 2: **Drying:** Tie pods in bundle and dry under the sun for a couple of days until pods are completely dry.

Pods tied and sun dry

Note: Pods are ready to be threshed once they turn golden brown in colour.

1

Step 3: **Threshing:** Thresh seeds by gently beating with sticks to avoid breaking injuries into a small tray or container.

Remove seeds by gently beating with sticks

Step 4: **Storage:** Store seeds in airtight container, manila envelopes (for small quantities), cloth or mesh bags, plastic containers, metal containers, foil envelopes or any other suitable container.

Seeds stored in cloth bag

2

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Introduction To Basic Crop Management Techniques Manual

Seta-Waken, P. 2012. Introduction to Basic Crop Management Techniques Manual. Women's Vegetable Farmers Training. NARI SRC, Laloki, CP, PNG. 14th – 18th May 2012

INTRODUCTION TO BASIC CROP MANAGEMENT TECHNIQUES MANUAL

NARI- ACIAR Vegetable Project Team

WOMEN'S TRAINING

For

RIGO/KOIARI & HIRI VEGETABLE FARMERS FROM PRODUCTION SITES OF THE LOW ALTITUDE AREAS IN CENTRAL PROVINCE

A follow up training on the Needs Analysis Workshop in September 2011 conducted by the Project Team with Barbara Chambers and Gomathy Palaniappan.

SMCN/2008/008 Increasing Vegetable Production in Central Province, Papua New Guinea to Supply Port Moresby Markets

May 14th -18th 2012

NARI Southern Regional Centre, Laloki, Central Province,

Papua New Guinea

Table of Contents

Introduction

This manual is part of a series of training conducted by the National Agriculture Research Institute, Southern Regional Centre in conjunction with Fresh Produce Development Agency and the Pacific Adventist University as partners in this ACIAR funded Vegetable Project for the Central Province.

This is a follow up training from a previous Needs Analysis Workshop conducted for these women farmers from the production sites of the low altitude areas of the Central Province from the Rigo/Koiari and Bautama areas in September 2011.

Needs identified by these women farmers were in Farm Production (soil management, crop protection and irrigation), Marketing (product readiness, postharvest and negotiating price) and Business Skills (banking and book-keeping). Hence, NARI SRC- Laloki was nominated to provide training especially on Farm Production needs as identified.

The notes in this manual capture basic information on farm production techniques especially on soil management techniques, crop protection and a basic introduction to drip irrigation. Therefore, these notes are very brief and from the Trainer's personal knowledge and experiences in vegetable farming.

Training Objectives

By the end of this training, these women farmers will be able to:

1) Identify six soil management practices and appreciate the importance of soil management.
2) Learn and know about some new irrigation technologies and how they can adopt it in their current farming practices.
3) Identify common weeds, pests and diseases of common vegetables and some of their management practices.

Topic 1 Soil Management

Objectives

By the end of this topic, you should be able to:

1. Know what soil management is;
2. Identify ways to properly manage your soil; and
3. Appreciate these soil management practices to maintain soil fertility.

Introduction

A soil can lose its ability to support plant growth if it is not looked after (*managed*) properly. This may happen through landslides, flooding and erosion. Soil management means using it wisely so that it can support plant growth.

Soil management practices

Soil management practices include the following:

Mulching

What is mulching?

- Covering of the surface of the bed prepared for planting vegetables with dry grass, leaves, saw dust, food peelings.



Why is mulching good?

- Mulching helps to:
  (1) **Hold back water and keep crops cool** during the dry season.
  (2) **Minimize weed growth.**
  (3) **Preventing soil erosion** by reducing the impact of raindrops on the soil surface and runoff.
  (4) **Improve soil fertility and structure.**

Types of mulches
Mulches can be divided into two types:

1. **Organic mulches-** The most common ingredients of organic mulches are dry grass, leaves and saw-dust and crop by-products like peanut shells, coffee hulls, rice hulls, coconut husks and corn cobs.



2. **Artificial mulches**. These include polyethylene plastics, fibreglass and aluminium foil, sand, stones and gravel.



Crop rotation

What is crop rotation?

Crop rotation is the process whereby a first crop (e.g. peanuts) planted on the land is followed by planting a different crop (e.g. capsicum) on the same land after harvesting the first crop. The diagram below shows an example of crop rotation.

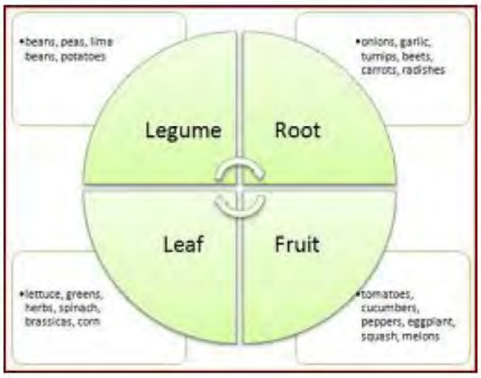


Figure 1: An example of a crop rotation. The non- legume crops (corn and cabbage) will use up nitrogen in the soil while legume crops (peanut and snake bean) will add nitrogen to the soil. After harvesting, the non-legume crops will be rotated as shown by the arrows. Corn and cabbage will use the nitrogen put in the soil by peanut and snake bean respectively.

Why is crop rotation good?

Crop rotation is good because:

(1) Avoiding disease attack on crops in the previous plot.
(2) Adding nitrogen in the soil by growing legume crops.
(3) Prevention of soil erosion by growing dense - foliaged or vined - crops such as snake beans.
(4) Varieties of crops are grown for farmer's use.




Green manuring

What is green manuring?

Green manuring is the process of growing legume plants such as cowpea into well prepared soil until they are leafy (4-6 weeks after planting). The green crop is then harvested before they develop flowers and fruits and buried by ploughing or digging, into the soil

Green Manuring

Why is green manuring good?

To improve the soil:

1. organic matter content;
2. fertility;
3. structure;
4. prevent erosion; and
5. Conserve soil moisture.

Cover cropping

What is cover cropping?

When the bare soil surface is protected by a cover of certain legume plants it is called *cover cropping*. An example is growing legume plants such as *Pueraria or Centrosema* in a plantation of coconut, cocoa, oil palm and rubber. The cover crops should be better established before these plantation crops are mature.


Pueraria


Centrosema

Why is cover cropping good?

Like green manuring, cover crops help to:

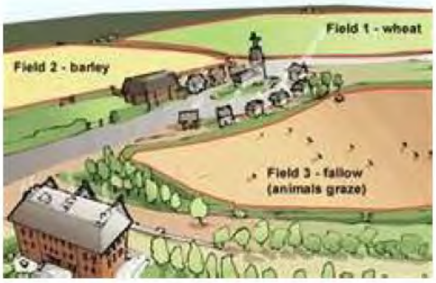
1. reduce weed growth,
2. conserves soil moisture,
3. adds nitrogen into the soil,
4. improves soil organic matter content and soil structure; and
5. Prevents soil erosion.



Land fallow
What is land fallow?
Land fallow is a process where the land is rested from cropping for a period of time, which may be many years. In the past the fallow period used to be 10 to 25 years. Today, this period is in some areas only 3 to 5 years as a result of land pressures due to increases in population.



Why is land fallow good?
Land fallow helps to restore:
1. Organic matter content of the soil,
2. Soil fertility and
3. Soil structure.
4. Prevents soil erosion

Activity 1

1. Think back to your village garden.
   a. Write down 6 types of crops grown.

   b. For each crop tell us if they are mulched and if so with what type of material.

   c. For each crop, what rotation system is used? For example if sweet potato is grown, what is the next crop grown in the same ground?

   d. Is your land left to fallow? How long do you normally fallow your land?

How fertilizers are applied to crops

There are 4 methods of applying fertilizers to crops.

1. Broadcasting Method

The fertilizer is held by the hand or machine and is evenly distributed over the soil surface and then carefully mixed into the soil. This method is easy to use but usually the crops may not utilize fertilizer as it may be out of reach of the roots of the crops. Also the fertilizer is usually applied before the crops are planted and if it rains heavily some loss of the fertilizer may occur by leaching.

2. Placement of fertilizer

The fertilizer is placed as a band to the side of the seedlings, about 10cm from vegetables such as cabbages, tomatoes and capsicum. If seeds are planted the fertilizer is placed in the planting holes then covered with some soil before seeds are added. The placement method is good because fertilizer is given directly to individual plants. However, it requires more time and excess of fertilizer may kill the crops.


3. Foliar (leaf) application

Some fertilizers can be mixed in water and sprayed with machinery (manual or motorized sprayers) onto the leaves of growing crops. This has to be done carefully as too much fertilizer used will injure plants.


4. Fertigation method

In this method the fertilizer is mixed in a tank and a motorized pump is used to pump the fertilizer via an irrigation pipe or fixed irrigation sprayers/sprinklers onto the soil at the base of the crop.


When can you apply fertilizer?

Fertilizers can be applied
1. Before planting (*pre-planting* or *pre-emergence*),
2. At planting and
3. During the growth stages of a crop (*post- planting* or *post-emergence*).

The timing depends on types of crops and fertilizers.

Activity 2

2. Think back to your village garden/farm. Do you use fertilizers? Fill in the table.

Name of crop	**Is fertilizer applied?**	**What type of fertilizer is used?**

3. When (time) do you apply fertilizer?

4. What method do you use to apply fertilizer?

Summary

Appropriate soil management practices should be used where possible to maintain high soil organic matter content to
1. Protect the soil from erosion,
2. Improve the soil properties that will benefit the soil, which in turn will
3. Improve crop growth and bring better yield to the farmer.

Topic 2 Irrigation Techniques

Objectives

By the end of this topic you should be able to:

1. Identify different types of irrigation;
2. Know about drip irrigation;
3. Appreciate and use the drip irrigation method in your farm setting.

Introduction

Like people and animals, plants also need water for its healthy and normal growth. Many farmers rely only on the rainfall to water their crops (gardens). Water for irrigation is very important to successfully grow vegetables all year round even in dry periods without rain. The fertilisers / nutrients in the soil are absorbed into the plant along with the water through its roots in the soil for the plant to grow well and produce more.

Some vegetable require relatively more and frequent water than others. Example, cabbages requires more water than tomatoes, capsicums and watermelons that grows well in drier conditions. A form of irrigation system is a must to successfully grow our vegetables especially in the drier periods when there is no rain.

Types of Irrigation

The type of irrigation system depends on the size of the farm, the source of water (from a water-well, dam or river) and the how much the farmer can afford.

1. Manual – the simplest but less efficient system is watering by hand using buckets and watering cans for irrigation. Water is fetched and applied to plants by hand.
2. Canal or farrow – water pumped (using manual or motorised water pump) and stored in reservoir which is then directed to flow into the open field between the farrows or ridges. May need a water pump to draw water from water well or from a river.
3. Drip – water is pumped into a tank (a reservoir) and then delivered as drips to the plants' base through small and narrow tubes through gravity force. This system is effective when the tubes are not blocked by dirt or build-up of chlorine from the water.
4. Overhead Sprinklers- this system requires sufficient pressure from the water-pump to force water to shoot out of the upright sprinklers as sprays as it rotates.

Drip irrigation

What is drip irrigation?

Drip irrigation/ micro-irrigation is a method that allows a farmer to control the application of water and fertilizer by allowing water to drip slowly near the plant roots through a network of valves, pipes, tubing and emitters. However, drip irrigation is not applicable to all farms.

Advantages of drip irrigation

1. Less water can be used
2. Lower operating pressure means low cost for fuel/petrol for pumping.
3. Water used well because plants can be supplied with water.
4. Water is applied directly to the plant root zone.
5. Reduce weeding
6. Reduce pests/disease infestation
7. Reduce soil erosion
8. Reduce labor




Disadvantages of drip irrigation

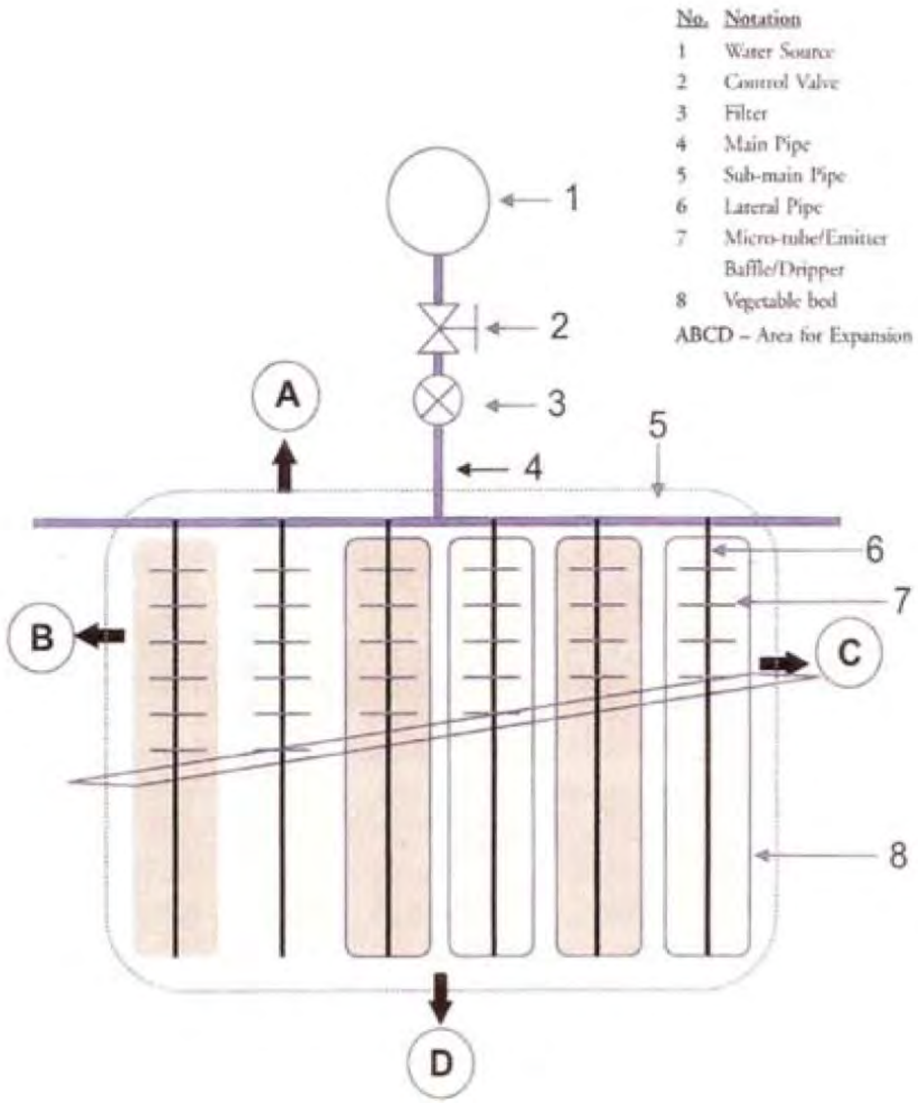
1. Higher initial investment
2. Requires regular maintenance and high quality water
3. Tubes may be lifted by wind or displaced.

Water source

The water for irrigation can come from wells, streams, ponds, tanks, rain, recycled water from wastewater treatment plants or other sources.

Components of a drip irrigation system

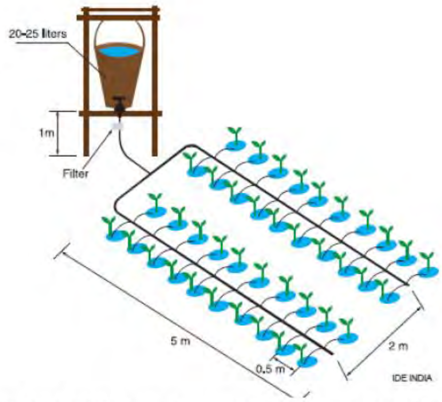
A typical drip irrigation system has seven major components.



Some simple drip irrigation systems

International Development Enterprises (IDE) in India has developed simple, affordable low-cost drip irrigation systems for smallholder vegetable growers. These systems include:

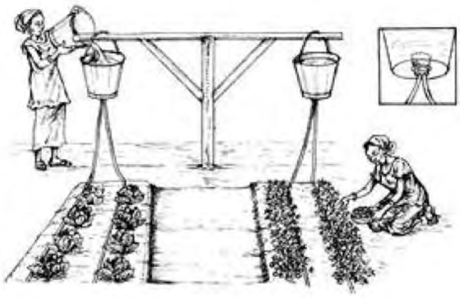
- Bucket Kit
- Family Nutrition Kit
- Drum Kit
- Customized System
- Combo Kit



A simple bucket kit for irrigating a small vegetable garden plot of approximately 20m^2.

Bucket Kit Features

- A pre-assembled kit to irrigate vegetables in home gardens.
- Has a 20-liter bucket with one or two rows of lateral drip lines 5 to 10 meters in length, depending on the space available.
- Can irrigate up to 20 square meters.
- Bucket can be hung from a tree or pole 1 meter high.



Topic 3 Crop Protection

Objectives

By the end of this topic you should be able to:

1. Describe which plants are called weeds;
2. Identify ways to control and mange weeds;
3. Know what an insect pest is;
4. Recognize which insects are pests to a particular crop;
5. Identify ways to control and manage insect pests;
6. Learn some PDP techniques;
7. Define plant disease;
8. Describe symptoms of plant disease.

Introduction

The Crop Protection deals with the agents that cause crop losses and how they are managed to minimise these losses. There are 3 main agents Weeds; Insect pests and Plant diseases.

Weeds

What are weeds?

A weed is a plant that is growing in the wrong place.

For example, volunteer tomatoes, or beans become weeds if they grow in ground that has been planted with a crop of sweet potatoes. Weeds, which interfere with cropping or grazing activities or block waterways, can compete with nutrients in the soil resulting in low crop yields. Some examples of introduced weeds of economic importance to PNG are shown below:



The effects of weeds on crops

Harmful effects of weeds

Weeds directly **compete** with crop plants for light, nutrients and water and this causes a reduction in crop yields. Some weeds can also act as hosts for insect pests and disease agents.

Beneficial effects of weeds

However, in abandoned land, weeds can help reduce soil erosion and add organic matter to the soils when they decompose. Some may also act as a source of food and may have medicinal properties.

Ways to control weeds

1. Physical Control

a. Hand weeding
b. Hoeing and cultivation
c. Mowing and slashing

2. Cultural practices

1. Mulching
2. Cover cropping especially using leguminous crops also helps to reduce weed growth. Cover crops also help to improve soil fertility.

3. Using chemicals

- These chemicals are called herbicides.
- Herbicides are expensive and dangerous to use without proper equipment and training.
- Some herbicides kill the plant by contact with the plant surface and are called contact herbicides.
- Others can be applied to one part of the plant and they are then absorbed and distributed through the plant's vascular system to the whole plant. These, e.g. glyphosate or roundup are called translocated herbicides. However, care must be taken as these can also kill crop plants.
- Manufacturers therefore give strict instructions on the label of the containers as to how and when a particular herbicide can be applied and its potential danger to humans and animals and crops.
- Chemicals do result in a quick kill of weeds and may only be economic if used in large plantation crops such as cocoa, coffee, and oil palm.

14th -18th May 2012

Insect Pests

What are insect pests?

Pests refer to mostly the bad insects and their larvae which feed and damage food crops. They include

1. Sucking insects (e.g. aphids, stink bugs, plant hoppers, thrips etc.);
2. Chewing insects (e.g. grasshoppers, caterpillars and beetles etc), leaf rollers (e.g. aibika leaf roller, banana skippers etc.); and
3. Barrowing insects (e.g. taro beetles, sweet potato weevils, red banded caterpillars etc).

Ways to control insect pests

a) Physical Control

- Do hand picking and killing them. Possible for small garden only. Best time to hand pick insects are early in the mornings when the sun is not too high on a weekly basis.

b) Cultural control

- Cultural Control involves:
  - Crop Rotation
  - Planting of repellent crops in the vegetable garden
  - Planting resistant crop varieties.

c) Biological Control

- Biological control encourages the use of other natural living organisms (e.g. insects, birds, etc) to control/kill other bad insects. The good insects are called parasites / parasitoids) like spiders, praying mantis, lady bird beetles etc. which feeds on other bad insects which destroys our vegetables.

d) Chemical Control

- Using of organic or in-organic pesticides to kill the bad insect pests attacking our vegetables.

e) Organic pesticides

- Organic insecticides are naturally derived pesticides made from plants like:
  - Derris (poison root)
  - Tabocco leaf and stalk

- Neem leaves, bark & seeds
- Marigold leaves and stem
- Chili fruits
- Pawpaw leaves

f) Inorganic pesticides

- These are pesticides that are produced using chemicals. They are very effective but are very harmful to the environment and are very costly. There are strict safety measures to follow to avoid poisoning yourself, others and polluting the environment.

- It is best not to use in-organic pesticides in your home garden unless you are sure and know how to safely handle the chemicals and correctly mixing and applying the chemicals to your crops. This is because they are poisonous to humans. However, it is useful on commercial scale farming.
- Examples of insecticides & their mixing rate sold in Didiman stores in PNG include:

Chemicals	**Mixing rates**	**Comments**
Karate	10mls into 10L water	
Thunder	5ml in 1L water	
Confidor		
Othin		
Biefenthrin & Mustang	50ml into 20L water	For taro beetle control

Note: Application of these chemicals requires knapsack sprayers. The application rates defer from chemical to chemical. On every chemical container there should be labels and instruction guides given on the rate for mixing and application (e.g. 10mls into 10L water) and how to apply them.

Activity 1

1. Below are some photos (1 –8) of different insects. Do you see some of these insects in your gardens? If yes, what crops do they attack?


Tomato Hornworm


Corn Earworm

Brown Sting bug

Pumpkin Beetles

Cane Toad

Capsicum Maggots

Giant African Snail

Plant diseases

What is plant disease?

A plant can be defined as diseased if it is not growing well or looks sick compared to a normal healthy plant. We can usually see with our eyes some of the symptoms that plants are not growing well.

What causes plant disease?

Most plant diseases are caused by:

1. Fungi
   - Fungi cause plant tissue to rot, spots on the flowers, leaves and stem.

2. Bacteria
    - Bacteria diseases are similar but the only difference is, it gives off an awful smell.




3. Virus
    - Virus diseases, the symptoms are closely similar to nutritional deficiency.

Mosaic virus

Ways to control diseases

There are three (3) common controls that can be used.

- Cultural control – practice crop rotation, use resistant varieties etc.
- Physical control – preventing excess water e.g. use glass -house.
- Chemical control – use of copper based fungicide chemicals.

Some common diseases in vegetable crops

Wilt diseases
Here the symptom is shown by the leaves, which are no longer erect and turgid but are drooping downwards and are limp.

Photo 9: Capsicum plants showing typical signs of wilting.

Wilt may be caused by not enough water in the plant in which case the plant recovers as soon as water is applied to the soil and taken up by the roots. But if the plant does not recover from the wilting even though there is enough water given it means that the wilting is caused by a disease.

We can test this further by slicing the plant stem. If the tissue is sliced longitudinally (along the stem length) the vascular tissue (which allows water to move from the roots to the leaves) shows a brown streak running along the length; if the tissues are sliced horizontally (or across the stem), the vascular system appears as a brown ring. This browning shows that the wilt is due to a blockage of the vascular system and the disease is known as *vascular wilt disease*.

Leaf blight

The symptoms of leaf blight start from the appearance of tiny brown spots of dead tissue on the green leaves. These enlarge and merge together until the whole leaf is dead.

Early and late symptoms of potato late blight on potato leaves

Under good environmental conditions the disease can spread from one plant to another plant until the entire crop is affected. If the disease starts when plants are young it is called *Early leaf blight*, but if it occurs later when plants are flowering or producing fruit, it is called *late blight*. Leaf blight disease is common on Tomatoes, capsicum, potato crops and taro.

Activity 2

1. Take a walk in the garden and see if any tomatoes are showing signs of wilt. Scrape the top layer of soil and test if the soil is moist or dry.

   If the soil is moist then remove a wilted plant and take a knife and cut open of the stem, horizontally and longitudinally and examine to see if you see any signs of vascular browning.

2. Examine the leaves for brown spots. If the spots are brown with concentric rings that look like a target board of darts - it is called *target spot* and this is indicative of early blight disease.

3. Take a walk amongst some taro plants growing in the field. Examine both young and old leaves. Note if young leaves have any circular brown spots on them. Now examine older leaves and see whether there are huge areas of brown spots or dead tissue due to the merging of a number of dead leaf spots. Examine the under surface of the leaves and check whether there is any white ring around the border of the leaf spot. If so, this is Taro leaf blight disease. It is best to observe this in the early morning.

   Symptoms observed…………………………………………………………...

   Number of plants affected……………………………………………………..

Leaf spots

Sometimes there may be a number of different types of leaf spots on a plant. Some may be regular or round and small; others may be irregular, and others are where the diseased brown dead tissues drop off leaving a hole. More than one disease may occur on the same plant.

Activity 3

1. Examine leaves of bananas growing in the gardens around you.
   (a) Take a leaf showing symptoms and describe the leaf spots you observe by making a drawing of the type of spots present.

   (b) Count the number of different types of spots present and their colour.

   The symptoms help to identify what the cause is.

Ways to control disease

There are a number of simple ways in which the losses caused by plant diseases can be controlled. These are as follows:

- **Using disease –free planting materials** i.e. healthy seeds or cuttings obtained from a healthy crop.
- **Good hygiene**, i.e., Removing and destroying infected material, e.g. cocoa pods with black pod disease by burning; destroying crop residues after the crop is harvested.
- **Crop rotation** by planting a different host crops after the first crop is harvested i.e. beans after sweet potato. Avoid too close spacing when planting corn, peanuts, and taro.
- **Planting cultivars, which are resistant to disease**– e.g. new taro and potato varieties with tolerance to Leaf blight, hybrid cocoa, corn.
- **Managing insect pests** such as aphids which transmit plant viruses
- **Farm quarantine** – stop unnecessary movement of people animal, machines in and out of the farm.
- **Chemicals** -As with herbicides there are chemicals that can be used to control diseases caused by micro-organisms such as fungi. These are called fungicides. However these are also costly and require care in using the right chemical for the right disease. Copper based compounds have been long used to control some diseases like coffee rust but these are generally only used in bigger plantations rather than on smallholder blocks.

Activity 4

1. Do you use any of these practices in your gardens/farms and if so, why?

Summary

Weeds grow in any environment. They are found in gardens, pastures, in water, on trees and in all environments. Weeds compete with crops for water, nutrients and sunlight resulting from loss of yield. Weeds can be controlled by physical, cultural, mechanical, chemical (herbicides) and biological control.

Pests refer to mostly the bad insects and their larvae which feed and damage our vegetables. Insect pests can be controlled by physical, cultural, biological, organic and inorganic pesticides.

Plant diseases are hard to see or recognize at an early stage until the crop has been affected. Observing the visible symptoms indicate there is a plant disease problem. To control crop diseases, some of these include good cultural practices, physical and using chemicals.

TASMANIAN INSTITUTE OF AGRICULTURE

SMCN/2008/008 Increasing vegetable production on Central Province, Papua New Guinea, for Port Moresby Markets

COLLATION OF TRIP REPORTS

Volume 1

May 2010 to March 2012

C. J. Birch

Project Leader

25/8/15

REPORTS TO ACIAR ON TRIP TO PAPUA NEW GUINEA (PNG)

TASMANIAN INSTITUTE OF AGRICULTURAL RESEARCH

SMCN/2008/008 Increasing vegetable production in Central Province, Papua New Guinea to supply Port Moresby Markets

REPORT TO ACIAR ON TRIP TO PAPUA NEW GUINEA (PNG)

5-13 May 2010

C. J. Birch and L. Sparrow

Introduction

This report covers objectives and outcomes of a visit to Papua New Guinea from 5th to 13th May 2010, as a pre-inception visit. It contains a summary of objectives and outcomes, supported by two more detailed documents arising from the visit – titled 'Proceedings of meetings and field trips, (7-13 May 2010)' and 'Activities in ACIAR funded project'. These two documents will be supplied to project partners in PNG – Central Province Government, National Agricultural Research Institute (NARI), Fresh Produce Development Agency (FPDA), Pacific Adventist University (PAU) and Green Fresh. This report relies on these two documents, though a small amount of additional information is included here.

Participants from Tasmanian Institute of Agricultural Research

Assoc Prof Colin Birch, Dr Leigh Sparrow

Objectives of trip

The objectives of the trip were:

(i) Meet with all project partner organisations as a group to provide a general overview of the project
(ii) Gain agreement on the establishment, management and terms of reference of a Project Management Advisory Committee
(iii) Meet individually with partner organisations to clarify involvement, and consider future work plans (in general terms), and appointment of local staff within the project budget
(iv) Formalise liaison/communication arrangements among project partners, with the project leader and with TIAR
(v) Discuss financial arrangements in general terms
(vi) Identify additional local contacts

(vii) Undertake additional field visits and inspect infrastructure to clarify capacity and potential locations of project activities

Outcomes of Visit

The visit was very successful, and progress was made on all objectives. Outcomes are listed under each of the objectives below, and expanded on in the attached documents ‘Proceedings of meetings and field trips, (7-13 May 2010)’ and ‘Activities in ACIAR funded project’. The first document records meetings, meeting attendance, discussions and actions/outcomes from each meeting or field trip, the latter document is an expansion of Section 5 of the project application and contains additional information related to project activities, and will be used as the basis of development of project activities for the next 12 months as part of the project inception process.

Objective (i) Meet with all project partner organisations as a group to provide a general overview of the project.

Meeting held on 7th May, outcomes detailed in ‘Proceedings of meetings and field trips, (7-13 May 2010)’ pp 1-3.

Objective (ii) Gain agreement on the establishment, management and terms of reference of a Project Management Advisory Committee

All PNG participants agreed to establishment of project management advisory committee, its membership and terms of reference. Detail included in ‘Proceedings of meetings and field trips, (7-13 May 2010)’ pp 4-5

Objective (iii) Meet individually with partner organisations to clarify involvement, and consider future work plans (in general terms), and appointment of local staff within the project budget

Meetings held with Central Government, NARI, FPDA, PAU and Green Fresh over Friday 7th May to Wednesday 12th May, outcomes of and actions arising from these meetings detailed in the attached documents ‘Proceedings of meetings and field trips, (7-13 May 2010)’ pp 6-14, and in ‘Activities in ACIAR funded project’.

Objective (iv) Formalise liaison/communication arrangements among project partners, with the project leader and with TIAR

This objective was achieved through the establishment of the Management Advisory Committee (Objective (ii)) and a number of action items arising from meetings with individual partners. Specifically, each partner will provide a ‘key contact’ for communication with TIAR, with this person being responsible for internal communications within each partner organisation. The main local partner in each activity is also identified in the attached document ‘Activities in ACIAR funded project’

Objective (v) Discuss financial arrangements in general terms

Completed, with detail to follow once project is being implemented. As with Objective (iv), each partner organisation will provide a financial contact for liaison with TIAR.

Objective (vi) Identify additional local contacts

Additional local contacts were identified, including some who may provide sites for project activities.

Objective (vii) Undertake additional field visits and inspect infrastructure to clarify capacity and potential locations of project activities

Four field visits to Sogeri Plateau, NARI Laloki Southern Region Research Centre (2 sites), PAU and Green Fresh were undertaken, with outcomes briefly described in 'Proceedings of meetings and field trips, (7-13 May 2010)' pp 15 – 16. Observations of resources in the coastal lowlands were also made. In addition to the material in the attached documents, the following assessments are provided.

Sogeri Plateau

Lack of infrastructure and apparent low population, coupled with difficult terrain and limited water supplies likely to limit opportunities for field based production. There is a clear need for detailed resource assessment as an initial step in any research on the plateau.

Figure 1. Sogeri Plateau (clockwise from top left) Sogeri Plateau topography, hydroponic tomatoes at Sogeri Village, hydroponic lettuce and other leafy greens at Sogeri Village, Sogeri Plateau village with ginger plots

Coastal Lowlands

Areas out of flood and with access to underground water would be suitable. There appear to be significant areas of land resources that meet this criteria and in which soil drainage is adequate. Previous farming of maize and vegetables and would indicate that land suitability is not a major limitation. The previous production of rice indicates care would be needed in site selection, as impeded drainage is necessary for paddy rice (but not upland rice).

NARI Laloki

We have some concern on equipment (tractors out of service), infrastructure (irrigation), irrigation water (from Laloki River and may be infested with nematodes) and security (lack of security fences).

Figure 2. NARI Laloki (clockwise from top left) Yam germplasm collection, Taro germplasm collection,

Cassava germplasm collection, plant nursery (vegetables, fruits, ornamentals)

PAU

Commercial production at PAU supplies resident students and the surplus is sold in Port Moresby. Equipment and infrastructure are impressive (6 tractors, cool room, packing shed, delivery van) and the estimated 20-30 ha of irrigated land for vegetable and fruit production is supplied by shallow bore water. Labour is plentiful, with 5 farms staff and many unskilled labourers. The farm must be supported by other PAU resources. NARI Laloki (Rosa Kambuou) have worked with Peter Sale on sigatoka disease of bananas so there is some history of collaboration. Security seems quite strong, with a guarded entrance with electrified fencing.

PAU may be the preferred site for field experiments because of its infrastructure, greater scale of current vegetable production and supply of bore water.

Figure 3. Pacific Adventist University. Top left- Sprinkle irrigation of seedlings, top right – trickle irrigation of seedlings, centre left – green manure crop, centre right – sweet corn, bottom left – PAU delivery vehicle, bottom right – use of plastic mulch with cucurbits. (Note the weed population)

Colin Birch Leigh Sparrow

19/5/10

TASMANIAN INSTITUTE OF ARGICULTURAL RESEARCH

VEGETABLE CENTRE

REPORT TO ACIAR ON VISIT TO PNG

14-18TH June 2010

C Birch, R. Doyle and L. Bonney

Introduction

Associate Professor Colin Birch (Project Leader), Dr Richard Doyle and Mr Laurie Bonney visited PNG from 14th to 18th June 2010, though Assoc Prof Colin birch returned on 17th June 2010. The primary purpose of the visit was to conduct the project Inception Meeting with representatives of all participants in the project (National Agricultural Research Institute, Fresh Produce development Agency, Pacific Adventist University, Green Fresh and the Government of Central Province. The outcomes of that meeting, held over two days in Port Moresby appears in Table 1, and associated text.

Mr Laurie Bonney visited several locations likely to be used in the project, and commenced activities related to the value chain component of the project. Table 2 summarises his activities and their outcomes. He has had considerable subsequent email discussion with Michael Atuai, FPDA, on commencing the field activity associated with the Value Chains component of the project.

Dr Richard Doyle visited Dr Sergei Bang and Jimmy Maro, NARI, Lae, and discussed the GIS components of the project, and implementation of them in accordance with agreed stages in Table 1 (e) with Jimmy Maro. A map of districts, agricultural land use, agricultural systems and infrastructure associated with villages and the agricultural areas has been produced as a project output (Figure 1). Richard also received a copy of PNGRIS (PNG Resource Information System) data bases (16 GB of data) and handbook and GEOBook (a basic land resource GIS data base). He also visited the GIS team at University of Papua New Guinea.

Assoc Prof Colin Birch

1/7/10

TASMANIAN INSTITUTE OF AGRICULTURAL RESEARCH

ACTIVITIES IN ACIAR FUNDED PROJECT

SMCN/2008/008 Increasing vegetable production in Central Province, Papua New Guinea to supply Port Moresby Markets

OUTCOMES OF INCEPTION MEETING, Port Moresby 15-16 June 2010

Detailed listing of activities and outcomes for year 1 of project showing persons responsible for specific outcomes, PNG participants and dates for completion

The material that follows was agreed at the project Inception Meeting. It is organised around Activities and Outcomes also includes participants, agreed dates for completion of tasks and some explanatory notes. Bolded initials/organisation indicates local lead/contact in PNG. (Abbreviations used in the tables are shown on the first page of tables and highlighted items are those where additional information or clarification is awaited).

Note: This file has been edited to remove the name of one person who is deceased. Her contribution in the early stages of the project is acknowledged.

CJB 6/8/12

Abbreviations Used

TIAR - Tasmanian Institute of Agricultural Research CB – Colin Birch LB – Laurie Bonney RD – Richard Doyle LS – Leigh Sparrow	**CP - Central Province** SH – Shirley Hopa
NARI - National Agricultural Research Institute UP – Udai Pal CG – Clifton Gwaba JM – Jimmy Maro RK – Rosa Kambouru RO – Research Officer HR Human Resources SRC – Staff Representative	**FPDA - Fresh Produce Development Agency (FPDA)** RL – Robert Lutulele MA – Michael Atuai Poela Utama
UC - Canberra Uni BC – Barbara Chambers	**PAU - Pacific Adventist University** LS – Lalen Simeon TM – Tracie Mafile'o PS – Peter Sale Another to be advised
GF - Green Fresh Erna Momo	

Table 1 Detailed listing of activities to be undertaken in Year 1 of the project to achieve Year 1 outcomes and contribute to Year 2 outcomes, by activity and outcomes listed in Table 1 above.

(a) Activity 1.1 Survey participants in smallholder and large scale vegetable value chains in Central Province to identify and rank barriers to profitable and sustainable supply

(i) Outcome 1.1.1. Product quality and supply barriers identified and ranked

Activity	Person/s responsible	PNG Participants	Target date for completion	Completed	Notes
Identify & brief NARI & FPDA operational staff involved	L.Bonney	**MA (FPDA)**, UP (NARI), Erna (GF), LS (PAU)	30/6/10		All steps in Activity 1.1 must be complete by end Feb 2011
What vegetables are produced and where in relation to PoM	Laurie Bonney	**MA (FPDA)**, UP (NARI), Erna (GF), LS (PAU)	7/7/10		
Identify desired community attributes	L.Bonney/Post Doc Value Chains	**MA (FPDA)**, UP (NARI), Erna (GF), LS (PAU)	7/7/10		
Review & select communities to be involved	L.Bonney/Post Doc Value Chains	**MA (FPDA)**, UP (NARI), Erna (GF), LS (PAU)	15/7/10		
Interview/focus group schedule prepared	L.Bonney/Post Doc Value Chains	**MA (FPDA)**, UP (NARI), Erna (GF), LS (PAU)	31/7/10		
Resources, travel etc required identified	L.Bonney/Post Doc Value Chains	**MA (FPDA)**, UP (NARI), Erna (GF), LS (PAU)	31/7/10		
Hold focus groups to inform & discuss: 1. Participation with communities 2. Choice of focal crops	L.Bonney/Post Doc Value Chains	**MA (FPDA)**, UP (NARI), Erna (GF), LS (PAU), SH (CP)	31/7/10		

3. Identify constraints & opportunities					
Identify key chain participants for interview	L.Bonney/Post Doc Value Chains	**MA (FPDA)**, UP (NARI), Erna (GF), LS (PAU)	31/7/10		Repeat trip by LB, Post Doc in October, a second date to be advised
Interview schedule prepared	L.Bonney/Post Doc Value Chains	**MA (FPDA)**, UP (NARI), Erna (GF), LS (PAU)	31/7/10		
Design semi-structured questions for chain participants & conditions of interview	L.Bonney/Post Doc Value Chains	**MA (FPDA)**, UP (NARI), Erna (GF), LS (PAU)	31/7/10		
Consumer/retailer interviews to determine value attributes	L.Bonney/Post Doc Value Chains	**MA (FPDA)**, UP (NARI), Erna (GF), LS (PAU)	31/7/10		Repeat trip by LB, Post Doc in October, a second date to be advised
Arrange interviews	**MA** (FPDA)	**MA (FPDA)**, UP (NARI), Erna (GF), LS (PAU)	7/8/10		Repeat trip by LB, Post Doc in October, a second date to be advised
Conduct interviews	L.Bonney/Post Doc Value Chains	**MA (FPDA)**, UP (NARI), Erna (GF), LS (PAU)	31/8/10		Repeat trip by LB, Post Doc in October, a second date to be advised
Training VCA	L. Bonney	**MA (FPDA)**, UP (NARI), Erna (GF), LS (PAU)	TBA		

Analyse data	**L.Bonney**/Post Doc Value Chains	UP (NARI), LS (PAU)	31/12/10		
OUTCOME 1.1.1 completed	L.Bonney/Post Doc Value Chains	**MA (FPDA)**, UP (NARI), Erna (GF), LS (PAU)	25th February 2011		
OUTCOME 1.1.2 Agronomic, soil, water and nutrient management barriers identified	L.Bonney/Post Doc Value Chains, LS, CB, RD,	**MA (FPDA)**, UP (NARI), Erna (GF), LS (PAU)	31st March 2011		
OUTCOME 1.1.3 Integrated chain improvement projects identified in: 1. Soil and water management 2. Vegetable agronomy and integrated crop protection 3. Chain and market processes	L.Bonney/Post Doc Value Chains, LS, CB, RD,	**MA (FPDA)**, UP (NARI), Erna (GF), LS (PAU)	31st March 2011		

(b) Activity 1.2 Interviews commenced with women and youth on opportunities and constraints affecting their participation in the value chain

(i) Outcome 1.2.1 Identification and/or confirmation of impediments to full participation in the supply chain

Activity	Person responsible	PNG participants	Target date for completion	Completed	Notes
Staff from Project to be involved in interviews identified	Barbara Chambers	**Poela Utama (FPDA)**,LS (PAU), Maria Linibi (PNG WiADF Executive), CG (NARI), SH (CP)	16/6/10		Have already talked with Poela Utama (Acting OIC and Extension advisor, FPDA Boroko, NCP
Interview/focus group questions determined	Barbara Chambers	**Poela Utama (FPDA)**,LS (PAU), CG (NARI), SH (CP)	16//07/2010		Focus groups may be used instead of interviews for youth and women, depending on cultural advice.
Interview/focus group questions sent to UTAS Ethics Committee	Barbara Chambers via Colin Birch	LS	16/07/2010		Copy of documents to PAU REC
Ethics clearance of questionnaires	Colin Birch to Barbara Chambers		31/7/10		Provisional clearance Copy of documents to PAU REC
Interview/focus group schedule prepared	Barbara Chambers	**Poela Utama (FPDA)**,LS (PAU), CG (NARI)	30/08/2010		
Interview/focus group locations identified	Barbara Chambers	**Poela Utama (FPDA)**,LS (PAU), CG (NARI)	30/08/2010		
Resources, travel etc required identified	Barbara Chambers	**Poela Utama (FPDA)**,LS (PAU), CG (NARI)	30/08/2010		

Interview/focus group participants identified	Barbara Chambers	**Poela Utama (FPDA)**,LS (PAU), CG (NARI), PNG WiADF executive (list of women members in central province identified)	06//09/2010		Invariably in PNG others (unknown) also turn-up for focus groups because of word of mouth.
Interviews/focus groups conducted and recorded	Barbara Chambers	**Poela Utama (FPDA)**,LS (PAU), CG (NARI)	13/09/2010 – 24/09/2010		May involve bringing people in to a central location if focus groups used instead of interviews.
N-Vivo or other analysis completed	Barbara Chambers	LS (PAU	29/10/2010		Assistance with transcription
Constraints to participation identified	Barbara Chambers	**FPDA (Poela Utama),** PAU (LS) NARI (Clifton)	15/11/2010		
Future R, D and E actions recommended	Barbara Chambers	**FPDA (Poela Utama),** PAU (LS), NARI (Clifton	15/11/2010		
Draft report submitted	Barbara Chambers	**Poela Utama (FPDA)**,LS (PAU), CG (NARI), PNG WiA (Maria Linibi) for comment	15/11/2010		To Colin Birch (project leader) for final comment
Final report submitted	Barbara Chambers		30/11/2010		To Colin Birch

(c) Activity 1.3 Develop, implement and review best practice value chain management models for participants in each stage of the focal chains

(i) Outcome 1.3.1 Develop Best practice models developed, implemented and reviewed

Activity	Person/s to implement	PNG Participants	Target date for completion	Completed	Notes
NARI, FPDA , PAU, GF, CP operational staff involved in interviews identified & briefed	L.Bonney	**MA (FPDA)**, UP (NARI), Erna (GF), LS (PAU), SH (CP)	31/8/10		
Discuss participation with smallholders	L.Bonney/Post Doc Value Chains	**MA (FPDA)**, UP (NARI), Erna (GF), LS (PAU), SH (CP)	31/8/10		
Discuss participation with other chain participants	L.Bonney/Post Doc Value Chains	**MA (FPDA)**, UP (NARI), Erna (GF), LS (PAU), SH (CP)	31/8/10		
Collaboratively develop draft BP value chain model	L.Bonney/Post Doc Value Chains	**MA (FPDA)**, UP (NARI), Erna (GF), LS (PAU), SH (CP)	31/10/10		
Identify the resources required	L.Bonney/Post Doc Value Chains	**MA (FPDA)**, UP (NARI), Erna (GF), LS (PAU), SH (CP)	31/10/10		
Identify the roles of FPDA, NARI, PAU, GF, CP and Australian staff and resources required	L.Bonney/Post Doc Value Chains	**MA (FPDA)**, UP (NARI), Erna (GF), LS (PAU), SH (CP)	31/10/10		
Obtain commitment of chain participants	L.Bonney/Post Doc Value Chains	**MA (FPDA)**, UP (NARI), Erna (GF), LS (PAU), SH (CP)	31/10/10		
Allocate the resources required	L.Bonney/Post Doc Value Chains	**MA (FPDA)**, UP (NARI), Erna (GF), LS (PAU), SH (CP)	28/2/11		

Plan implementation with chain participants and FPDA/NARI/GF/PAU/CP staff	L.Bonney/Post Doc Value Chains	**MA (FPDA)**, UP (NARI), Erna (GF), LS (PAU), SH (CP)	31/3/11		
Provide training as needed	L.Bonney/Post Doc Value Chains	**MA (FPDA)**, UP (NARI), Erna (GF), LS (PAU), SH (CP)	April 2011		
Implement & monitor with chain participants	L.Bonney/Post Doc Value Chains	**MA (FPDA)**, UP (NARI), Erna (GF), LS (PAU), SH (CP)	Dry season 2011 – commencing April 2011		First iteration of continuous improvement process
Report to participating agencies	L.Bonney/Post Doc Value Chains	MA (FPDA), UP (NARI), Erna (GF), LS (PAU), SH (CP)	December 2011		
Review model & implement with chain participants	L.Bonney/Post Doc Value Chains	**MA (FPDA)**, UP (NARI), Erna (GF), LS (PAU), SH (CP)	Dry season 2012 – commencing April 2012		
Report to participating agencies	L.Bonney/Post Doc Value Chains	MA (FPDA), UP (NARI), Erna (GF), LS (PAU), SH (CP)	December 2012		
Review model & implement with chain participants	L.Bonney/Post Doc Value Chains	**MA (FPDA)**, UP (NARI), Erna (GF), LS (PAU), SH (CP)	Dry season 2013 – commencing April 2013		
Report to participating agencies	L.Bonney/Post Doc Value Chains	MA (FPDA), UP (NARI), Erna (GF), LS (PAU), SH (CP)	December 2013		

(e) Activity 2.1. Field trials with smallholders and large scale operators identified in 1.1 to test practices to overcome soil and water management and crop protection barriers for vegetable production identified in 1.1

(i) Activity 2.1.1 R & D field trials in PNG established, implemented and data collected and analysed

Activity	Person/s responsible	PNG participants	Target date for completion	Completed	Notes
Staff from Project to be involved identified	Colin Birch	**UP** (NARI), MA (FPDA) Lelan (PAU), Erna (PAU), SH (CP)	16/6/10		
Preliminary selection of potential candidate vegetables / cultivars	Mark Boersma, Colin Birch, Laurie Bonney	**UP** (NARI), MA (FPDA) Lelan (PAU), Erna (PAU), SH (CP)	15/8/10		Assuming we proceed with this in 2010 dry season, practicality to be considered in early August. Avoid 'going too early'.
Establishment of preliminary trials	Mark Boersma	**UP** (NAR)I, **PS (**PAU)	TBA		Assuming we proceed with this in 2010 dry season
Preliminary assessment of potential candidate vegetables / cultivars completed	Mark Boersma	**UP** (NARI), Research Officer/s, PS (PAU), Erna (GF), SH (CP)	Consequent on date in cell above		Option – literature review, past research surveyed desk top study
Receive guidance from the value chain work on target vegetables	Laurie Bonney, Leigh Sparrow	**UP** (NARI), PS (PAU), Erna (GF), SH (CP)	31/3/11		
Receive guidance from partners and GIS assessment on suitable sites for field trials	Richard Doyle, Leigh Sparrow, Mark Boersma	**JM** (NAR)I Research Officer/s, PS (PAU), Erna (GF), SH (CP)	31/3/11		
Site selection and characterisation incl. soil analyses	Richard Doyle, Leigh Sparrow, Mark Boersma,	**JM** (NARI) Research Officer/s, (NARI), PS	15/4/11		Replicated experiments on research stations/high

	Colin Birch	(PAU), Erna (GF), SH (CP)			security locations (4-5 sites), a number of demonstrations elsewhere
Experimental design, data to be collected	Richard Doyle, Leigh Sparrow, Mark Boersma, Colin Birch	**UP** (NARI) Research Officer/s, (NARI), PS (PAU), Erna (GF), SH (CP)	15/4/11		
Identify resources needed for year 1 trials	Richard Doyle, Leigh Sparrow, Mark Boersma, Colin Birch	**UP** (NARI) (NARI), PS (PAU), Erna (GF), SH (CP)	15/4/11		
Allocate necessary resources and equipment	Colin Birch	**UP** (NARI), PS (PAU)	30/4/11		
Prepare sites	Leigh Sparrow, Mark Boersma	**UP** (NARI) Research Officer/s, PS (PAU)	30/4/11		
Establish trials	Leigh Sparrow, Mark Boersma	**UP** (NARI) Research Officer/s, PS (PAU)	31/5/11		
Data collection: vegetative stage	Leigh Sparrow, Mark Boersma	**UP** (NARI) Research Officer/s, PS (PAU)	31/8/11		
Data collection: at harvest maturity	Leigh Sparrow, Mark Boersma	**UP** (NARI) Research Officer/s, PS (PAU)	30/9/11		
Data collection: post harvest	Leigh Sparrow, Mark Boersma	**UP** (NARI) Research Officer/s, PS (PAU)	30/10/11		
Data analysis and reporting	Richard Doyle, Leigh Sparrow, Mark Boersma, Colin Birch	**UP** (NARI) Research Officer/s, PS (PAU)	31/1/12		

(d) Activity 2.2 Crop adaptation studies under controlled conditions at University of Tasmania

(i) Outcome 2.2.1 Detailed data on adaptation to high and low temperatures in near constant photoperiod collected, analysed and reported

Activity	Person/s to implement	PNG Participants	Target date for completion	Completed	Notes
Staff involved identified	Colin Birch, Mark Boersma	UP (NARI), PS (PAU)	16/6/10		Visits to Australia by ROs
Detailed pre-schedule of experiments prepared	Mark Boersma, Al Gracie, (CB)	UP (NARI), PS (PAU)	7/7/10		
Quarantine regulations and procedures	Mark Boersma	Keep informed - [UP (NARI), PS (PAU)]	7/7/10		
Potential seed sources identified	Mark Boersma, Al Gracie	UP NARI, Peter PAU	31/8/2010		Indigenous varieties to Australia Or know non-photoperiod sensitive Australian varieties
Seed available	Mark Boersma	UP (NARI), PS (PAU)	TBA		
Growth cabinet space reserved	Mark Boersma	-			
Controlled environment experiment/s established	Mark Boersma, Al Gracie	Visiting RO from NARI	30/11/2010		
Data Collection	Mark Boersma, Al Gracie	Visiting RO from NARI and UP	28/2/2011		
Data Analysis	Mark Boersma, Al Gracie, Colin Birch	Visiting RO from NARI and UP	31/3/2011		

Report compiled and circulated in draft form	Mark Boersma	RO from NARI and UP	15/3/2011		
Report Completed	Mark Boersma, Al Gracie, Colin BirchB	RO from NARI and UP	31/3/2011		
Recommendations arising from controlled environment studies available	Mark Boersma, Al Gracie, Colin Birch	RO from NARI and UP	31/3/2011		
Group visit/meeting	Leigh Sparrow, Colin Birch, Richard Doyle, Laurie Bonney	All meeting PoM	30/ 4/2011		

(e) Activity 2.3 GIS studies land suitability (incl. wetness, slope, hydrology and climate) of land in highlands and lowlands of Central Province

(i) Outcome 2.3.1 Improved maps of land suitability and:

(ii) Outcome 2.3.2 Increased GIS capability at NARI (PC)

Activity	Person responsible	PNG participants (names to be added)	Target date for completion	Completed	Notes
Staff from Project to be involved identified	Richard Doyle	**JM** (NARI), MA (FPDA),	16/6/10		
Visit to Lae re GIS activities	Richard Doyle	**JM (**NARI)	17/6/10		
Discussion with UTAS GIS Unit	Richard Doyle, Arco (GIS UTAS)	**JM (**NARI)	30/6/10		

Document Data Layers available for CP, PNG	Richard Doyle, Jimmy Maro	**JM** (NARI), [Keep Informed MA (FPDA), SH (CP)]	21/6/10		
Acquire Land Use Maps from CP	Richard Doyle	**JM (**NARI), SH (CP)	30/6/10		
Generate digitised Land Resource maps of CP	Richard Doyle, Geography/SAS	**JM** (NARI) [Keep Informed MA (FPDA), SH (CP)]	30/11/10		
Generate digitised Land Capability maps of CP	Richard Doyle, Jimmy Maro, Geography/SAS	**JM** (NARI) [Keep Informed MA (FPDA), SH (CP)]	31/1/11		
Augment with Infrastructure resources	Richard Doyle, Jimmy Maro, Geography/SAS	**JM** (NARI) [Keep Informed MA (FPDA), SH (CP)]	21/2/11		
Augment with Climate data, maps	Richard Doyle, Jimmy Maro, Geography/SAS	**JM** (NARI) [Keep Informed MA (FPDA), SH (CP)]	31/3/11		
Move to Activity 4.1 on basis of Activity 1.1	Richard Doyle, Jimmy Maro, Geography/SAS	**JM** (NARI) [Keep Informed MA (FPDA), SH (CP)]	30/4/11		
Report compiled and circulated in draft form	Richard Doyle	**JM** (NARI) [Keep Informed MA (FPDA), SH (CP)]	15/3/2011		
Report Completed	Richard Doyle	**JM** (NARI) [Keep Informed MA (FPDA), SH (CP)]	31/3/2011		

Recommendations arising from GIS studies available	Richard Doyle	**JM** (NARI) [Keep Informed MA (FPDA), SH (CP)]	31/3/2011		
Group visit/meeting	Leigh Sparrow, Colin Birch, Richard Doyle, Laurie Bonney	All meeting PoM	30/4/2011		

Staff Appointment – (Research Officer 1 NARI)

Activity	Person responsible	Participants involved (names to be added)	Target date for completion	Completed	Notes
Skills, qualifications and Competencies required identified	UP	UP, CG, RK	18/6/10		
Draft Position description competed	UP	UP, CG, RK	18/6/10		Copy to CB
Vacancy advertised	UP/HR	UP, HR, SRC	30/6/10		
Interview held	UP	UP, RK, CG, SRC	30/7/10		
Appointment made	HR (NARI)	HR (NARI)	30/8/10		

Staff Appointment – Research Officer 2 NARI

Activity	Person responsible	Participants involved (names to be added)	Target date for completion	Completed	Notes
Skills and Competencices required identified	UP	UP, CG, RK	18/6/10		
Draft Position description competed	UP	UP, CG, RK	18/6/10		Copy to CB
Vacancy advertised	UP/HR	UP, HR, SRC	30/6/10		
Interview held	UP	UP, RK, CG, SRC	30/7/10		
Appointment made	HR (NARI)	HR (NARI)	30/8/10		

Staff Appointment – Technical Officer

Activity	Person responsible	Participants involved (names to be added)	Target date for completion	Completed	Notes
Skills and Competencices required identified	UP	UP, CG, RK	18/6/10		
Draft Position description competed	UP	UP, CG, RK	18/6/10		Copy to CB
Vacancy advertised	UP/HR	UP, HR, SRC	30/6/10		
Interview held	UP	UP, RK, CG, SRC	30/7/10		
Appointment made	HR (NARI)	HR (NARI)	30/8/10		

Staff Appointment – Extension Officer 1 FPDA

Activity	Person responsible	Participants involved (names to be added)	Target date for completion	Completed	Notes
Skills, qualifications and Competencies required identified	RL	MA, GM, ?	30/6/10		Subject to confirmation
Draft Position description competed	RL	MA, GM, ?	30/6/10		Copy to CB
Vacancy advertised	RL	MA, GM, ?	15/7/10		
Interview held	RL	MA, GM,?	31/7/10		
Appointment made	RL HR (FPDA)	RL HR (FPDA)	31/8/10		

Staff Appointment – Extension Officer 2, FPDA

Activity	Person responsible	Participants involved (names to be added)	Target date for completion	Completed	Notes
Skills, qualifications and Competencies required identified	RL	MA, GM, ?	30/6/10		
Draft Position description competed	RL	MA, GM, ?	30/6/10		
Vacancy advertised	RL	MA, GM, ?	15/7/10		
Interview held	RL	MA, GM,?	31/7/10		
Appointment made	RL HR (FPDA)	HR (FPDA)	31/8/10		
Advise Poela Utama to work with BC					Poela Utama is Acting OIC and Extension Advisor in NCP*

- Ms Poela Utama, Acting OIC and normally Extension Advisor, PO Box 2788, Boroko, NCD. Email: poelautama@yahoo.com.au
- Ph:+ 675 3215520/3408070
- Fax: +675 3215519

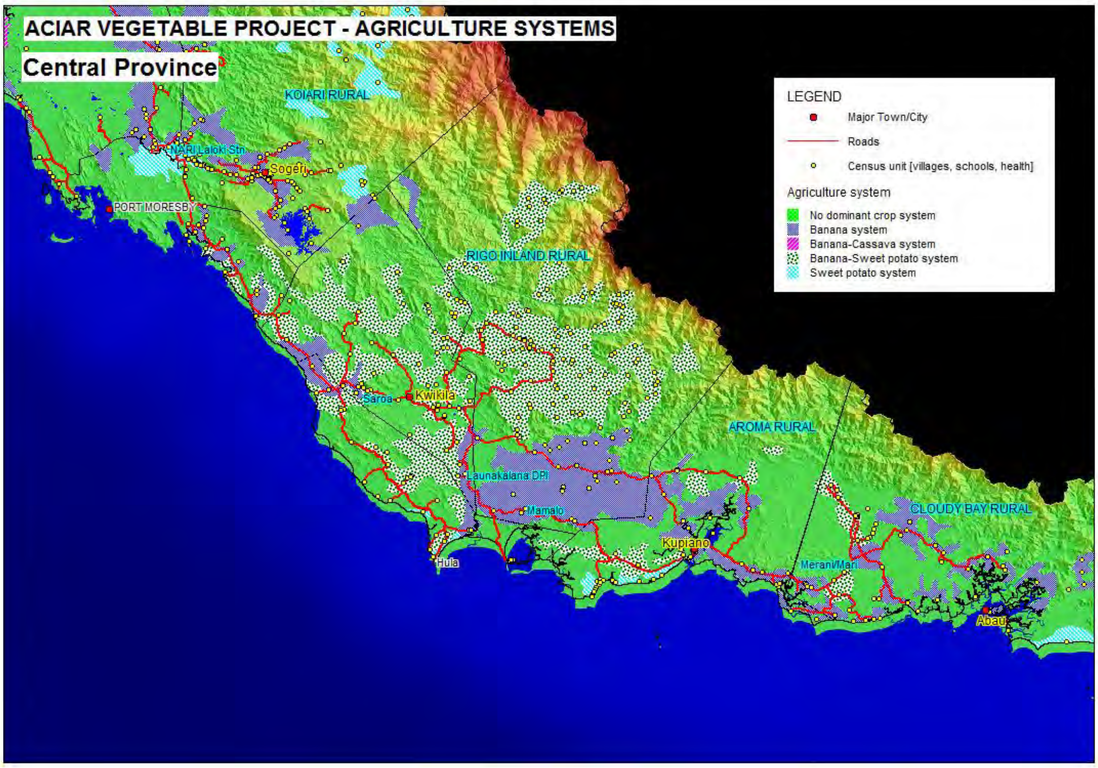
Staff Appointment – Research Officer, PAU

Activity	Person responsible	Participants involved (names to be added)	Target date for completion	Completed	Notes
Skills, qualifications, and competences required identified	LS	LS, TM, BT	30/6/10		
Draft Position description competed	LS	LS, TM, BT	30/6/10		Copy to CB
Vacancy advertised	N/A				Internal Appointment
Interview held	LS	LS, TM, BT	31/7/10		
Appointment made	LS, HR (PAU)	LS, HR (PAU)	15/8/10		

Table 2 Summary of Activities, Laurie Bonney Thursday 17th June 2010

Location/s	Activity	Outcomes
Gordon's Market	Observe smallholder-black marketer interaction in the 'receivals' area of the market	• Understanding of marketing process • Observation of relationships, including the harassment of women and conflict between chain participants
PoM to Brown River area and return to Laloki	Inspection of the landscape, agriculture and marketing processes	• Assessment of agricultural/vegetable growing potential • Observe vegetable transport process • Discussions with roadside marketers
Laloki to Sogeri Plateau	Inspection of the landscape, agriculture and marketing processes	• Assessment of agricultural/vegetable growing potential • Observe vegetable transport process and problems • Discussions with roadside marketers
Inspect PAU farm	Inspect PAU farm	• Assess potential for conduct of field trials and project hosting • Discussions with Peter Sale, Farm & Marketing Manager, the market research process
Visit to Greenfresh (new premises)	Assessment of the nature and scale of commercial vegetable import and local vegetable marketing	• Understanding of marketing process • Discussions with Erna Momo regarding her assistance with the market research process

Figure 1. Agricultural Systems of Central Province, PNG



TASMANIAN INSTITUTE OF AGRICULTURAL RESEARCH

SMCN/2008/008 Increasing vegetable production in Central Province, Papua New Guinea to supply Port Moresby Markets

REPORT TO ACIAR ON TRIP TO PAPUA NEW GUINEA (PNG)

5-15 October 2010

L. B. Bonney, C. J. Birch and G. Palaniappan

Day 1: 5th May 2010

Meeting of Local Management Advisory Committee, Crowne Plaza Hotel, Port Moresby

Objectives of the meeting

1. Clarification of the role of each agency in the project
2. Review of the Activity Plan to clarify involvement of agencies in specific activities
3. Discussion and recommendations from local partners on interviewees and 31rganizations to be visited as part of the Value Chains part of the project
4. Discussion and initial recommendations on vegetables to be used in the experimental part of the project and some guidance on sites for this work
5. Address General Business and additional Items
   Purchase of Services, Equipment
   Local travel budget and recovery of travel costs incurred by project partners.
   Staff Appointments
   Future developments

Meeting Attendance

(i) TIAR – Colin Birch, Laurie Bonney, Gomathy Palaniappan
(ii) NARI – Udai Pal, Clifton Gwabu, Tony Ovia
(iii) FPDA – Michael Atuai, Poela Utama
(iv) Central Province Administration – Daniel Apina, Shirley Hopa
(v) PAU – Lalen Simeon and Carter Ako
(vi) Greenfresh – Erna Momo
(vii) ACIAR – Emily Flowers

Meeting Outcomes

1. Objective 1 Clarification of the role of each agency in the project

(i) Prof Barbara Chambers, Gomathy Palaniappan, Shirley Hopa and WiA groups to consider linkages, adding value to the projects containing women and youth in agriculture aspects

(ii Laurie Bonney and Gomathy Palaniappan to endeavor to coordinate visits with activities relevant to women and youth in agriculture

(iii) Daniel Apina (Central Province Government) advised that vegetable production in Central Province is a priotity, and explained the need to engage with district officers, especially in relation to linkage between research and extension - Colin Birch to ensure district officers invited to a meeting in the first half of 2011 to discuss the project with them.

2. Objective 2 Review of the Activity Plan to clarify involvement of agencies in specific activities

(i) Amendments to participation in and leading specific activities agreed, an amended table to be circulated by Colin Birch

(ii) Due dates for activities delayed since June 2010 to be revised by Colin Birch and Laurie Bonney and circulated to partners. However, the intention is to complete all items previously identified as due by April 2011 by that date.

(iii) Value Chains component to proceed from 6/10/10, Laurie Bonney to liaise with partners and advise of Central Province representative in Value Chains area after further consultation with Daniel Apina (Central Province). Laurie Bonney, Gomathy Palaniappan, Michael Atuai to proceed, in consultation with other identified participants

(iv) Richard Doyle to advise of partner representation in GIS studies (Activity 2.3) after further consultation with NARI (for a Laloki based person), FPFA and Central Province Government

3. Objective 3. Discussion and recommendations from local partners on interviewees and organisations to be visited as part of the Value Chains part of the project

(i) List prepared by Laurie Bonney to be circulated to and discussed partners, to ensure appropriate coverage and participation.

4. **Objective 4. Discussion and initial recommendations on vegetables to be used in the experimental part of the project and some guidance on sites for this work**

(ii) There was general discussion around location/geographic position selection. Locations mentioned – Cloudy Bay, Laloki – NARI, Laloki – PAU (all in lowlands), Sogeri (medium altitude), Goilala (high altitude). Issues explored included access for service, access to markets/marketing infrastructure, environmental contrasts, environmental suitability for candidate crops, risk of failure of experiments, water supply and irrigation availability

(ii) There was also general discussion around potential vegetables to be used in project. A list was prepared and retained by Laurie Bonney

(iii) Re (i) and (ii) above, the project team will review potential locations and vegetables to be included after completion of Value Chains research and receiving recommendations from it.

5. Objective 5. Address General Business and Additional Agenda Items

(i) Purchase of Services, Equipment

(a) Colin Birch outlined ability to make minor adjustments to proposed purchases according to project needs.

(b) The meeting discussed local travel budget (held in NARI) and recovery of these costs incurred by project activity by partners. Accounts to be forwarded to NARI Laloki for reimbursement.

(ii) Staff Appointments

An update on staff appointments in NARI, FPDA and PAU was received – NARI appointments are in progress and PAU appointment has been made. Advice after the meeting was that FPDA appointments should be in place by November 30.

(iii) Future developments – there was a brief discussion of developments from this project, especially in relation to extension activities and participation of Central Province field staff in the project. It was agreed that field staff be engaged in the project at an appropriate time (ie when extension activities commence), and how that occurs be determined at that time.

Days 2 – 8: Value Chain Analysis

The aim of this component of the trip was to commence data collection to:

(i) Identify which vegetables we will be focusing on through discussion with the stakeholder agencies FPDA, NARI, Central Province, PAU and Greenfresh;
(ii) Identify some institutional outlets for these vegetables and:
    (a) The quality attributes required;
    (b) The volume that they require as well as future growth in volume;
    (c) The timing of supply (days of the week, time of year);
(iii) Identify the regions in which we would prefer to grow those vegetables;
    (a) Have initial discussions with some landholders (without raising hopes or confirming a selection at this point) in order to:
    (b) Gauge their level of interest and capacity to grow the selected vegetable and grow the volume produced over time;
    (c) Identify the agricultural and other constraints to production in that area e.g. water, soil, seed, fertilizer inputs, land tenure, storage, labour supply, skills, transport, social constraints etc).
(iv) Meet and discuss with any other people who may be involved in the chain between the farmers and the institutional buyers e.g. transporters, cool-stores, wholesalers (such as Greenfresh);
(v) Initiate discussions with NARI regarding the possible varieties available;

(vi) Refine the operational research design through further discussion with stakeholder research agencies of the cultural and practical issues associated with participatory action research in Central Province.

Day 2: 6th October 2010

Meetings were held with:

- *Daniel Apina Hirongopa, Program Manager, Central Province Division of Agriculture & Livestock (CP-DAL) and staff Ms Shirley Hopa, George Aminae, Augustine Yabina and Charles Ofu.*
    - The Central Province is poorly funded and lacks resources and infrastructure. However as part of the Govt. Project women cooperatives have been initiated through microcredit.
    - It appears (yet to be confirmed) that a key strategy for the PNG Government in addressing the issues associated with 'customary title' is to encourage clan groups (i.e. extended family groups) to organise and apply for formal recognition as Incorporated Land Groups (ILG). This requires the agreement of an extended family group to work together by electing a chairperson, office-holders, committee structure and also agreeing to the adoption of standard procedures and submitting an application to become legally recognised incorporated bodies. The process after application takes approximately one month and is handled by the CP-DAL. This appears to offer an important implementation vehicle for this project because it provides:
        - Legal recognition with the usual corporate obligations for any group involved in the project;
        - Access to land for growth of a business;
        - A labour force that has agreed with formal obligations to accept the responsibilities associated with supply to a market outlet.
    - The CP-DAL has a network of District Officers who will be able to provide detailed local knowledge of smallholders, production conditions and local resources. To gain local engagement with the project it will be necessary that these people are used as the conduit. Initially, they can simply be given an overview of the project and its benefits and provide the broad introductions to prospective smallholder groups. Once the selection of a producer group has been made the District Officers concerned must be fully engaged with the project through all planning, communication and training activities. I then requested that in consultation with their District Administrators the CP-DAL officers present develop a list of potential smallholders that may be suitable for the project as soon as possible and that in doing so they liaise with Michael Atuai. This was agreed.
    - CP-DAL has carriage of the newly introduced Smallholder Support Services Expansion Project (SSSEP) funded by NZAID through NDAL for Central Province and particularly for the Goilala and Kairuki districts. This program will promote the establishment of an effective agriculture support services delivery system easily accessible to male and female farmers for the establishment of production systems

such as those proposed by this project. Specifically it recognises the "absolute lack of agricultural extension services in all districts of Central Province"[1] and consequently is a project for the capacity-building of service officers including infrastructure and skills. This program is highly complementary to this project and may provide an important component for a joint focus of CP-DAL activities as well as a complementary 'template' for their expanded operations.

- *Dr Lalen Simeon, Coordinator, School of Business, PAU and other staff.*
    - Methodological approaches that have emerged from her research experiences in community engagement are:
        - Communicate benefits to prospective smallholder and women's groups as well as project and methodological descriptions; in particular, a better future for their children/PNG society;
        - Foreign project staff should always be accompanied by local male and female PNG nationals known to the participants when conducting interviews and workshops;
        - Project methodology may need to take into account significant cultural differences between tribal cultures that are geographically adjacent or in close proximity;
        - Group functions organised by the project should include the sharing of food where possible as food is customary for participation and of cultural significance and promotes communication;
        - Poela Utama, FPDA, is an important link in understanding the cultural dynamics and women's issues;
    - It will be important for bio-physical research projects to be incorporated into the Action Learning cycle when the time comes;
    - The process of engagement both vertically and horizontally will be a larger task and more important than first envisaged.
    - Daniel also suggested that local vegetables be included in the project but it was explained that because the project was specifically focussed on cool temperate vegetables this may not be possible. Laurie indicated he would confirm that with ACIAR.
    - Some attributes to be considered in selecting the smallholder groups to be involved in the project are:
        1. Previous experience in vegetable growing and marketing;
        2. Scale of production;
        3. Distance to PoM;
        4. Access to water;
        5. Access to sufficient suitable land for production;
        6. Access to labour and/or state of clan relationships;
        7. Ownership or access to key production equipment (e.g. pumps, vehicles);
        8. Motivation to work beyond fulfilling the family consumption requirement;
        9. Land tenure arrangements;
        10. Registration as an ILG or willingness to do so.

[1] Proposal to Central Provincial Executive Council, Central Province Government, p.3.

Day 3: 7th October 2010

- *Visit Andrew Sirab, smallholder, Baramatta, Brown River Region(approx. 25 km North)*[2]

Figure 1: Smallholder Andrew Sirab (Left) with his family in front of his house on his farm in the Brown River District, Central Province, with Dr Gomathy Palaniappan TIAR/UQ (Centre-Right).

An extended family who had migrated from Goilala to Port Moresby after WW2 then been forced out and settled on the flood plain of the Brown River some 30 km north of the NCD. They had squatted there since the early 1960s by permission from the traditional owners who lived only a couple of kilometres further north next to the Brown River. No rent was being charged but there were obligations associated with the right to squat e.g. to help out in troubled times; to vote for a traditional family member who was standing for parliament. Apparently they have good relationship with the land owners and can use the land as they want but they are not allowed to exploit the gravel and the timber reserves. They have the rights to use an area approximately 12 km X 8 km of the flat fertile, red ferrosol flood plain. They had built substantial semi-permanent houses about 1 km off the main road as well as shelters 12 km away next to the Brown River (Figure 1).

They farmed a range of traditional and imported crops for personal consumption and cash generation to pay for school fees, medications, and other staples such as soap etc. The main product marketed was Papaya but were also marketing pumpkin, banana and greens. Cropping was carried out near their home during the Wet and 12 km away at the Brown River in the Dry Season to gain easier access to water for the crops. Everything had to be carried to these sites and to the main road for marketing as there were no vehicles in the family or clan.

Figure 2: Fish ponds excavated but never filled with water.

Their crops were systematically laid out, appeared to be healthy and well managed and covered a large area.

Andrew, the smallholder, had excavated two fish ponds about 20 m X 5m X 1.5m in size, intending to grow fish for market but was unable to fill the ponds with water or to obtain advice from government advisory services on how to go about it (Figure 2).

Water was the main limiting resource for cropping and the main house did not have fresh water available so it was either bought in PoM or carried from the range of hills across the road to the North East. They used to get to the river twelve kilometres away for laundry, cooking and drinking water and but have been told that the river is polluted from the timber mill and also people as they urinate and excrete in the water.

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[2] Note that a regional map is provided in Appendix A.

Figure 3: Andrew Sirab's brother holding the family's farming tools.

No electricity is available in the region so they had hurricane lamps or used a wood fire for light and cooking.

The tools possessed by the family to work the ground or excavate fish ponds were few and rudimentary (Figure 3) and this was an important constraint to the scale of their activities as well as the effort expended.

The family market to Gordon's Market because this is the only destination available using the PMVs that ply the Brown River Road. They usually sell to the 'middlemen' at the back of the market because it saves time, avoids the stress of withstanding the pressure and harassment applied by the middlemen and the problem of having to downgrade price at the end of the day if their produce is not sold. However, they sometimes sell in the market personally but because the Highlanders occupy all the under-cover stalls they have to market their produce in the open air. The women do most of the marketing and the clan women take it in turns to transport everyone else's produce to town after each family has carried the bags to a collecting point on the road, thus saving time.

A communal cool store at this central point could facilitate improved quality and economies of scale in the transport of produce to market.

Figure 4: A typical 'bilum' made by the women to carry vegetables to market takes 6 weeks to construct.

Andrew works every Wednesday with his extended family on their community projects. The entire clan now numbers a total of about 600-800 people. He is able to bring his whole clan to assist with projects or problems. Both he and his family and clan are committed to the concept of bettering their family through educating themselves and their children. He wanted his children to go to university and return to their farm. In spite of all their struggles they continue to send children to school as this becomes a major part of their family expenditure. Andrew recently attended a Cropping Gross Margins Workshop run by Michael Atuai, FPDA, and he clearly now had a good understanding of that concept.

During their free time the women engage in making nylon bags called a "bilum" which is used for transporting vegetables to market. It takes about 6 weeks for them to make the large sized bag usually used to transport bananas and there are small bags used for the greens like the Aibica.

Andrew was very keen to grow his business. This had been demonstrated by his entrepreneurial activities prior to the development of the current relationship with FPDA over the last year.

- *Simon Ino, Manari, Brown River District – not at home – his error*

- *Bunni Morna, Laloki*

Figure 5: Bunni showing the river running through his property

Bunni was a Goilala man who had moved to Laloki and purchased several hectares on a government title. The gardens are operated by Bunni, his wife and adopted son and two elder sisters. He had two plots each of about 0.1 ha separated by about 300 meters, bounded by a large barely-flowing creek that was a tributary of the Laloki River. The water level was about five meters below the land surface and the family was carrying water in garden watering cans from the creek to the vegetable crops.

The soil appeared to be a grey clay-loam, reasonably friable and the garden area was flat although bounded by low hillocks.

There was a much larger area of land than was being cultivated and some had been loaned to relatives to cultivate under the Wontok system of familial obligation.

The first plot had recently been ploughed at a cost of K210 (K70 per hour) and partly laid out with staggered plantings of white radishes, corn, cucumber and pumpkins. Bunni had participated in Michael Atuai's gross margins workshop and he estimated that what he had planted was worth approximately K8,000 which they would realise after three months growing time. He tailors his production to suit what different markets want (e.g. picking Chinese Cabbage early getting 50 toya for a small bunch or later as a head getting K1.00).

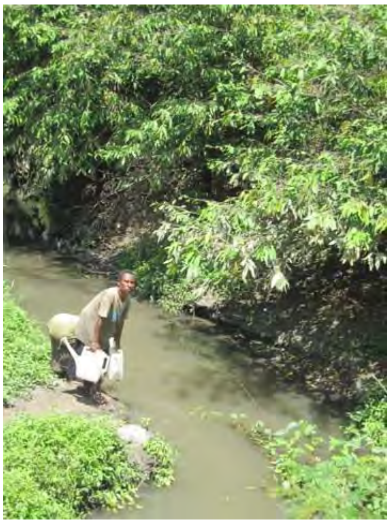


Figure 6: Bunni's sisters-in-law carrying water.

The second plot, also only partly planted out, was growing only Chinese Cabbages also in staggered plantings. The women present estimated that it took three hours to carry the water to irrigate the whole plot once and they were doing this twice per day.

The seeds for planting were purchased from the Brian Bell store in Boroka and were large domestic gardening packets. No pesticides or fertilisers were being used but the plants looked healthy from the natural fertility and no pests or diseases were observed.

Produce was transported to Gordon's Market on PMVs and sold at the back gate to middlemen because it saved time. Because

Figure 7: Bunni's sisters-in-law watering Chinese Cabbages.

they were much closer to Gordon's Market than the previous gardens visited, these people complained that by the time the PMVs got to them they were often full so they sometimes had to wait until quite late in the day to arrive at the market which meant that they often had to take much lower prices.

They had no vehicles, no irrigation pumps (although were aiming to buy one in the near future) and no electricity. However, they were on 'town water' supply for their homes and were hoping to fill two small header dams they had constructed to water their crops.

The family was highly committed to educating their children and school fees were a significant reason for their farming activities. The children were all full time at school but also looked after the farm if the adults were away at the markets and undertook their share of the farm work. Bunni himself was keen to learn all he could that would improve their farming.

Project Implications of the visit to Baramata/Brown River Area and the Laloki Area, Hiratomo Highway:

- The type of land tenure held by any prospective project smallholder participants may be an issue for consideration. Some squatters may have inhabited land for several generations but still be squatters with no formal rights to the land. Project arrangements with such groups may destabilise the socio-economic balance between the two parties and result in social problems. Hence, it is recommended that a high level of care and consideration be given to the inclusion of growers in the project and that priority be given to traditional owners, formal leasehold arrangements or freehold tenure;
- The main issues faced by smallholders in up-scaling production are:
    - Access to water and uplifting water from incised river systems;
    - Soil cultivation by contractors or own machinery to achieve scale;
    - Accessing sufficient labour when needed;
    - Accessing appropriate vegetable varieties;
    - Employing appropriate agronomic practices;
    - Low input soil fertility management practices;
    - Low input pest management practices;
    - Aggregation of sustainable, commercial quantities of produce;
    - Storage and cooling of aggregated produce;
    - Transport to buyers;
    - Possibly access to cool storage of produce in Port Moresby;
    - Financial exchange systems (bank accounts etc);
    - Access to micro-finance as well as larger scale financing.

These are the core project problems.

Day 4: 8th October 2010 – Tubusereaia Region

- *Shirley Hopa, CP-DAL – Impromptu conversation*

  In the meeting with CP-DAL on Wednesday they had stressed the need for the project to gain the support of the District Administrators to ensure engagement with the appropriate smallholders and facilitate the operation of the project activities. CP-DAL had agreed to provide us a list of potential participants to be contacted as soosn as possible. The party called in shortly after 9 am to reinforce that we needed the information as soon as possible so that appointments could be planned for this current visit to PNG. Shirley said Daniel was at a meeting but she would contact the CP-DAL district administrators and generate a list by noon.

- *Brian Bell Store, Boroko*

  As this has been mentioned by many on this and other trips as the source of seeds and farming inputs for smallholders we asked to visit the local store.

Figure 9: American Takii and Tokita seed packs (10g - 20g) available for smallholders at the Brian Bell, Boroko store.

Figure 8: Australian home gardener packs of pesticides available for smallholders at Brian Bell's Boroko store.

The photos in Figures 7 & 8 illustrate several potentially significant problems for smallholder vegetable production generally and also for this project. They are:

1. Domestic seed packs as above may not be suitable varieties for Central Province soils and climate. It is more appropriate that vegetable seed for commercial production in PNG be sourced from the World Vegetable Seed Bank in Taiwan;
2. Such seed may be F1 hybrids which will revert to parental type if seed is collected and used in following years. Open pollinated varieties may be more appropriate in this situation because they produce reasonable quality seed when self-collected;
3. It is common for smallholders to buy the 10-20g packs of seed even though larger tins and packs up to 500g are in stock at the counter. This is likely to be more expensive than buying commercial amounts and sharing with a cooperating group;
4. Seed bought in this manner may be older and therefore have lower germination rates than commercial supplies;

5. Australian domestic pesticide packs may not be appropriate in either type of chemical or rates to control pests. If so, then at best they will be ineffective and at worst in the medium term promote the development of pest and disease resistance;
6. Domestic size packs are not economic at even smallholder scale commercial production.

For example, of those seed packs in Figure 8, most are listed on American Takii's website as "Asian Vegetables" with little detail[3]. Many of the same company's cool temperate vegetables have been bred in North America, Mexico or South America. All are F1 hybrids. Tokita is a large Japanese-based seed company founded in 1917.[4] Little technical information is provided about its seeds.

Brian Bell also supplies the tools and equipment commonly used by smallholders. Portable water pumps were available; petrol versions from K2,000 and diesel versions from K3,000. Hand tools such as spades, hoes, mattocks (or adze) etc in varying quality for between K30-60.

- *Nandai & Salama at Tubusereaia (25 km East of PoM on Magi Hwy)*

Nandai, his brother Salama and two women were farming very fertile river flats about 25 km from Port Moresby which were part of their traditional land stretching back many kilometres to and including the escarpment of the Sogeri Plateau. Whilst they were farming separately relationships appeared to be workable between them and it seemed that they were doing so because it made the business transactions more clearly delineated. They periodically moved their operations to other sites on their land.

Figure 10: Salama showing his channel flood irrigated vegetables at Tubusereaia.

Salama's block was 100m X 100m or one hectare of a dark brown-black river clay loam. He was growing mainly Cucumbers, Capsicum, English (or Ball) Cabbages, Water Melon and Snake Beans. Crop beds were laid out running with the slope and he was pumping water from the adjacent river using a transportable pump and running a collapsible three inch hose to a header ditch at the top of the rows then wildcat flooding the trenches between vegetable beds. His systematic approach and entrepreneurialism may have been due to his having some agricultural training prior to coming back to the family land in the mid-1990s. He has demonstrated a desire to expand his operation and obtain a better price for his produce by his approach to both production and marketing.

[3] Takii & Company Ltd, based in Kyoto, Japan is one of the world's largest breeder/producers of vegetable and flower seeds and has six experimental stations in Japan and international facilities located in U.S.A, Holland, France, Chile, Thailand & China (http://varieties.takii.com/default.asp?type=General).

[4] Tokita Seed's web site: http://www.tokitaseed.co.jp/eng/index_e.htm

Nandai had a similar area and had similarly laid out his vegetable production with irrigation pumps and channels under Salama's tutelage. They had typical smallholder houses on their land although for reasons not explained Salama lived in the village close to the main highway about two kilometres away.


Figure 11: Some of Salama's female relatives preparing the green vegetable Aibeca for market in the nearby river to keep it fresh.

Power lines run down the nearby highway and mobile communications towers provide these families with good communications to Port Moresby.

The cucumbers seen had been planted during August and due to be harvested in October/November. The three families market mostly to the super markets and gets about K1.50 per cucumber which is an average price although he believes his produce is top quality. The best they have ever received was K3.00 negotiated by his wife. Some quantities are also sold to the Gordon's Markets. Salama and the brothers each have their own 4 X Wheel Drive and so transport their own produce to the supermarkets. He has also planted water melon and anticipates a good demand for them during the Christmas period.


Figure 12: The high quality cucumbers produced by Nandai, Salama and family.

Salama maintains a nursery shade house adjacent to the field where the crops are planted out and uses some insecticide sprays from the Brian Bell store at Boroko. He hires labour and pays them as well as providing food (rice and fish). Although he lives in the nearby village, he is somewhat exasperated that few of them want to work on his farm and would like government support to set up a training farm for young people. Labour is a constraining factor although not absolutely limiting.

- *Jealous Tau at Barakau (30 km East of PoM on the Magi Hwy)*


Figure 13: Jealous Tau explains to Dr Gomathy Palaniappan how he produces and markets his Zucchini.

Jealous Tau farms 168 ha on 99 year leasehold land approximately 30 km from Port Moresby at Barakau and has built a quite substantial house by smallholder standards. He has just returned to working his ground after being laid off due to illness and during that period he employed a Highland man to keep the farm operating. He pays a wage plus provides a 'share cropping' garden site for the labourer's own use.

Jealous grows a number of cash crops to spread his risk including watermelons, zucchini, tomato, capsicum, snake beans, and vanilla. He has demonstrated good agricultural and gross margins knowledge as well as an entrepreneurial approach. Jealous planted 600 Glyricidia trees and vanilla after the boom in prices several years ago in anticipation of a return to higher prices. He has his own tractor and implements and recently ploughed an area of about one hectare where he plans to plant Sweet Potato when the Wet Season arrives in a few weeks.

He is a Central Province man and claims to be in his traditional area. He is frustrated that his own people are not interested in working for him as he is currently expanding both the area he cultivates and the range of crops grown. He believes "…Central Province people are lazy…"


Figure 14: Jealous Tau and his Glyricidia trees and vanilla plantings in anticipation of price rises.

Jealous has his own 4XWheel Drive Utility and markets through multiple outlets like the supermarkets and a catering company. He tailors his production to suit what different markets want (e.g. zucchini which he picks small or large for the Asian market), he 'cold calls' on shops to see where he can sell his produce and his wife sometimes takes produce to the local market for domestic cash flow to buy sugar, rice etc.

He has some water available in a well adjacent to the main vegetable garden but the main source is a creek several hundred meters away and has, in the past, pumped via a windmill from that site. He is planning to repair the windmill in the near future.

Project Implications of the Day 3 and the Tubusereaia Region, Magi Highway:

- The region should be a Lowland production site as it has some highly suitable farming areas, many with water currently accessed, is 25 – 30km from Port Moresby via an excellent road, have access to electricity and has growers who are already quite commercial;
- Two suitable growers have been identified, Jealous Tau (Barakau), Nandai & Salama (Tubusereaia). Two additional commercial growers who will be interviewed on the next trip (1-12 November 2010) are Arthur Chapman (producing tomatoes) and Boio Vaita (producing Green, Red and Yellow capsicum) are highly recommended by FPDA. It is proposed that these four growers form the first producer's cooperative. These growers already have their own transport, irrigation pumps and Jealous has a tractor and implements;
- Variety and agronomy trials conducted at Laloki on either NARI or PAU may be applicable to this area;
- Additional research may be necessary on existing pest control problems;
- Arrangements for commercial quantities of appropriate seed and pesticides will need to be included in the development of all project groups;
- The production of a 'basket' of different produce may be more appropriate.

Day 5: 11th October 2010 – Visit to Sogeri Plateau

Guided tour of facilities of Sogeri Plateau with Augustine Maino,[5] Special Projects Officer (Ginger) FPDA. Very valuable discussions were held during this trip about PNG smallholder culture, the problems of the vegetable industry and possible approaches that might be employed by this project.

- *Laurence Thomason at Sogeri Primary Produce*

  A company producing hydroponic vegetables near Sogeri township. Mr Thomason was very supportive of the project and contributed the following:

  - He had tried to grow Broccoli but with little success and suggested that with different varieties it may be possible;
  - He succinctly identified the problems he believed the project would face; the most significant being the poor cultural attitudes to continuous work;
  - He believed that using cooperatives with an organiser to ensure that produce was delivered in full, on time and quality (DIFOTQ) was the only model that would work. He stated that the only person he had known of to achieve such an arrangement was Ken Houten at Mt Hagen.
- *Bisianumu Station, Upper Sogeri Plateau*

Figure 15: View of undulating country that comprises Bisianumu Station, Upper Sogeri.

Observed the undulating, red ferrosol country at the Ower's Corner end of Sogeri and identified that it may be a prospective site for vegetable variety trials testing cultivar suitability (e.g. broccoli) for mid-altitude (800m) production. The station is government –owned but currently leased to Koitaki Beef, a beef operation owned and operated by Peter Murray from Tasmania.

- *Peter Murray, Koitaki Beef, Sogeri*

  Mr Murray had just left for Tasmania and an arrangement was made to contact him at his next visit in two weeks which will coincide with Laurie Bonney's next visit.

[5] Gus Maino is probably the most experienced agricultural officer in PNG. He was one of the first class of 26 people through the Popondetta Agricultural Training Centre in 1966 and soon became the First Assistant Secretary of Horticultural Policy in PNG DAL and Chair of the PNG Nutrition Board undertaking post-graduate training in extension at Reading University. He went on to work as a Regional Business Development Manager for Reckitt & Coleman, farm in his own right and played a key role in the Coffee Development Authority during a serious outbreak of coffee rust in the Mt Hagen area before being headhunted to help set up the FPDA in which he has undertaken a number of important tasks including the marketing of new crops.

Figure 16: Organic pineapples being grown for juice and fresh market by an ex-pat in lower Sogeri.

- *Ginger Project Smallholders, Ower's Corner*

The inspection of project sites around Ower's Corner.

- *Organic Pineapple Plantation, East of Sogeri*

Largely producing organic pineapple juice rather than marketable fruit.

These sites highlighted the importance of the project

addressing soil management for cropping on steep slopes. Gus Maino suggested that some form of terracing may be necessary.

Project Implications of the Sogeri Region:

- Sogeri should be a prime site for any medium altitude varietal or agronomy trials for cool temperate vegetables such as broccoli or beans. Apparently, FPDA knows of land near the township that may be available for such trials in Lower Sogeri. These will be investigated on the next trip (1-12 November, 2010);
- Upper Sogeri (the Ower's Corner end) may be a better site for the production of highly temperature sensitive vegetables such as broccoli. Land may be available from the Central Province Government (Figure 15) although it is currently under lease to Koitaki Beef. Investigation of this possibility will occur on the next trip 1-12 November, 2010;
- It is NOT recommended that the project enters ANY sub-leasing or any other arrangements with the owner of Koitaki Beef;
- It appears more appropriate that each of the project 'chains' produce a 'basket' of vegetables due to issues such as seasonality, risk management for the smallholder and the diversity of market requirements.

Day 6: 12th October 2010 – Visit to Tapini Station, Goilala Region

Figure 17: Looking South at this mid-point, the road can be seen zig-zagging through the valley floor and up the mountains to the left hand side.

The Goilala Region, with an area of approximately 3,578 square miles is NW of Port Moresby is an hour on the Hiritamo Highway followed by at least four hours of often very poor gravel road with one potentially bad river crossing and numerous opportunities for road blockage by landslides and fallen trees. Travel time by air 25 minutes.

It has a population of 27,131, Households 5726- 3 LLGs: 7315 (Tapini LLG), Woitape (14,379), Guari (5438) – 23 Wards. The district has very high out-migration to Port Moresby. Tapini Station, the district headquarters, is about 126 kilometres northwest of Port Moresby. The district reaches over 3000 metres, with the highest peak of Mt Albert Edward approx. 3990 m. The average rainfall ranges between 2200 mm near Tapini, to 3200 mm.

The region is now a strategic development priority for the Central Province Government and there are plans to upgrade and seal the road but this may take 3-5 years to complete. Goilala is potentially a very productive area for cool temperate vegetables but its development is constrained by the state of the road and the lack of phone communications (the area relies on VHF radio).

Figure 18: As well as a shovel.

Figure 19: The carriage of more than one spare wheel is advisable.

Dr Gomathy Palianappen used the trip as an opportunity to develop her relationship with key women's advisors Poela Utama (FPDA) and Shirley Hopa (CP-DAL) and gain an understanding of women's roles in the region.

Along the Goilala road frequent villages are encountered, often set back off the road and not immediately observable although children and villagers abound on the road. As the highland areas are approached, gardens are evident on the hillsides amid the bush around the valleys. Closer to Goilala large areas of grassland appear on the upland slopes of the mountains evidently where accumulated historical clearing has resulted in regeneration by tropical grasses. Gardens appear to be rotated around these areas.

Figure 20: Villages are frequent and smallholder vegetable gardens are common on the mountain sides.

Vegetables grown include kaukau, sweet potatoes, ball cabbages, chinese cabbages, paw paw, pineapples, corn, pumpkins, sugarcane, bananas, yams, greens, beans, watermelons, kasawa, carrots, onions, spring onions as well as guavas, apples and oranges.

Tapini Station (Figure 21) is comprised of about 50 buildings around a grass airstrip; most being the houses of school and other government staff and some locals. The airfield once had a regular air service but now only charter flights use the strip. A charter from Port Moresby costs about K9,000. Tapini also has a small unused cool store and equipment shed. There are some level areas here near the school and to the eastern end of the village that may be suitable for plot trials. The DA has organised and registered a farmer's cooperative of 39 farmers at Tapini.

There is a narrow road leading off to the right of Figure 21 which leads to Woitape and Petromin's Tolukuma Gold Mines Limited. This mine needs to buy vegetables locally which may present an opportunity for this project. The National Executive Council has recently approved the Tolukuma Mine Access Road project which will connect to the existing Tapini Road that starts from the Aropokina junction of the Hiritano Highway to the Tolokuma Gold Mine, a distance of approximately 142.4 kilometres.

Figure 21: Tapini Station (Centre) from the ridge above looking north east towards Kosipe. The road to Waitape and the Tolukuma Mine is off to the right.

Figure 22: A 4WD tractor has recently been donated.

A tractor has been donated for the Tapini community to use however the donation does not appear to have included wheel weights and so will be of limited use on the steep slopes or heavy implements (Figure 22). In many of the traditional gardens it could not be used due to the extreme slope and the small size (Figure 23). It does not appear to have been used at this point and implements were not observed.

Figure 23: Gardening is conducted on very steep ground in a 'slash & burn' subsistence system.

Other resource projects planned are at Olom, Saki, Kerau, Aigora, Minaru, Mt. Yule, Mt. Albert Edward, Sindo

Whilst there are some small areas of level ground around Tapini, most vegetable gardening appears to be undertaken on very steep land. However, the 'slash and burn' technique combined with minimal tillage by hand does not appear to result in major erosion problems although some does appear to occur.

The FPDA concluded in a report (Utama, Maino Atuai and Chang, 2010) that Goilala was not yet ready for commercial agricultural development due to the transport infrastructure. However, due to the apparent changed priorities of the CP Government, the conduct of trials in the region may be justified. If so, in addition to Tapini itself, an area to the north of Tapini (the right of Figure 21), near the village of Killavava, about an hour and half's further drive North, once hosted an ex-pat farmer who grew fat lambs, cattle and temperate vegetables and may be another suitable site for trials.

Figure 24: Looking North from the ridge above Tapini. (L to R) Michael Atui (FPDA), Titus Girau (CP-DAL District Administrator), Casmiro Boa (CP-DAL Agricultural Officer - Tapini) & Assistant.

Project Implications of the Goilala Region:

- Given the apparent changed government priorities for the region (yet to be confirmed), trials may need to be conducted to underpin commercial market development;
- The soils, temperature and rainfall appear to suit cool temperate vegetable production (fine ball cabbages are already grown here) but appropriate varieties will need to be identified and low-input farming systems will need to be developed to cope with the steep terrain;
- The farmer's cooperative at Tapini and the Tolukuma Mine near Woitape appear to offer the most promising sites for research and the development of production;
- The ACIAR Country Manager, Ms Emily Flowers has commercial contacts in Port Moresby who may be interested in trialling a refrigerated road transport service out of Tapini. This will be investigated on the next trip (1-12 November, 2010).

Day 7: 13th October 2010 – Visit to vegetable buyers, Port Moresby

- *Stuart Fancy, Greenfresh Wholesalers, Port Moresby*

  Stuart and Erna, his assistant manager, are strong supporters of the project and provided an update of current Greenfresh prices. He described the highly diversified nature of the Greenfresh business which extends beyond food. They employ over 300 people and have their own kitchens to feed staff.

  They need continuous, timely, supply of reasonably blemish-free, well-shaped vegetables. No size grading is undertaken as they supply restaurants and caterers rather than the retail consumers and some quality issues can be accommodated in preparation for consumption. This market requires regularity and timeliness. Some lower quality can also be accommodated in the food manufacturing side of their business (pies etc) and their own catering to staff. Capsicum need to be larger in size. They prefer Highland tomatoes to the hydroponically produced tomatoes from Sogeri because they are better flavoured.

  Stuart indicated that he would buy any vegetables we could produce (subject to acceptable quality) but particularly the following – capsicum (red, yellow, green), carrots, celery, wombuk (Chinese cabbage), asparagus, broccoli, cauliflower, tomatoes, zucchini and herbs.

  Stuart believed that the main problem for the project will be encouraging farmers to work and supply continuously. He also indicated that Greenfresh would pay a small premium to any women's groups who were able to supply them.

- *Ezra (Produce Buyer) Ela Beach Hotel, Port Moresby*

  They would prefer local suppliers because they are cheaper, quicker and more direct (therefore the produce is fresh). He waits for suppliers to approach him and he would prefer a few larger, more regular suppliers rather than large numbers of small ones so that they are easier to manage and he knows in advance what is available. Sometimes, because of seasonality and other factors he buys from Gordon's markets or even retail (e.g. he buys 200kg English potatoes every 2 days).

  The problems of the current system are:

  - The timing of delivery
  - Continuous supply
  - Obtaining the quantity when he needs it

  There needs to be cool storage space in PoM for produce, especially coming down from the Highlands.

  Ezra's procurement emphasises the salad vegetables because of the type of menu the hotel delivers. His priorities are:

  - English potato
  - Capsicum
  - Tomatoes

- Carrots
    - Herbs
    - Heart lettuce
    - Fancy lettuce
    - Watermelons
    - Pineapples

Broccoli is not a big seller in his hotel because it is rarely on the menu.

Packaging sizes are important to him because of the way the hotel uses its vegetables. Bulk vegetables generally need to be in smaller packs that can be more easily handled out of the cooler (e.g. potatoes in 10kg rather than 50kg bags).

He believes that the hotel supply system needs to communicate the prices they are paying to local suppliers. He firmly believes the hotels would agree to a set price for vegetables.

The hotel may need some advice/training on post-harvest handling as they were storing ethylene-producing bananas with other fruit and vegetables causing accelerated ripening and therefore potential wastage.

- *Providing a Public Motor Vehicle (PMV) perspective*

Laurie Bonney undertook a fare-paying ride in a PMV from Gordon's Market to the brown River area to interview smallholders, the PMV driver and owner. The smallholders and others engaged in conversation at the market transport hub were very supportive of "anything that will help us…" The following points were made:

Figure 25: Laurie Bonney (TIAR) heads to the passenger pickup point in a PMV during his investigation of vegetable transport logistics.

- Owners & drivers are often middlemen too, undertaking buying/selling at the farm-gate or importing from the Highlands;
- PMVs also contract individual pickups of bulk loads for farmers;
- Some PMVs will undertake the rounds of the hotels and institutions to help smallholders sell the products;
- Typical charges for approx.20Km are around K2 Ind & K4/bag (no set prices);
- Some PMVs are not registered and many are not roadworthy.

Day 8: 14th October 2010 – Visit to vegetable buyers, Port Moresby and CP-DAL

- *Micky (Fresh Produce Buyer), Boroko Food World (BFW),Port Moresby*

The main ex-pat shopping mart. BFW currently buy from many smallholders who approach their back door, but they would prefer to buy from fewer, more regular suppliers. They were interested in collaborating with the project when it has produce to sell.

Their priorities as a general supermarket retailer are across the board but their priorities would be capsicum (red, green), carrots, celery, wombuk, pak choy (Chinese cabbage), asparagus, broccoli, cauliflower, tomatoes, zucchini, herbs, watermelons and pineapples.

- *Mr John Hulse, Operations & Business Development Manager, The Alliance Group, Port Moresby*

  Alliance is the largest caterer to the resource projects in PNG. The LNG project was discussed in some detail as an example but other projects, almost as large will be commencing in the next 1-2 years.

  The PNG Gas Project is the PNG's largest LNG project. It will develop the Hides gas field in the Southern Highlands/Gulf Provinces of Papua New Guinea, and to construct a natural gas liquefaction plant. Originally it was planned to transport the gas to Australia via 4,000 kilometres long offshore pipeline but the LNG plant will now be built adjacent to the oil refinery owned by InterOil near Port Moresby with a shorter pipeline. The LNG plant will pipe up to 9 million tonnes of LNG and 1 million tonnes of natural gas liquids per year from the Southern Highlands south to the Gulf and then east to near POM. ExxonMobil owns the participating interest and other partners of the project are Oil Search Limited, Santos Ltd., AGL Energy, Nippon Oil and MRDC (a PNG company representing landowner interests) and the PNG Government (19.2%). The project is expected to cost US$5 billion to US$7 billion. The first cargo of LNG is planned to be delivered in 2012.

  PNG Gas alone will employ 10,500 people who are currently being hired with the full complement being in the province by June 2011. These people will be in camps in the Southern Highlands and be supplied with food from POM. There will be another 4,000 people on the pipeline also supplied with food from POM;

  Alliance are calculating supply needs on 2.5 Kg produce per person per day which includes 1 Kg of vegetables. So this project alone needs 14,500 Kgs per day of vegetables. Alliance are also contracted to supply 2-3 pieces of fruit per person per day.

  John Hulse commented (from extensive local knowledge) that the project should operate using village-based cooperatives based on the Wontok system and that women need to be used to drive the family and the men in particular to work appropriately. He also said that such enterprises need external drive and supervision in the early phases, training and then hand-over to the local participants.

  Alliance's quality standards are:

  - Fewer suppliers with large volumes who are consistent
  - Produce delivered at the door in Port Moresby
  - No browning
  - No spots
  - Not picked over or under-mature with the exception of green tomatoes which need to be green to allow ripening during transport

Imports are the mainstay of Alliances' provisioning at this point because of the volumes required. Transport costs within PNG are also very high; the comparative figures quoted today were:

- Lae to POM by sea container and takes a week – K27,000 (A$10,300)
- Australia (?) to POM – K7,000 (A$2,670)

Because of the logistics of getting produce to the Highlands in reasonable shape packaging and shelf life will be a challenge. Air freight from Cairns is being considered by Alliance.

- *Meeting with CP-DAL - Baru Morea (Planning), Titus Girau (DA Goilala) & Casmiro Boa (Ag Officer – Goilala) present*

The meeting updated Mr Morea on progress and discussed the project's need for further information on various aspects of project development.

It was identified that just as the project process had engaged the District Administrator and Agricultural Officer for Goilala, on the next trip the DA staff of the other project areas should also be briefed.

Project Implications of fresh produce buyer's views:

- All buyers interviewed will basically take whatever the project produces within conditions of quality requirements. They are enthusiastic and want to support the project and, more to the point, they can't get enough local produce;
- The priority vegetables appear to be capsicum (red, yellow, green), carrots, celery, wombuk, pak choy (Chinese cabbage), asparagus, broccoli, cauliflower, tomatoes, zucchini, herbs, watermelons and pineapples. Therefore, the following 'baskets' of ***vegetables*** and ***production sites*** are suggested for the project chains:
    - <u>Low Altitude Chain</u> - capsicum (red, yellow, green), carrots, wombuk (Chinese cabbage), tomatoes, zucchini, herbs, watermelons;
    - <u>Medium Altitude Chain</u> - asparagus, broccoli, cauliflower, tomatoes, herbs

Learnings about the role of smallholder women

1. People work to meet their immediate demands like rice, sugar, tea, medical and school expenses and so motivates them to work continuously need to be addressed. Typical school expenses are approx:
    a. Primary School - K500 p.a.
    b. High School – K1,500 p.a.

   There appears to be a high level of family commitment to education for the younger generation;

2. Women play an important role in both farming and marketing of the produce at the local markets
3. Women's' groups are currently focusing on spiritual and moral support which could be a good start to lead the group from that direction to also support the family through economic activity like vegetable production
4. Gender training is provided by the FPDA to the family men, women and children so as to help each other and share responsibilities - this is very important if the women were involved in vegetable production to see this as a family activity and to also support each other
5. Girls are encouraged to go to school and there is no gender bias in terms of providing education although being very expensive
6. Women doing backyard gardening supply herbs to the Ela Beach Hotel. There continues to be a demand for the herbs which can be encouraged through some of the existing women groups.

Follow up

a) New life Skills Training Centre on the Magi Hwy. This centre helps young people to get some training in farming and prepares them for future life in a way also preventing crimes and offences in the city by reducing the unemployment;
b) Inconsistency in labour – the capacity of the community in terms of their attitude towards work need to be understood;
c) The community capacity in terms of leadership, management etc need to be analysed.

Interim Conclusions (to be finalised following 1-12 November trip)

The project should:

- Work through clan groups in a village or a small area using the Wontok system of obligation and relationships, thus making a sustainable labour supply more possible;
- If possible ensure that the smallholders are the traditional landholders or have formal leasehold or freehold tenure of the land they will use in the project. An alternative may be to work through **Incorporated Land Group**[6] (ILG) facilitated by CP-DAL;
- Form two grower cooperatives (See regional map in Appendix A):
    - A low altitude chain in the Tubusereaia Region, Magi Highway, east of PoM;
    - A medium altitude chain in the Sogeri region, north east of PoM;
- Commence vegetable production in 2011 Dry Season with ‘best bet’ vegetable varieties from the World Vegetable Center (formerly AVRDC) using best existing low input soil management, agronomic and Integrated Pest Management (IPM) practices;
- Establish variety and agronomy trials in the following areas to underpin the chain development (See regional map in Appendix A):
    - A low altitude site in the Laloki Region at NARI or PAU north of PoM **OR** in the Tubusereaia Region, Magi Highway, east of PoM;
    - A medium altitude chain in the Sogeri region, north east of PoM;
    - Contingent on confirming the policy priority of the Goilala Region, a high altitude trial site at Tapini or Woitape;
- Establish ‘collection points’ to aggregate the production of the clans involved in preparation for transport to market;
- Such collection points may eventually be the site of a ‘cool store’ to help preserve the quality of produce. Such a development could be the subject of an external application for assistance from a Development Agency;
- Some of the intractable smallholder problems, such as irrigation and cool stores may benefit if a study was made of appropriate low input, low cost International Development engineering designs to solve such problems (e.g. mud brick cool stores, or chain bucket irrigation ‘lifts’ to raise water from rivers or wells);
- Produce be transported to market via a contracted truck where a private utility is not available within the group. This is in preference to a Public Motor Vehicle (PMV) due to their unreliability, relatively high cost and the time wastage by individual producer who accompany their produce to market;
- The fresh produce buyers interviewed be the first resort for produce produced from project chains.

Laurie Bonney (Senior Research Fellow)
Assoc Prof Colin Birch, Team Leader & Centre Leader, TIAR Vegetable Centre
Dr Gomathy Palaniappan (Post-doctoral Research Fellow)
Project Members
18 October 2010

[6] ILG status is a government sponsored program that facilitates the registration of legal title which then confers eligibility for normal bank loans.

APPENDIX A: Map of Central Province Vegetable Project Trial and Production Sites

APPENDIX B: Question Framework for Smallholders

- Tell us about what you grow and eat for yourselves?
- What things do you buy from outside the garden?
- Do you grow other crops for cash?
    - Have you ever grown English vegetables?
- What do you do with the crops that you grow?
    - Do you sell any produce?
    - If so, where?
- How do you get the produce to market?
    - Are there any problems getting to market that way?
    - Who is involved in getting the produce to market?
    - How much does that cost?
    - What happens at the market?
- How much land does your clan have?
    - How much of this do you use?
- Who is involved in the working of the land and the growing of the crops?
    - Who does the digging?
    - Who does the planting?
    - Where do you get your seeds or seedlings?
    - How do you water your crops in the dry?
    - Who does the watering?
    - Who does the harvesting?
    - How do you control the insect pests and diseases?
- Are there any problems in growing your crops?
- How do you market your crops?
    - Who is involved with the marketing?
    - Are there any problems in marketing?
- Would you like to grow and sell more crops?
    - What would help you grow more crops?
    - What would help you sell more produce?
- What other resources are there within the clan that might help you grow and market crops?
- Has anyone been trained in how to grow better crops?
    - Would you like to have training in how to grow better crops?
- Has anyone been trained in how to better market crops?
    - Would you like to have training in how to better market your crops?
- Is there anything else you would like to tell us?

APPENDIX C: Question Framework for Buyers

- What vegetables have the highest price?
- What vegetables have the highest margins for you?
- What vegetables do you have the most trouble obtaining the quality or quantity you want?
- Are your main sources of these vegetables local or international?
- What quality attributes are consumers looking for?
- Do you pay higher prices for better quality?
- Do you have contracts OR schedules of supply with anyone?
- What quantity of these vegetables do you buy?
- How regularly?
- Do you have any 'preferred local suppliers'?
- What makes them 'preferred' as far as you're concerned? What do they do?
- If not, can you describe what you want from suppliers?

TASMANIAN INSTITUTE OF AGRICULTURAL RESEARCH

SMCN/2008/008 Increasing vegetable production in Central Province, Papua New Guinea to supply Port Moresby Markets

REPORT TO ACIAR ON TRIP TO PAPUA NEW GUINEA (PNG)

1 – 12 November 2010

Laurie Bonney, Leigh Sparrow, Mark Boersma, Richard Doyle, Alistair Gracie

Value Chain Analysis

The aims of the November 2010 trip were to continue the data collection from the previous trip (3rd – 15th October, 2010) to:

(vii) Identify which vegetables to be focussed on through discussion with the stakeholder agencies FPDA, NARI, Central Province, PAU and Greenfresh;
(viii) Identify the preferred regions in which to grow those vegetables and ;
  (d) Have initial discussions with some landholders (without raising hopes or confirming a selection at this point) in order to:
    i. Gauge their level of interest and capacity to grow the selected vegetable and grow the volume produced over time;
  (e) Identify the agricultural and other constraints to production in that area e.g. water, soil, seed, fertiliser inputs, land tenure, storage, labour supply, skills, transport, social etc).
(ix) Discuss with the research collaborators, NARI and PAU, the key researchable issues and where replicated trials should be located;
(x) Discuss with Central Province and FPDA the focus and location of possible demonstration trials for grower extension.

Monday 1st November

- Udai Pal & Clifton Gwabu
  - Agree with the model of chain best practice (CBP) being developed
  - The model is as follows:
    - Flexible to fit the characteristics of the group.
    - Work with clans and the Wontok system.
    - Have a collection point for the clan smallholders with specific times and days for transport.
    - Transport provided by contractor, not necessarily a PMV. Specific, reliable times. Transport to the buyers. Including possibly making a round robin of the hotels and supermarkets. Buy on weight and quality for agreed price.

- Noted that FPDA Liaison Horticulturalist, Michael Atuai, would contribute most effectively through undertaking organisational tasks necessary to facilitate team visits

Tuesday 2nd November

Sogeri

- Travel to Upper Sogeri to speak with smallholders and community leaders.
- Effectiveness of trip constrained as prior arrangements for meetings had not been made by FPDA. When working in this area, necessary to take account of local factors, including :
  - The best time to make contact is therefore on Saturdays or Sundays when the smallholders are not working;
  - Farmers leave for their gardens at 6-7am, which are usually some distance away in the valleys near water-courses, not returning till late afternoon; and
  - Their cell phone numbers are usually not known to the FPDA or are not operational in the deep valleys where their gardens are situated; and therefore
  - Team visits must be pre-arranged some time before the actual visit;
- Notes were left with a community elder in an attempt to make contact with smallholders and community leaders over the next few days.

Koitaki Beef – Peter Murray

- The Koitaki Beef property was first developed for Western style agriculture by Peter Murray's Grandfather around 1900. Peter's family has a long history with PNG with both his Grandfather and father being Directors of Agriculture prior to WW2;
- The property is 25,000 acres and currently runs 9,500 cattle with an aim to eventually run 15,000 breeding stock;
- Peter Murray is two years away from registering a 'New Guinea Grey' breed based on the Murray Grey and tropical breeds;
- Whilst the issue of obtaining part of the Bisianamu Station land which he leases from the PNG Government was not raised, discussions appear to indicate that there would be neither possible nor desirable. Despite that conclusion, Peter Murray offered any help the project might need.

Wednesday 3rd November

Arthur Chapman, Bautama (approx 15 km from PoM)

- The Magi Highway at this point is excellent. The farm visited was approximately 2 km from the highway and was mostly an all-weather tertiary (gravel/dirt) road.
- The area was a wide, shallow valley heading north towards Port Moresby (PoM). A large area of probably several hundred hectares was being farmed by Arthur Chapman and his two brothers and relatives. The land was very flat, soils were black volcanic, highly fertile clays with an incised creek system running through the area.
- Their main crops are tomatoes, water melons, cucumbers, capsicum and zucchini.
- The group supplies Greenfresh, some supermarkets and hotels.

- It was not possible to speak with Arthur however one of his collaborating growers, Varite Bore, was available, and explained his arrangements with the Chapmans and some aspects of his farming.
    - There are four members of his family farming separately here. Varite had about a hectare presently under cultivation.
    - They grow mainly tomatoes, water melons, cucumbers and zucchini under several different arrangements:
        1. Chapmans supply the seed and sprays for specific vegetables then buy the vegetables from Varite and market them;
        2. They grow vegetables to fill specific orders obtained by Chapmans from buyers and Chapmans transport it to the buyer for them for a small fee;
        3. They occasionally sell into Gordon's Market and Chapmans transport them there.
    - Chapmans take an appropriate fee from the gross income received for produce, dependant on the level of inputs they provide.
    - They are quite happy with the prices they receive.
    - Varite would be very pleased to speak with the rest of the team next week.
    - A number of agricultural sustainability issues were observed on this property:
        - ✓ A range of viral and insect pests and diseases;
        - ✓ Maintenance of soil fertility;
        - ✓ Possible rotational issues.

Rigo Koiari Cooperative (approx 65-70 km from PoM)

- The road traversed is the little-known back road to Sogeri so travels almost due north through the foothills of the Sogeri escarpment.
- The area visited is about 10 km from the Magi Highway along a bush track that is quite rough at times and involves fording two small creeks that, whilst perfectly safe in the Dry Season, may be impassable at times during the Wet Season.
- The country is small hills of up to 50 – 75 m vertical height, similar ridges, generally quite open, tropical savannah vegetation with grass interspersed with scrubby trees. Around the water courses the vegetation has greater density. The soil is largely black reactive silty clays from basic igneous rocks.
    - The cooperative has membership of approximately 220 families in 18 villages covering about 3,000 people on traditional land. It emerged out of women's group started by Poela Utama (FPDA) some seven years ago. Men started to attend and thought it so valuable they got more men engaged which then grew into a registered cooperative. This is highly organised with an elected leader and has purchased significant items of equipment that are well managed and used by the community for the community's benefit. They have:
        - ✓ Their own PMV which transports people and their vegetables to market;
        - ✓ A near-new tractor with a range of implements such as a 3-disk disk plough, large slasher, disk harrows etc. The tractor is operated by a permanent team who cultivate the soil etc for everyone in the community.
        - ✓ Agricultural equipment such as hand-held rotary hoes, irrigation pumps;

- The cooperative incorporates different tribes and clans who, in Value Chain Management (VCM) terms, cooperate but do not coordinate activities. That is, they don't control the crop types planted, planting dates or differentiate quality. They would like to coordinate more but see transport as their major barrier.
- The community grow capsicums, tomatoes, watermelon, cucumber, aibeka, bok choi, papaya, bulb onion (var. Gladalan Brown) and had, in the past, grown some broccoli (var. Green Comet).
- The community also buy seed and chemicals in bulk quantities from Brian Bells, Boroko, and have a seed nursery with a full time nurseryman growing and supplying seed for the whole community. This person deliberately schedules staggered plantings of crops by the timing and size of the batches of seedlings supplied.
- The cooperative supplies Greenfresh, SVS supermarkets and Boroko Food World and hotels. They receive the same price for all produce regardless of quality. They do not produce on contract.
- An appropriate fee is taken out of the sale proceeds which represents the cost of inputs by the cooperative and this includes an amortisation of the machinery involved.
- One plot was visited but the owner was not present. He had an area of about 2ha of land with a southerly aspect and 5% slope beside a small flowing creek. He currently had Aibeka, tomatoes and sweet potato. Michael Atuai stated that he had grown tomatoes in about one quarter of the area last year and had grossed K10,000 and received K5,000 net proceeds from the cooperative.
- A number of agricultural sustainability issues were observed in this community:
  - ✓ Sheet and gully erosion into the road at the bottom of his land;
  - ✓ A range of viral and insect pests and diseases;
  - ✓ Maintenance of soil fertility;
  - ✓ A plot layout (long rows in narrow blocks) and possible rotational issues.

Api Kassman, Transport Contractor

- Api is the Government Liaison Manager for Ela Motors and also has a transport business. His traditional lands are just south east of Kwikila and he and his family have a large amount of potential vegetable growing land and relatives who are interested in growing for the PoM market.
- Api made the comment that people and communities further away from PoM will be more keen to engage in vegetable growing because they have few other income-generating options. This was supported by Gus Maino and Michael Atuai.
- Api believes that it is possible to develop a commercially viable business based on small 4WD trucks with chiller boxes specifically for transporting vegetables out from remote areas on the rough roads then transferring them to larger trucks on the main highway to increase efficiency. The trucks will back-load trade supplies that smallholders normally buy when they come to town to assist with profitability.
- Since that meeting Mr Kassman has progressed his investigations and remains enthusiastic to commence a trial.

- The trialling of such a provisional freight service could enable a full feasibility study of the viability of Goilala vegetable exports to Port Moresby.

Friday 5 November, 2010

Interview with Sogeri farmers Charles Kaita, his son Anton Kaita

This was the initial contact with this community about this project. As such it was intended to establish some understanding of the scale of operation, experience and interest in developing their business.

- The terrain was very steep with slopes of 40 – 60%. The group was living on the ridges near the road and farming gardens of about 30 by 50 metres square in the more flat, fertile areas at the bottom of the steep gullies. The soil type appeared to be red ferrosols.
- Vegetables such as Tomatoes, Ball Cabbages, Chinese Cabbages, Spring Onions were being grown along with staples such as Yams, Taro, Tapioca and Cassava for family consumption.
- The group was producing Ginger as part of a project being run by Gus Maino and was being marketed in Gordon's Market, Boroko Food World, Koki SVS, Murray Barracks, Papindo (Gerehu) and the University of Papua New Guinea.
- The harvesting season for Ginger is mainly between January to June and in this period the market is very competitive. These Sogeri farmers are able to produce early Ginger when there is little on the market and therefore get better prices. The price varies from K130 to K400 per 50kg bag.
- They take a PMV to Gordon's and then get a taxi to the other buyers which costs K30 per 50Kg bag[7] plus their own fare.
- Wild pigs were their major problem in production.
- They had tried English Potatoes but the plants had grown all top and produced few tubers. They had not tried Broccoli.
- The group was enthusiastic about allowing trials of new vegetables on their land as a basis for then considering whether they wanted to be involved as a group in marketing them to new markets in PoM.

Inspection of the DAL Rubber Research Farm near MacDonald's Corner, Upper Sogeri (adjacent to the Bisianumu Station leased by Koitaki Beef)

- The land appears to be moderately undulating terrain with native grass vegetation on red ferrosol soils.
- Parts of the farm are available for other research projects and FPDA has already negotiated access for another project. This project could be piggy-backed in that arrangement.

[7] Gus Maino (FPDA) has done a study on the ACTUAL weight of bags of vegetables per se and found that they average about 87 kg.

- There are two small dams and some underground galvanised irrigation piping left over from the rubber company days. It is not know if the pipes are usable but it should be assumed that they are unserviceable.
- The traditional owners believe they have some rights and tend to encroach on un-used land so any trials sited here should negotiate security with the local community.
- If suitable, access needs to be negotiated with DAL.

Meeting of research stakeholders at Gateway Hotel, Port Moresby

Present: Udai Pal, Rosa Kambuou, Tony Ovia, Clifton Gwabu (NARI), Carter Ako (PAU), Erna Momo (Greenfresh), Richard Doyle, Laurie Bonney, Leigh Sparrow (UTAS/TIAR). Apologies from Michael Atuai and Gus Maino (FPDA).

Richard Doyle chaired the meeting.

Laurie Bonney described the progress he had made during his past two visits. With Michael Atuai and Gus Maino (FPDA) and Clifton Gwabu (NARI), Laurie had met with a number of smallholders in Central Province with potential to be part of temperate vegetable value chains.

Laurie outlined the way in which he now considered such chains might work:

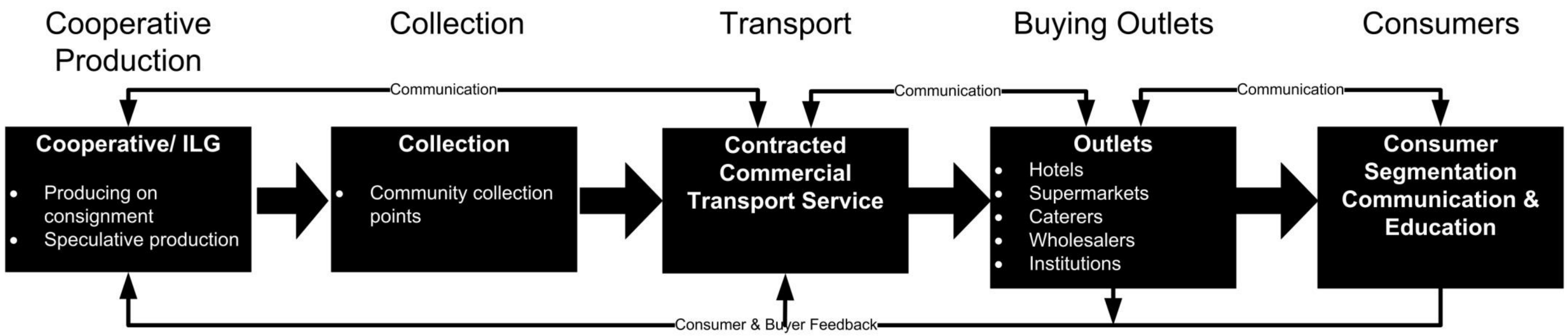
1. Chains would be based around clans or family groups.
2. Temperate vegetables would be grown either to fill a specific order from a supermarket, hotel or other business, or be grown speculatively for PoM markets.
3. Each chain would grow a number of vegetable type, to spread risk.
4. Initial production would be based on current “best bet” management (variety, erosion control, fertility, pests, diseases, irrigation), which would subsequently be refined and improved from the collective project learnings.
5. Produce would be collected at a single point for dedicated transport to market, rather than have individuals take their own by PMVs. The aim at least for some chains would be to have a dedicated vehicle with refrigeration capacity. For others it the aim may be to secure dedicated space and scheduling on PMVs. Produce would be weighed at the collection point, and growers would be paid either an agreed price on the spot or their share of the return realized at the market.

The draft Best Practice model (Figure 1) was agreed to be worth pursuing and in line with the project’s aims. Some concerns were expressed about transport on PMVs, especially for perishable vegetables, but it was agreed that dedicated space and scheduling could minimize the risk of damage.

The meeting discussed options for visits to potential participating growers and also to potential sites for supporting trials at PAU and NARI Laloki. A schedule for November 8-10 was agreed:

- Monday 8th – Rigo-Koiari Cooperative and Chapman Brothers at Bautama, Magi Highway;
- Tuesday 9th – Upper Sogeri and Bisianumu DAL Research Station;
- Wednesday 10th – PAU visit of facilities and NARI meeting of research collaborators.

Figure 26: Best Practice Smallholder Vegetable Value Chain Management Model



Critical Factors (Cooperative Production)

- Form of land ownership
- Based on a legal entity for contracting purposes
- Best available varieties
- Appropriate agronomic management (e.g. rotation, layout)
- Appropriate physical soil management
- Low input soil fertility management
- Low input IPM
- Appropriate irrigation methods
- Coordinated, staggered plantings
- Agronomic & business skills development
- Communication inc. price data
- Possible distinct women's production

Critical Factors

- Cooperative-owned wholesaler purchasing by price per unit weight from individual families

OR

- Price per unit weight recording into a cooperative pool
- Quality scale incorporated
- Future potential for the development of community-owned low cost-low input cool stores

Critical Factors

- Contracted services with specific times and collection points
- Reliable vehicles
- Not PMVs
- 4WD based off-road collection with chiller boxes
- Transferring to large trucks at the main road
- Trade goods back-loaded for the community

Critical Factors

- Differentiated price for Quality
- Market price communication or set price
- Supply scheduling
- Formal agreements with producers

Critical Factors

- Basic segmentation
- Basic target marketing
- Establish communication & feedback processes
- Introduce consumer educational functions

Udai Pal (NARI) had kindly arranged for a 10 seater 4WD vehicle from NARI to be made available for these three days.

Udai also announced that, in addition to its agreed support to the project, NARI would also conduct additional work to evaluate varieties of a range of temperate and indigenous vegetables, and had arranged for the importation of open pollinated seed from the World Vegetable Centre in Taiwan. The meeting thanked NARI for this initiative and agreed that it would add considerable value to the project.

Carter Ako mentioned that PAU were already importing hybrid seeds direct from overseas suppliers for their vegetable production and offered to identify the varieties concerned so that they could be considered for use in the project.

Monday 8th

Visit to Rigo-Koiari Cooperative, Old Sogeri Road & DAL Research Station, Kwikila - Murray Konido (DAL Agricultural Officer)

- The team visited two farm sites on either side of the Kemp-Welsh River. Steady rain during the day highlighted some of the potential issues regarding access to research sites and for cooperative members accessing markets during the Wet Season.

Figure 27 Rigo-Koiari Site 1 – (Left) steam steriliser for nursery; (Right) Rigo-Koiari Cooperative tractor and implements.

- Suitable demo sites appear plentiful within the Rigo-Koiari community of villages which Murray Konido from DAL showed us. With the community's apparent resources (sufficient to purchase tanks, pumps and pipes for irrigation) it should be possible to establish the basis for more productive and reliable cropping system. Incorporation of basic soil conservation measures and perhaps IPM as well (part of a best-bet package) would be straightforward and of help. Access and transport are perhaps more important issues to resolve. The road was in quite fair condition but if production increases as intended then pressure on the road will increase. This is not a reason to defer involvement, rather an indication of what may have to be addressed as the demonstration proceeds.


Figure 28: (Left) Rigo-Koiari Site 2 – Drs Richard Doyle (L) & Mark Boersma (R) inspect water-melon, tomato, aibeka and other crops on 2ha garden. (Right) Soil type was well structured dark light clay of mafic origins. Note soil erosion due to long down slope run in field, easily prevented with sufficient field breaks.

- The next site near Kwikila was interesting but being more remote than the Rigo-Koiari site it is not preferred. Also, it is not clear that the growers there had experience with vegetables.


Figure 29: (Left) Rigo-Koiari Site 3 near Kwikila – a rich dark clayey soil from mixed mafic alluvium and field. Site is on a flood plain and flooding and wetness may be issues but steam is nearby for irrigation purposes.

- Unfortunately it was too wet to get to Chapman's, again, even though the rain in the catchment was hardly torrential. This suggests that access may frequently be a problem and that project activities should probably be concentrated in Rigo in the first instance.

Tuesday 9th November

Visited NARI Chemistry Laboratory, Pari Road (Peter Corbett, Manager).

The laboratory was visited to determine its capability to analyse soils from research and demonstration sites selected for the project. Met Maurice the laboratory supervisor who clarified methods for a range of tests (1M ammonium acetate pH 7 for exchangeable cations, Olsen P, Walkley-Black organic carbon, CEC by saturation with ammonium chloride at pH 7 then displacement with sodium chloride). A number of new (or new to the laboratory) instruments are being commissioned including a combustion furnace for carbon and nitrogen analysis, ICP-AES and ICP-MS for multi-element analysis of soil, plant and other environmental samples at a range of concentrations. Xray fluorescence spectroscopy was also planned to be installed. This will increase the range of tests that can be done. The laboratory is currently having QA assessed by a consultant (Alain). However, the laboratory is not currently certified as proficient by ASPAC (Australasian Soil and Plant Analysis Council). This limits confidence in the laboratories results. It is not evident that they use other systems or measures (such as internal standard soils) to help assure quality of results. Suggest this be explored , along with the issues and costs of Australian analysis, before a final decision.

Visit to Upper Sogeri (near Ower's Corner)

- Inspected Anton Kaita's farm where he was growing approximately 1 ha of ginger on up to 40% slopes. Two gardens side by side are cultivated in every alternative year. In the off-year, the garden self-regenerates to grass other native vegetation.

Figure 30: Anton Kaita's ginger fields near Sogeri, note drains down very steep slope to remove runoff and minimise erosion.

- Anton looked a good, cooperative operator. Not much level ground for an irrigation demo, but possible. Irrigation on the steep slopes would be very difficult.
- Anton provided income figures which suggested he may be grossing perhaps PNG K30,000 - 50,000 for his ginger. This will mean that growing vegetables may present an opportunity cost to him although there is a need for crops to grow for an income stream when ginger is not being harvested.
- DAL Field Station soils looked eroded in many places, perhaps because of heavy grazing in the past. Combined with the lease / ownership issues, this is not a suitable site for research or demonstration sites in the near future.

Figure 31: Somewhat degraded and compacted Red Ferrosol (left) at the DAL Bisianumu Research Station (right) at Upper Sogeri.

- Kokoda Track Motel near the township of Sogeri is at a lower altitude than the first two Sogeri sites and looked to have suitable land and security, and was close to Laloki River. Negotiation with motel management will be required to establish if the project is able to use some of that land for trials.

Figure 32: Dr Gracie (Left) with Red Ferrosol (observed in post holes) in the overflow car park of the Kokoda Track Motel, site is adjacent to the Laloki River (right).

- Two sites were inspected at Iarowari High School but one was not suitable because of poor soils and both lacked security in highly populated environments. The school may be considered for establishing a demonstration plot there in years 2 or 3 for educational purposes.

Figure 33: (Left) Lillian, Sogeri High School agriculture teacher with Drs Graice & Sparrow inspecting the school training gardens with corn and sweet potato (right).

Wednesday 10th

Pacific Adventist University

Excellent security, irrigation and post-harvest infrastructure. Land looks to have been overcropped and overwatered, with gleyed horizons at 20-30 cm and poor surface structure. Internal road interferes with surface drainage. Still possible to grow decent crops and some simple guidance on water balance and cultivation in relation to soil moisture will help. Definitely a good site for a research trial. Peter Sale has earmarked 100 x 15 m strip for this purpose. 3000 people attend market at PAU each Sunday which may have potential for promotion of trials and extension.


Figure 34: (Left) PAU farm with (Right) heavy clayey alluvial soils showing signs of excessive irrigation (anaerobic mottling/gleying) but coarse sandy layers below (pit is about 60 cm deep).

NARI Laloki

- Research Director Professor Udai Pal showed us potential sites for research trials. Security not quite as good as PAU but much better than on private land elsewhere. Udai explained that irrigation mains, 4 inch pipes with risers at 5.8 meter spacings, and a Southern Cross pump in a shed near the river were in place. An area suitable for trials was agreed on.


Figure 35: NARI research station with soil profile of dark silty clay loam with moderately well developed structure and moderate drainage.

- The afternoon meeting of all stakeholders discussed potential crops and sites. Udai pressed for indigenous plants to be included, but despite the logic of this, a reminder that ACIAR had set the scope of the project to encompass temperate vegetables only was needed. Spacing trials were also discussed but it was agreed that, like irrigation, spacing could not easily be accommodated as an experimental treatment in the trials so it was agreed that 'best bet' spacings from the literature would be sufficient (Mark to follow up). After the meeting, Carter Ako and Clifton Gwabu approached Leigh Sparrow to suggest a possible site at Sogeri at a church-run primary school run by an acquaintance of Carter's. Carter thought this could be a secure site but he needed to check out irrigation.
- It was agreed that research trials for the:
    - Low altitude crops could be conducted at NARI and PAU.
    - Medium altitude crops could be conducted at a secure site near Sogeri township.

Visit to Brian Bell's Store, Boroko – Discussion with Egi Mada, Manager, Agricultural Supplies, Brian Bell's store, Boroko

The group visited Brian Bell's Store to inspect the types of products stocked. The manager, Egi Mada, was briefly appraised of the project because the store plays an important supply chain function as the main input supplier to smallholders. Egi is agriculturally trained and stated that he stocked the seed, agricultural chemicals and fertilisers that were in demand but was quite willing to stock different varieties and pack sizes if they were more appropriate. He indicated interest in being invited to chain development meetings as appropriate.

Figure 36: Illustrates the range of seeds, fertilisers and pumps available at the Brian Bells store in Boroko. Larger pack sizes of all inputs were available by order. A good range of irrigation pipes, nozzles, spray equipment, spades/shoves, machetes etc were also available.

Thursday 11th November

Meeting with Colin Wiltshire and John Here (Central Province Administration)

- Colin and John were briefed on the progress so far in selecting focal vegetables and farming areas as well as sites for the scientific trials.
- Colin emphasised that Agriculture is the responsibility of provinces and the importance of working with Central Province Administration. It was clearly indicated that on the team's next trip a presentation would be made to District Administrators on the project and the team would then discuss with the DAs their involvement and assistance in implementing value chain development projects in the locations when finally selected.

- Colin and John stated that production and associated trials in Goilala (Tapini) would be advantageous whether or not it proved viable because it would provide Central Province Government with valuable data on development priorities.

Meeting with Gus Maino & Michael Atuai (FPDA)

- Explained that on the next trip in early February Laurie Bonney wanted to formally engage with communities and farmers and commence the in-depth value chain research.
- Indicated that on the next trip we (Laurie Bonney and one other team member) would like to make a presentation to District Administrators regarding the project and discussing how they could assist to implement value chain development projects in the indicated locations.

Meeting with Daniel Apina (Central Province)

- Informed Daniel in broad terms of findings to-date, including that that an entrepreneur with interest in initiating a commercial freight service into Goilala to carry out vegetables produced from any value chain project initiated there.
- Indicated that on the next trip, the team would like to make a presentation to District Administrators regarding the project and enlist their assistance to implement value chain development projects in the selected locations. Daniel indicated that because of the remoteness of the DAs that he would need considerable notice to set a suitable date.
- It was also conveyed that the attendance of Shirley Hopa,Coordinator of Women in Agriculture and Livestock, Central Province, the first women's desk in any of the provinces, would be an important component of that presentation.

Significant Biophysical Issues for Vegetable Production in PNG

1. **Little diversity in genotype**
    a. Carrots: the main variety grown, 'Kuroda', is expensive as seed and difficult to grow. Other cheaper varieties of similar shape and colour are available.
    b. Potato: The majority of potato grown in PNG is a clone of the cultivar 'Sequoia' and susceptible to late blight. The wide spread use of clones of 'Sequoia' leaves the production system open to mass failure from pest and disease or abiotic stressors.
    c. Many varieties are F1 hybrids and therefore seed multiplication by the farmer is unsuccessful. Open pollinated varieties would provide farmers with an opportunity to select and bulk their own seed supplies reducing their reliance on retail stores such as Brian Bell. In some cases, such as the *Brassica* family, the species are highly diverse and readily outcross to produce intermediate phenotypes.
2. **Irrigation**
    a. Very little irrigation infrastructure exists. Small landholders predominantly irrigate by watering can.

b. Many crops exhibited symptoms consistent with chronic water deficits.

c. Irrigation will be necessary to ensure the continuity of supply during unexpected periods of reduced rainfall.

d. An appropriated method or methods of irrigation based on existing technology and previous project work in PNG is required.

3. Ground preparation

a. Land for cropping is prepared by slash and burn.

b. The local Kunai grass (*Imperata cylindrica)* has rhizomes (underground stems) from which it reproduces. Consequently burning, slashing and cultivation provide only short term control. This plant is a significant weed in the current system.

c. The mounding system provides significant benefits:

   i. Nutrition: organic matter is incorporated into the base of the mounds providing slow nutrient release and heat.

   ii. Protection against water logging

   iii. A trench system for irrigation.

   iv. High organic matter levels

d. Most terrain is steep and prone to erosion. This influences the size of production plots.

4. Propagation

a. PNG growers use mounds as a nursery to raise seedlings from seed. This seed is planted at a high density and the seedlings then pricked into the production mounds.

b. A large proportion of farmers who grow brassicas produce their own seed. However, no selection is involved and plant crosses are uncontrolled.

5. Weed control

a. Currently most weed control is by hand with the spade being the most common tool type. Little hand-hoeing or harrowing was observed.

b. NARI research station use paraquat, a schedule 7 pesticide. Glyphosate products are available in PNG.

c. Weeds between the beds are not controlled. These plants will produce seed and will compete for moisture.

6. Nutrition

a. Many crops showed signs of N deficiency. Not many other deficiencies were recognized.

b. Increased outputs will most likely require increased inputs of both water and nutritional elements, particularly N, P, K and S.
c. Only one fertiliser mix (12:12:17 + trace elements) is used. This appears sourced from Brian Bells and is the only mix available.

Conclusions

The trip achieved all the initial aims as stated:

(i) Identify which vegetables to be focussed on through discussion with the stakeholder agencies FPDA, NARI, Central Province, PAU and Greenfresh;

The investigation has established that rather than focusing on 'single vegetable' chains it is more practical from the risk management as well as marketing perspectives to focus on a 'basket of vegetables'.

It is recommended that having identified low, medium and high altitude categories of production that the 'baskets' of vegetables be:

- Low altitude – Tomatoes, French Beans, Capsicums
- Medium altitude – Tomatoes, Broccoli, Carrots
- High altitude – Broccoli, Ball Cabbage, English potatoes[8]

It should be noted that these are likely to be the focal vegetables for which the project will conduct research and demonstration trials.

(ii) Identify the preferred regions in which those vegetables would be grown;

After considering agricultural, marketing and socio-economic factors, the priorities regions selected for production, research and demonstration sites are:

1) Low altitude - the Rigo Koiari Cooperative and the Chapman's group on the Magi Highway represent the best opportunity to achieve early small wins and eventually supply Port Moresby and large caterers such as The Allied Group;
2) Medium altitude - the Sogeri Community dependant on finding suitable secure trial sites,and
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(iii) Discuss with the research collaborators, NARI and PAU, the key researchable issues and where replicated scientific research should be located;

The key researchable issues were:

1) Suitable varieties of the finally selected focal crops.
2) Low-input composting systems suitable for smallholder farmers.
3) Low-input IPM systems suitable for smallholder farmers.

[8] FPDA currently has a project in Goilala where they have supplied English potato seed tubers to a number of growers.

4) Irrigation input to be compared to no irrigation inputs.

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Demonstration plots in all production regions for:

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- Nitrogen management.
- Soil erosion management.
- Locally relevant, crop specific IPM

(v) Other related issues

The Draft Best Practice Model as described appears to be corroborated by the existence of some existing commercially developed arrangements. It also appears to have the support of the Stakeholder Committee.

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ACIAR Project: SMCN/2008/008 Increasing Vegetable Production in Central Province, Papua New Guinea to Supply Port Moresby Markets

Tasmanian Institute of Agricultural Research

Trip Report for 6th – 25th Feb 2011

by

Colin Birch, Gomathy Palaniappan, Laurie Bonney, Barbara Chambers, Mark Boersma

Abstract

This report provides information on activities of Australian (TIAR, University of Canberra) participants in a visit to Papua New Guinea on various dates during February, in a chronological sequence of consultations, activities and participant attendance. It also provides detail of the contribution by local partners (National Agricultural Research Institute, Fresh Produce Development Agency, Pacific Adventist University, Central Province Administration and Green Fresh, and local farmers and farmer groups. It also provides some preliminary comment on outcomes from the consultations, activities undertaken, but does not seek to consolidate information into one or more documents of a 'publishable' nature.

Structure of this Report

The report consists of two parts, the first being 'Activities of the project team members from TIAR and PNG Partner organisations', the second, commencing on page 23 relates to activities undertaken by Professor Barbara Chambers during her visit.

Dates of Participation

Assoc Prof Colin Birch - 6th to 10th February

Laurie Bonney - 6th to 18th February

Dr Gomathy Palaniappan - 13rd to 25th February

Dr Mark Boersma 14th to 18th February

Prof Barbara Chambers-19th to 23rd February

PART 1: 'Activities of the project team members from TIAR and PNG Partner organisations'

Purposes of the Trip

The aims of this trip were to:

1. Integrate Central Province Administration into the project

2. Undertake capacity building activities with project stakeholders; specifically 'awareness raising' with District Administrators and methodology development with the social researchers;
3. Commence the process of engaging with the chain participants to plan and implement agronomic research and value chain development;
4. Conduct group interviews with farmer participants and their families to understand their local knowledge, experiences with vegetable production and future intentions using an Appreciative Inquiry form of Action Research.

Monday 7th February 2011

Colin Birch and Laurie Bonney met with Emily Flowers (ACIAR) and Colin Wiltshire (AusAID) to:

(i) consider role of Central Province in the project, specifically in relation to community mobilization, site selection, maintenance, management and site security for on farm experimental sites, liaison with FPDA, NARI, PAU and Green Fresh, and participation in the sociological aspects of the project;

(ii) Clarify roles of other participants
   i. NARI and PAU – supply of skills – scientific, data collection, recording and analysis, fertiliser and chemical application
   ii. FPDA and Green Fresh – whole of chain activity, including contribution to VCA research, training and capacity building.

(iii) Governance structure, with incorporation of Central Province
   i. Dispute resolution
   ii. Communication lines
   iii. TIAR activity in relationship building

Subsequently, Colin Birch and Laurie Bonney met with Central Province representatives, The Provincial Administrator and his Deputy (Mr Apila), Mr John Here, Ms Shirley Hopa, and Mr Daniel Apina. The meeting was also attended by Emily Flowers and Colin Wiltshire. The Deputy Provincial Administrator outlined Central Province's (CP) policy and administrative positions, followed by a discussion of how CP staff and staff in the districts (District Administrators and others who report to them) could contribute to delivering on project outcomes, especially through their community links. They were particularly keen to participate in the interviews to be undertaken later in the visit, and subsequently did so.

The Provincial Administrator emphasized the role of CP administration, its assistance to Cooperative Societies e.g. Women in Agriculture), and that CP would like to participate in the set up and implementation of the project through an activities plan for CP staff.

Discussion followed on a range of topics including specific aspects of CP involvement, the role/s of partners in the project, funding and finance administration, communication with the District Administrators to ensure their being kept up to date and involved, and providing contacts in other areas e.g. Health, Lands Departments.

Actions to arise from the meeting included;

(i) Seek approval by ACIAR of revised project document and budget - Colin Birch
(ii) CP staff to provide necessary documentation for use in (i) above – CP Staff
(iii) CP staff to participate in interviews (survey component of the project) – Laurie Bonney and CP Staff
(iv) CP staff to participate in site selection for field experiments – CP Staff, TIAR Staff
(v) Once funding formally approved, CP to provide invoices to TIAR - Provincial Administrator as CFO of CP.

Tuesday 8th February 2011

A Project Management Advisory Committee meeting was held at Pacific Adventist University (PAU), attended by representatives of all partners and ACIAR (Emily Flowers), chaired by Colin Birch. Agenda items included:

Report on the October meeting, and update on action items from that meeting (Value Chains Research, Women and Youth in Agriculture, staff appointments – PNG partners, research locations and research designs)

Project and Budget – proposed changes (reallocation to CP), ground travel in PNG

Publications and training opportunities (e.g. Crawford Fund)

This was a very positive meeting, with a real 'collegiate feel' arising from it, with positive reactions by all partner organizations and their staff who also attended by invitation. The meeting also agreed to the general direction and parameters surrounding the implementation of the project, with all partners being committed to their roles in it. A substantial list of follow up actions and plans for the duration of the visit were prepared from this meeting, and are not repeated here.

Wednesday 9th February

Laurie Bonney and Colin Birch visited NARI Laloki and met with staff there, including two new recruits Dickson Benny (Economist) and Philmah Seta (Agronomist). Actions by NARI arising from the Project Management Advisory Sub Committee and Project Documentation were discussed, and a number of action items agreed (not detailed here). The field sites and equipment, especially irrigation equipment, for research work at NARI Laloki were inspected.

Subsequently, Laurie and Colin met with Peter Sale (Farm Manager, PAU) and inspected the likely trial location at that site.

Thursday 10th February

Colin Birch and Laurie Bonney visited CP Administration for follow up discussions on the mechanics of CP involvement, particularly in relation to transport, funding and financial control and participation of people from outside Port Moresby i.e. in districts such as Rigo and Goilala. They then visited Fresh Produce Development Agency for further discussions on project implementation. These discussions contributed to the extensive list of action items to be undertaken by TIAR and partners prior to and during the planting and establishment of field experiments in the early dry season (late April – May).

Friday 11th February 2011

Laurie Bonney met with Mr James Cooper, LNG Project Manager at Ela Motors, Port Moresby to discuss a business case for a freight service for the vegetable project.

Agronomic Activities: Mark Boersma met with Udai Pal and Rosa Kambouo (NARI Laloki) to discuss experimental trial design and trial locations. Interviewed Rosa and Tony Avia regarding agricultural system practices in the areas they work in, also discussions with Laurie Bonney and Gomathy Palaniappan to discuss project linkage between agronomy and value chain research. Worked on trial logistics during evening.

Monday 14th February 2011

Meeting with Stake holders at PAU

Aim: The aim of the meeting was to incorporate scientific knowledge and to work with chain participants in practice to:

- **a. Discuss the research framework with the stake holders and to get feedback.**
- **b. Emphasize the roles of each organization in the project**
- **c. Develop culturally appropriate questions using the frame work**

Participants:

	Name
1.	Roselyn Winston - NARI
2.	Dickson Benny- NARI
3.	Philma Seta- NARI
4.	Poela Utama- FPDA
5.	Michael Atai- FPDA
6.	Lalen Simeon- PAU
7..	Shirley Hopa- CP

Activity Morning: All the stakeholders had previous experiences in data collection methods such as surveys and interviews.

Laurie Bonney and Gomathy Palaniappan briefed the group about the need for unifying and adapting Rapid Value Chain Analysis methods and the Organic Research and Collaborative Development.

The need for unifying Appreciative Inquiry and Rapid Value Chain Appraisal was also explained to the stakeholders. The stakeholders agreed to the research frame work used. Some of the participants accepted that appreciative inquiry was practiced in previous studies without understanding that it was a research frame work.

Figure 38: Discussing the research frame work with the stake holders (L-R: Roselyn Winston (NARI), Laurie Bonney (TIAR), Michael Atuai (FPDA), Shirley Hopa (CP), Poela Utama (FPDA), Philma Seta (NARI) and Dr Lalen Simeon (PAU).

Laurie Bonney emphasized the roles of the stakeholders in the project that were agreed during the previous meetings:

- NARI – scientific skills & Social skills
- PAU – social skills & Education
- CP – community mobilization (policy, planning, extension)
- FPDA - extension

Activity Afternoon: The participants divided into 3 groups, one men's group and 2 women's groups to develop questions. All the questions were pooled together to finalize the set of questions for story-telling.

Outcomes:

- The stakeholders agreed to the research frame work used
- Understanding of appreciative inquiry as a research frame work was recalled to be practiced in previous studies.
- Understanding of the roles of each organization in the project by the participants.
- Questions were developed and prepared for field visit.
- The aim to work with stakeholders has helped them to not only be familiar with the research frameworks but applying participatory principles in development of the questions has ensured that the research is conducted jointly.
- This has also strengthened the team building among the stakeholders.

15th February 2011

Aims: to

a. **Emphasize FPDA's role in the project**

b. **Discuss about the sites selected for project initiation and to plan the visits**

c. **Provide information on the progress to Green Fresh**

Morning meeting at FPDA:

One on one discussion with:

1. Michael Atuai and Gus Maino to discuss:
   a. The FPDA role as the only project partner with an overview of the whole value chain – monitoring progress and chain participant training;
   b. Development of a visual vegetable grading system to be used as the basis for a more objective pricing system in the project's new value chains;
   c. Development of a range of payment mechanisms for smallholders to enable them to be paid for the vegetables supplied to the new chains.
2. Poela Utama at FPDA office in regards to their experiences with their previous projects in the sites selected:
   a. Bautama: The Chapman family has been helping other growers to grow vegetables and supply to POM. The village has fertile soil but will not be able to grow during wet seasons. Bauatama was a part of the Eri District and we agreed that the DAL of the Eri District Mr. Coplan Tapio be contacted during the value chain work shop.
   b. Rigo: In this District the cooperative society is well established. FPDA has played a vital role in encouraging the farmers to build a cooperative society and the community has high regards for FPDA. Farmers face challenges in transporting vegetables during wet season. We agreed that Mr. Murray Konido, Agriculture Coordinator of Rigo District be contacted during the value chain workshop.
   c. Tapini: In Tapini the lack of transportation has limited the cash flow within the community as vegetables cannot be transported to the market at POM. It was

decided to contact Mr. Titus Girau the District Administrator for Goilala during the value chain workshop and organize for visiting the community to conduct the story telling.

3. **Agronomic Activities:** Mark Boersma met with Udai Pal, Tony Ovia, Philma, Dickson Benny, and Paul Osiri (NARI, Laloki) to explain and modify trial design and the associated logistics. He also travelled to Sogeri to meet with the principal of the Sogeri National High school, Mr Benny Rayappan, to discuss the potential of using school land as an experimental site.

16th February 2011

Value chain workshop conducted at PAU

AIM: To explain value chain theory to the stake holders and to discuss about the strengths and weakness in implementing theory.

Laurie Bonney and Gomathy Palaniappan facilitated the value chain workshop for the stakeholders from the District Administrators of Central Province, FPDA, NARI and PAU. 30 participants attended the workshop at PAU. 5 participants from FPDA, 2 participants from PAU, 8 participants from NARI and 15 participants from Central Province attended the workshop. Laurie Bonney discussed the concepts of supply chain and value chain.

Agronomic Activities: Mark Boersma also participated in this workshop, to gain additional insight into local conditions and relationships among project partners and participant groups, and how these may influence implementation of the projects experimental work. He also developed a trial parameter calculator for NARI staff to use, based on the previous day's discussion, as part of preparation for the research meeting on 17th February.

Figure 39: Value chain awareness workshop for PNG Project Partners. Left to Right (Foreground) in a plenary session are Rosa Kambuou (NARI) and Roselyn Winston (NARI).

As a part of the workshop small group discussions were held on some key themes to provide input to the project. The groups were comprised of mixed genders from different organizations and showed high level enthusiasm in discussing the questions.

Figure 40: Mixed small groups provided good input to project data.

Question 1: What customers want from suppliers?

Mark's Team	Udai's Team	Clifton's Team
Quality	Regular	Quality
Reliable	Reliable	Quantity
Constant	High Quality	Value/ Reasonable
Affordable Price	Competitive Price	Consistent Supply
Timeliness of Supply	Trust the Supplier	Trust
Quantity & Volume	Supply information	Reliable
Origin of product	Excel at customer service	Healthy environment
Product Label		Range of products
Presentation of product harvest		
Brand		
Trust & Understanding		

The participants were surprised to see the views they had in common in regards to the requirement of the customers. All the three groups had quality of the produce, regular supply and reasonable price as the most immediate response in regards to what customers wanted from suppliers.

Question 2: What suppliers want from customers?

Mark's Team	Udai's Team	Clifton's Team
Information & Feedback	Feed back on Supply	Better Price
Regular	Know customer demand	Trust
Loyalty	Loyalty	Reliable
Agreeable price	Trust	Consistency
Preference	Good Income	Mutual understanding
		Information & communication
		Timeliness

The first two groups had feed back as their immediate response and the third group had better price for the produce as their immediate response in regards to what suppliers want from the customers.

Question 3: Attributes of Product - When consumers buy fresh food, what kind of attributes do they value?

Mark's Team	Udai's Team	Clifton's Team
Freshness	Quality (Taste, Size, Shape)	Freshness
Variety	Price	Quality
Appearance	Origin	Size
Colour	Production	Palatability
Nutritive		Colour
Size		Maturity
Quantity		Organic
Customer preference		
Choice/ range		

All the 3 groups had freshness and quality as their immediate response in regards to the attributes of product.

Question 4: Attributes of the way the product is sold

Mark's Team	Udai's Team	Clifton's Team
Price	Quality	Labels (dates)
Presentation	Way harvested	Cleanliness
Product Maturity	Packed	Healthy
Timeliness delivery	Sufficient label info	Proper packing and handling
Good Condition [post harvest]	Presentation	Orderly display
Good salesmanship	Timely processing	
	Value adding	

Question 5: What is stopping us from working together?

Mark's Team	**Udai's Team**	**Clifton's Team**
Topography	Lack of infrastructure -Roads markets etc	Distrust
Attitude	Distrust	Lack of information dissemination & networking
Awareness & Training	Education + awareness	Fear of loss
Land ownership	Lack of Leadership skills	Land of disputes
Infrastructure	Lack of vision	Lack of support
Leadership + coordination + Skills	Lack of economic conditions	Cultural variation
Lack of financial management + skills	Fear of risk	Lack of logistics
Distrust	Wontok	Illiteracy
Lack of finance &equipment resources	Few cooperatives	Lack of Capital
Marketing knowledge		Poor transport infrastructure
		Lack of cooperation
		Lack of ownership
		Lack of access to market
		Lack of Government support
		Rigid credit facilities

All the 3 groups listed the following factors as the cause for not working together.

- *Cultural factors (norms & values)* like the Wontok, cultural variation, attitude, distrust, land ownership
- *Educational factors (knowledge, attitude, skill)* like lack of vision, education + awareness, awareness & training, lack of information dissemination & networking, marketing knowledge, leadership + coordination + skills, illiteracy, fear of loss
- *Infrastructure* like rigid credit facilities, lack of access to market, poor transport infrastructure, lack of capital, lack of finance &equipment resources

17th February 2011- DAL planning meeting at NARI

Aim: To work with the chain participants in planning the next round of data collection and the implementation of production

Morning:

Presentation by **Laurie Bonney** on the plan of activities for the project

Agronomic Activities Presentation by Dr Mark Boersma on the plan of activities for agronomy experiments planned for the coming dry season.

Mark also met with NARI, FPDA and District Administrators from Central Province to discuss the social and biophysical aspects of the project.

Outcomes:

- Potato was chosen as one of the vegetables for Tapini as the vegetable is hardy and can withstand the issues around transport.
- Protection & security for trials at Tapini was assured by Mr. Titus Girau (DAL CP) by building ownership of the project with the community. However the Sogeri trials will be taken care of by the High School Head Master
- Evaluation of the trial has to be completed by the community to understand their criteria for evaluation
- Production for the 1st year value chain at Bautama and Rigo - the provision of seed needs to be

Figure 41: TIAR's agronomist Dr Mark Boersma outlining the agronomy research design.

18th February 2011

Aim: To conduct group interviews with farmer participants and their families to understand their local knowledge and strengths using appreciative inquiry at Bautama

The community was briefed on the project and the reason for collecting information was explained in English and was also translated in Pidgin by Michael Atuai.

With the agreement of the participants men and women were interviewed in 2 different groups.

The participants were thanked for participating in the interview.

Participants in interviews:

Government Agents
Roselyn Wintson - NARI
Dickson Benny- NARI
Philma Seta- NARI
Poela Utama- FPDA
Michael Atuai- FPDA
Gus Maino- FPDA
Lalen Simeon- PAU
Shirley Hopa- CP
Copland Tapio

Farmer Participants
Arthur Chapman – 72175560
Stanley Chapman – 7331533
Valo aruna
Dainaiku Gorari
Ian Goro
Bore abari
Omia Degia

Stanley Chapman & Warren Chapman group

Tomato varieties commonly grown are Queensland Blue or Summer Taste that suited their climatic conditions but unable to purchase the seeds in the market. The participants expressed the need to for a variety that could produce firm tomato that can withstand the transportation. Participants have had previous experiences of buying seeds with wrong labels. The local variety doesn't have good shelf life. The participants strongly felt that tomatoes grew best in their village but have not reached their best price yet because of lack of transport.

The participants mentioned that they used to spray pesticide and fungicide to keep pests and diseases under control. They also used Neem[10] for biological control. Fertilizers like NPK and chicken manure are used. They used to supply tomatoes in 10 kg boxes to Boroko Food World, super markets and coffee shops. They have good relationships as they are regular suppliers of tomato. Regular pruning, thinning, labor intensive and furrow irrigation practiced. They grow the tomato plants in the nursery at different stages so that they will be able to get regular harvest of tomato over the season. Minimum of 3 months of harvesting continues to provide regular supply of tomato. They are quite happy with the price they get and they understand that more hard work and input will bring them a better outcome. Most of the learning was through trial and error with some minimum support from DPA.

[10] Neem (*Azadirachta indica*) is a tree in the mahogany family Meliaceae. Oil can be extracted from the seeds which contains a complex secondary metabolite azadirachtin that has been observed to be anthelmintic, antifungal, antidiabetic, antibacterial, antiviral, contraceptive and sedative.

Figure 42: Story telling sessions and interviews at Bautama

Outcomes:

- The best vegetables in terms of income are watermelon and tomato during the dry season and aibika, pumpkin and corn during the wet season.
- The farmers knew what to produce and when to produce based on the season, income, yield and cultural activities. They received no other information on what the market required.
- No firm arrangement with the transporters, wholesalers, buyers. They fit into whatever opportunity is available in the market.
- Most of the small farmers follow the Chapman farm (leading farmer) closely on both practices and marketing of the produce mainly tomato. Watermelons are preferably sold in the open markets rather than the supermarkets as they get better price by selling them as individual fruit where as the supermarkets purchase them based on their weights.
- In future, they are aiming to:
    - Increase the yield they are aiming for better varieties of tomatoes;
    - Improve their pest and disease control practices;
    - Achieve a more stable market with better information on the prices. They believe cooperative marketing will provide them better prices.
- The youths prefer to continue with farming as working in the farm helps them to get better

Reflections on practice and questions:

The practice of coordinating the visit as a team and few questions were re-worded during the reflection process. The dream question was very hard to explain to women participants whereas the male participants were comfortable answering the dream questions.

Figure 43: The TIAR Project Social Research Team review experience with the method.

Rigo visit:

Please refer to Prof Barbara Chamber's report.

Tapini visit:

Participants conducted interviews:

	Name
1.	Roselyn Wintson - NARI
2.	Dickson Benny- NARI
3.	Philma Seta- NARI
4.	Poela Utama- FPDA
5.	Michael Atuai- FPDA
6.	Gus Maino- FPDA
7..	Lalen Simeon- PAU
8.	Shirley Hopa- CP

Figure 44: Goilala District Administrator Titus Girau speaking to Cooperative Members in Rigo-Koiari.

Figure 45: Rigo-Koiari Cooperative members.

Outcome:

- The most attractive vegetables in terms of income are ripe banana, kaukau, and green peanut
- They knew what to produce and when to produce based on the season, income, yield, cultural activities and need arises.
- No firm arrangement with the transporters, wholesalers, buyers. Lucky one gets the transport.
- To increase the yield they are aiming for a good packaging for transportation of the produce and need for storage facilities and preservation techniques.
- In future they are for a more stable market. Also cooperative marketing will provide them better prices.
- The youths prefer to continue with farming as working in the farm helps them to get better income and freedom to make their own decisions.

Agronomic Activities: Mark Boersma met with Peter Sale, Assistant Manager, PAU farm to discuss upcoming trial work, and discussed agricultural subsistence practices in the nearby Solomon Islands, to gain greater understanding of the socio-cultural environment in Melanesian populations. He also visited Brian Bell stores and met with Egi Mada, Manager of Agricultural Supplies to discuss seed lines available in PNG for the experiments to commence in the coming dry season.

Outcomes of the Trip

With respect to the original trip aims:

1. Undertake capacity building activities with project stakeholders:
   - The social research group actively and enthusiastically engaged in the process. As one of them said: “Now we’ve stopped talking and are starting to do something…” The process of utilising their skills and experience both assisted the development of the method and was educative for all concerned.
   - The DAs were made aware of the nature of value chain management and its potential benefits to smallholders. They were strongly supportive and keen to get their communities engaged.
   - The process enabled the DAs to make a real contribution to the project methodology from their understanding of a smallholder’s perspective.
2. Commence the process of engaging with the chain participants to plan and implement agronomic research and value chain development:
   - The involvement of the DAs was a critical step in gaining the commitment of the local communities.
   - The DAs were tasked with assisting the selection of research and production sites and gaining the commitment of their communities.
3. Conduct group interviews with farmer participants and their families using an Appreciative Inquiry form of Action Research. The community meetings:
   - Informed smallholders about the project.
   - Commenced gathering data on their aspirations for the future and issues they were facing in vegetable marketing.
   - They were made aware of a further meeting in May where more detailed production (value chain) and research planning would occur collaboratively with other chain participants.

Appendix 1: Questions developed with co researchers for Bautama village to conduct interviews.

Friday 18th Feb 2011 Plan of activity: Story telling Place of visit Bautama, Hiri District

Interviewer's Name: Name of participants:

Discovery Questions

1. What vegetable has benefitted you in terms of income/Quality (good)/yield?
2. How did you know what to produce and when to produce?
3. What is good about the relationship with the transporters, wholesalers, buyers?

Dream Questions

1. How do you make sure you get the best price?
2. What is your aim for good yield and quality?
3. In the future, what would you like to know about the market, price, quality & demand?
4. What would you like your future marketing relationship to be like?
5. What motivates you to farm?

Appendix 2: List of Participants who attended the Value chain workshop (Infill colour shows groups of attendees by organization or closely related groupings)

	Name	Designation	Contact Details
1	Poela Utama	FPDA PO Box 2788 Boroko NCD	poelautama@ yahoo.com.au Ph:3215520/3426306
2	Gus Maino	FPDA – POM	3408072, 71487459
3	Michael Atuai	FPDA POM Horticulture Advisor Southern Region	Ph: 72 905133 matuail@hotmail.com
4	Raphael Kombukon	FPDA PO Box 2788 Boroko NCD	730784461 rkombukon@hotmail.com
5	Mark Worinu	Coordinator Market Support Programme	73777576 worinu@yahoo.com
6	Lalen Simeon	Director Research & Post Graduate Studies	Ph: 73265624/ office 3280200
7	Carter Ako	School of Business PAU	3280229 carter.ako@pau.ac.pg
8	Shirley Hopa	CP-DAL-WIA-coordinator	3214782/73406381
9	Grace Manai (Abau district)	CPA, Provincial Food Security Officer, CP	Ph: 3214782 Mobile:73707001 Greggy.manai @gmail.com
10	Titus Girau(Abau district)	CPA, CP	Ph:3214782 Mobile:72739494
11	Michael Ralai (Abau district)	CPA, CP	Ph:3214782 Mobile: 73528021
12	Lob Lalaivaina (Rigo)	District Administrator, Rigo	73434047
13	Gabi Tau	Provincial Food Security Officer (PHQ)	72364129
14	Ruga Amo (Rigo)	Rigo Dist Food Security Officer	71479731
15	Roselyn Winston	NARI Southern Regional Centre PO Box 1828 POM PNG	PH: (675) 3235511/3281170 roselyn.wintson @nari.org.pg
16	Dickson Benny	SRC NARI Laloki	71877996
17	Rosa Kambuou	SRC- NARI Laloki [Scientist]	3235511
18	Paul Osilis	SRC – NARI, Laloki [Research Asst]	3235511 -71034552
19	Udai Pal	NARI-SRC, Laloki	3235511 Udai.pal@nari.org.pg
20	Philmah Seta	NARI- SRC, Laloki	3235511 71696595 Phil_seta@yahoo.com.au
21	Tony Ovia	NARI – Program Manager	3235511 Tony.ovia@nari.org.pg
22	Clifton Gwabu	NARI – SRC- LALOKI	3235511 clifton-gwabu@nari.org.pg
23	Coplan Tapio [Bautama]	CPA – DAL- Food Security Officer Hiri District	73201579
24	Henry Ray	CPA – DAL- Food Security Officer	71201371

	[Bautama]	Hiri District	
25	Peter Sale	PAU Farm Assistant manager	71225542
26	Apatia Puri	District Administrator ABAU District, CPA	72091862/off:3292069
27	Murray Kondo (Rigo)	Agriculture Coordinator – Rigo	71618926
28	Felix Gitai	CPE Administration	gitaisf@gmail.com 3214003
29	George Aminae	DAL Coordinator –Kairuku	71999450
30	Oa Ure	Food Security Officer Kairuku	71180533

Report Part 2

Australian Institute for Sustainable Communities

University of Canberra
SMCN/2008/008 Increasing vegetable production in Central Province, Papua New Guinea to supply Port Moresby Markets

Trip Report to Central Province

19-23 February 2010

Barbara Chambers

Introduction

Laurie Bonney and Gomathy Palaniappan travelled to PNG on 14 – 18 February 2011 prior to my visit in order to inform the Central Province District Advisors about the project and value chain management and to trial some interview questions about vegetable production with the village of Bautama. Prior to their visit we had discussed a possible methodology for interviews based on the Appreciative Inquiry (AI) and Rapid Supply Chain Appraisal (RSCA) methods (see Figure 1). These intersecting methods were sent to our social science PNG partners at FPDA, PAU and Central Province Administration (Poela Utama, Lalen Simeon and Shirley Hopa) for comment and for suggestions for alternative wording in the local language. It was agreed that these questions would be trialled at Bautama prior to my trip and visit to Rigo-Koiari.

Purpose of the trip

1. Commence social research on the specific communities involved in the project
   1.1 Train PNG partners in the research methods to be used
   1.2 Review social research methods for village interviews, based on a trial at Bautama Village.
   1.3 Interview villagers at Rigo-Koiari about their successes and dreams for growing vegetables

Background and Protocols

Laurie Bonney presented the rationale for the selection of sites (Bautama, Rigo-Koiari and Tapini) for the value chain activities to the meeting of District Administrators at the DAL planning day. Rigo-Koiari was selected as a low altitude region to initiate the value chain. Following this, Mr Murray Konido, District Administrator and Agricultural Coordinator and Ruga Amo Provincial Food Security Officer was contacted to make arrangements for the interviews.
PNG partner representatives were inducted into the methodology and interview questions prior to the visit to Bautama. Afterwards, a debriefing was undertaken and questions revised in terms of translation into the local language. The team was composed of Roselyn Wintson, Dickson Benny and

Philma Seta (NARI); Poela Utama and Gus Maino (FPDA); Lalen Simeon (PAU); and Shirley Hopa (CP). The team was led by Dr Gomathy Palaniappan and me in the second week.

1. **Commence social research on the specific communities involved in the project.**
   Prior to my trip to PNG, Laurie Bonney, Gomathy Palaniappan and I had developed a matrix intersecting two methodologies: Appreciative Inquiry and Rapid Supply Chain Appraisal. We decided to concentrate on the first two sets of questions for the interviews: Discovery (the best of what is) and Dream (what might be). This matrix appears below in Figure 1.

Figure 1: Matrix of AI and RSCA

Appreciative Inquiry (AI) Process		**Rapid Supply Chain Appraisal (Collins & Dunne, 2008)**			
(Cooperrider, Whitney & Stavros, 2003) *The co-evolutionary search for the best in people and cultures. It asks questions that strengthen capacity to apprehend anticipate & heighten positive potential. It mobilises imagination, innovation &change.*		**Value creation** *Ultimately price is the determinant of consumer value whether it's extrinsic or intrinsic value. However, creating 'customer value' for the next in the chain is also an important issue.*	**Product integrity** *Technical aspects of the harvest and post-harvest processes, packing, storage, handling and transport.*	**Communication** *Involves **information flows** (market requirements & price/volume data) as well as **inter-personal** sense-making, problem-solving, decision-making, compliance gaining, leading, motivating and influencing, conflict management, negotiating and bargaining.*	**Chain governance** *How the activities of the supply chain are coordinated and how the value created from the sum of the chain's activities is distributed among its participants.*
Discovery **(The best of what is...)**	1. What has worked well for you in growing crops in your village? 2. What have been your successes in marketing horticultural products?	• What are you most proud of in growing crops? • What do buyers see as being different or good about your produce?	• What is it that has worked well for you in growing crops in your village? • What has worked well for you in marketing crops in your village?	• Who was responsible? (Identification of the leader) • How did you know what to produce? • How did the group make the decisions?	• What has been the greatest achievement of the cooperative since it was formed? • What made this possible? What happened to achieve success? • Why did this work so well?

Dream (What might be...)	3. What dreams (ideas) do you have for the future, given your successes in horticulture?	• How might you get the best prices?	• What might your produce look like when you harvested it? • What might your produce look like when it arrived at the buyers?	• How might you find out what the buyers wanted? • How might you find out what the transporters wanted? • How might you make sure that everybody in your group knew what to do?	• How might you make sure (motivation) everyone in the family/village/cooperative did what they needed to do for everyone to be more successful?

2. Review social research methods with PNG Partners

The visit to Bautama prior to my arrival enabled the PNG partners with Gomathy Palaniappan to trial the interview questions. They suggested modifications for Rigo-Koiari which were adopted as follows in Figure 2. The revised questions meant that the matrix template for recording results also had to be changed (see Figure 3).

Figure 2: Revised interview questions

Discovery – the best of what is...

Big Questions: ***What has worked well for you in growing crops in your village?***
What have been your successes in marketing vegetables?

Supplementary Questions:

Q1. What vegetable has benefited you in terms of income/quality (good vegetable)/yield?
Q2. How did you know what to produce and when to produce?
Q3. What is good about your relationship with transporters, wholesalers and buyers?

Dream – what might be...

Big Question: ***What dreams (ideas) do you have for the future, given your successes in growing vegetables?***

Supplementary Questions:

Q4. How might you make sure you get the best price for your vegetables?
Q5. What is your aim for good yield and quality?
Q6. In the future, what would you like to know about the market (price, quality and demand)?
Q7. What might your future marketing relationship be like?
Q8. How might you make sure that everyone (in the family, village, cooperative) did what they needed to do for everyone to be successful?
Q9. What motivates you and others to grow vegetables?

Figure 3 Interview Results Template For AI and RSCA

Appreciative Inquiry (AI) Process	Basic Questions	Value Creation	Product Integrity	Communication	Chain governance
Discovery **(The best of what is...)** **Questions**	1.What has worked well for you in growing crops in your village?	1b. What are you most proud of in growing crops?	1c.What is it that has worked well for you in growing crops in your village?	1d. Who was responsible for this?	1e. What has been the greatest achievement of the cooperative since it was formed (or family/ village since people started working together)?
Discovery Qs	2.What have been your successes in marketing horticultural products?	2bi. What do buyers sees as being different or good about your produce?	2ci. What has worked well for you in marketing crops in your village?	2di.How did you know what to produce?	2ei. What made this possible? (What happened to achieve success?)
Discover Qs				2dii.How did the group make the decision?	2eii.Why did this work so well?
Dream **(What might be...)** **Questions**	1. What dreams (ideas) do you have for the future, given your success in horticulture?	3ai. How might you get the best prices?	3bi. What might your produce look like when you harvested it?	3ci. How might you find out what the buyers wanted?	3di. How might you make sure (motivation) everyone in the family/village/cooperative did what they needed to do for everyone to be successful?
Dream Qs			3bii.What might your produce look like when it arrived at the buyers?	3cii.How might you find out what the transporters wanted?	

Dream Qs				3ciii.How might you make sure that everybody in your group knew what to do? Probe for further training.	

Other Questions that Arose and Other Responses, especially to do with training discoveries and dreams.

- **Visit to Rigo-Koiari**

On Monday 21 February we travelled to Rigo-Koiari by bus and were greeted by Mr Murray Konido and co-operative office bearers representing the village. Rigo-Koirari Co-operative was registered in 2005 and comprises 18 villages. At the moment, there are no women leaders/office bearers in the co-operative. The village in which we were meeting was called Girabu. The vegetables they grow include cabbages, pakchoi, choisum, aibika, watermelon, tomatoes and cucumber. I briefly introduced the project, the purpose of the visit and introduced the rest of the team. Experienced interviewers were teamed with less experienced interviewers and small groups of villagers formed for interviews which were conducted over the next hour. In terms of women's perspectives, an initial analysis indicates that women would be interested in having women leaders who could be trained and then train other women, especially in micro finance, farm management – GIS - and pruning of watermelons. However, they found it difficult to 'dream' beyond addressing compelling present problems.

Photographs: Story telling sessions and interviews with women in the village of Rigo-Koiari, Central Province. Picture show Barbara Chambers and women smallholders.

- **Outcomes**

Professor Barbara Chambers and Dr Gomathy Palaniappan led a team of PNG partners from NARI, FPDA and PAU in trialing a new methodology designed to enhance understanding of and make improvement to the value chain in horticulture. As part of the horticulture project, smallholders from three villages in the central province have participated in a trial story telling method, whereby past successes and future dreams and ideas about growing vegetables are shared. These shared stories will form the basis of strategic planning in workshops later in the year.

Training of team members in the Appreciative Inquiry and Rapid Supply Chain Appraisal Method and subsequent refinements of questions was important in building a team. PNG partner representatives were acutely aware of how some concepts would translate into local languages and made pertinent suggestions for change.
The villagers at the Rigo-Koiari Village Cooperative were very keen to be involved in the project and their open sharing of local knowledge began the process of understanding how to develop community engagement. The results of interviews will be completed in the next two weeks and responses of women will be separately analysed to those of men to see if there are implications for different methods of community engagement and for training possibilities.

Photographs: Story telling sessions and interviews with women smallholders in the village of Rigo-Koiari, Central Province

Adjunct Professor Barbara Chambers
25/03/2011

Photographs: Story telling sessions and interviews with women in the village of Rigo-Koiari, Central Province. Picture show Barbara Chambers and women smallholders.

1. Outcomes

Professor Barbara Chambers and Dr Gomathy Palaniappan led a team of PNG partners from NARI, FPDA and PAU in trialing a new methodology designed to enhance understanding of and make improvement to the value chain in horticulture. As part of the horticulture project, smallholders from three villages in the central province have participated in a trial story telling method, whereby past successes and future dreams and ideas about growing vegetables are shared. These shared stories will form the basis of strategic planning in workshops later in the year.

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Adjunct Professor Barbara Chambers
25/03/2011

ACIAR SMCN-2008-008 Increasing Vegetable Production in Central Province PNG to Supply Port Moresby Markets

Report for Trip 27th April to 6th May 2011

Laurie Bonney and Mark Boersma

Trip Objectives

1. To plan and initiate the implementation of the vegetable production component of the project;
2. To plan and initiate the implementation of the agronomic research component of the project.

Vegetable Production Component

The trip activities associated with planning and initiating the vegetable production component of the project involved conducting meetings with prospective chain participants to develop the operational marketing model and plan its implementation over the remainder of the Dry Season. This involved meetings with:

- The principals of the prospective freight business;
- The leaders of the Rigo-Koiari Cooperative;
- The leaders of the Tapini Cooperative;
- Greenfresh Pty Ltd.

A meeting was planned with the leaders of the Bautama Group but at the last minute this had to be cancelled due to the illness of its Principal, Mr Arthur Chapman. This was to be re-scheduled and held at a later date by FPDA.

A representative of Greenfresh, Ms Erna Momo, the Senior Buyer, attended each of the meetings with the cooperatives. Each of these meetings was also attended by many farmers from each cooperative (Rigo-Koiari – approx. 25 people; Tapini – approx. 12).

1.1. The vegetable marketing model

This model (Figure 1) was developed to describe how a range of vegetables produced by PNG smallholder farmers in different regions within Central Province, PNG will be marketed to Port Moresby under conditions of infrastructural constraints. The model is based on supply from Rigo-Koiari Cooperative and Bautama, Rigo District, in the south east coastal area of Central Province and Tapini in the remote north western Goilala District.

Different vegetables will be produced at different altitudes. In broad terms these are:

- Low altitude – Rigo-Koiari and Bautama – Tomatoes, French Beans and Capsicums
- Medium alititude – Sogeri – Tomatoes, Broccoli and Carrots

- High altitude – Tapini, Goilala – Broccoli, Ball Cabbage and English Potatoes

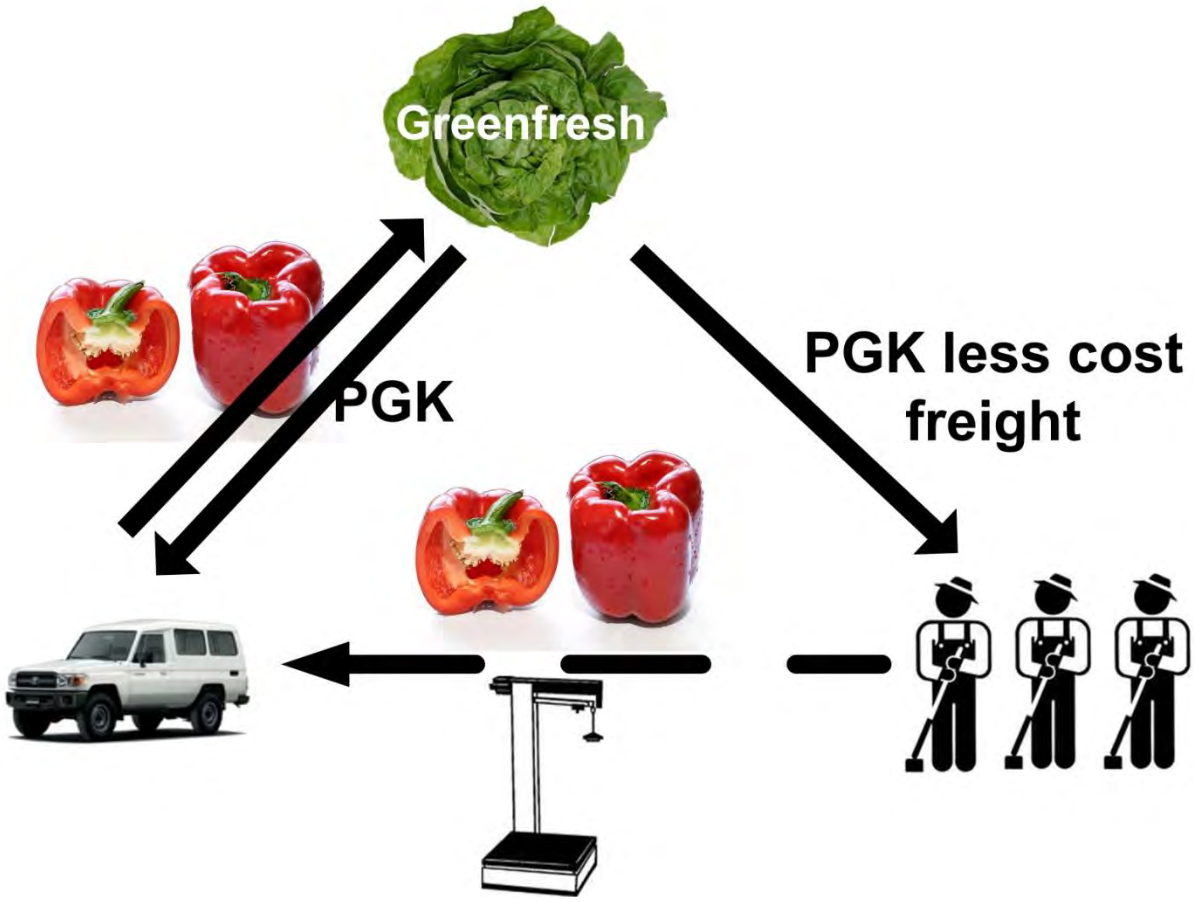
The issue of how to pay farmers for their produce is critical, especially for Tapini, where cash is not an option due to security issues and the lack of a banking system. The model also recognises that transparency and trust-building are fundamental to the success of the model. Hence, a three-way contracting system is proposed between Greenfresh Pty Ltd, Rigo-Koiari Cooperative and the soon-to-be registered cooperatives at Bautama and Tapini (Figure 1).

In this model, Greenfresh would have a supply/volume contract with the cooperative and a 'per truck-load freight rate' contract with the freight contractor. The set freight rate could be deducted from the farmer's payment, then forwarded to the freight contractor and the balance into the cooperative account.

The contracts will be for the supply of the vegetables listed above. Cooperatives may send vegetables other than the contracted ones but the project vegetables MUST get priority.

A simple visual grading system and a sale-by-weight process will be employed. The co-operatives will grade the produce (some, such as tomatoes, will be pre-packed to preserve quality) and the truck driver will weigh, identify and receipt at the truck door. If there's a problem with grading and rejects, the soon-to-be-commenced 3G Digicel system will allow photos of the problem to be SMSd to the co-operative's supply coordinator and/or farmer concerned. This will give Greenfresh reasonably firm expectations of both volume and quality.

Figure 46: The three-way contracting arrangement



Whilst the price obtained by the farmers may not be close to the top of the market for the day, they will get a more consistent price for a much larger volume of vegetables at a fewer number of large outlets over the long term. It will reduce the peaks and troughs of unmanaged demand. They will save costs on transport, wastage of vegetables and their own time in hawking their produce around a range of outlets. It will also reduce the harassment involved in the existing formal/informal marketing system.

The freight contractor is guaranteed their freight costs because contracting is on a per truck basis whether it's full or not.....that's an incentive for the co-operatives to fill the truck every time. It also reduces the problem of driver honesty or competence.

The cooperatives will need to appoint a 'supply coordinator' which in effect they already have in DA Titus Girau (Tapini), DA Murray Konido (Rigo) and Arthur Chapman (Bautama). The co-operatives will guarantee supply and that gives the farmers the flexibility of dropping in and out of production as they wish for cultural events etc. This will be managed by the supply coordinator.

Greenfresh will SMS rates to the cooperating farmers so they know what the price will be for that week (apparently it doesn't vary much on a seasonal basis) and pay on the quality grading (they already do this on an informal basis).

The freight contractor will front-load trucks with trade goods and co-operatives will have the option of establishing a trade store so there's no need for cash and neither is the trade goods supplier having to keep individualised records. In Rigo and Bautama this could be a pretty normal business operating in the banking system, but at Tapini a trading account could be established with someone like SVS supermarket so the trade goods are either paid for from the cash balance at Greenfresh or by the supply of vegetables.

The truck/s will have cab protection for the driver and a shotgun guard plus Kevlar lined doors, ballistic glass, plus GPS tracking and alcohol security to start the vehicle......apparently fairly common with the mining companies and not overly expensive.

The model is quite simple and robust and incorporates many of the principles of value chain management; for example:

- Reduces the complexity of dealing with large numbers of suppliers and outlets
- Incentives are built in to improve volume, quality, consistency and sustainability of supply
- Waste is reduced (both vegetable produce, smallholder’s time and money)
- Transport is more efficient
- Post-harvest handling is improved

The key is building honesty and transparency into the system and the provision of training so that everyone understands the cost structure of the chain partners.

The Work Plan for the implementation of this model is attached as Appendix 1.

Agronomic Research Component

The purpose of this trip was to assist the projects in country staff at NARI and PAU with the preparations necessary for implementing agronomic trials for the 2011 dry season. Initial meetings were held at NARI and later in the day, FPDA, on the 28th April 2011 and with PAU on 2 May 2011. At the first meeting held with the NARI, discussion focused on the specifics of the trial design for the systems trial treatments, and for the variety trials, the confirmation of which crops to grow and at what altitude.

The systems trial treatments arrived at were:

1. Traditional practice
2. Improved practice
3. High input

For each system treatment, the following areas were addressed in detail:

1. Fallow / rotation
2. Maintenance of soil fertility
3. Irrigation
4. Physical soil management
5. Bedding practice
6. Pest control

Only one crop will be planted for each systems trial.

The crops selected for each location are:

- NARI – Tomato
- PAU – Capsicum
- Sogeri NHS – Capsicum
- Tapini - carrots

Detailed information on the systems trial design can be found at the end of this document.

On Friday 29th March, Mark Boersma, Philmah Seta-Waken, Paul Osiris, Dickson Benny and Tony Ovia visited Bells to discuss the selection of varieties and obtain seed prices. Based on prices, availability and previous research into the suitability of each variety, the following were selected for each crop (Table 1):

Table 1. Seed varieties by crop selected for inclusion in the variety trial assessments.

Crop	Varieties	Locations
Tomato	Tropic Boy, Summer Star, Grosse Lisse, Roma, Money Maker, Tough Boy	Laloki PAU Sogeri
Capsicum	Giant Bell, Yolo Wonder, Yellow, California Wonder, SRC-CF 6	Laloki PAU
French bean	Climbing Stringless Blue Lake, Dwarf Gourmet's Delight, Contender, Dwarf Snap bean, Stringless	Laloki PAU
Cabbage	Sweet Eureka, Racer Drumhead, Tropical Delight, Cophenhagen Market, KK Cross, KY Cross, KK Improved	Sogeri Tapini

Carrot	New Kuroda, Manchester Table, Top Weight, Kuroda, Improved Kuroda, Chantenay Red Cored	Sogeri Tapini
Broccoli	Southern Comet, Green King, Summer King, Shogun, Southern Star, Green Beret, Prominence	Tapini

Seed for the value chains was purchased by UTAS on Friday 5th May 2011.

On the 3rd May Mark Boersma accompanied NARI staff to Sogeri to mark out the trial area at the Sogeri National High School. Knee high in February, this grass was now in places more than 2 metres high and requires slashing (Figure 1). NARI have contracted slashing of the block with a local operator.

Figure 2. Sogeri National High School trial site, looking west.

Systems trial design

*1.2. **Low Input SYSTEM - Based on Traditional Practice***

This system is based on the common features of local systems described in the Mapping Agricultural Systems Project (MASP). There is some variation between the traditional systems used in each locality, and even between gardens with in a system. To allow comparison between trial locations, this system treatment incorporates the predominant trends, and it should be noted that it is only an approximate of traditional practice for each location.

4.1.1 Fallow / Rotation

- Prepare ground after long fallow in the first year. Crop again in years two and three after a short grass fallow or no fallow at all.
- Fallow is cleared by slash and burn

4.1.2 Maintenance of Soil Fertility

- Dependent on nutritional capacity of the soil after slash and burn of the fallow vegetation.
- No compost, animal manure or legumes are used to maintain soil fertility.

4.1.3 Irrigation

- Not watered in the wet season. Use only watering cans in the dry, when necessary.
- Drainage

4.1.4 Physical Soil Management

- Tractor tilling on flat ground
- Hand preparation using spades on slopes

4.1.5 Bedding Practice

- Plant on ridges of long beds, or small mounds 10-40cm high. The bedding system is determined by crop species. Plants are staked where this is needed.

4.1.6 Pest Control

- Very little done
- Weeds – carried out using a conventional hoe or hand pulling. No mulching is used.
- Insects - manual
- Fungal disease

1.3. *Improved Practice System*

This system is loosely based on the common features of local systems described in the Mapping Agricultural Systems Project (MASP) however geared towards maximum yield with a lower return on total inputs. This system requires a significant investment in fertiliser, irrigation, pesticides and related infrastructure.

4.1.7 Fallow / Rotation

- Prepare ground after long fallow in the first year. Crop again in years two and three after a short fallow of Piper, intercropped with a legume cover crop such as peanuts or winged beans.
- Fallow is cleared by slashing and burned on the beds to sterilise soil and provide ash for plant nutrition

4.1.8 Maintenance of Soil Fertility

- Compost is prepared from local vegetation and chicken manure if available, and applied under the mound or beds.

- A minimum quantity (200 kg/ha) of NPK (12:12:17) is added. Applied as a split application.

4.1.9 Irrigation

- Watered using a micro-drip irrigation system using a 200 litre drum or similar as a head. Water is pumped into the drum using a rope and washer pump, or treadle pump.
- Plants are watered as needed, to around 25-30 mm per week.
- Kunai grass is cut from adjacent ground and applied as a mulch to reduce evaporation.

4.1.10 Physical Soil Management

- Tractor tilling on flat ground and gentle slopes.
- Hand preparation using spades on steep slopes

4.1.11 Bedding Practice

- Plant on ridges of long beds, or small mounds 10-40cm high. The bedding system is determined by crop species. Plants are staked where this is needed.

4.1.12 Pest Control

- Weekly crop scout
- Weeds – carried out using a Dutch hoe or hand pulling. Kunai grass is cut from adjacent ground and applied as mulch to the beds/mounds.
- Insects - Neem (Azadirachtin) oil, Derris (rotenone), 1% soap, and chili solutions applied in rotation. Marigolds planted nearby as deterrent and nematicide.
- Fungal disease –Mulch of un-burnt grass can reduce the splash spread of fungal spores. Removal of infected leaves and plants. Use of Neem oil, milk and bi-carbonate of soda as fungicides.

1.4. High Input System

This system retains common features of local systems described in the Mapping Agricultural Systems Project (MASP) however gives preference to techniques and technology used in agricultural systems in developed countries, where these can reasonably be applied.

4.1.13 Fallow / Rotation

- Grasses and other plants are sprayed out with roundup and then incorporated using a tractor or mechanical tillage such as a self-propelled rotary hoe.
- Crops are rotated with green manure crops in-between each planting.

4.1.14 Maintenance of Soil Fertility

- Soil tests used to determine nutritional status
- Expected plant recovery used to calculate the required nutritional supplement .
- The required fertiliser is applied as NPK + trace elements (12:12:17). Crops side dressed as required.

4.1.15 Irrigation

- Watered using a micro-drip irrigation system using a 44 gallon drum or similar as a head. Water is pumped into the drum using a rope and washer pump, or treadle pump.

- Plants are watered as needed, to around 25-30 mm per week.

4.1.16 Physical Soil Management

- Tractor tilling on flat ground and gentle slopes.
- Hand preparation using a rotary hoe on steep slopes.

4.1.17 Bedding Practice

- Long, flat topped beds created using tillage equipment.
- Weed seedling burn off prior to transplant / seedling emergence.

4.1.18 Pest Control

- Pest control undertaken as both preventative measures, and us curative / control measures based on crop scouting.
- Weeds – controlled using Glyphosate and Sprayseed.
- Fungal disease - Controlled using Belltek Chlorothalonil with Belltek Mancozeb applied as a preventative.
- Insects – Controlled using Karate 2.5 EC (Lambda cyhalothrin – pyrethroid), Belltek bifenthrin, Derris Dust, or Confidor as required.

Appendix 1: Vegetable Value Chain Work Plan May – September 2011

Activity	Timing
Freight Company & Greenfresh	
• Meet ASAP with James Cooper to ensure the freight processes are OK and arrange anything else required (e.g. banking)	27th May
• Get the visual grading system designed, printed off on large laminated colour sheets and distributed to cooperatives	27th May
• Liaise with freight firm to get the trade goods mechanism in place – it may be different for Rigo and Tapini	22 July
• Liaise with Cooperative Coordinators (Rigo – Murray Konido; Tapini – start with James Komae) to get the trade goods mechanism in place	22 July
Rigo	
• Follow-up with delivering seed and planning with Murray Konido the schedule to deliver the planned vegetables	27th May
• Record the type and quantities of seed delivered to each farmer	27th May
• Monitor planting and production	On-going
• Identify extension information or training short courses needed by the project members	On-going
• Order sufficient follow-up seeds as necessary to get to the end of Dry Season (liaise with PAU re their budget for seeds)	17 June
• Liaise with cooperative leader to identify harvest schedule and communicate to freight company	Mid-July+
• Arrange texting of prices and shipment feedback to cooperative coordinators and monitor progress	Mid-July+
Tapini	
• Follow-up with delivering seed and planning with James Komae the schedule to deliver the planned vegetables	27th May
• Record the type and quantities of seed delivered to each farmer	27th May
• Monitor planting and production	On-going
• Identify extension information or training short courses needed by the project members	On-going
• Order sufficient follow-up seeds as necessary to get to the end of Dry Season (liaise with PAU re their budget for seeds)	17 June
• Arrange texting of prices and shipment feedback to cooperative coordinators and monitor progress	Mid-July+
• Liaise with cooperative leader to identify harvest schedule and communicate to freight company	Mid-July+

UNIVERSITY OF TASMANIA

TASMANIAN INSTITUTE OF AGRICULTURE

ACIAR Project: SMCN/2008/008

Increasing Vegetable Production in Central Province, Papua New Guinea to Supply Port Moresby Markets

Trip Report for 28th August to 3rd September 2011

Colin Birch, Richard Doyle, Mark Boersma

15th November 2011

ACIAR Project: SMCN/2008/008

Increasing Vegetable Production in Central Province, Papua New Guinea to Supply Port Moresby Markets

Tasmanian Institute of Agriculture

Trip Report for 28th August to 3rd September 2011

by

Colin Birch, Richard Doyle, Mark Boersma

Abstract

This report provides information on a visit to PNG from 28th August to 3rd September 2011, in which TIAR staff undertook liaison with local PNG partners and visited trial and demonstration sites. Maps of land capability had been prepared prior to the visit and were provided to PNG partners. Experimental and production activities were examined and soil profiles described and samples retained for chemical analyses. Extension activities were undertaken, largely as impromptu meetings, and were both very informative and successful. Agronomic practices and limitations were described, and implications for the future and for project implementation identified. Finally, some implications for future extension activities to farmers and input suppliers are identified.

1. Introduction

A visit to PNG by Colin Birch, Richard Doyle and Mark Boersma was undertaken to:

(i) Support field experimentation and demonstration/commercial trials of vegetables selected for use in the project;
(ii) Engage with local PNG partners on administrative matters and project activity

The trip was divided into several components as follows

(i) Administrative and Coordination Activities

Visit Fresh Produce Development Agency (FPDA), Goroka Office – 29th August, Colin Birch and Rebecca Bagosia, ACIAR Country Office, Port Moresby

Visit to Central Province Administration Offices, Port Moresby – 31 st August, Colin Birch, Emily Flowers (ACIAR) and Mark Chambers (AusAID)

(ii) Field Visits – Experimental and Demonstration Sites

Field site at Tapini – Richard Doyle and Mark Boersma

Field sites at National Agricultural Research Institute, Laloki Research Station, Pacific Adventist University, Rigo- Kwikila and Sogeri – Colin Birch, Richard Doyle and Mark Boersma. Staff of PNG partners accompanied TIAR staff on all field visits and participated well in discussions and activities at each site.

2. Administrative and Coordination Activities

2.1FPDA

Discussions surrounded operational and logistical matters related to the project. FPDA staff have identified some additional cultivars of crops that may be able to be included in 2012 and 2013, it was too late for 2011. FPDA management and staff were also very pleased that their contribution was being recognized through authorship on papers written from project activities. Copies of all project publications (conference papers etc) in final published form with bibliographic details have now been provided to FPDA.

2.2 Central Province Administration (CPA)

Discussions involved staff of ACIAR, AusAID and Central Province Administration and centred around financial matters, operational and logistical matters.

3. Field Visits

The field visits covered a range of activities at each site, depending on the status of the site and work in progress at each site. Soil pits were dug at all sites for full profile descriptions, and where trials had been established (NARI, Laloki and PAU), these were examined and progress discussed with staff concerned. Areas where crops were to be established (Rigo-Bautama-Kwikala, Sogeri and Tapini) for demonstration and commercial purposes were examined, though no crops had been planted.

Impromptu ‘extension and development activities’ were delivered at farms in the Rigo-Bautama-Kwikala district, at the initiative of local farmers, and at Sogeri (with project staff).

3.1 Outcomes of Field Visits

Comment on Land Resources and expected follow up on mapping, soil descriptions and soil analyses are included in Section 4, agronomic aspects in Section 5, and extension activities in Section 6.

4. Land Resources

Prior to departure several maps of land suitability were prepared using data from PNGRIS and a Digital Elevation model by Matthew Dell, University of Tasmania. Mapped areas included Tapini, Port Moresby area (Browns River , Lakoki Area), Sogeri and Rigo-Kwikila. These maps are attached with extended legend and information on the data sets used from PNGRIS (Appendix 1). The maps clearly indicate discontinuous areas of land most suitable for agriculture.

Soil profiles were examined at all the key trial sites and also some of the key gardens in the Rigo district. Profiles descriptions will be used to interpret landscape productivity and the results from experimental trials and demonstration areas. Soil horizon samples were collected from each profile and submitted to the NARI laboratories in Port Moresby for analysis. A decision on the type of analysis will be made, but is likely to include key wet chemical characterisation along with some particle size analysis and mineralogical analysis.

Detailed discussion of maps, profile descriptions and soil analysis will be provided as data becomes available, and is likely to include suitably for agriculture, and other issues including likely degradation and nutritional problems, and thus sustainability for vegetable production.

*1.5. **5. Agronomic Observations and Implications for Vegetable Production Practices***

5.1 Tapini

Richard Doyle and Mark Boersma travelled to Tapini on Monday 29th August to Tuesday 30th August 2011to view the establishment of the variety trial site arranged during a previous visit. Accompanying us on this trip was Michael Atui from FPDA and Clifton Gwabu (NARI). Our main contact on this visit to the village was Titus, the District Administrator. The establishment of this trial site was negotiated on a previous visit and while principally the responsibility of NARI, its implementation was contingent on assistance from the villagers, in particular the preparation of the chosen site. Since our first visit, the site has now been dug over once, and while there, the local youth were turning the soil over once more before tilling the soil by chipping to form a suitable tilth. The site had also been fenced to prevent crop damage from wildlife. During this visit Dr Doyle dug a soil pit and assessed the profile against the Australian Soil Classification system. Samples of each (sub) horizon were taken for analysis by the NARI labs. The vegetation growing in and around the site did not show any signs of deficiency, indicating that the soil is reasonably fertile. There were two significant agronomic challenges. Firstly, the availability of water, and secondly, the presence of the sedge Nut Grass, *Cyperus rotundus*, so named because of its nut like tubers. This species is regarded as one of the worlds most challenging weed species being both competitive and allelopathic. The combination of tubers, rhizomes and a resistance to herbicides will mean this plant provides some threat to the success of the trial. Given that 'Sempra' (halosulfuron) is not available in PNG, this infestation will require constant removal of the shoots and heavy mulching if possible. In future seasons, repeated applications of glyphosate may also help with control. Water availability is a consistent limiting factor for cropping in PNG. As part of the project, TIAR on behalf of

NARI has purchased irrigation components for the establishment of 3 Affordable Micro-irrigation Technology (AMIT) systems. NARI's intention for this first season is to water the plots using watering cans. In discussing this with Dickson, I stressed the importance of using the AMIT system to ensure that a large volume of water can be applied, and also to use the site as a demonstration of the technology to the locals. Dickson mentioned that it would be difficult for NARI to transport the gear to Tapini. In discussing this with Titus, the DA indicated that he would be willing to assist in delivery to Tapini. During the visit NARI staff also advised the nursery seedlings would be transported to Tapini the following week. At this time, the successful establishment of the trials site looks promising.

5.2. PAU

TIAR, FPDA and NARI staff visited the PAU trial site on Wednesday 31st August. At this time the variety trial had been successfully established by Japhet Nivi evaluating varieties of bean, capsicum and tomato. Both tomatoes and capsicum were developing fruit while the beans had begun flowering. Varietal differences were evident, and at this stage it appears the trial will be able to segregate these based on performance. The tomato variety 'Summer Star', a replacement by Yates for the popular variety 'Summer Taste' was included in this trial. This is the variety provided to the Rigo – Koirari cooperative based on its similarity to 'Summer Taste' to support the development of the value chain and subsequently rejected by the locals as a poor performer. Early indications support this assessment, and 'Summer Taste' in this trial was evidently struggling. A few days prior to this, the trial was also unintentionally subjected to a significant water deficit. In response to this, the Yates variety 'Roma' has uniformly developed blossom end rot, a calcium deficiency induced through soil moisture stress. Early indications are that the variety 'Money Maker' is performing well, having plants with good stature and producing early. It remains to be seen how long this variety will continue to produce. All varieties of Capsicum appeared to be growing well, with some evidently producing earlier, 'New Ace' looking particularly promising. Due to resource limitations, the systems trial has not yet started, with Japhet intending to implement this after the conclusion of the variety trial. Dr Doyle again evaluated the soil profile at this site. There was some discussion with Japhet regarding amount of water being applied by sprinkler to the site, as soil cracking was evident, and the quantity being supplied seemed low.

5.3 NARI – Laloki Research Station

The NARI research site at Laloki was visited on the afternoon of the above visit to PAU and was attended by staff from TIAR, FPDA and PAU. While a fortnight or two behind the PAU site, both the systems trial and variety trials had been established. While PAU are using their existing irrigation system, NARI have established the AMIT system. The system appeared to be working well, with an estimated output of 1.6 L per hour. NARI staff reported that while time consuming to set up, the system itself is uncomplicated. There were some issues with spacing of the emitters in the bean trial which I was unable to resolve in discussion with Philma Seta-Waken. Philma also reported that water supply was a problem, as the pump supplying the header tank had broken down. The tomato and capsicum plants at this site were recently established, and varietal differences similar to that at PAU were observed. Of particular note was the difference in performance of the bean varieties. While all varieties had established successfully at PAU, whole plots had failed to germinate in the NARI trial. While Philma thought that this might be due to uneven watering leading to a water deficit, it is also possible that direct watering with the hose may have deprived the seed of oxygen, with some varieties being more sensitive to this stress than others. While established, not all treatments had been fully applied, with mulching and fertiliser application yet to occur. The importance of doing this as soon as possible was stressed.

5.4 Rigo-Kwikila

Two sites were visited on Thursday 1st September by TIAR staff, and staff from TIAR, FPDA, PAU and NARI. Also, an extended impromptu extension session was undertaken at the initiative of local farmers in Rigo Cooperative at their village base. The two field sites were being prepared for planting shortly after our visit, using equipment (tractor, ground working equipment) owned by the Rigo Cooperative. There was still considerable soil preparation to be completed at one site, the other was closer to planting condition. Both sites were in near vicinity of streams for water supply, so watering/irrigation should be possible. Soil profiles were described by Richard Doyle at both sites and samples retained for chemical analysis by NARI.

5.5 NARI – Sogeri Trial Site

This site was visited on Friday 2nd September by staff from TIAR, FPDA, PAU and NARI. This site has been made available by the Sogeri National High School, and is principally grassland. During our last visit, negotiations to cultivate the soil by tractor had begun with a local pineapple grower. The site has now been cultivated and is ready for establishment of both the variety and systems trials. There is some evidence of soil deficiency, specifically nitrogen. NARI staff informed us that seedlings for this site were ready for transplanting, and that this would occur in the following week. Preparations were also being made for establishment of the AMIT system, using a tank provided by the school. This sites soil profile was assessed by Richard Doyle, with samples being delivered to NARI for analysis.

6. Extension Activities

Several meetings with villagers and local leaders were held notably in Tapini and with the Rigo cooperative. Issues around soil conservation, reduction in soil compaction and irrigation technology were discussed. Extension opportunities and methods were also discussed with Moses Worinu, FPDA, Goroka, and he emphasized the need for simple pictorial representations to be used in meetings etc because of limited literacy or illiteracy of farmers.

6.1 Rigo District Cooperative

Rigo is said to represent 18 villages with, 10 taking a regular part in the cooperative group and includes approximately 4000 villagers. The Rigo district covers an area of 600-800 km/square with currently only 20 hectares mechanically cultivated for production annually.

Vanilla is increasing in value but key crops include; water melon, capsicum, tomato, bok-choi, pawpaw, pineapple and coconut. These are sold to Green Fresh Supermarkets however a reliable and regular supply to markets is seen as an issue. Is there a need for a separate wholesalers/commercial market supply to the hotels, mines, supermarkets and other retailing operations? This issue was discussed and there seemed to be support for this idea.

Many of the farmers go directly to the open markets and do not work through the cooperative. Costs for cultivation at 30 toia/square metre for two passes over the land. Other issues raised were around the cost recovery and accounting of the cooperative, for instance. how key capital items like tractors, transport vehicles and cultivators are costed and in the longer term, provisions made for their replacement. While operation costs like fuel, oil and labour for transport, tillage, harvesting are charged for this does not take in to account replacement costs of machinery. There was support for inclusion of input suppliers to be involved in project extension, especially in relation to suitability of cultivars, reliability of supply of inputs and participation in project field days eg at PAU, NARI and at farm sites.

Of interest, prices reported by Rigo Cooperative for products in the markets were;

13 K/kg for beans

7 K/kg tomatoes

7 K/kg capsicums

2-3K/kg Bok-choi

2.4 K/kg pawpaw

2.75 – 3 K/kg water melon (1.9K/kg is the production costs for watermelons at PAU).

6.2 Outcomes from extension activities

Identification of need for Input suppliers to be included in extension activities and the project more broadly

Field days and group meetings to be undertaken at suitable times at project sites by PNG partners, using project funds

Books ‘Keeping soil on your Farm’ (UTAS) to be supplied in the extension part of the project

Pictorial posters to be prepared for extension activities

Need for Laurie Bonney to explore the input value chain as well as farm production to market/consumer value chain.

7. Extension activities and opportunities for follow up

The following extension activities and opportunities were identified for follow up, with the TIAR staff member to lead the activity shown

- Mentoring of PNG staff and farmers –Mark Boersma to lead, others as available

- Soil Conservation - Richard Doyle, Leigh Sparrow (as available)

- Soil Compaction – Richard Doyle

- Soil Fertility – Richard Doyle, Colin Birch, Leigh Sparrow (as available)

- Production costs – Colin Birch, Laurie Bonney

- supply of brochures and book – Colin Birch (as project leader)

- Inclusion of input suppliers in value chain – Laurie Bonney

- Field days – PNG partners

- extension into markets – PNG partners

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Appendix 1

Land Capability Maps

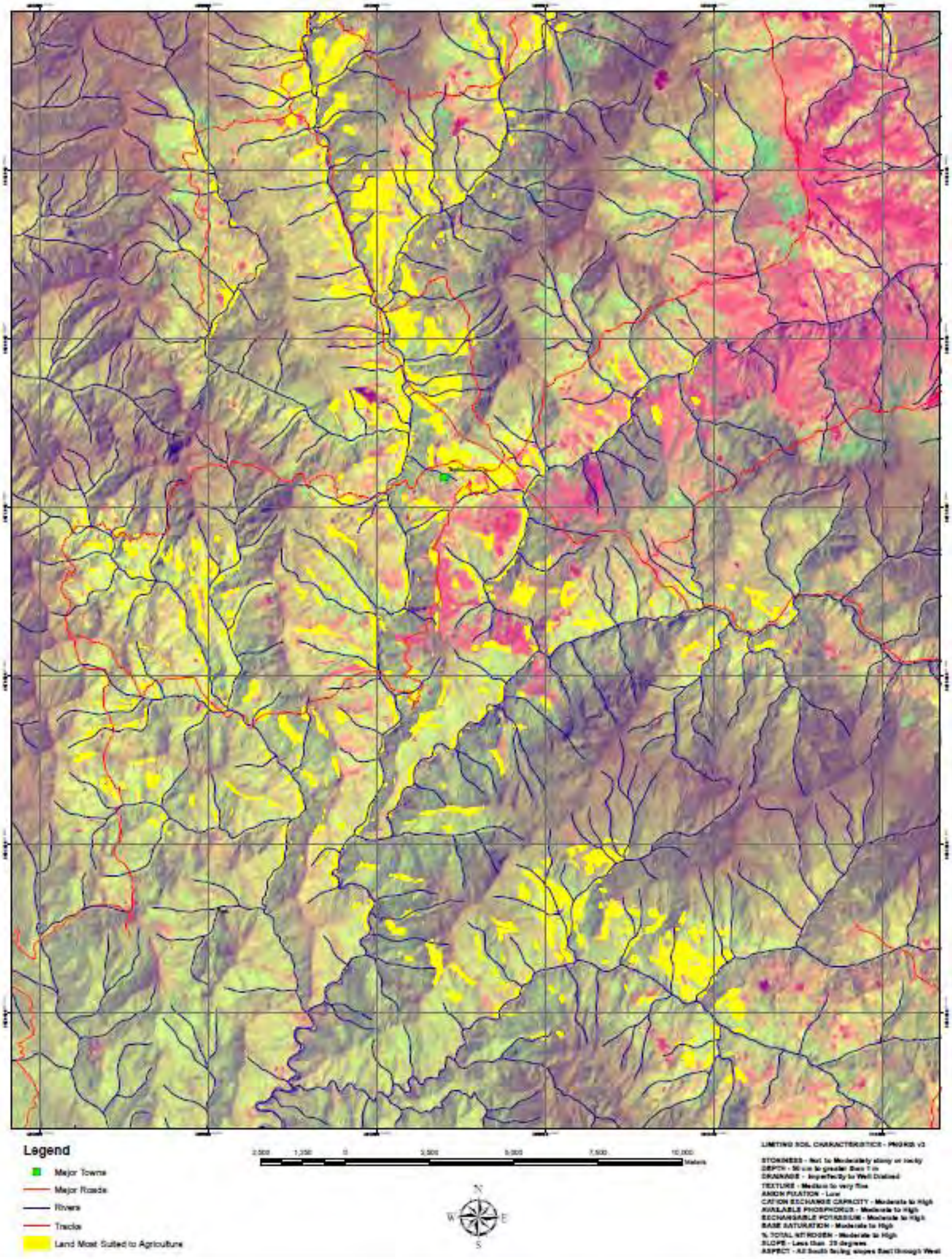
Tapini

Port Moresby area (Browns River, Laloki)

Sogeri

Rigo-Kwikila

Highest Agricultural Potential Land Areas near Tapini

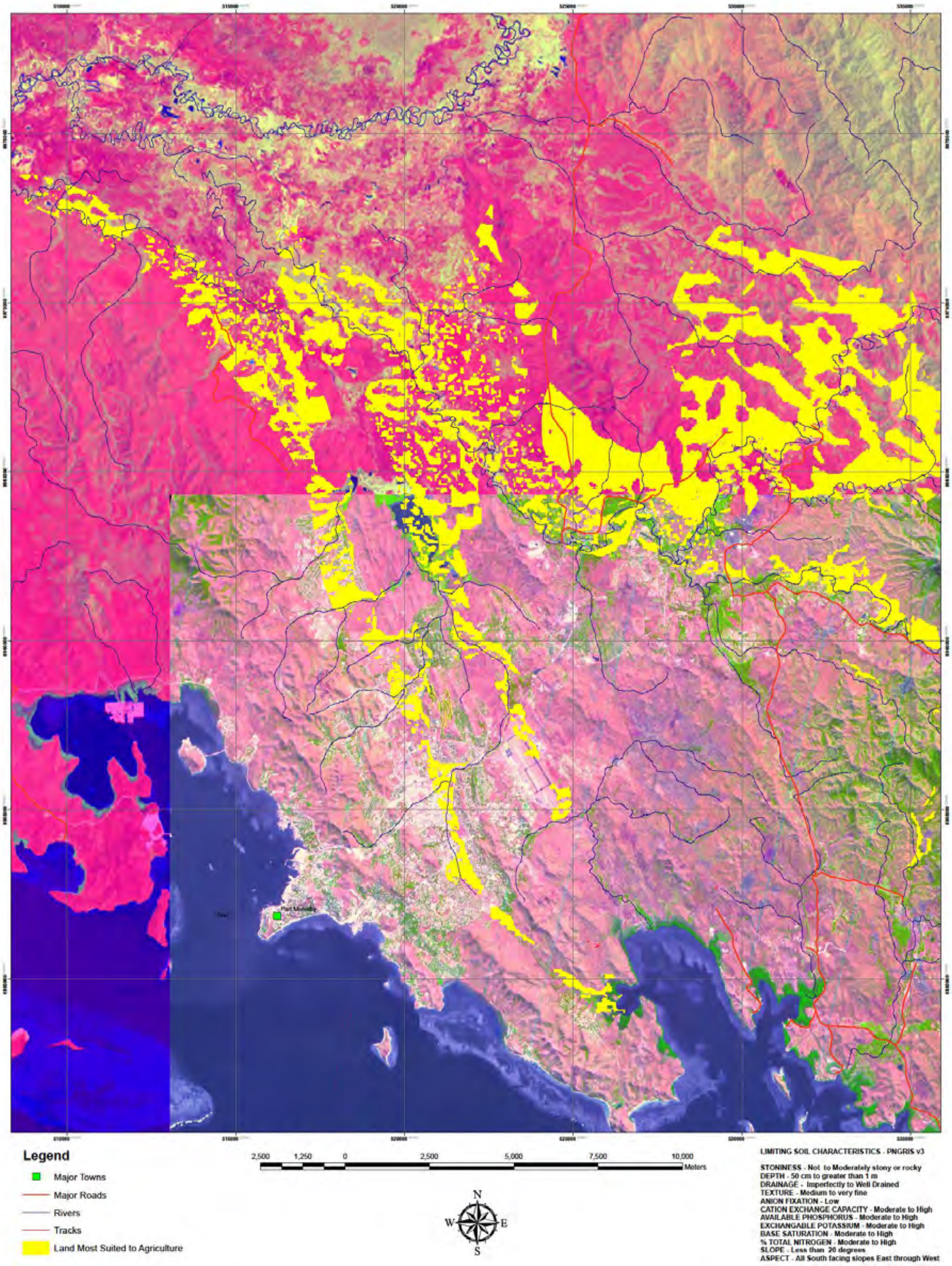


Papua New Guinea National Agricultural Research Institute

tiar

Australian Government
Australian Centre for International Agricultural Research

Highest Agricultural Potential Land Areas near Port Moresby



Papua New Guinea
National Agricultural Research Institute

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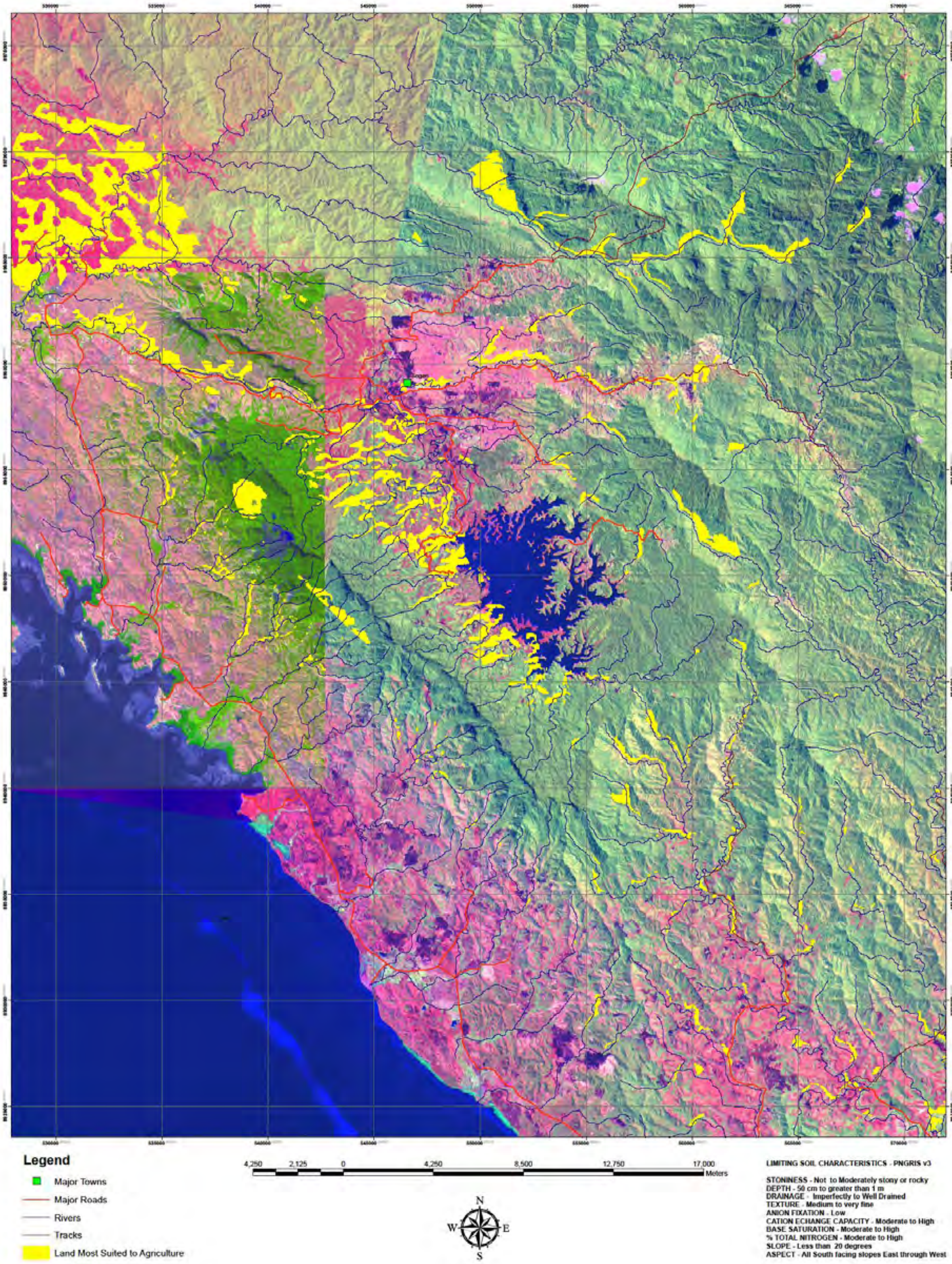
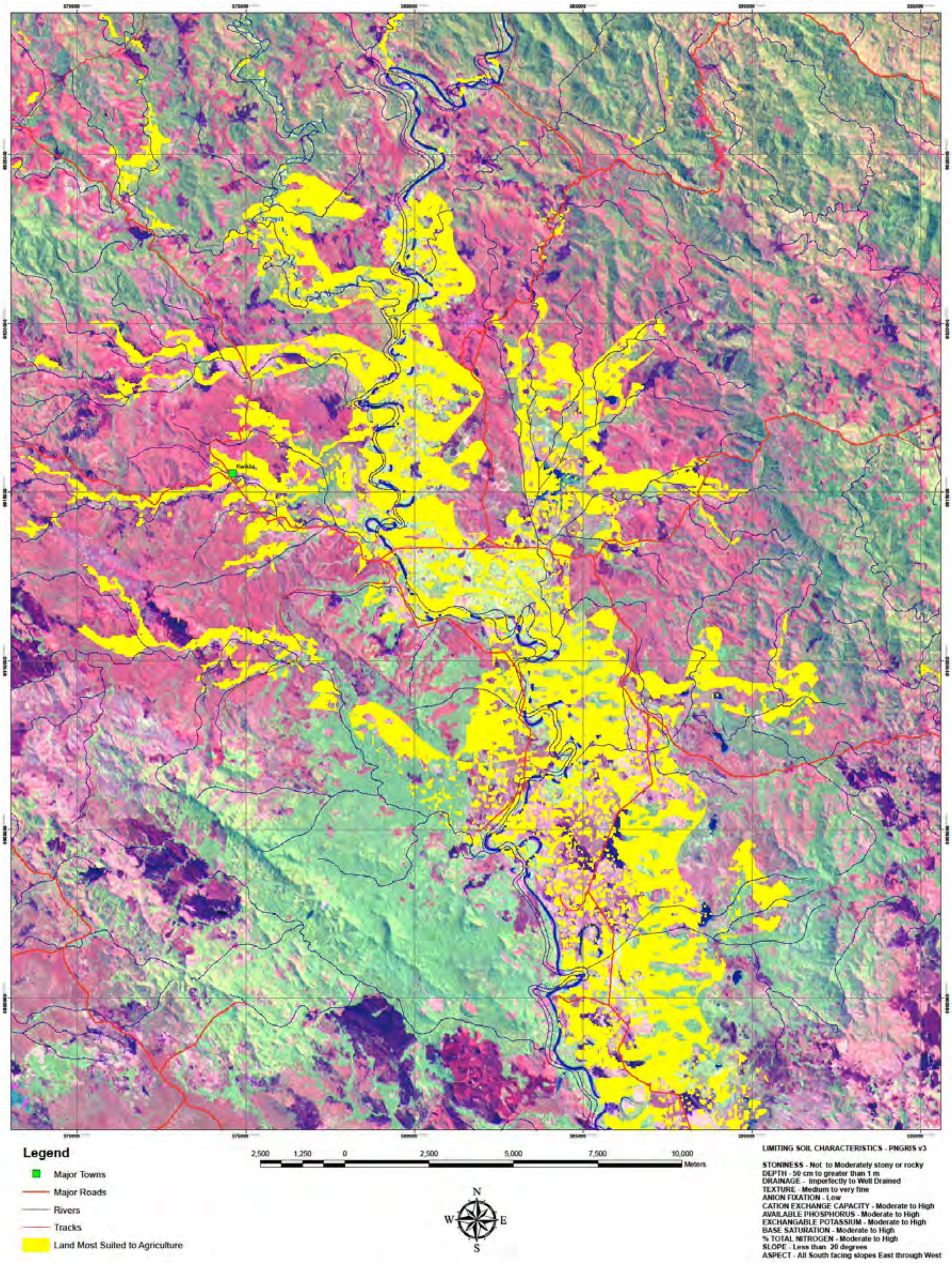
Australian Government
Australian Centre for International Agricultural Research

Highest Agricultural Potential Land Areas near Sogeri



Highest Agricultural Potential Land Areas near Kwikila



Soil and Land Resources Report

Central Province of PNG, ACIAR visit September 2011

SOIL AND LAND RESOURCES RESEARCH

Overview

Prior to departure to Port Moresby and the Central Province we produced and printed several digitally generated maps of agricultural land suitability based on interrogation and analysis of the PNGRIS land resource data set. Mapped areas included Tapini, Rigo - Kwikila, Browns River (Lakoki) and the Sogeri plateau. Copies of the maps were provided to our research partners at NARI, FPDA and the Pacific Adventist University (PAU).

Whilst in Central Province soil profiles were examined at all the key trial sites and also some of the key gardens in the Rigo - Kwikila district. Soil profile descriptions are provided here and are also shown in Plate 1. Soil horizon samples were collected from each profile and submitted to the NARI analytical laboratories in Port Moresby for analysis. Analysis will be undertaken over coming months and interpretations of the data will be made in due course. It is likely to include key wet chemical characterisation along with some particle size analysis and mineralogical analysis.

Plate 1 Soil profiles from the four trial sites located at A – Tapini old DPI station, B – Pacific Adventist University, C – NARI's Laloki Field Station and D – Sogeri High School.

Soil and Land Resources

Maps of highest agricultural land suitability

The agricultural land suitability maps are derived using data provided in the PNGRIS database which provides various data layers on soils, geology, landforms, population, climate and inundation. The PNGRIS layers are largely based on earlier regional and national mapping of soils, geology and landforms by the CSRIO combined with use of the UPNG 90 m digital elevation model. The PNGRIS data set was primarily developed for use in sustainable agricultural land development by the PNG Department of Agriculture and Livestock, UPNG and CSIRO. It was first published in 1986 but has undergone several revisions and updates with the 3rd Edition used in this analysis (Bryan and Sherman, 2007). The key reference for this work and the map legends and layers can be found at:- http://gis.mortonblacketer.com.au/upngis/research.htm

We combined several soil and landform layers to identify most suitable land for arable cropping in the various regions under investigation. This essentially came down to utilising the PNGRIS derived soils and topographic layers and selecting the best classes in each of the mapped layers.

These 3rd Edition PNGRIS layers were;

1) Inherent Fertility
    a. Soil Field Texture - moderate to fine
    b. Cation Exchange Capacity - moderate to high
    c. Anion Fixation - low
2) General Fertility
    a. Available Phosphorus – moderate to high
    b. Exchangeable Potassium – moderate to high
    c. Base Saturation – moderate to high
    d. Total Nitrogen – moderate to high
3) Stoniness - Not to moderately stony or rocky
4) Soil Drainage - Imperfect or better drainage class
5) Soil depth – solum >60 cm

However, these land class rules did vary a little based on region, on the Sogeri Plateau for example we relaxed the "Exchangeable Potassium" class to "low".

We then combined these soil classes with areas based on lower slope classes, generally less than 20 degrees and W-S-E aspects using the PNGRIS topographic classes. The areas meeting all these criteria were then indicated on the satellite base for each region. The type or land and the size and distribution of the areas depicted in each map are discussed below in the relevant section below.

In this provisional mapping of the most suitable land area the amount of land identified in each area is; Kwikila 99 sq/km, Sogeri 92 sq/km, Tapini 40 sq/km, Port Moresby 66 sq/km. These values suggest there is no shortage of suitable land in the regions, however further analysis and ground truthing is required.

Next steps in Land Suitability Mapping

The next steps in land suitability mapping will involve development of soil erosion potential modelling using higher resolution DEM data from the Australian Defence Industry Geographic Organisation (DIGO). This would also be combined with horticultural information derived from project trials, to determine the specific crop suitability based on temperature, rainfall and evaporation data. This will provide specific rankings of suitability to allow for mapping of high, moderate and low suitability land including non-suitable areas for each crop selected.

Tapini (Goilala District) Soil and Land Resources

The soils in the Tapini region of the Goilala District ranged from very deep, multilayered, colluvial soils to shallower rocky soils on spurs and steeper slopes. The topography is dominated by steep to very steep sloping valley side with deeply incised rivers and streams (see Plate 2). The landscape reflects powerful streams, high rates of uplift and an intensive tropical weathering environment. The geological substrate materials ranged from shales and weakly metamorphosed slates to dark fine grained igneous rocks and hard limestone's. This provides a mixed mineralogy of mafic, siliceous and calcareous parent materials for soil formation. The soil depth was generally much greater than might have been expected based on the steepness of the terrain and the rainfall (see Plate 2). However the high rate of weathering, the fractured nature of much of the bedrock materials and the dense forest cover appear to be providing a sufficiently quasi-stable environment to result in many quite deep and multilayered colluvial soils (see Plate 3).

A soil profile description was undertaken on the site at Tapini which is adjacent to the airfield on a relatively flattish site (see Plate 4). The soil is developed in fine-textured colluvium derived from mixed fine-grained sedimentary and mafic igneous sources. The soil profile texture is dominated by silty clay loams and silty clays. The strong yellowish brown hues of the soil suggest a mafic and sesqui-oxic parent rocks may be dominant at the site. The topsoil is moderately thick but with only moderate amounts of soil organic matter (2.2 – 2.3% organic carbon to 20 cm – NARI) and low levels of total nitrogen (ca 0.2%).

The map of the best agricultural land at Tapini shows strips of land indicated as suitable along stream valleys, however flooding and possibly unmapped occurrences of stony and waterlogged soils may limit the total area available for vegetable cropping. The other areas depicted include W-S-E facing ridgelines and various benches and flatter spurs on the slopes, like that at Tapini itself which forms the local airfield.

Plate 2 A - Steep terrain on the road up to Tapini village in the Goilala District; B - Deeply incised streams on route to Tapini, C - Tapini village, airfield and trial site (indicated by circle)

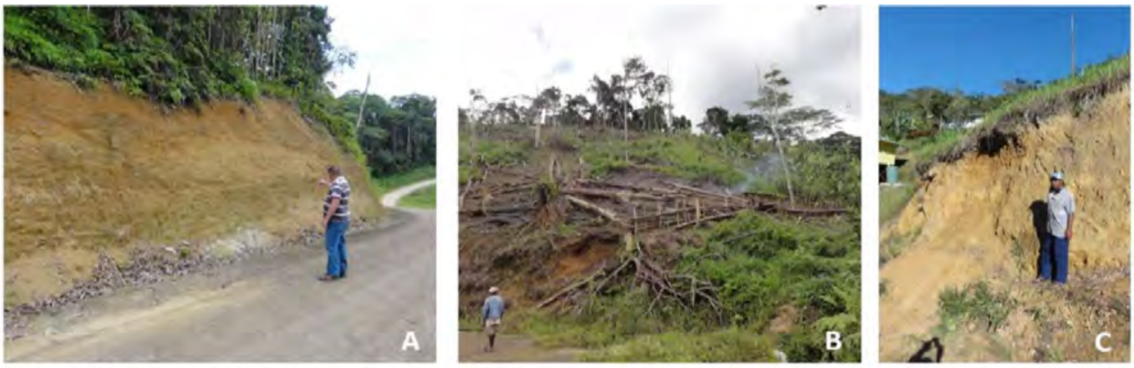


Plate 3 Deep colluvial soils are common on the hillsides on the road to Tapini (A, B and C), food gardens are created by slash and burn on deep colluvial soils (B), deep colluvial soils at Tapini (C).

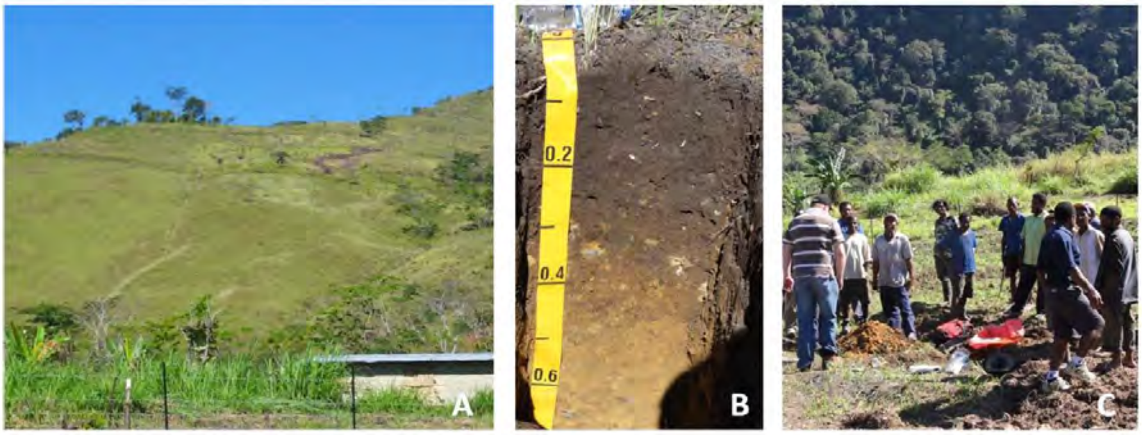


Plate 4 A – Slopes adjacent to the site showing hummocky surface indicating active mass movement, B – Soil profile at the Tapini site, note 30 cm thick topsoil and C – Local agriculturists, small holders and the agricultural science teacher visiting the site, note forest cover on surrounding slopes.

Plate 5 GIS generated map of the most suitable agricultural land near Tapini (Goilala District) derived from PNGRIS soil and landform layers (see legend in lower right-hand corner). The area in yellow shows the deeper, freer draining and more fertile soils on slopes less than or equal to 20 degrees.

Soil Profile Description – Tapini

Site:	Adjacent to Ex-DPI Station at Tapini, adjacent to airstrip
Date/Describer	30/08/2011 / Richard Doyle UTAS and ACIAR
Description Type:	Soil pit to 80 cm and auger below
Drainage/Permeability	Moderately well drained soil/Moderately permeable soil profile
Site Run off:	Slow rate of run-off, due to flattish site and permeable soil
Landform Element:	Very gentle (1-3% slope at soil pit)
Element Type:	Flat (broad bench in landscape – perhaps formed by limestone outcrops)
Geomorphic Agent:	Gravity (colluvial deposition from surrounding moderate – steep slopes)
Element Type/Pattern	Bench (sloping)/Moderate (10 - 32% slope angle - terrain within 300 m)
Pattern Relief Class/Type	High (90 – 300 m), Hills
Land Surface:	5%, sloping WSW
Land Disturbance:	Cultivated, rain fed
Condition Soil Surface:	Soft when moist, but firm when dry
Soil Erosion:	No evidence of surface soil erosion, but mass movement is a feature of this landscape
Surface stone/outcrops:	Very few medium gravels (6 – 20 mm), no rock outcrops
Geological setting:	Shale and limestone above site, meta-sedimentary fragments in pit
Substrate:	Silty/clay sized, amorphous, massive, weak colluviums, shale derived?
Vegetation:	Kuni grasses, Kowkow and nut grass, all as weeds in cultivate field

A11	0 – 15 cm	7.5YR 2.5/1; silty clay loam; moderately structured very fine (2 – 5 mm) polyhedral structure plus moderately well developed fine (5 – 10 mm) polyhedral structure; non-sticky; weak moist strength; very firm dry strength; earthy fabric; few (2 – 10%) weak, sub-angular, dispersed medium gravels (6 – 20 mm) of shale; common fine (1 – 2 mm) roots; non water repellent; gradual smooth boundary;
A12	15 – 25 cm	7.5YR 3/1; silty clay loam; moderately structured very fine (2 – 5 mm) polyhedral structure plus moderately well developed fine (5 – 10 mm) polyhedral structure; non-sticky; weak moist strength; very firm dry strength; earthy fabric; few (2 – 10%) moderately weak, sub-angular, dispersed medium gravels (6 – 20 mm) of shale; common fine (1 – 2 mm) roots; non water repellent; gradual smooth boundary;
AB	25 – 35 cm	5YR 3/2; silty light clay; moderately developed medium (10 – 20 mm) angular blocky structure; parting to moderately well developed fine (5 – 10 mm) angular blocky structure; slightly sticky; weak moist strength; very firm dry strength; earth fabric; common (10 – 20%) weak rock, sub-angular stratified coarse gravels (20 – 60 mm) of shale; few fine (1 – 2 mm) roots; non water repellent; clear smooth boundary;
B21	35 – 45 cm	7.5YR 4/4; silty light clay; moderately developed fine (5 – 10 mm) angular blocky structure; parting to moderately well developed very fine (2 – 5 mm) angular blocky structure; slightly sticky; weak moist strength; earth fabric; few (5 – 10%) moderately weak rock, sub-angular dispersed medium gravels (6 – 20 mm) of shale; few fine (1 – 2 mm) roots; non water repellent; gradual smooth boundary;

B22	45 – 65 cm	10YR 5/6; silty light medium clay; moderately developed medium (10 – 20 mm) angular blocky structure; slightly sticky; weak moist strength; earth fabric; very few (<2%) weak sub-angular dispersed medium gravels (6 – 20 mm) of shale; no roots; non water repellent; gradual smooth boundary;
B23	65 – 80 cm	10YR 5/6; silty medium clay; moderately developed medium (10 – 20 mm) angular blocky structure; slightly sticky; weak moist strength; earth fabric; very few (<2%) moderately weak sub-angular dispersed medium gravels (6 – 20 mm) of shale; no roots; non water repellent; gradual smooth boundary;
B24	80 – 100 cm	10YR 5/6; silty medium clay; weakly developed fine (5 - 10 mm) angular blocky structure; slightly sticky; weak moist strength; earth fabric; few (2 – 10 %) strong sub-angular dispersed medium gravels (6 – 20 mm) of shale; no roots; non water repellent; gradual smooth boundary;
B25	100 – 110 cm+	10YR 5/6; very few medium (5 – 15 mm) distinct 2.5Y 6/2 mottles; silty medium clay; weakly developed fine (5 – 10 mm) angular blocky structure; slightly sticky; weak moist strength; earth fabric; few (2 – 10 %) moderately weak sub-angular dispersed medium gravels (6 – 20 mm) of shale; no roots; non water repellent

Soil and Land Resources at Pacific Adventist University near Port Moresby

At Pacific Adventist University (PAU) the site was located on the lower component of a gently sloping colluvial fan (see Plate 6). The soils are typically dark cracking clays on greyer clays suggesting a shallow watertable in the area. The site had several lateral open drains and this along with the waterlogged subsoil suggest there is significant subsurface lateral flow of groundwater.

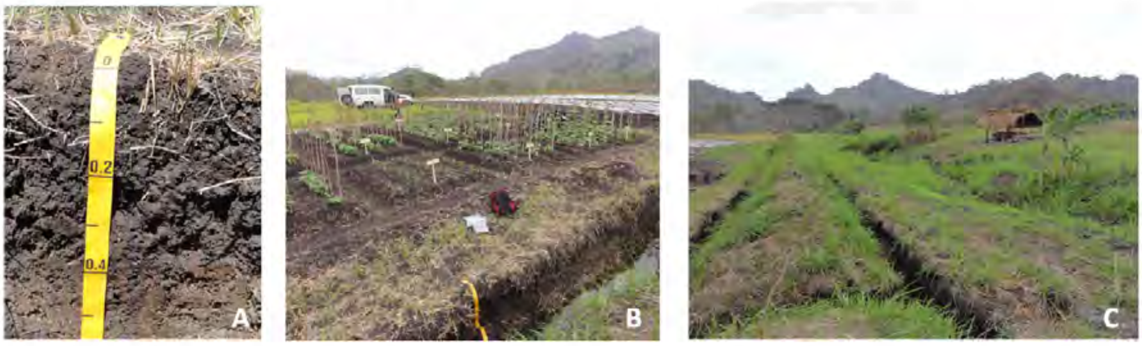


Plate 6 A- Soil profile form clayey colluviums, B – Trial site at PAU with soil profile exposed in drain, C – Local site showing the colluvial fan and surrounding steeper hills of meta-sediments.

The PAU site has moderate agricultural suitability due to the naturally fertile reactive clay surface soils, the lower slope angle and reasonable soils structure which will limit erosion potential. However potential soil compaction and high soil stickiness are likely to be issues along with a high watertable. Other soils of the PAU property include alluvial soils formed on the floodplain of the Laloki River. These soils were examined in previous visits and found to be silty clays with uniform profiles and moderately fertility but prone to compaction and formation of plough pans. Overall the land use potential of the PAU property is in the moderate class. Potential land use limitations include flooding, compaction and soil organic matter decline.

Soil Profile Description – Pacific Adventist University

Site:	Block E, Pacific Adventist University
Date/Describer	31/08/2011 / Richard Doyle UTAS and ACIAR
Description Type:	Cutting and auger below 60 cm
Drainage/Permeability	Imperfectly drained soil/Slowly permeable soil profile
Site Run off:	Slow rate of run-off, due to flattish site and permeable soil
Landform Element:	Very gentle (1 – 3% slope at soil pit)
Element Type:	Lower slope (broad colluvial fan)
Geomorphic Agent:	Gravity (colluvial deposition from surrounding moderate – steep slopes)
Element Type/Pattern	Foot slope, very gentle (1 – 3% slope angle - terrain within 300 m)
Pattern Relief Class/Type	Very low (9 – 30 m), Low Hills
Land Surface:	5%, sloping N
Land Disturbance:	Cultivated, rain fed
Surface/micro relief:	Self-mulching and cracking; normal gilgai; Soft when moist, but firm when dry
Soil Erosion:	No evidence of surface soil erosion, but mass movement is a feature of this landscape
Surface stone/outcrops:	Very few course gravels (20 – 60 mm), no rock outcrops
Geological setting:	Mixed substrate, not parent material. Deep colluvium derived soil
Substrate:	Silty/clay sized, amorphous, mixed rock origins. Black clay, ASC Vertosol, water table approx 3 – 5 m
Vegetation:	Kuni Grass

A11	0 – 10 cm	Black (10YR 2/1); medium clay; dry; strongly developed very fine (2 – 5 mm) polyhedral structure; plus strongly developed medium-course (20 – 50 mm) polyhedral structure; moderately sticky; moderately plastic; firm moist strength; strong dry strength; rough ped fabric; fine cracks; many fine (1 – 2 mm) roots; clear smooth boundary;
A12	10 – 25 cm	Black (10YR 2/1); medium clay; slightly moist; strongly developed fine (5 – 10 mm) polyhedral structure; plus strongly developed medium-course (20 – 50 mm) polyhedral structure; moderately sticky; moderately plastic; very firm moist strength; fine cracks; few (2 – 10%) strong rock, sub-rounded dispersed medium gravels (6 – 20 mm); common fine (1 – 2 mm) roots; clear smooth boundary;
B21g	25 – 40 cm	Brown (10YR 4/1); few fine (<5 mm) prominent red (2.5YR 4/8) mottles; light medium clay; moist; moderately developed fine (5 – 10 mm) angular blocky structure; plus moderately developed medium (10 – 20 mm) angular blocky structure; moderately sticky; moderately plastic; firm moist soil strength; few (<10%) faint organic humus cutans, very dark grey (10YR 3/1), lining pores/cracks; few very fine (<1 mm) roots; gradual smooth boundary;
B22g	40 – 60 cm	Greyish brown (2.5Y 5/2); few fine (<5 mm) prominent yellowish red (5YR 4/8) mottles; light medium clay; wet; weakly developed fine (5 – 10 mm) angular blocky structure; plus weakly developed medium (10 – 20 mm)

		angular blocky structure; moderately sticky; moderately plastic; firm moist soil strength; smooth ped fabric; faint slicken-sides; few fine (<2 mm) carbonate nodules; few very fine (<1 mm) roots; clear smooth boundary;
C1g	60 – 80 cm	Greyish brown (2.5Y 5/2); medium clay; wet; massive structure; moderately sticky; moderately plastic; firm moist soil strength; smooth ped fabric; faint slicken-sides; common medium (2 – 6 mm) carbonate nodules; no roots; diffuse boundary;
C2g	80 – 95 cm	Light brownish grey (2.5Y 6/2); few fine (<5 mm) distinct gleyed (10GY 5/) mottles; medium clay; wet; massive structure; moderately sticky; moderately plastic; firm moist soil strength; earthy fabric; many medium (2 – 6 mm) carbonate nodules; no roots; diffuse boundary;
C3g	95 – 115+ cm	Light yellow (5Y 7/8); common fine (<5 mm) distinct (10GY 5/) mottles; medium clay; moist; massive structure; moderately sticky; moderately plastic; firm moist soil strength; earthy fabric; many medium (2 – 6 mm) carbonate nodules; no roots;

Soils and Land Resources at NARI's Laloki Station

The NARI lowland trial site is located at the Laloki field station with the trials and soil pit located on the active floodplain of the Laloki River (see Plate 7). The soil profile is derived from fine textured alluvium and would be highly susceptible to regular inundation from the adjacent streams. The soil also appears to be susceptible to compaction with the zone 20 – 40 cm appearing very compact and duller in soil colour in the pit face, suggesting water perching. This may be due to excessive cultivation and declining soil organic carbon levels which are only 1.4 % in the surface. NARI soil test data indicate the soil pH is favourable at 5.9 – 6.1 in the upper profile with good exchangeable magnesium and potassium levels and moderate CEC 16 cmol(+)/kg.

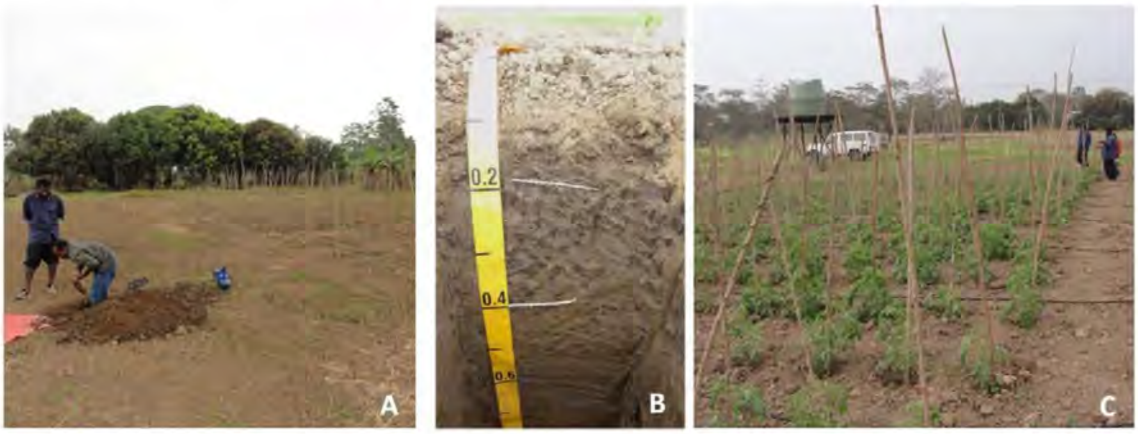


Plate 7 A – NARI Laloki soil pit location and trail site with stream channel marked by tree line, B – Soil profile formed from silty-clay alluvium, note compaction zone at 20 – 40 cm, C – Trial showing irrigation set-up.

Soil Profile Description – NARI Laloki

Site:	NARI Trial site, Laloki
Date/Describer	31/08/2011 / Richard Doyle UTAS and ACIAR
Description Type:	Soil pit to 80 cm and auger below
Drainage/Permeability	Imperfectly drained soil/Slowly permeable soil profile
Site Run off:	Slow rate of run-off, due to flat site and slowly permeable soil
Landform Element:	Level (<1% slope at soil pit)
Element Type:	Flat, alluvial plain
Geomorphic Agent:	Over bank stream
Element Type/Pattern	Level, flood plain
Pattern Relief Class/Type	Extremely Low (<9 m), alluvial plain
Land Surface:	1%, sloping S
Land Disturbance:	Cultivated, rain fed
Condition Soil Surface:	Hard setting, No micro relief
Soil Erosion:	No evidence of surface soil erosion.
Inundation:	> once per year, for 1-20 days, at 300 mm – 1 m depth
Surface stone/outcrops:	None
Geological setting:	Alluvium, unknown underlying substrate
Substrate:	Silty/clay sized, amorphous, massive, weak silt
Vegetation:	Signal grass

A11	0 – 5 cm	Dark greyish brown (10YR 4/2, moist); pale brown (10YR 6/3, dry); texture; dry; moderately developed medium-course (20 – 50 mm) polyhedral structure; plus moderately developed very fine (2 – 5 mm) polyhedral structure; clear irregular boundary;
A12	5 – 12 cm	Dark greyish brown (10YR 4/2, moist); pale brown (10YR 6/3, dry); texture; slightly moist; moderately developed medium-course (20 – 50 mm) polyhedral structure; plus moderately developed very fine (2 – 5 mm) polyhedral structure; clear wavy boundary;
B11	12 – 30 cm	Very dark greyish brown (10YR 3/2 ,moist); texture; slightly moist; moderately developed course-very course (100 – 200 mm) prismatic structure, plus massive structure; clear smooth boundary;
B12	30 – 50 cm	Brown (10YR 4/3); many medium (5 – 15 mm) faint dark grey (10YR 4/1) mottles; texture; moist; strongly developed medium-course (20 – 50 mm) polyhedral structure; parting to strongly developed very fine (2 – 5 mm) angular blocky structure; gradual smooth boundary;
B21	50 – 75 cm	Dark greyish brown (10YR 4/2); common medium (5 – 15 mm) faint dark yellowish brown (10YR 4/4) mottles; texture; moist; strongly developed medium-course (20 – 50 mm) polyhedral structure; parting to strongly developed very fine (2 – 5 mm) angular blocky structure; gradual smooth boundary;
B22	75 – 95 cm	Dark greyish brown (10YR 4/2); common medium (5 – 15 mm) faint dark yellowish brown (10YR 4/4) mottles; texture; moist; gradual smooth;
B31/32	95 – 110+ cm	Dark greyish brown (10YR 4/2); gradual smooth boundary

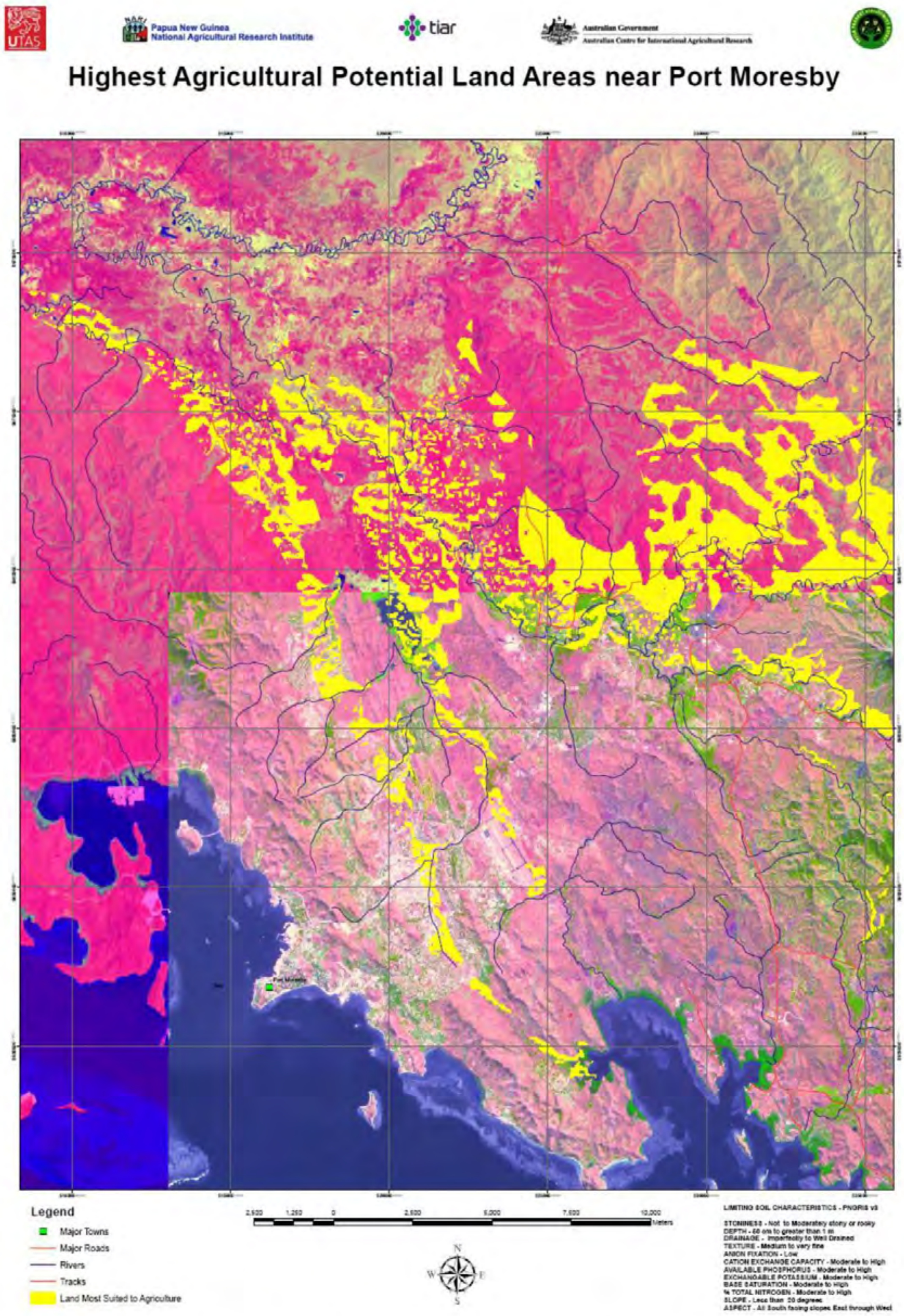


Plate 8 GIS generated map of the most suitable agricultural land near PAU and Laloki derived from PNGRIS soil and landform layers (see legend in lower right-hand corner). The area in yellow shows the deeper, freer draining and more fertile soils on slopes less than or equal to 20 degrees.

Soils and Land Resources at Sogeri Plateau

The site is adjacent to the Sogeri High School and lies on a flat to gently undulating river terrace above the Browns River (see Plate 9). The soil is reddish brown in colour and well structured with common manganese segregations all of which suggest formation from mafic dominated parent materials. The high iron oxide content may also indicate an issue with phosphorus fixation. This is supported by the very low Olsen P values in the NARI topsoil test data (3.5 – 2.9 mg/kg) and low pH (5.1 – 4.9). Otherwise the soil has good organic carbon (2.95 - 3.76 %), total nitrogen (0.28%) and Cation Exchange (22 – 24 cmol(+)/kg) levels.

Plate 9 A – Sogeri Plateau soil pit location and trail site (behind), B – Soil profile formed from mafic material, probably alluvium C – Trial site behind pit, cultivated but not planted.

Soil Profile Description – Sogeri Plateau

Site:	Sogeri High School, Sogeri, Central Province
Date/Describer	2/09/2011 / Richard Doyle UTAS and ACIAR
Description Type:	Soil pit to 80 cm and auger below
Drainage/Permeability	Moderate drainage
Site Run off:	Slow to moderate rate of run-off, due to flat site and good drainage
Landform Element:	Level (<1% slope at soil pit)
Element Type:	Flat, Terrace plain
Geomorphic Agent:	Over bank stream
Element Type/Pattern	Level, Terrace plain
Pattern Relief Class/Type	Extremely Low (<9 m)
Land Surface:	1%, sloping N
Land Disturbance:	Cultivated, irrigated
Condition Soil Surface:	Cracking, Mild micro relief of normal gilgai
Soil Erosion:	No evidence of surface soil erosion.
Inundation:	> once per year, for 1-20 days, at 100 - 300mm depth
Surface stone/outcrops:	None
Geological setting:	Alluvium of mafic origin
Substrate:	Silt/clay sized particles, sandy clay substrate
Vegetation:	Grasses, *Panicum maximum* and *Digitaria bothriochloa*

A1	0 – 10 cm	Dark brown (7.5YR 3/3); light clay; slightly moist; strongly developed medium-course (20 – 50 mm) polyhedral structure; parting to strongly developed very fine (2 – 5 mm) polyhedral structure; slightly sticky; moderately plastic; firm moist strength; many fine (1 – 2 mm) roots; clear smooth boundary;
A3	10 – 25 cm	Dark Brown (7.5YR 4/3); fine sandy light clay; moist; strongly developed medium-course (20 – 50 mm) polyhedral structure; parting to strongly developed fine (5 – 10 mm) polyhedral structure; slightly sticky; moderately plastic; firm moist strength; common (10 – 50%) distinct mangans (N 1/0); common fine (1 – 2 mm) roots; gradual smooth boundary;
B1	25 – 35 cm	Dark brown (7.5YR 4/4); sandy clay loam; moist; moderately developed medium – course (20 – 50 mm) polyhedral structure; parting to strongly developed very fine (2 – 5 mm) polyhedral structure; slightly sticky; moderately plastic; firm moist strength; common (10 – 50%) distinct mangan mottles (N 1/0); few very fine (<1 mm) roots; clear wavy boundary;
B21	35 - 50 cm	Strong brown (7.5YR 5/6); many medium (5 – 15 mm) faint brown (7.5YR 5/3) mottles; clay loam, sandy; moist; massive structure; parting to moderately developed medium (10 – 20 mm) angular blocky structure; slightly sticky; moderately plastic; firm moist strength; common (10 – 50%) distinct mangans (N 1/0); few very fine (<1 mm) roots; diffuse boundary;
B22	50 – 85 cm	Brown (7.5YR 5/2); many medium (5 – 15 mm) distinct strong brown (7.5YR 5/6 mottles); sandy light clay; moist; massive structure; parting to weakly developed medium (10 – 20 mm) angular blocky structure; slightly sticky; moderately plastic; firm moist strength; common (10 – 50%) prominent mangans (N 1/0); few very fine (<1 mm) roots; diffuse boundary;
B3	85 – 120 cm	Strong brown (7.5YR 5/6); common medium (5 – 15 mm) distinct brown (7.5YR 5/2) mottles; sandy light clay; moist; massive structure; slightly sticky; moderately plastic; strength; few (<10%) distinct mangans (N 1/0); no roots; undefined lower boundary;

Land and Soil Resources at Kwikila – Rigo District

Two gardens were visited in the Rigo district and auger soil profile descriptions were undertaken. Both where dark reactive clay soils from mafic to mixed parent materials, one colluvial the other alluvial in nature. At the colluvial site the issue of soil erosion due to long cultivated slopes and moderate slope angles, while at the alluvial site compaction and inundation are both potential hazards. These issues were discussed with the small holders and the district cooperative manager. Soil description sheets are lodged with NARI Analytical Laboratories and so detail descriptions will be reported elsewhere (later).

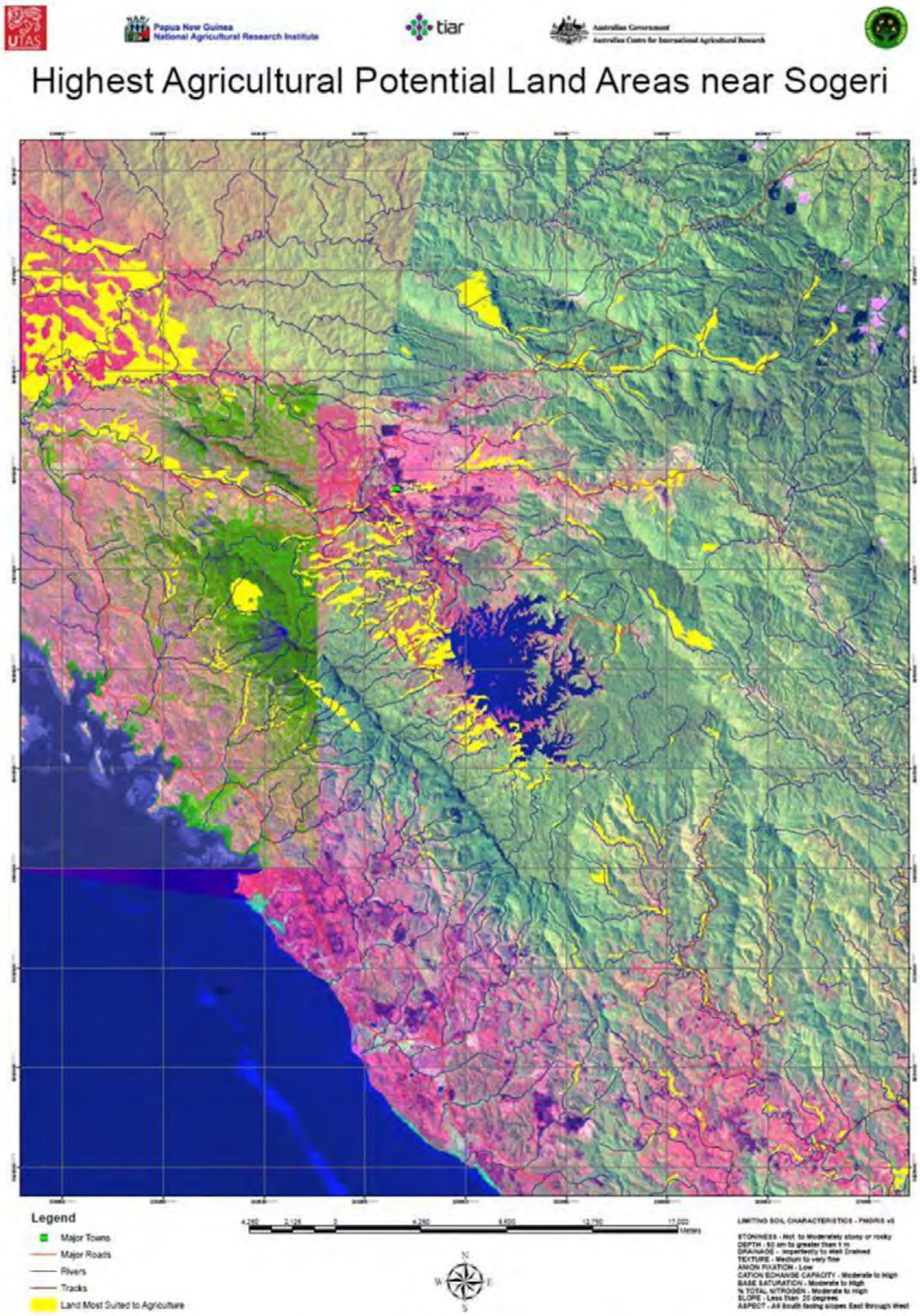


Plate 10 GIS generated map of the most suitable agricultural land near Sogeri derived from PNGRIS soil and landform layers (see legend in lower right-hand corner). The area in yellow shows the deeper, freer draining and more fertile soils on slopes less than or equal to 20 degrees.

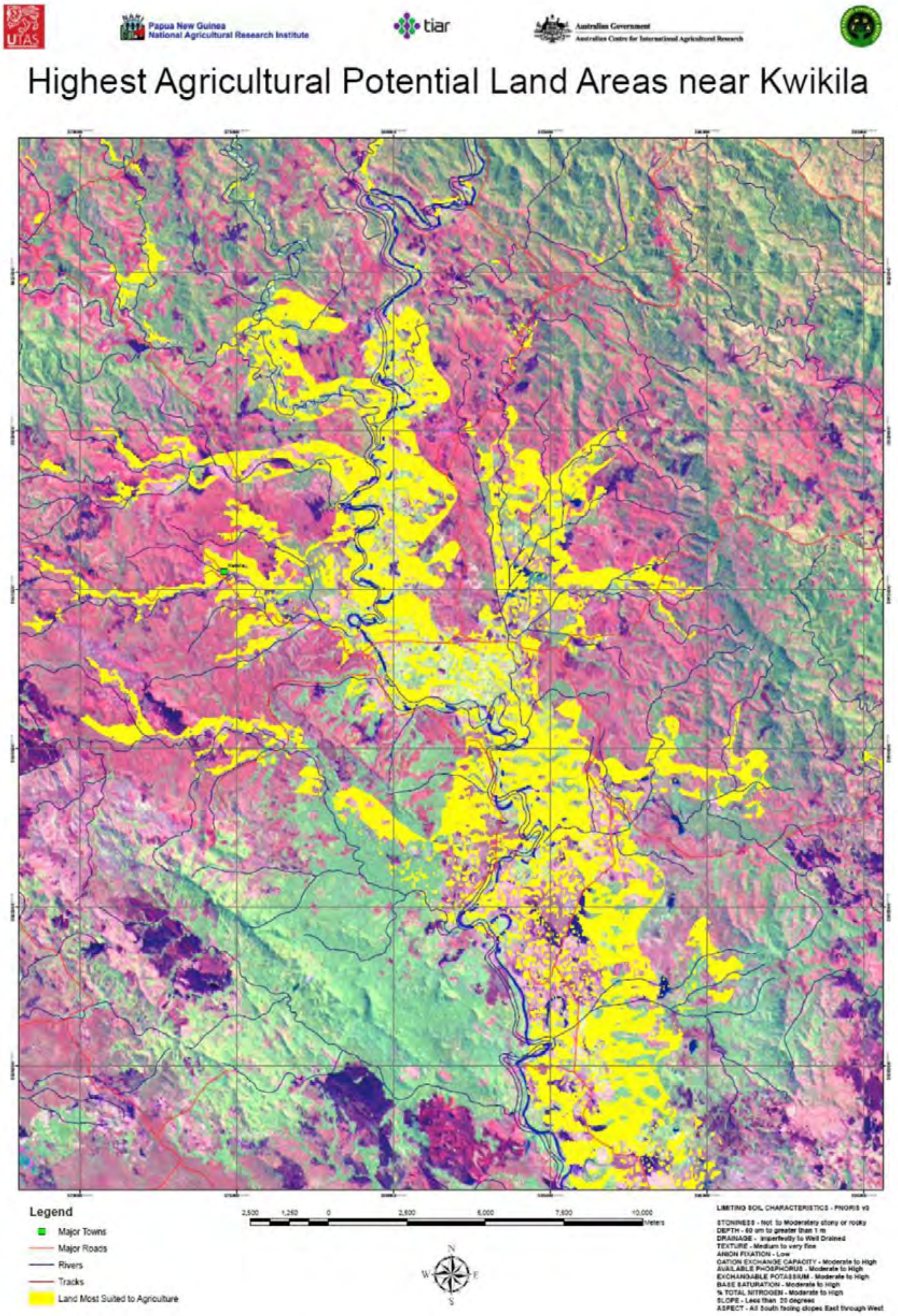


Plate 11 GIS generated map of the most suitable agricultural land near Kwikila (Rigo) derived from PNGRIS soil and landform layers (see legend in lower right-hand corner). The area in yellow shows the deeper, freer draining and more fertile soils on slopes less than or equal to 20 degrees.

APPENDICIES

Appendix 1 Soil Data for Trial Sites

Detailed discussion on Soil Analysis

Soil fertility – N cycling in the system – is fire depleting it? Is the high rainfall leaching it?

NATIONAL AGRICULTURAL RESEARCH INSTITUTE
Chemistry Section
P.O. Box 8277, Boroko, National Capital District, Papua New Guinea.
Telephone: (675) 320 1516, (675) 320 2345, (675) 321 2690. Fax: (675) 320 2411
Email: narichem@.dg.com.pg

Soil Analysis Results

Accession Number 11107
Agent Philmah Seta
Address NARI SRC Laloki
Area
District Kairuku
Province Central

File ref. 42-1-3
Sample type soil
Number of samples 12
Date rec'd 7/4/2011
Date completed 8/8/2011

Lab Number	Sender Reference	Site	pH	Extractable bases Ca	Mg (me%)	K	Na	CEC (me%)	BS (%)	Olsen P (mg/kg)	Organic C (%)	Total N (%)	C/N ratio	Mg:K ratio
111077		Laloki T.Soil	6.1		3.93	0.46		15.7		34.1	1.4	0.19	7	9
111078		Laloki T.Soil	5.9		4.09	0.46		16.7		35.1	1.44	0.14	10	9
111079		Laloki S.Soil	6		4.08	0.47		16.7		34.1	1.55	0.14	11	9
111080		Laloki S.Soil	6.1		4.24	0.46		14.9		36.3	1.43	0.15	10	9
111081		Sogeri T.Soil	5.1		4.58	0.2		24.4		3.5	2.95	0.28	11	23
111082		Sogeri T.Soil	4.9		4.25	0.22		21.7		2.9	3.76	0.28	13	19
111083		Sogeri S.Soil	5.2		3.95	0.1		25.4		2.9	1.55	0.15	10	40
111084		Sogeri S.Soil	6		3.87	0.1		17		1.8	1.51	0.14	11	39
111085		Tapini T.Soil	6		1.39	0.44		14.4		31	2.39	0.21	11	3
111086		Tapini T.Soil	6.1		1.34	0.45		14.9		31	2.2	0.2	11	3
111087		Tapini S.Soil	6		1.05	0.34		12.8		28.1	2.24	0.18	12	3
111088		Tapini S.Soil	6		1.16	0.36		12.1		31.5	2.29	0.19	12	3
Critical values			<5.5	<5.0	<1.0	<0.3	>0.7	<6.0	<30	<5.0	<3.0	<0.3	<10	>15

Laboratory Manager ....

Methods Used:
Samples analysed as received at NARI Chemistry Laboratory using methods NACL - S1, S3, S5, S8, S9, S10, S11, S12, S13, S15, S16, S22, S25. Detection limits are as follows:- available P (Olsen) 0.1mg/kg; extractable Mg, K, Na 0.1 me%; extractable Ca 0.1 me%; CEC 0.1 me%; Organic carbon 0.01 %; total nitrogen 0.01 %; micronutrients (Cu, Zn, Mn Fe) 1mg/kg; available boron 0.01mg/kg. Results quoted on air dry basis (2mm soil)

Wednesday, August 10, 2011

Page 1 of 1

Appendix 2 Notes from Agricultural Co-operative Meetings

Several meetings with villagers and local leaders were held notably in Tapini and with the Rigo cooperative. Issues around soil conservation, reduction in soil compaction and irrigation technology were discussed.

Rigo District Cooperative

Rigo is said to represent 18 villages with, 10 taking a regular part in the cooperative group and includes approximately 4000 villagers. The Rigo district covers an area of 600-800 km/square with currently only 20 hectares mechanically cultivated for production annually.

Vanilla is increasing in value but key crops include; water melon, capsicum, tomato, bok-choi, pawpaw, pineapple and coconut. These are sold to Green Fresh, Supermarkets however a reliable and regular supply to markets is seen as an issue. Is there a need for a separate wholesalers/commercial market supply to the hotels, mines, supermarkets and other retailing operations? This issue was discussed and there seemed to be support for this idea.

Many of the farmers go directly to the open markets and do not work through the cooperative. Costs for cultivation at 30 toia for two passes over the land.

Other issues raised were around the cost recovery and accounting of the cooperative. How are key capital costs like tractors, transport vehicles and cultivators costed? While operation costs like fuel, oil and labour for transport, tillage, harvesting are charged for this does not take in to account replacement costs.

Input suppliers – there is a need for reverse (upward?) management of the input supply part of the chain. How can messages about varieties and input supplies be effectively sent and responded to for farmers to the suppliers (Note to Lauire).

Prices for products in the markets are;

13 K/kg for beans

7 K/kg tomatoes

7 K/kg capsicums

2-3K/kg Bok-choi

2.4 K/kg pawpaw

2.75 – 3 K/kg water melon (1.9K/kg is the production costs for at PAU)

Trip Report

Women's Workshop in Central Province of PNG

Barbara Chambers and Gomathy Palaniappan

Gender and Youth Team

SMCN/2008/008Increasing Vegetable Production in Central Province, Papua New Guinea to Supply Port Moresby Markets

28 September 2011

Workshop Report

Women and their Daughters in Horticulture

A Pictorial Training Needs Assessment Using a Collaborative Problem Solving Method (CPSM)

Executive Summary

In February 2011, group interviews were carried out in the villages of Rigo-Koiari and Bautama with men and women to determine what crops they produced. An appreciative inquiry (AI) technique was employed against a template of Rapid Value Chain Appraisal (RVCA). Villagers spoke about their crops, what they were proud of and what they hoped to do in the future. Out of this came a desire for horticultural, business and market training for women and girls, men and boys. Before this could happen, a training needs analysis had to be conducted and it was decided that a women's workshop should be held and a pictorial training needs assessment trialed. The reasoning behind the development of a pictorial training needs assessment was the low level of literacy, especially amongst women, and that if a traditional pen and paper test was used, it would be time consuming and labor intensive because of the need to use Tok Pisin translators in the field. Criteria were developed to guide the selection of women, including a range of ages and willingness to share training with other women (and men). The outcome was better than we had hoped with 29 women and their daughters from the villages of Rigo-Koiari and Bautama attending a two day consultative workshop. Overwhelmingly, their training needs were identified as Farm Production (crop management and irrigation), Marketing (product readiness and negotiating price) and Business Skills (banking and book-keeping). A steering or communication group representing workshop participants was set-up to monitor the Action Plan on training priorities and which will be the key contact point for researchers and trainers for the next year, at least.

Background to the Workshop

From our research in the villages of Rigo-Koiari and Bautama in February 2011, villagers talked about the crops they grew, what they were most proud of and what their dreams were for the future. Men and women were in agreement about what they were proud of in their horticulture, identifying what they could do better and what their constraints were but when it came to dreams for the future, the women said initially that they had none. Men were proud of the establishment of their Rigo-Koiari Cooperative, and women were able to explain its facilitative role, but at the time there were no women office bearers. When probed and given examples, women tentatively offered dreams grounded in the present of getting a better truck for transport, buying a tractor, improvements to the road and ensuring a selling space at the market. Only one woman said, tentatively, that she dreamed of growing grapes in future. In Bautama, there is no cooperative, but some men and women owned their own farms. However, their issues and constraints are similar to those at Rigo-Koiari, and Bautama women also had difficulty dreaming the future. For this reason a priority was given to a women's workshop to assess their training needs.

The PNG Partners formed a planning group led by Dr Lalen Simeon and composed of Ms Roselyn Winston (NARI), Ms Poela Utama (FPDA), Ms Philmah Seta-Waken(NARI)and Mr Gus Maino (FPDA). Dr Simeon liaised with Professor Barbara Chambers in the planning of the workshop, including allocation of responsibilities, budget and selection of participants. It was decided to conduct the workshop at the Pacific Adventist University, as it was safe and had the requisite facilities. One month before the workshop, Professor Chambers met with the team in Port Moresby and briefed the team about the Collaborative Problem Solving Methodology (CPSM), table facilitation and final planning details. This ensured that the workshop itself worked smoothly.

Method

The team decided to devise criteria for the selection of women participants given the workshop can only reasonably accommodate 30-35 people. These criteria were:

- women who have had previous training of some kind
- women who are actively involved in horticulture and/or keen to develop their gardens
- women who are members of a women's agricultural organization or association
- women who are committed to sharing their learning with other women
- ensuring a mix of ages i.e. mothers and daughters/daughters in law

When the team reflected on earlier research experience, it was clear that if a pen and paper training needs assessment were to be used it would require translation into Tok Pisin. The low level of literacy meant that such an assessment would have to be administered by a research team preferably prior to the workshop. After a careful review of different assessment techniques, the team decided to use a pictorial method of assessment similar to one Gomathy Palaniappan had used in India with women's micro-credit groups. Barbara Chambers had previous experience using pictorial methods of gaining information in low literacy, cross cultural settings when she used stimulus pictures with youth about their attitudes to other ethnic groups. It was therefore decided to find suitable PNG horticultural pictures and to modify the probe questions used in the Indian example. The final probe questions are attached in Appendix 1, having been reviewed by our PNG partners in NARI, FPDA and PAU during Barbara Chambers' previous trip to PNG in late August, 2011.

A broad selection of pictures representing the various themes that emerged during previous field trips to Rigo-Koiari and Bautama was initially compiled. The themes that had emerged were soil preparation, planting, irrigation, crop management, harvesting, packaging, marketing, transport, banking and book keeping. From this, the picture categories of horticulture, marketing and business were chosen. To ensure ethical compliance (subject or agency permission), 'best practice' pictures were selected from a previous ACIAR project publication (*Quality Management of Fresh Produce from the Highlands of Papua New Guinea: A Postharvest Manual*, 2007). Two remaining pictures on Business, without human subjects being portrayed, were constructed by Gomathy Palaniappan.

The pictures were first shared and ranked by the Australian team members. After that, pictures were sent by 'Drop Box' to FPDA. Staff members, given their role as village extension workers, were asked to rank the pictures representing the themes in terms of how clearly the picture showed the category (horticulture, marketing or business) and to explain their choice. Poela Utama responded on behalf of FPDA staff and the final selection of pictures was printed as sets of posters of A3 size sufficient for 32 participants in groups of 8. Examples of each are given below.

Poster – Card for Horticulture: Soil preparation (H1)

This photo was ranked as number one because in everyday farming in rural areas, people value land. Eighty per cent (80%) of PNG's population rely on land as the most important resource for farming. In other words, a picture of land cleared and prepared for agriculture said it all, more than pictures showing any process for soil preparation.

Poster – Card for Horticulture: Planting (H2)

The photo below was ranked as priority one for planting because the women need to know about seed packaging, the content of that package, the expiry date and growing locations.

Poster – Card for Marketing: Packaging (M2)

This picture was chosen as the ideal way to pack produce, such as onions, and it showed how to store them correctly. It was thought that storing produce on packing trays will not cause damage to crops and the picture showed what the right packing material was for the onions i.e. the open weave bags are ideal for air circulation.

Poster – Card for Business: Banking and Savings (B1)

Although ANZ and Westpac banks operate in PNG and we could have taken photos of them in Australia, we decided to symbolically represent savings as a piggy bank with money rather than identify any particular bank. We had already understood that PNG people have quite strong attitudes to the bank they prefer or dislike.

Poster –Card for Business: Book keeping (B2)

The poster for book keeping is appropriate and self explanatory.

Training in Collaborative Problem Solving Methodology for the Workshop

In Port Moresby during late August, Barbara Chambers met with PNG partners from FPDA (Poela Utama and Gus Mano), NARI (Roselyn Winston) and PAU (Lalen Simeon) and inducted them into the Collaborative Problem Solving Methodology (CPSM)[1] for the workshop. She also talked through the role of table facilitation (see Barbara Chambers' previous trip report for August 2011).

Workshop Program (26 and 27 September, 2011 at PAU)

Day One (Divergent or Creative Phase) - AM

1. **Introductions**

The room was organised so that tables were in a fan shape with eight per table, rather than in classroom rows. This arrangement ensures that all could see the front of the room and the facilitator could easily move around tables. Prior to commencing the workshop, women were asked to complete a Workshop Consent Form (Appendix2).

Barbara Chambers introduced herself as the lead facilitator of the workshop and also introduced table facilitators Dr. Gomathy Palaniappan (also workshop recorder), Ms Roselyn Winston, Ms Poela Utama and Dr Lalen Simeon.

The women from villages of Rigo-Koiari were seated on 3 tables and the women from villages of Bautama seated on one table.[2] A woman leader each representing Rigo-Koiari and Bautama villages was asked to talk briefly about their village and the produce they grew.

Mrs Gaugu Keina introduced herself as the vice president of the women's co-operative for Rigo-Koiari village. She mentioned that many vegetables were grown in their villages like capsicum, tomato, cucumber, bok choi, broccoli, water melon. She said, "You can name it, we grow a lot of

[1] CPSM (copyright) was developed from Value Management methods by Barbara Chambers and Carole Kayrooz for the Australian Institute for Sustainable Communities, University of Canberra and since 2003, has been modified for several ACIAR projects depending on the cultural context.

[2] It was clear that Rigo-Koiari women outnumbered Bautama women by virtue of the number of villages in the Rigo-Koiari cooperative. However, Bautama women were given an equal participatory voice in the workshop.

vegetables". She also mentioned, "We women are powerful in spite of several issues like the need for transport, especially a tractor. Our cooperative has only one and we are waiting a long time to hire it. We also need a good road and good seeds."

Mrs Mellen Ahara was the women's representative from Bautama and she mentioned that they did not have a co-operative in their village, although some women and men owned their own farms. She said, "We grow watermelon, tomato, capsicum and sell them to Greenfresh. We have good roads linking the village to Port Moresby, but we have transport problems (unreliable, unsuitable and irregular)."

2. Expectations of the workshop

The facilitator asked the participants what were their expectations of the workshop.

Team 1 (Group leader: Mrs Lalau Konido)

- We came here to know what we don't know
- To increase what we are doing
- To know more on fertilizer management
- To know the types of variety for their types of soil

Team 2 (Group leader: Mrs Mellen Ahara)
Same as Team1

- We want to teach what we learned from here
- We want to know crop management and timely management

Team 3 (Group leader: Mrs Begori Rome)
Same as Team 1 and Team 2

- To improve output and production

Team 4 (Group leader: Mrs Vaburi Konido)

- To develop and attend training
- To help our community to grow well
- To learn new things

Team 5 (Group leader: Mrs Joyce Duna)

- To motivate our farmers
- To encourage our young youth what we learned from the workshop
- Succeed in LIFE

3. Overview and Objectives of the Program

The objectives of the workshop were then presented by the facilitator using a PowerPoint presentation and a program handed out (see Appendix 3).

The *overall aim or purpose* of the workshop was to identify the training needs of women and youth in horticulture in the central province of PNG.

On the morning of Day One, the first objective is to discover what horticultural jobs women and youth find easy, more difficult and very hard to do. The second objective will be to discover what gets in the way of doing the difficult and hard to do jobs and what resources might make those jobs easier.

In the afternoon of Day One, objective three will be to find out what dreams or ideas women and youth have for their futures and Objective 4 asks what needs to be done to make those dreams happen.

On the morning of Day 2, objective five will be to prioritize the horticultural, marketing and business training needs for the villages of Rigo-Koiari and Bautama for

i. Youth

ii. Women.

Finally, on the afternoon of Day 2, objective six will be to develop an Action Plan which will identify

i. who might conduct training in:

   a) Horticulture

   b) Marketing

   c) Business And

ii. Who should be trained first?

During tea break the participants continued to discuss the issues and a lot of interaction among the women was observed.

4. Training Needs Assessment in Small Village Based Groups

Objective 1: To discover what horticultural jobs women and youth find easy, more difficult and very hard to do.

Objective 2: To discover what gets in the way of doing the difficult and hard to do jobs and what resources might make those jobs easier.

In the workshop, each table was given a set of poster cards in horticulture, marketing and business. With the help of a table facilitator, each group was asked to discuss each picture and then decide which tasks were easy, which were quite difficult and which were very difficult and why this was so (see Appendix 4). They were then asked to allocate poster cards to one of three stacks based on those assessments.

(Dr Gomathy Palaniappan with Rigo-Koiari Group)

Some groups began their task with difficult tasks and others with easy tasks. Each group presented their findings to the whole workshop by posting the poster cards on the wall under the headings of easy, moderately difficult and most difficult and explaining their ratings. The facilitator asked the workshop to find similarities and difference between and amongst groups. Table 1 below shows the rankings for each group.

Table 1: Ranking horticulture task based on difficulty

	Very Difficult tasks	**Quite Difficult tasks**	**Easy tasks**
Vaburi's group (Gomathy Palaniappan, table facilitator)	H1 Soil Preparation (men's job) H3 Irrigation B3 Transport	H4 Crop management (identification of pest and diseases is difficult) M3 Marketing	B2 Book Keeping B1 Banking M2 Packaging H2 Planting M1 Harvesting
Mellen's group* (Poela Utama, table facilitator)	H2 Planting H4 Crop management. (We know how to use chemicals. But the price is too high.) B2 Book Keeping B1 Banking B3 Transport	M3 Marketing	H3 Irrigation M1 Harvesting M2 Packaging H1 Soil Preparation
Japhed's group (Lalen Simeon, table facilitator)	H3 Irrigation M3 Marketing B3 Transport M2 Packaging	H1 Soil Preparation H4 Crop management H2 Planting M1 Harvesting	B2 Book Keeping B1 Banking
Begori's group (Roselyn Winston, table facilitator) *Bautama Table. The other three tables were Rigo-Koiari)	H4 Crop management (Men attended training on application of chemicals and the knowledge was not transferred to us) B3 Transport M2 Packaging (appropriate packaging is very difficult as there is a need to take it to market at a longer distance)	B2 Book Keeping M1 Harvesting H3 Irrigation	H1 Soil Preparation H2 Planting B1 Banking M3 Marketing

B3 Transport – Women agreed that they did not have reliable transport and had to depend on the public motor vehicles (PMVs). If the PMVs arrive late then they get to the market very late and if they could not bring the produce back they had to sell it at a very low price or pay the same charge for transporting it back to the village, as there is no storage point.
The pickup point was further away from their fields and they had to carry all their loads. Animals, like using buffalos for transport were observed by Roselyn during her visit to India and she asked the participants about their views on finding alternative resources for transport.
The members also thought about ways to provide road access for the PMVs to collect vegetables closer to their fields.
All groups agreed that transport was the most difficult task and were trying hard to find alternate resources.

H4 Crop management is also a very difficult task. Men had attended training on the application of chemicals but the knowledge was not transferred to women.
Mellen Ahara's group: We know how to use chemicals. But the price is too high.
Vaburi Konido's group: identification of pest and diseases is difficult as in our garden we have capsicum. Once the fruit grows it dries and falls off. We don't know the reason.
Japhed's group agreed with their views.
All groups agreed that crop management was a difficult task (2 groups considered as difficult and 2 groups as quite difficult).

M2 Packaging is a very difficult task as appropriate packaging for vegetables like capsicum and bok choi is very different and it is hard to maintain quality. Mostly we use the same material for packing all produce and it is difficult as there is a need to take it to a longer distance from the field before getting it to the transport site.
Japhed's group agreed with their views.
Mellen Ahara's group and Vaburi Konido's group agreed with their views that packaging was difficult but mentioned that they had overcome these issues through experiential learning.
Two groups agreed that packaging was a difficult task and two groups disagreed.

H3 Irrigation was agreed to be a difficult task by 2 groups and quite difficult by one group. The difficulty was because the women had to carry water cans to water their gardens and depending upon the distance of their garden from the river and the area to water some groups found it difficult. The group that found easy had an irrigation pump to water their field.

M3 Marketing was considered as a difficult task by one group and was considered quite difficult by two groups. They all agreed that the reason was that it was hard to find a space to sell their produce as the market is dominated by Highlanders. One of the group also mentioned that they had no say on the price as it was graded by the middle men at the market and the price was fixed.

Day One - PM

Objective 3: To find out what dreams or ideas women and youth have for their futures and

Objective 4: To find out what needs to be done to make those dreams happen.

Gomathy Palaniappan facilitated this session so that Barbara Chambers could work with a youth group on the question of dreams and making them happen. For this exercise, the 'Older Mother's Groups' were mixed rather than organised by village. The Youth Group was most interesting, not the least of which was because the President of the Rigo-Koirari Co-operative, a man, told Barbara Chambers that women had no dreams and wouldn't be able to answer the question. He said only men had dreams and the co-operative was the men's dream. Women were 'down there' and took direction from the men in the central province. "That is what happens in our culture", he said. Despite this assertion, one of the male FPDA staff invited the President to view PAU's farm and so the young women, one of which was the President's wife, were able to participate in the small group un-prompted. Their results were as shown in Table 2 below.

Table 2: Dreams and How to Make it True

	Dreams	**How to Make it True**
Esther's group (Youth Group)	➢ Improve Lives and support Church and Community	➢ Educate children
	➢ To become small business women in agriculture	➢ Improve agricultural production through training program ➢ Improve technology (e.g. tractor, bank accounts)
	➢ Further education	➢ Mark farming more profitable
	➢ Be a broker/middle woman	➢ Buying surplus produce and selling to market
	➢ Have a home of my own	➢ Making farming more profitable
	➢ Be financially secure	➢ Invest for the future

Lalau's Group (Older Mother's group)	➢ Education for their children to achieve the highest level and work ➢ Receive help from the children in future ➢ To have a good productive farm by owning a tractor, build a new house ➢ To improve transport and road maintenance	➢ Maintain farm production, selling must be good to help pay for fees ➢ Despite hardship like bad transportation conditions, mother must still carry produce to sell, so child can get education ➢ I must commit my time to farming so I can harvest crops to sell everyday and money will come in everyday ➢ Co-operative must own a PMV and a tractor ➢ People maintain the road

	➢ To have full resources to run the farm ➢ To share knowledge with friends and family	without government help ➢ Support the child good ➢ Keep sharing ideas
Gaugui's group (Older Mother's Group)	➢ Vehicle ➢ Permanent House ➢ Education (school fees) ➢ Son to become a successful farmer ➢ Gain more knowledge in agriculture ➢ To have farming equipment (water pump, own tractor) ➢ Extension of farm ➢ To have a bank account	Overall strategies: ➢ Be a strong farmer ➢ Set your target ➢ Know book-keeping ➢ Have a farm plan ➢ From growing vegetables
Begori's group (Older Mother's Group)	➢ Buy second-hand vehicle ➢ Buy tractor ➢ ➢ Buy water pump and build house ➢ Build semi-permanent dwellings ➢ Make trade store and educate her child ➢ Go overseas to learn ➢ Get a mobile phone ➢ Buy a spray can	➢ From farming ➢ From the profit of the trade store ➢ From farming ➢ From teaching ➢ From farming ➢ Call wholesalers for marketing ➢ From farming

In essence, the well being of the home and the community was high on the agenda of the older mothers. Children's education is seen to be the one of the most important dreams of the older mothers, followed by useful technology and improved infrastructure. The youth group, which included young mothers, deviated quite markedly because the single women had individuated and career oriented dreams (to become a broker/middle woman); to be a small business women; to gain further education; to have a home of my own and to be financially secure.

At the end of Day One, the facilitator summarized Day One activities and thanked the women for their participation and knowledge sharing. The women were reminded about the celebration dinner that evening and the activities for Day Two were foreshadowed.

Day Two (Convergent or Judgement Phase) – AM

The facilitator recapped activities from yesterday and outlined what would happen today. The workshop was reminded of the posters on the wall that identified horticultural activities that were very difficult and quite difficult.

Objective Five: To prioritize the horticultural, marketing and business training needs for the villages of Rigo-Koiari and Bautama for

i. *Youth*
ii. *Women*

It was explained that gold and silver stars were going to be given out representing the highest preference (gold) and second highest preference (silver) for training: 6 each for women and youth in each of the areas of horticulture, marketing and business were provided. It was explained that they had two sets of stars – gold and silver - to allocate to each of the areas. It was a bit like voting in that the method gave every individual member of the group an opportunity to express their individual needs without influence from other members of the group.

In order to differentiate the older mothers from the youth and/or younger mothers, the youth were provided with green adhesive stickers so that they could stick the stars on to the stickers.

The older mothers of Bautama village identified and ranked their highest training need as crop management, followed by banking, irrigation and planting. The youth of Bautama showed similarity in the preference and ranking of training needs. In addition to the training needs identified by older mothers, they also identified the importance of marketing a shown in the table below.

The older mothers of Rigo-Koiari village had identified similar training needs in crop management, although their highest ranking was for book-keeping, followed by harvesting, soil preparation, marketing and packaging. Youth put their highest emphasis on soil preparation, crop management and irrigation and were therefore quite different than their older mothers in prioritizing compared with Bautama women. It transpired that some older mothers had received training in soil preparation, packaging, irrigation and marketing, but other younger women were not aware of this and vice-versa for banking, harvesting and marketing training for youth. The point was made about the importance of sharing the knowledge in the community between older and younger mothers.

The two villages were quite different in terms of their priority training needs for both older and younger mothers. It appears that the training needs at Rigo-Koiari are at another, possibly higher, level of management than those at Bautama, where basic horticultural and crop management needs are of priority.

Table 3: Training Needs Priorities by number of stars

WOMEN PARTICIPANTS	BAUTAMA	RIGO-KOIARI
OLDER MOTHERS	CROP MANAGEMENT (I)	BOOK KEEPING (I)
	BANKING (II)	HARVESTING (II)
	IRRIGATION (III)	SOIL PREPARATION, CROP MANAGEMENT (III)
	PLANTING (IV)	IRRIGATION (IV)
		MARKETING (V)
		PACKAGING (VI)
YOUTH	CROP MANAGEMENT (I)	SOIL PREPARATION, CROP MANAGEMENT , IRRIGATION (I)
	BANKING (II)	BOOK KEEPING (II)
	PLANTING, MARKETING (III)	IRRIGATION (III)
		HARVESTING (IV)
		PACKAGING (V)
		BANKING (VI)
		MARKETING (VII)

The facilitator then posed the question, as a matter of priority which group should be trained first – younger or older mothers – and why? A lively discussion ensued with much laughter and gentle ribbing of youth by older women. It wasn't so much a question of status, but life experience and the confidence that comes with it is highly valued by women. What was learned through the workshop, though, was that knowledge should be shared between and amongst all in the village for the community and individuals to prosper (see Table 4).

Table 4: Priority Training

Table Groups	Who should attend training first	Reason
1.	Older mothers	Mature women have grown up children and so they will have more time As they have some previous experience they will be able to learn faster compared to youth Youth get married and move out of the village so the learning will not be shared
2.	Youth/Young mothers	Youth should attend training first as they will be willing to change Youth have a higher literacy rate than older mothers and therefore will be able to learn more easily.
3.	Older mothers	Older mothers can share ideas and are not shy Older mothers can train others Youth are very shy to share ideas
4.	Mature women and Youth	Both can be trained together as a mixed group.

Day Two – PM

After lunch, the facilitator gave an overview of the final session and outlined the purpose behind an Action Plan.

Objective 6: To develop an Action Plan which will identify

i. *who might conduct training in:*
   a) *Horticulture*
   b) *Marketing*
   c) *Business and*
ii. *who should be trained first.*

Having identified the training needs for Bautama and Rigo-Koiari and who needs to attend the training first, we then asked the groups to draw an action plan as to who might conduct training (see Table 5). Participants matched their training needs with FPDA, NARI, PAU and DAL and requested Dr Lalen Simen (PAU), Ms Roselyn Winston (NARI) and Ms Poela Utama (FPDA) to follow up to organize training to meet the needs of the participants. Village extension workers are well equipped to do in the field horticultural training, but NARI also has done research work in Lae and the Highlands on marketing and consumer preferences (Dr Norah Omot, NARI, Lae head office). Obviously some coordination is needed here between organizations, including the facilitative skills of the research team from Australia in terms of advocating for funds or free training sessions from agencies such as banks.

Table 5: Possible Trainers in Business, Horticulture and Marketing

	Training needs	**Priority**	**Possible Trainer**
Group 1 Rigo-Koiari	Business skills Horticulture	Youth	➢ Rigo-Koiari Co-operative officers ➢ PNG microfinance ➢ Other organizations such as ANZ bank was identified as a possible trainer in banking and micro-finance FPDA, NARI, DPI officers
Group 2 Rigo-Koiari	Horticulture Marketing Business	Older mothers	➢ FPDA, NARI, PAU ➢ FPDA, NARI, PAU ➢ FPDA, NARI, PAU
Group 3 Rigo-Koiari	Horticulture (crop management and irrigation) Marketing Business.	Older mothers	➢ FPDA, NARI, PAU, DAL ➢ FPDA, NARI ➢ FPDA, ANZ Bank
Group 4 Bautama	Horticulture (crop management and planting) Marketing (transport and packaging) Business (Banking and book keeping)	Youth	➢ FPDA, NARI ➢ NARI (to follow up marketing skills training and research on packaging done by previous ACIAR projects in the Highlands), FPDA ➢ PNG Microfinance, ANZ

Where to from here

At the end of the afternoon, the facilitator asked how we can make sure that the Action Plan is implemented. A steering or communication committee was suggested and the workshop decided who would be on it to liaise with the research team and to ensure that the workshop outcomes were achieved.

Two youth – one from each village - and four older mothers were chosen.

Gaugu Keina from Rigo-Koiari was nominated to lead the steering committee and to ensure that training was organized by relevant agencies. The other members nominated for the steering committee were: Joyce Duna, Vaburi Konido and Naomi Vetari representing different villages of Rigo-Koiari and Mellen Ahara and Esther Kiroki from Bautama.

Finally, participants were asked if they would provide personal biographical information (Appendix 5) in confidence to table facilitators for use in selecting participants for possible future training programs. All agreed. The difference between the two villages was most apparent in this data. Most women from Rigo-Koiari were members of PNG Women in Agriculture Development Foundation (PNGWiADF) and one was a Vice President of Women in Agriculture. No woman in Bautama was a member of a women's agricultural organization or association. In Rigo-Koiari eleven out of twenty women had had previous training; in Bautama only two out of nine women had.

Evaluation of Workshop

Finally, the groups were requested to evaluate the workshops and report to the large group about whether the workshop met most of their expectations, exceeded most of their expectations or failed to meet most of their expectations.

All the groups agreed that the workshop met most of their expectations. Individual comments were as follow:

- "This is first of its kind. We have never been to any workshops".
- "We appreciate the facilitators for including us as a part of the action plan".
- "Everything we learned from the workshop has been very fruitful".
- "We have learned many ideas from the Australian team and FPDA, NARI and PAU and just by talking to each other".
- "We have enjoyed being in this workshop".

Barbara Chambers then thanked the participants urging them to cooperate in sharing important knowledge and skills amongst women and men. She then distributed a previous ACIAR publication - *Quality Management of Fresh Produce from the Highlands of Papua New Guinea: A Postharvest Manual*, 2007 - as a gift to leaders of the groups of women from each village. Individuals begged afterwards for their own personal copies and Poela Utama agreed to follow-up with the FPDA

Goroka office to see if more are available and could be sent to the Port Moresby office for distribution. It made a telling point about the need for training manuals in the field.

(Barbara Chambers and the President of the Rigo-Kiori Co-operative)

The leaders of the group thanked the workshop facilitator, table facilitators and the Australian and PNG research team for the workshop. Each village performed songs as a thank you and the President of the Rigo-Koiari Co-operative made a speech of appreciation.

Post Workshop Reflection and Debriefing with PNG partners - 28 September 2011

- The objectives of the workshop were clearly explained by FPDA staff to the participants of Bautama and Rigo.
- Venue: PAU was an excellent choice because it was remote, peaceful and a natural place. It meant that women could concentrate on the workshop activities and it was a kind of gift in that they were appropriately and safely accommodated and all their meals provided. Lalen Simeon was a most effective coordinator of the PNG partner team and in liaison with Barbara Chambers. The Vice-Chancellor of PAU was most hospitable and warm in his welcome to workshop participants. He asked that if the team came back in February or March, would we be able to run a seminar for his staff on Applying for Research Funding.
- FPDA did a wonderful job transporting the women from villages and the staff from Port Moresby. However, transport (petrol) costs are very high and FPDA went way over budget of $2,000 per agency. Poela Utama estimated that it would be around PNG K 9,000 but she will advise us of the final cost. In future, instead of transporting workshop participants in a small vehicle, a bus should be hired to be more cost effective. It would also be more cost effective if staff stayed on site and usually this could happen at PAU provided enough notice was given.

- NARI provided workshop materials and stationery. Roselyn Winston did an outstanding job translating for the workshop as necessary.
- For future workshops, it was agreed that we could incorporate more pictures for the respective themes
- Gomathy Palaniappan was thanked for her role as workshop recorder and assistant facilitator for one of the sessions.
- All research staff undertook table facilitation in a very competent manner and demonstrated their understanding of the CPSM workshop method and objectives of the workshop. It was agreed that the prior visit to Port Moresby one month earlier was important to staff training and management of workshop tasks and responsibilities.
- The evaluation of the workshop was outstanding, although it may well be that as this is the first workshop for most of the women, the sheer novelty of being asked for their opinion, sharing knowledge and taking time out from everyday tasks may well have skewed the feedback in our favour.
- It is now clear that PNG research partners can conduct subsequent workshops using the CPSM method.

Conclusion

Overwhelmingly, the training needs of women and their daughters from Rigo-Koiari and Bautama villages were identified as Farm Production (crop management and irrigation), Marketing (product readiness and negotiating price) and Business Skills (banking and book-keeping). Bautama village indicated a greater need for more basic horticultural training than did Rigo-Koiari, who wanted more information on marketing and business skills. In terms of their Action Plan, women nominated FPDA and NARI as the agencies of choice in providing the requested training. Barbara Chambers could coordinate monitoring and evaluation of this training in future.

It will be interesting to see how the women of Tapini respond to a training needs assessment workshop and what the results will be once a workshop is held for men and youth from the three villages. It is possible that a workshop run by PNG partners for Tapini women could be held during the period of PNG elections, when the Australian team is advised not to visit. PNG partners led by Dr Lalen Simeon (PAU) and involving Poela Utama (FPDA) and Roselyn Winston (NARI) are now well-trained to undertake the Collaborative Problem Solving Methodology and in the use of the pictorial method of training needs assessment.

On the other hand, it is advised for cultural reasons that a Men and Youth Workshop will require a male co-facilitator and there is no one at the moment trained in our workshop methods. It is suggested that Barbara Chambers, Gomathy Palaniappan and Laurie Bonney conduct at least one men’s workshop in March 2012 with a nominated male PNG research partner. After that, our PNG research partners should be able to conduct all such workshops by themselves.

Appendix 1: Pictorial Training Needs Assessment Probe Questions

It was decided to undertake a training needs assessment within the workshop for two main reasons: first, it enabled the research leader to monitor how this was to be done; second, it meant that there was more time to select appropriate photographs as prompts for training needs assessment. The method is as follows:

- Cards will show pictures of major horticultural tasks which were identified during previous visits to the villages as well as pictures of activities related to business that may not have been mentioned but were not evident e.g. micro-credit, opening a bank account; drawing up a seasonal calendar and/or business plan.
- Participants sit together in a circle of up to five members from the same village with a facilitator and with photo-cards scattered in the middle.
- The facilitator should make clear that the cards are meant to depict women performing different tasks. The participants discuss the cards, explaining to each other and to the facilitator what the different tasks are showing.
- Next, the facilitator asks participants to divide the cards into three groups - tasks which are most difficult to perform; tasks which are easiest to perform and tasks that are in between difficult and easy.
- The facilitator keeps track of the discussion, noting when consensus is reached or not easily reached and the minority opinions.
- Participants should then turn their focus to the problematic tasks, discussing the obstacles and resources available to them for easing the difficulties.
- The facilitator should ask if training is needed for the most difficult tasks.
- The facilitator then posts pictures of the most difficult tasks onto butcher's paper so that other groups can see them and compare what each group came up with. The workshop facilitator will then lead a discussion about similarities and differences amongst groups and between villages.
- The exercise can be replicated at another workshop or in the village with cards showing men's most common tasks, so that a comparative analysis is possible.

Appendix 2: Women and their Daughters in Horticulture.
Workshop Consent form

1. I agree to participate in the women and their daughters in horticulture workshop on the 26th and 27th of September 2011.
2. As a part of the process I agree to provide confidential personal information to enable contact for possible future training.
3. I agree to the subsequent publication of workshop photographs that might identify me to others.

Name	Village	Signature	Date

Gender and Youth Sub-Project Leader
Barbara Chambers

Signature
Date:

Appendix 3: Workshop Daily Program

7:45 am - 8:15am	Breakfast
Monday 26th September	Welcome note - PAU Vice Chancellor
8:30 am- 10:00am	**Session One** Introductions Expectations of the Workshop Overview and Objectives of the Program
10:00am - 10:15am	Tea Break
10:15 - 12noon	**Session Two** Training Needs Assessment in Small Village Based Groups Putting Results on Butchers' Paper
12:00noon -1.00 pm	Lunch
1.00pm - 2:00pm	**Session Three** Reviewing Small Group Work Displayed on Walls: What are the similarities and differences between groups? Using Post-It Notes, could you add ideas for overcoming these obstacles?
2:00pm - 2:15pm	Tea Break
2:15pm - 4pm	**Session Four** Small Group Work on Dreams for the Future: Mixed Villagers including a Youth Group Sharing those dreams in the large group
4pm	End of Day one sessions

7pm - 8:30 pm - Dinner (PAU Dining Hall)

Tuesday 27th September	
7:45 am to 8:15am	Breakfast
8:30 am— 10:00am	**Session One**

Making Judgements about Training Priorities in Rigo-Koiari and Bautama in

a) Horticulture
b) Marketing
c) Business

<u>for</u>

i. Women
ii. Youth

(Using 12 gold and 12 silver stars: 6 each for women and youth in each of the areas of horticulture, marketing and business)

10:00am—10:15am Tea Break

10:15—12noon **Session Two**

Developing an Action Plan about

i. Who might conduct training in a) Horticulture
   b) Marketing
   c) Business

ii. Who should be trained first – older women, younger women and why.

iii. Group Action Plans should be written on butchers' paper and stuck on the wall for everyone to read

12:00 noon—1.00pm Lunch

1.00pm—2:00pm **Session Three**

Facilitator reviews with the group each Action Plan and looks for agreement and disagreement.

2:00pm—2:15pm Tea Break

2:15pm—3pm **Session Four**

Evaluation of Workshop in small groups.

Report to large group about whether the workshop

a) Met most of your expectations
b) Exceeded most of your expectations
c) Failed to meet most of your expectations

3pm End of Day Two sessions

Thank You from the ACIAR Team:

Professor Barbara Chambers, Workshop Facilitator

Dr Lalen Simeon Dr Gomathy Palaniappan Ms Roselyn Winston

Ms Poela Utama Ms Shirley Hopa Ms Philmah Seta-Waken Mr Gus Maino

Appendix 4: Guidelines for Table facilitators for Training Needs Assessment Recording

From which village is this group? ________________________________
What is the age range of group members? _________________________
Name of Table facilitator: _______________________________________

Horticultural Jobs Very Hard to do (List)	Why? What obstacles get in your way?	What resources do you have that would make the job easier to do?	What other resources do you need to make the job easier to do?
Horticultural Jobs Quite Difficult to do (List)	Why? What obstacles get in your way?	What resources do you have that would make the job easier to do?	What other resources do you need to make the job easier to do?
Horticultural Jobs Easy to do (List)	Why? What obstacles if any get in your way?	What resources do you have that would make the job even easier to do?	What other resources do you need to make the job even easier to do?

Appendix 5: Personal Information Sheet of participants at the Women and their Daughters in Horticulture workshop

We appreciate your cooperation in providing this information. This information cannot be attributed to any single individual.

This information would enable us to design possible future training programs.

Initials of facilitator							
Name of Village	Age 14-21 22-29 30-37 38+	Education Primary Middle High Tertiary	Number of members in their family	Any previous training (Yes/No)	Actively involved in horticulture (Yes/No)	Member of any women's agricultural organizations or association (If yes please name)	Actively involved in developing your community (Please give example)
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							

UNIVERSITY OF TASMANIA

TASMANIAN INSTITUTE OF AGRICULTURE

ACIAR Project: SMCN/2008/008

Increasing Vegetable Production in Central Province, Papua New Guinea to Supply Port Moresby Markets

Trip Report for 11th to 17th March 2012

by

Colin Birch, Laurie Bonney, Leigh Sparrow and Barbara Chambers

19th April 2011

ACIAR Project: SMCN/2008/008

Increasing Vegetable Production in Central Province, Papua New Guinea to Supply Port Moresby Markets

Tasmanian Institute of Agriculture

Trip Report for 11th to 18th March 2012

by

Colin Birch[1], Laurie Bonney[2], Leigh Sparrow[3] and Barbara Chambers[4]

[1] Tasmanian Institute of Agriculture, University of Tasmania, Burnie, Tasmania.

[2] Tasmanian Institute of Agriculture, University of Tasmania, Hobart, Tasmania.

[3] Tasmanian Institute of Agriculture, University of Tasmania, Launceston, Tasmania.

[4] University of Canberra, Canberra, ACT

1. Abstract

This report provides information on a visit to PNG from 11th to 17th March 2012, in which TIA and University of Canberra staff undertook project review and planning meeting at National Agricultural Research Institute (NARI), Laloki Research Station (13th and 14th March) in association with project partners in PNG, participated in a Project Showcase (14th March 2012), also at NARI Laloki, and conducted liaison meetings with representatives of partners (13th, 15th and 16th March). Specific purpose meetings were also held in relation to planning of training of women, project operational matters and potential training opportunities for staff (15th and 16th March 2012).

In the review and planning meeting partners presented reports on successes, challenges and outcomes from project work to date, a workshop was undertaken to identify solutions to challenges that were identified followed by a workshop to plan activities in 2012. Staff from PNG partners were heavily involved in the presentation of the review and planning meeting, through presentations, Chairing of sessions and Chairing the Showcase.

The Showcase presented posters from project activities and associated research work in PNG funded from other sources. These were prepared and presented by staff of TIA and PNG partners. The Showcase was attended by project staff, and some other staff of project partners, a group of farmers from the coastal lowlands and a group from Sogeri.

2. Introduction

A visit to PNG by Colin Birch, Laurie Bonney, Leigh Sparrow and Barbara Chambers was undertaken to:

(iii) Liaise with PNG partners in the project on operational, financial, management and training aspects of the project;
(iv) In conjunction with PNG partners, carry out a mid-project review and planning meeting;
(v) In conjunction with PNG partners, plan activities for 2012 (also understanding that travel to PNG may not be possible during the election period of 2012);
(vi) In conjunction with PNG partners, plan for Women's training;
(vii) Start the process leading the mid –project review required by ACIAR, scheduled for October – November 2012; and
(viii) Participate in presentation of a 'Showcase' on the project and associated activities.

The trip was divided into several components as follows

(iii) Administrative and Coordination Activities

Visit to Central Province Administration, Port Moresby and Fresh Produce Development Agency (FPDA), Port Moresby Office – 12th March - Colin Birch and Laurie Bonney

Visit to Pacific Adventist University, 15th March – Colin Birch and Leigh Sparrow

Liaison with project partners – by Colin Birch, Laurie Bonney, Leigh Sparrow (TIA) and Barbara Chambers (University of Canberra) during the visit.

(iv) Mid - Project Planning and Review Meeting (13th and 14th March)

This was held at NARI, Laloki, and attended by operational and management staff of project partners, NARI, FPDA, PAU and Central Province Administration, Emily Flowers and Rebecca Bogosia (ACIAR), Colin Birch, Laurie Bonney, Leigh Sparrow (TIA) and Barbara Chambers (University of Canberra). Also, Dr Sergei Bang and Dr Sim Sar, both senior staff from NARI Head Office (Lae) also attended

(v) Showcase

This was held on the afternoon of the second day of the mid – project planning and review meeting

(vi) Planning of Women's training

This was conducted by Barbara Chambers, with Poela Utama (FPDA), Ros Winston and Philma Seton-Waken (NARI and Lalen Simeon (PAU) on 15th and 16th March (see Appendix 3)

3. Scope of Report

This report consists largely of documents prepared for the planning and review meeting, records of specific sessions of that meeting and a report on the women's training planning meeting conducted by Prof. Barbara Chambers and colleagues from Fresh Produce Development Agency and Pacific Adventist University. These documents are provided as attachments or appendices.

3.1 Administrative and Coordination activities

These were undertaken to maintain communication and committment among project partners, and with few exceptions were basically routine liaison, The exceptions were:

(i) a meeting with Central Province Administration in an attempt to finalise much delayed documents (this remains pending and advice on when it will be available has been sought);

(ii) meeting with FPDA Port Moresby staff, as one of our previous participants there, Michael Atuai, who was a major player in the Value Chain work and of considerable assistance to the trial program and in local coordination, was transferred to Mt Hagen. His replacement, Mr Pus Weisis (ex NARI) had only just taken up duties, so we met with him for project familiarisation and to assist him with understanding of FPDA involvement and commitments; and

(iii) meetings with the acting Dean of Science and Japhet Nivi, PAU regarding Japhet's potential PhD enrolment and means of funding it, and potential supervisors in PNG, if the PhD studies proceeded in PNG.

We also attended a retirement function for Professor Udai Pal, NARI, Laloki, and would like to record here our appreciation for Prof Pal's energetic support for the project.

3.2 Project Review and Planning Meeting

a. *Project review*

Partner organisations provided presentations on Achievements, Outcomes and Challenges of the project to date, either in writing and orally or orally only. Where available in writing, these are included in a Booklet prepared prior to the meeting (Attachment 1, pages 6 to 28), others were presented orally and notes recorded. Included among these were extra details of the outcomes of a workshop on Women and their Daughters in Horticulture (Attachment 1, pages 19-23).

Mr Pus Weisis, newly appointed to Port Moresby office of FPDA presented an oral report on behalf of FPDA, and concentrated on project implementation (suggesting extension to the project duration due to lateness of start), crops and cultivars used, staff availability and staff training, commercial viability of crops used, and access constraints, especially to Tapini. The review highlighted challenges which were addressed in planning 2012 activities.

A workshop was conducted to identify what had progressed well and where constraints existed. From the latter, strategies were developed for implementation during 2012 to ensure, as far as practicable, that the constraints were mitigated.

b Planning for 2012 Activities

A planning workshop was held to agree to activities to be undertaken during 2012, to effectively implement the project plan, as approved. Records of discussions and outcomes from this workshop are contained in Attachment 2A, with a GANTT chart of Activities included in Attachment 2B. Attachment 2A cross references to Attachment 2B

3.3 Showcase

Project partners and staff provided posters for the showcase, which was held at NARI Laloki. Most posters are included in Attachment 1 (pages 29 to 43), though these were supplemented by posters on associated projects being conducted by NARI. Despite inclement weather, the Showcase was a success, with attendance of farmers from the coastal lowlands and Sogeri, including a group of women farmers. Posters were presented orally by their authors to an attentive audience.

3.4 ***Integrated Action Research Team on Women and Youth (NARI, FPDA, PAU) Meeting***

This meeting was held at FPDA Port Moresby on 15th March. The purposes of meeting were:

(i) To provide collaborative prioritised training to women farmers in Rigo-Koiari and Bautama in a timely and rigorous manner
(ii) To meet with the Women's Workshop Steering Committee on a regular basis to plan and implement priority training

The meeting produced an action plan for training, which is described in the minutes of the meeting (Attachment 3), including the first meeting of the Steering Committee on 16th March.

Attachment 1

SMCN/2008/008 Increasing vegetable production in Central Province, PNG for Port Moresby markets

Project Meeting

NARI Southern Region Centre, Laloki

Mid Project Review and Planning Meeting

Proceedings Booklet

Proceedings of Project Meeting - Increasing vegetable production in Central Province, PNG, for Port Moresby Markets

13th March 2012 and 14th March 2012

NARI, Laloki Research Station, Laloki, Papua New Guinea

Edited by C. J. Birch

Forward

The ACIAR funded project, ***SMCN/2008/008 Increasing vegetable production in Central Province, PNG, for Port Moresby Markets*** commenced in 2010 and consists of a number of aspects, including Value Chain Analysis, Land Capability Assessment, Field experimentation at a number of sites in Central Province of Papua New Guinea, Socio-Economic Research and Extension activities. The balance among these varies during the conduct of the project, scheduled for 4 years. The project is a collaborative endeavour involving the Tasmanian Institute of Agriculture, as the lead agency and University of Canberra in Australia and National Agricultural Research Institute (NARI), Fresh Produce Development Agency (FPDA), Central Province Administration (CPA), Pacific Adventist University(PAU) and Greenfresh Limited (GF) in Papua New Guinea. The project is funded by the Australian Centre for International Agricultural Research (ACIAR), with some liaison also provided by AusAID.

There have been a number of meetings of project participants during the planning and early implementation stages. As the project approaches its mid – point when a mid project review is required, it is timely for project participants to meet and review progress to date and plan for the coming years activities.

This booklet has been prepared as a record of progress to date and to provide insights to help planning the 2012 activities and the mid – project review scheduled for later in 2012. As the lead agency, TIA looks forward to our ongoing partnership to produce outcomes for Papua New Guinea.

Associate Professor Colin Birch

Project Leader.

3/3/12

Tasmanian Institute of Agriculture,
University of Tasmania,
Sandy Bay, Hobart, Tasmania

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AGENDA

IN COUNTRY MEETING

SMCN/2008/008 Increasing vegetable production in Central Province, PNG, for Port Moresby Markets

DATE 13th March 2012 and 14th March 2012

VENUE NARI, Laloki Research Station

Meeting Chair Colin Birch

Day 1

9.30 am – 10.15am

1.	Welcome and Introduction	Colin Birch
2.	Opening	Dr Sim Sar or Dr Sergei Bang
3.	Objectives of Meeting	Colin Birch

10.15am – 10.40am

4.	ACIAR Presentation	Emily Flowers

10.40am – 11.00am Morning Tea

11.00am – 12. 40pm

5. Review of 2010-2012 – Achievements, Outcomes and Challenges Session
Session Chair – Dr. Udai Pal

- NARI — Philmah Seta-Waken/Dickson Benny
- FPDA — FPDA
- PAU — Japhet Nivi
- Greenfresh — Erna Momo
- Central Province — Felix Gitai

12.40 – 1.30 pm Lunch

1.30 – 2.30pm

6. Review of 2010-2012 – Achievements, Outcomes and Challenges
Session Chair: Robert Lutulele, FPDA

- ‘Families Together’ for Economic and Social development — Barbara Chambers
- The TIA perspective — Colin Birch

7. Summary of Review Sessions and Discussion Leigh Sparrow
Session Chair: Colin Birch

2.30 – 3.15pm

8. Operational Aspects – What has been done well and what can be done better (workshop format) Session Chair/Facilitator: Laurie Bonney

3.15 – 3.30 pm Afternoon Tea

3.30 – 4.45 pm

9. Financial Aspects – How to make the most of our money (workshop format)
Session Chair/Facilitator. Lalen Simeon

10. Staff Development and Capacity Building Chair Barbara Chambers
- Opportunities, Funding and Applications Leigh Sparrow
- Publications – Journals, Conferences, Newsletters, Extension articles Colin Birch

Day 2

9.30 am to 11.00am

11. Planning for 2012 activities and implementation (workshop format)

Session Chair/Facilitator Colin Birch

11.00-11.15 Morning Tea

11.15 am – 1.00pm

12. Planning for Mid – Project Review Session Chair Colin Birch
- Review – its aims, objectives an process Colin Birch
- Next steps incl. allocation of tasks Facilitated by Colin Birch

1.00 – 2.00pm Lunch

2.00 – end of day

Showcase of Projects/Activities, including Public Session on Vegetable project.
Location: Carpenters Shed, NARI, Laloki Chair: Dr Sim Sar

OBJECTIVES OF THE MEETING

The objectives of the meeting are:

(i) to review achievements and outcomes during 2010 and 2011

(ii) to identify challenges and constraints that have been encountered

(iii) to consider ways to overcome challenges and constraints to operate effectively and efficiently

(iv) to identify opportunities for staff development and capacity building

(v) to plan for project implementation during 2012-03-03

(vi) to plan for the mid – project review

Report by National Agricultural Research Institute, Laloki Research Station
On
Increasing vegetable production in Central Province, Papua New Guinea to supply Port Moresby Markets

NARI Staff

2011 Outcomes, achievements and challenges

Introduction

The following are a summary/outline of the outcomes, challenges, achievements and recommendations of the Agronomic trials conducted in three altitudinal sites, Laloki (low land), Sogeri (mid altitude) and Tapini (high altitude) undertaken by NARI Southern Regional Centre Laloki.

Outcomes

1.6. *Agronomic trials at Laloki*

4.1.19 Variety evaluation trial

Tomato

- Six entries - Money Maker, Spring Shine, Tough Boy, Tropic Boy, Grosse Lisse and Roma were evaluated in 2011. All seeds were purchased at Brian Bell & Co Ltd, Port Moresby.

- Observations on days to emergence, flowering, fruit set and harvest were recorded. In addition, observations on vegetative growth and adaption, reproductive adaptation, fruit characteristics of each entry and fresh fruit yields were also recorded.

- Tropic Boy and Spring Shine were the earliest in terms of maturity, while Roma and Money Maker were the latest maturing varieties.

- Tropic Boy produced highest fresh fruit yield (9808 Kg/ha), followed by Roma (7033 kg/ha), Spring Shine (6783 kg/ha), Money Maker (6609 kg/ha), Grosse Lisse (6359 kg/ha) and Tough Boy (5569 kg/ha)

- Spring Shine was the most affected by pests and diseases, Roma and Grosse Lisse were mostly affected by blossom end rot.

- Nonetheless, all entries were affected by common tomato pests (army worm, tomato fruit worm and leaf miner) and diseases (black leaf mould, late blight, damping off).

Sweet pepper (Capsicum)

- Six entries - Giant Bell, Yolo Wonder, California Wonder, SRC-CF 4, SRC-CF 5 and SRC-CF 6 were evaluated in 2011.

- Three entries (Giant Bell, Yolo Wonder and California Wonder) are hybrids and were purchased from Brian Bell & Co. Seeds of entries SRC-CF 4, 5 and 6 were obtained from AVRDC World Vegetable Centre and multiplied at SRC. Entries SRC-CF 4, 5 and 6 are open pollinated varieties.

- Observations on days to emergence, flowering, fruit set and harvest were recorded. In addition, observations on vegetative growth and adaptation, reproductive adaptation, fruit characteristics of each entry and fresh fruit yields were also recorded

- Entries Giant Bell, California Wonder, SRC-CF 4, 5 and 6 were the early maturing varieties while Yolo Wonder was the late maturing.

- Highest yielding variety appeared to be SRC-CF 5 (8641 kg/ha), while California Wonder (4936 kg/ha). Other varieties produced intermediate yields and were comparable with each other (Giant Bell -8021 kg/ha, SRC-CF 6 -7527 kg/ ha, Yolo Wonder -7218 kg/ha, SRC-CF 4 -6170 kg/ha).

- California Wonder was the variety severely affected by pests and diseases while other varieties experienced little or moderate infestation.

- None the less, in all entries, common sweet pepper pests (army worm, leaf minor, fruit fly) and diseases (bacterial wilt and black leaf moulds).

French bean

- Six entries - Contender, Bountiful Butter, Gourmet's Delight, Early Long Pod (Broad bean), Stringless Blue Lake and Dwarf Stringless were planted for evaluation but entries Early Long Pod (Broad bean) and Stringless Blue Lake did not germinate.

- Observations were recorded on days to emergence, flowering, pod setting, nodulation, pest and disease infestation and harvesting.

- The entries evaluated were Contender, Bountiful Butter, Gourmet's Delight and Dwarf Stringless.

- Contender was found to be the most promising out of the four that did well in terms of yield (20.89 t/ha) out of three harvests, pests & disease incidence and vegetative adaption.

- All other three entries; Gourmet's Delight, Bountiful Butter and Dwarf stringless produced yields ranging from 1481- 2637 kg/ha.

- Insect (aphids) and disease (rusts) incidence were found to be very high in these three entries compared to Contender.

Systems Trial

- Production Systems Trial (1) Low input system based on traditional farmer's practice (2) Improved practice system based on based on modified, improved technologies; and (3) high input system based on commercialized farmers' practice" was conducted to determine which production system farmers in the Central Province can adapt to use in their farming practices.

- Tomato crop, *Money Maker* variety was used as test variety for the Laloki site.

- Treatments of Production System 1 included irrigation as or when needed. Land preparation was done by slash and burn and manually ploughed, Pests and disease were controlled by application of wood ash and manually removing pests on plants, weeding was done manually and soil fertility was maintained by mulching and application of goat manure for low input production system.

- Treatments of Production System 2 were: land preparation was done by tractor ploughing, harrowing and rotor-tilling; PDP (chilli and soap) was applied as pest control. Weeding was also done manually. Surface drip irrigation was applied to the improved systems. Soil fertility was maintained by mulching and applying NPK at a rate of 200 kg/ha.

- Treatments of Production System 3 were: land preparation was also done by tractor ploughing, harrowing and rotor-tilling. Commercialised pesticides were used as pest control in high input system. No mulching was applied, NPK was applied for soil fertility management and surface drip irrigation was applied.

- Observations were recorded for days to emergence; flowering, fruit set and harvest were recorded. In addition, observations on vegetative growth and adaptation, reproductive adaptation, fruit characteristics of each entry and fresh fruit yields were also recorded.

- Yield levels in three systems were low and almost comparable with each other; most likely because faulty/interruptions in drip irrigation system.

- High input system showed a low rate of pests & disease incidence, followed by the improved system.

1.7. *Agronomic trials at Sogeri*

4.1.20 Variety evaluation trial

Tomato

- None of the varieties of tomatoes planted in Sogeri even reached maturity in 2011. No results are presented because of this reason.

Sweet pepper (Capsicum)

- Four entries - Giant Bell, Yolo Wonder, California Wonder and Yellow were evaluated at Sogeri as seeds of SRC CF 4, 5, 6 were insufficient.
- All four entries are hybrids and were purchased from Brian Bell & Co.
- Observations on days to emergence, flowering, fruit set and harvest were recorded. In addition, observations on vegetative growth and adaption, reproductive adaptation, fruit characteristics of each entry and frsh fruit yields were also recorded.
- Yellow and California Wonder were the first to flower and were early maturing , whereas Giant Bell and Yellow were late maturing.
- Fresh Fruit yields of Giant Bell (6790 kg/ha), Yellow (6663 kg/ha) and Yolo Wonder (6416 kg/ha) were comparable and higher than that of California Wonder (5491 kg/ha).
- California Wonder was the severely affected by pests and diseases and had the lowest rate of survival at last harvest.
- None the less, in all entries, common sweet pepper pests and diseases were found.

4.1.21

Broccoli

- None of the varieties of broccoli produced marketable heads this year. Thus no results are presented because of the very poor quality.

4.1.22

Systems trial

- The test variety grown for the system trial at Sogeri was the *Marathon* variety of broccoli. Similar to the broccoli evaluation trial, *Marathon* variety did not form head hence no results are presented because of the very poor quality.

4.1.23 Tapini

Cabbage evaluation trials

- Six entries of English cabbage; Racer Drumhead, Eureka, Copenhagen Market, KY Cross, KK Cross and Tropical Delight have been planted in early February.
- Seedlings have also been pricked and are yet to be transplanted in late February.

Broccoli

- Five entries of broccoli- Shogun, Summer King, Southern Comet, Southern Star and Marathon have been sowed in early February.
- Like the cabbage entries, they have also been pricked and are yet to be transplanted.

- Transplanting will be done in late February.

Carrots

- There six entries for the carrot trial this year.
- Entries are Manchester Table, Chantenay red cored, Kuroda, New Kuroda, Improved Kuroda and Top Weight.
- As soon as cabbage and broccoli trials are transplanted, carrot entries will also be direct seeded.

Achievements

- Recruitment of Jr. Agronomist/Breeder and Ag. Economist in the Project
- Procurement of two computers, colour printer, multi-media project, and drip irrigation system.
- Jr Agronomist/Breeder had training on vegetable production at AVRDC Regional Centre in Bangkok
- Varietal evaluation trials of tomato, capsicum and beans at Laloki and of tomato, capsicum and broccoli at Sogeri have been accomplished in 2011; though varietal trial on broccoli and tomato failed due to high temperature and flooding causing high water table, respectively.
- System trial on tomato at Laloki and on broccoli at Sogeri conducted but Sogeri trial faild due to high temperature and water logging.
- Vegetable Production cost survey accomplished.
- Drip irrigation mounted at Laloki & Sogeri.
- First season planting of variety evaluation trial at Tapini 2012.
- Hosting of mini-field day on the theme “Produce and saving your own vegetable seeds for sustainability and improved livelihood.”

Workshops, meetings, surveys and training

The following are a list of the workshops, surveys and trainings accomplished by NARI SRC staff involved in ACIAR Vegetable Project.

1. Value Chain Management Workshop – February 2011
2. Questionnaire development for Women and Youth workshop – February 2011
3. Women and Youth in Vegetable Farming survey – February 2012
4. Western Pacific NARI, EU ACP Training on Constraints, Opportunities and Potential in crop development – July 2011
5. 30th International Vegetable Training Course, AVRDC SEA, Thailand – September – October 2011.
6. Value Chain Production Cost Survey – November 2011

Challenges

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- Logistics support by DA and DPI officers for Tapini trials.
- Risky travelling to Tapini on the existing road conditions.
- Lodging/accommodation at Tapini site
- Relatively high temperature, flooding and high water table at Sogeri site. Need to relocate site at Sogeri.
- Vandalism at Sogeri.
- Unpredictable weather

Recommendations

The following are recommendations from first planting season experience.

1. Relocate site for to another area within Sogeri if the trial is to be continued at Sogeri due to the soil type of the current site and frequent vandalism.
2. Conduct mid altitude (about 600m.a.s) vegetable evaluation trial in the Bakoidu area in the Hiri/Kairuku District if a new site for Sogeri is not found. The altitude is about the same as the Sogeri site.
3. Need to repeat all variety evaluation and system trials both at Laloki and Sogeri
4. Training on vegetable breeding techniques to Jr. Agronomist/Breeder and value chain analysis & management for Junior Economist.

Increasing vegetable production in Central Province, Papua New Guinea to supply Port Moresby Markets – Report on Achievements, Outcomes and Challenges – 2010 2012 – FPDA Report

This will be an oral presentation

Agronomic Evaluations for Growth and Yield of selected vegetable crops in Central Province, Papua New Guinea at Pacific Adventist University

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Burnie (7320) Australia

Key words: Vegetable production, Crop yield and Quality

Introduction

Vegetable crops have a significant potential to help alleviate economic dependence, poverty and improve food security for the target 70-80% of the population in the rural areas of Papua New Guinea (PNG). However, to produce better quality and quantity of vegetable crops to improve the standard of living, there has be better agronomic trials on the evaluation of selected vegetable crop varieties for local farmers and small holder farmers.

In addition, agronomic evaluation of vegetable crops deserves research attention to improve vegetable production in the Central Province to supply PoM markets. Therefore, this research was conducted to investigate the potential of selected vegetable crops particularly, Tomato, capsicum and French bean cultivars at Pacific Adventist University farm around June-October, 2011.

Objective

The main objective of the study was to evaluate tomato, capsicum and French vars. for growth and yield performances and investigate the tolerance of the vegetable vars. against local insect pests in dry lowlands conditions, PAU.

Achievements

Experimental research had progressed significantly. Data from these investigations were collected and analysed for further write up. The field experimental results showed significant differences ($p<0.05$, LSD) on the growth and yield parameters on the three selected vegetable crops. Further evaluations have been done on scoring the crop damages by insect pests on the specific vegetable crops.

Furthermore, all the financial costs for the project have been taken care of by the research arm of the University.

Outcomes to date

Pacific Adventist University experimental data has been collected on investigating the plant growth and yield parameters of the selected vegetable crops i.e. *Tomato, Capsicum and French bean* vars., and the data are statistically analysed using Statistix software version 8.0 at $p<0.05$,LSD. From this, vars. to improve performances for vegetable production have been identified. Research has identified knowledge, skill, finance and infrastructure constraints improve the research. The collaboration between PAU and TIAR team has been exceptionally well established.

Challenges

The progress of the project was constraints by lack of facilities, equipment and research assistance for analysis. Furthermore, the investigating of vegetable varieties against local pests needs thorough research attention this year, 2012-2013 in PAU ACIAR partner project.

Acknowledgements

We would like to thank the UTAS and TIAR ACIAR research team for the financial support and advice.

Free Mail Bag Service
Port Moresby, NCD

Increasing vegetable production in Central Province, Papua New Guinea to supply Port Moresby Markets – Report on Achievements, Outcomes and Challenges – 2010 2012 Central Province report of three sites: - achievements, outcomes, challenges & way forward

F. Gitai and staff

Central Province Administration, Port Moresby, National Capital District

This is the report from Central Province Administration Agriculture Division on the three ACIAR activities in the Goilala, Rigo and Hiri districts.

1. Site 1: Rigo Inland (Londairi, Geresi and Girabu villages)

ACIAR Component: Supply Chain

1.1 Outcomes

- No yield data for the tomato and capsicum
- No harvests were made for tomato and capsicum, vegetables died during growth stages
- French beans harvests were made (2.5 harvests)
- No transport provided as agreed by ACIAR or NARI or Green Fresh

1.2 Challenges

- Less to no opportunity for information sharing between PDAL/DDAL/NARI/Green Fresh for various reasons
- Trialed vegetables (only French beans) sold to PAU, not Green Fresh Ltd
- District Agriculture staff were working in isolation with farmers in the 3 selected villages
- Data generated is insufficient and therefore cannot be guaranteed of accuracy
- Villagers were surprised to used vegetables not previously tried in the area by farmers themselves

1.3 *Way forward/next steps*

Rigo is by far the best performing district in Central, in agriculture activities. Data to verify this is not quantitative however, there are strong indications from participations by co-operatives, associations, groups and individuals to suggest this. The supply chain therefore is absolutely necessary to be understood by practitioners, administrators and the general public. Central's thoughts about the way forward are:

- District staff to be trained in basic research skills
- Rerun the supply chain study as it could help the local practitioners plan their activities
- District Agriculture staff to provide technical assistance consistently
- Varieties to be changed
- Transport to be provided by District Agriculture division

2. Site 2: Tapini, Goilala District

ACIAR Component: Nursery Establishment + Yield Trial

2.1 Outcomes

- No germination data for the 1st nursery establishment. Error ridden
- Successful germination data from re-run nursery. Meeting with NARI paving way for careful re-establishment of nursery
- Basic nursery management processes followed
- Re-run nursery was successfully.
- Trial plots underway for yield data

2.2 Challenges

- Limited opportunity for information sharing/progress updating between PDAL/DDAL/NARI
- In house HR matters-changes in Central staff affecting the participation of Central Agriculture
- Needed/still needing to appoint a responsible officer to step in after resignation of the previous appointee
- Need for research up-skilling of district staff-normal nursery establishment processes not followed
- Needed daily up-keeping and monitoring of nursery
- Funding availability was due to AAP not completed-DAL Advisor was a new appointee to head the division
- Non presence of DAL staff on site to provide daily monitoring of trials.

2.3 Way forward/next steps

- District agriculture staff to be provided with basic research skills (training required urgently)
- District agriculture staff to provide technical assistance on daily/weekly basis
- Implements/equipment to be made readily available for use
- Experiment to applied to other vegetables by DAL and NARI

3. Site 3: Sogeri National High, Hiri District

ACIAR Component

3.1 Outcomes

- Nil participation from Central Administration Agriculture division's Hiri district staff

3.2 Challenges

- Need for information sharing between PDAL/DDAL/NARI for Sogeri High School yield trial
- Provision for supervision of daily plot management/upkeeps by locals living near Sogeri school
- Need to educate/train local assistants who were not skilled-possibility of mistakes being made. One of the questions we would like to ask is whether transport of nutrients (exportation) in weeds during weeding from the trial plots is a point worth considering for this (yield) trial. If so, were the casual staff informed and guided well?

3.3 Way forward/next steps

- District Agriculture staff to provide technical assistance consistently
- Central Administration to carry out daily/weekly monitoring of trial plots
- Central Administration to take care of casual staff
- District and HQ staff to be trained with basic research skills

Increasing vegetable production in Central Province, Papua New Guinea to supply Port Moresby Markets – Report on Achievements, Outcomes and Challenges – 2010 2012 – Greenfresh Limited

This will be an oral presentation

Increasing vegetable production in Central Province, Papua New Guinea to supply Port Moresby Markets –Achievements, Outcomes and Challenges – 2010 2012

'Families Together' for Economic and Social Development

Barbara Chambers, University of Canberra, Canberra, 2600, ACT.

Executive Summary

In February 2011, group interviews were carried out in the villages of Rigo-Koiari and Bautama with men and women to determine what crops they produced[11]. An appreciative inquiry (AI) technique was employed against a template of Rapid Value Chain Appraisal (RVCA). Villagers spoke about their crops, what they were proud of and what they hoped to do in the future. Out of this came a desire for horticultural, business and market training for women and girls, men and boys. Before this could happen, a training needs analysis had to be conducted and it was decided that a women's workshop should be held in September 2011 using a Collaborative Problem Solving Method (CPSM) that had been previously and successfully used in other ACIAR projects by Chambers in PNG, Vietnam and Cambodia. A pictorial training needs assessment was trialed because of the concern about possible low levels of literacy, especially amongst women, and that if a traditional pen and paper test was used, it would be time consuming and labor intensive because of the need to use Tok Pisin translators in the field. Criteria were developed to guide the selection of women, including a range of ages and willingness to share training with other women (and men).

The outcome was better than we had hoped with 29 women and their daughters from the villages of Rigo-Koiari and Bautama attending a two day consultative workshop. The context was how the livelihoods of families and villages can be enhanced by the training of women to participate more effectively in horticulture. Overwhelmingly, their training needs were identified as Farm Production (crop management and irrigation), Marketing (product readiness and negotiating price) and Business Skills (banking and book-keeping). A steering or communication group representing workshop participants was set-up to monitor the Action Plan on training priorities and which will be the key contact point for researchers and trainers for the 2012, at least. A meeting of the steering committee and the women's team in PNG will be chaired by Barbara Chambers later in the week. Planning will commence for another women's workshop for the village of Tapini. Laurie Bonney and Barbara Chambers will conduct a Men and their Sons workshop from the same villages by mid 2012, together with male staff from FPDA and PAU, using the same workshop methodology and pictorial training needs assessment.

Increasing vegetable production in Central Province, Papua New Guinea to supply Port Moresby Markets –Achievements, Outcomes and Challenges –

[11] Australian members of the team determined the framework and methods to be used including Laurie Bonney, Gomathy Palaniappan and Barbara Chambers. In addition to Australian team members, those PNG partner members involved with interviews and analysis were Lalen Simeon, Poela Utama, Roselyn Winston and other staff from FPDA and NARI.

2010 2012 – Rigo-Koiari and Bautama Women and their Daughters in Horticulture Workshop

Barbara Chambers[1] and Gomathy Palaniappan[2]

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[2] Tasmanian Institute of Agriculture, University of Tasmanai

1. Introduction

This is a brief report of a two day workshop for women and their daughters held at PAU 26 and 27 September 2011. The overall aim or purpose of the workshop is to identify the training needs of women and youth in horticulture in the central province of PNG. It will be followed by a similar workshop for men and their sons during 2012, after which the results will be combined and interpreted to give a sound basis on which, for example, training and development needs of agricultural, specifically vegetable producing, communities can be based.

2. Objectives

2.1 Divergence

(i) To discover what horticultural jobs women and youth find easy, more difficult and very hard to do.

(ii) To discover what gets in the way of doing the difficult and hard to do jobs and what resources might make those jobs easier.

(iii)To find out what dreams or ideas women and youth have for their futures.

(iv) To find out what needs to be done to make those dreams happen.

2.2 Convergence

(i) To prioritise the horticultural, marketing and business training needs for the villages of Rigo-Koiari and Bautama for:

i. Youth
ii. Women

(ii) To develop an Action Plan which will identify

(a) who might conduct training in:
  (i) Horticulture
  (ii) Marketing

(iii) Business and

(b) who should be trained first.

3. Results

These are presented in the following tables. They are self explanatory, and when combined with results of a men's workshop yet to be held will provide guidance to the training and development needs of communities that depend on agriculture, and specifically vegetables for their economic wellbeing.

Table 1. Ranking of tasks into 'Very Difficult', 'Quite Difficult' and 'Easy' by various groups of participants

	Very Difficult tasks	**Quite Difficult tasks**	**Easy tasks**
Group (Gomathy Palaniappan, table facilitator)	Soil Preparation (men's job) Irrigation Transport	Crop management (identification of pest and diseases is difficult) Marketing	Book Keeping Banking Packaging Planting Harvesting
*Group (Poela Utama, table facilitator)	Planting Crop management. (We know how to use chemicals. But the price is too high.) Book Keeping Banking Transport	Marketing	Irrigation Harvesting Packaging Soil Preparation
Japhet's group (Lalen Simeon, table facilitator)	Irrigation Marketing Transport Packaging	Soil Preparation Crop management Planting Harvesting	Book Keeping Banking
Group (Roselyn Winston, table facilitator) *Bautama Table. The other three tables were Rigo-Koiari)	H4 Crop management (Men attended training on application of chemicals and the knowledge was not transferred to us) B3 Transport M2 Packaging (appropriate packaging is very difficult as there is a need to take it to market at a longer distance)	B2 Book Keeping M1 Harvesting H3 Irrigation	H1 Soil Preparation H2 Planting B1 Banking M3 Marketing

Table 2 Dreams and How to Make it True

	Dreams	How to Make it True
Youth Group	➢ Improve Lives and support Church and Community ➢ To become small business women in agriculture ➢ Further education ➢ Be a broker/middle woman ➢ Have a home of my own ➢ Be financially secure	➢ Educate children ➢ Improve agricultural production through training program ➢ Improve technology (e.g. tractor, bank accounts) ➢ Mark farming more profitable ➢ Buying surplus produce and selling to market ➢ Making farming more profitable ➢ Invest for the future
Older Mother's group	➢ Education for their children to achieve the highest level and work ➢ Receive help from the children in future ➢ To have a good productive farm by owning a tractor, build a new house ➢ To improve transport and road maintenance ➢ To have full resources to run the farm ➢ To share knowledge with friends and family	➢ Maintain farm production, selling must be good to help pay for fees ➢ Despite hardship like bad transportation conditions, mother must still carry produce to sell, so child can get education ➢ I must commit my time to farming so I can harvest crops to sell everyday and money will come in everyday ➢ Co-operative must own a PMV and a tractor ➢ People maintain the road without government help ➢ Support the child good ➢ Keep sharing ideas
Older Mother's Group	➢ Vehicle ➢ Permanent House ➢ Education (school fees) ➢ Son to become a successful farmer ➢ Gain more knowledge in agriculture ➢ To have farming equipment (water pump, own tractor) ➢ Extension of farm ➢ To have a bank account	Overall strategies: ➢ Be a strong farmer ➢ Set your target ➢ Know book-keeping ➢ Have a farm plan ➢ From growing vegetables
Older Mother's Group	➢ Buy second-hand vehicle ➢ Buy tractor ➢ ➢ Buy water pump and build house ➢ Build semi-permanent dwellings ➢ Make trade store and educate her child ➢ Go overseas to learn ➢ Get a mobile phone ➢ Buy a spray can	➢ From farming ➢ From the profit of the trade store ➢ From farming ➢ From teaching ➢ From farming ➢ Call wholesalers for marketing ➢ From farming

Table 3 Training Needs Priorities by number of stars

WOMEN PARTICIPANTS	BAUTAMA	RIGO-KOIARI
Older mothers	Crop management (i)	Book keeping (i)
	Banking (ii)	Harvesting (ii)
	Irrigation (iii)	Soil preparation, crop management (iii)
	Planting (iv)	Irrigation (iv)
		Marketing (v)
		Packaging (vi)
Youth	Crop management (i)	Soil preparation, crop management , irrigation (i)
	Banking (ii)	Book keeping (ii)
	Planting, marketing (iii)	Irrigation (iii)
		Harvesting (iv)
		Packaging (v)
		Banking (vi)
		Marketing (vii)

Table 4 Priorities Training

Table Groups	Who should attend training first	Reason
1.	Older mothers	Mature women have grown up children and so they will have more time As they have some previous experience they will be able to learn faster compared to youth Youth get married and move out of the village so the learning will not be shared
2.	Youth/Young mothers	Youth should attend training first as they will be willing to change Youth have a higher literacy rate than older mothers and therefore will be able to learn more easily.
3.	Older mothers	Older mothers can share ideas and are not shy Older mothers can train others Youth are very shy to share ideas
4.	Mature women and Youth	Both can be trained together as a mixed group.

Increasing vegetable production in Central Province, Papua New Guinea to supply Port Moresby Markets - Achievements, Outcomes and Challenges - The TIA perspective

C. J. Birch

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1. Introduction

This project, which commenced in 2010 following a scoping study in 2009 consists of a number of components and activities. These can be broadly classified as Value Chain Analysis and Innovation, Land Resource Capability Assessment, Agronomic Field Experimentation, Socio – Economic Research, and Extension. The project proposal contained detailed specification of timelines, activities and outcomes for the duration of the project. This short paper will not attempt to examine each activity and outcome in detail, but rather take an overview of the project, considering achievements and outcomes to date, and record some of the challenges faced in the first two years of the project. These will be summarised using the areas of activity listed above. Substantial progress in a number of activities has occurred, in no small part due to the combined efforts of the project partners.

Publication of project findings is important to their availability to the scientific and economic community, farmers and other stakeholders. It is also important to capacity building and to recognise the contribution of partners in the project. Thus, TIA has had a policy of publishing and encouraging our partners to contribute to publications to recognise their input to the project and develop their skills in publication. This is reflected in authorship of a high proportion of publications that have come from the project to date, and we would like to see authors from our PNG partners take lead authorship on some papers as the project develops further. This paper provides a list of publications from the project, and links the achievements in each activity are to them as a key output.

The project received considerable recognition at the World Congress on Conservation Agriculture in Brisbane in September 2011, with 2 papers presented orally and 2 by poster, followed by 2 radio interviews, one broadcast in Australia only, the other the Pacific. This is important as it gave the project and PNG International exposure.

1.1 Achievements and Outcomes

1.1 (a)Value Chain Research and Innovation

Substantial understanding of the nature of the value chains, constraints to their effective functioning and ways to improve them have been identified and have been reported in several papers (eg. Boersma et al, 2011, Bonney et al 2011, Palaniappan et al 2011a,b,c, Palaniappan and Birch, 2011). It had been planned to initiate improved value chain functioning into Port Moresby in the 2011 dry season. However, this was not achieved and it will be necessary to address how this can be rectified in 2012 as part of this meeting.

1.1 (b) Land Resource Capability Assessment

The use of Geographic Information Systems (GIS) has provided insights into land resource availability in the areas of Central Province in which project activities are located. The efforts of Jimmy Maro, NARI, Lae and Matthew Dell, School of Geography, University of Tasmania are acknowledged, as without their assistance, the progress that has been made in describing land resources and using the information to locate potential production and thus trial sites that can provide vegetables into the value chain would have been less effective. A number of publications related to land resource assessment have been produced (Birch et al, 2011, Sparrow et al 2011 a, b, Birch et al, 2010, Doyle et al 2010).

1.1 (c) Agronomic Field Experimentation

This activity commenced in 2011, based on the earlier Value Chain Analyses and concurrent land resource assessment. Sites were located at Tapini, Laloki (NARI), Pacific Adventist University, Rigo-Koiari and Sogeri. Demonstration trials of temperate vegetables were intended for Tapini, Rigo-Koiari and Sogeri, with fully replicated experiments to compare varieties of a number of crops and systems of production (from low to high input systems) at NARI and PAU. The tow fully replicated experimental sites have provided very useful data that is now being analysed and will be used as the basis of future experimentation of a similar nature. However, only one crop (Beans at Rigo) has been harvested from the demonstration sites, though there is still the opportunity to gain some data from Tapini. Publications on opportunities and potential for vegetable production and on experimental processes have been produced (Boersma et al 2011, Sparrow et al 2011 a, b, Birch et al 2011, Birch et al 2010, Doyle et al 2010. Achievements to date are providing strong guidance to future activities and the basis for successful work that will then be able to be used in Extension activities and in designing improved Value Chains. The assistance of assistance of staff of FPDA and CP in identifying potential field sites, is acknowledged. FPDA staff provided important liaison with other partners and farmers/villages to facilitate work in Value Chains, Filed Experimentation and Socio Economic Research.

1.1 (d) Socio – Economic Research

There has been considerable activity in this area, which links closely to Value Chain Analysis and to an extent the other research areas. The level of commitment of partners in PNG and of participants in workshops conducted as part of this research is commendable – it shows a real desire to improve the socio-economic well being of participants, Importantly, a follow up workshop after this meeting will be held to gain the views of additional groups that have not been part of the detailed socio economic work undertaken to date. The resilience of communities and individual farmers has been identified as a key driver of future production and socio-economic wellbeing of farmers and their communities. As in other areas, the projects findings are being published progressively (Palanappian et al 2011 a, b, c).

1.1 (e) Extension

Extension activities have not been a major formal component of the project to date. However, much incidental extension occurs through meetings with farmer groups and individuals in the course of other work, and through the media. A mini-field day at NARI, Laloki, instigated by NARI, is acknowledged as an important initiative, supported by quality extension material. This activity has, no doubt added value to the project.

1.2. Challenges

It is fair to say that most of the challenges of implementation of the project have been identified by our partners in the report provided by them in the following pages. From a TIA perspective, this is actually a strong outcome, as it indicates close engagement with the project and commitment to it.

Nevertheless, TIA sees the major challenges as

- availability and continuity of staff with the necessary knowledge and skills
- operational capacity and operational support staff to service project sites remote from their base
- timing of experimentation in relation to seasonal conditions
- security of sites for field experiments
- availability of appropriate transport and storage facilities to maintain quality of produce from farmer to consumer
- financial capacity of chain participants and socio-economic constraints associated with family and community structures
- commitment of agencies and communities to continue from the interrupted implementation of value chain activities and further develop the value chains
- timeliness of invoicing.

Most of these have been identified in the publications referred to above and listed in Appendix 1. However, we see these as opportunities for the project meeting to suggest solutions that may be taken up within the project during the remainder of its duration and in subsequent projects that may emerge. The knowledge will also be useful to all partners in the long term and would also be useful to other agencies engaging in similar or related work.

Acknowledgements

The contributions of staff of our partners and external co-operators to achievements of the project to date are acknowledged. They are too numerous to acknowledge individually but TIA recognises, acknowledges and thanks everyone, as without this input, the progress and outputs of the project could not have been achieved. The financial contribution of ACIAR and the in-kind contributions of our partners is also acknowledged.

Appendix 1. Publications related to the project

Scholarly Journal Papers

Sparrow, L**.,** Birch, C., Boersma, M., Doyle, R., Bonney, L., Kambouo, R. and Kapal, D. 2011 The role of soil organic matter additions in viable, sustainable temperate vegetable value chains in Central Province, Papua New Guinea: a short review. Acta Horticulturae. (Submitted)

Refereed Conference Papers

Boersma M., Gracie A. J., Sparrow, L., Bonney, L., Doyle, R., Pal, U. and Birch , C. 2011. Agronomic research to support the development of vegetable value chains in Papua New Guinea. World Congress on Conservation Agriculture and Farming Systems Design Conference, Brisbane 26-30 September 2011.

Palaniappan, G., Chambers, B., Bonney, L., Simeon, L., Hopa, S. and Birch, C. 2011 Building social resilience through understanding capacities of smallholder farming in Papua New Guinea. World Congress on Conservation Agriculture and Farming Systems Design Conference, Brisbane 26-30 September 2011

Bonney L., Palaniappan, G., Sparrow, L., Boersma, M., Doyle, R. and Birch, C. 2011. Using value chain systems modelling to develop more sustainable cool temperate vegetable marketing systems in a transitional economy: a case study in PNG. World Congress on Conservation Agriculture and Farming Systems Design Conference, Brisbane 26-30 September 2011.

Birch, C , Sparrow, L, Woruba, M, Kapal, D, Maino, G, Kambouo , R, Bonney, L and Doyle, R 2011 Future vegetable farming in Papua New Guinea – responding to resource constraints and population in a developing country: a case study. World Congress on Conservation Agriculture and Farming Systems Design Conference, Brisbane 26-30 September 2011.

Sparrow, L., Birch, C., Boersma, M., Doyle, R., Bonney, L., Kambouo, R. and Kapal, D. 2011 The role of soil organic matter additions in viable, sustainable temperate vegetable value chains in Central Province, Papua New Guinea: a short review. International Symposium on Organic Matter Management and Compost Use in Horticulture, Adelaide, April 2011.

Birch, C. Sparrow, L., Doyle, R. and Bonney, L. 2010. Implications of soil resources for vegetable crop options and agronomic practice for sustainable production – a comparison of Eastern Highlands and central Provinces, Papua New Guinea. In Proceedings, 19th World Congress of Soil Science, Brisbane 1-6 August 2010.

Doyle, R. Bonney, L., Birch, C. and Sparrow, L. 2010. Increasing food security for Port Moresby, PNG – issues of land suitability, technology, tenure and tribalism. In Proceedings, 19th World Congress of Soil Science, Brisbane 1-6 August 2010.

Other Conference and Workshop Proceedings

Palaniappan, G, Chambers, B, Simeon, L. Bonney, L, Hopa, S, and Birch, C. 2011.Small Scale Vegetable Gardens to Local Markets – A Case Study from PNG. Page 45 in Conference

Handbook, Horticulture for the Future. APHC/AuSHS/NZIAHS Joint Conference, Lorne, Vic. 18-22 September 2011.

Birch, C. J., Doyle, R., Sparrow, L. and Bonney, L., Maro, J. and Atuai, M. 2011. Vegetable project to guide production under current and future climates. The National Climate Change Research Strategy for Primary Industries Inaugural Conference, Melbourne, 15-17th February 2011.

Palaniappan, G., Birch, C., Chambers, B. and Bonney, L. 2011 Strengthening local vegetable production in Papua New Guinea using value chain analysis. Farming Matters Magazine (online) http://www.agriculturesnetwork.org/magazines/global

Birch, C., Sparrow, L., Bonney, L. and Doyle, R. 2011. Increasing vegetable production in Central Province, Papua New Guinea (PNG) to supply Port Moresby markets. p37 in Scott, J. (Ed) Research Development and Extension in the Vegetable Centre: sustaining vegetable production in vegetable and allied industries in Tasmania., Proceedings of the 2011 Tasmanian Institute of Agricultural Research Vegetable Centre Industry Communication Forum, 14th July 2011, Longford, Tasmania. University of Tasmania, Hobart.

Palanappian, G., Bonney, L., Chambers, B. and Birch, C. 2011. Chain members perception of vegetable value chains in Papua New Guinea (PNG) p38 in Scott, J. (Ed) Research Development and Extension in the Vegetable Centre: sustaining vegetable production in vegetable and allied industries in Tasmania., Proceedings of the 2011 Tasmanian Institute of Agricultural Research Vegetable Centre Industry Communication Forum, 14th July 2011, Longford, Tasmania. University of Tasmania, Hobart

Press Articles, Interviews

Birch, C. J. 2012 Sowing the seeds of improved vegetable production in PNG. Research to Reality, University of Tasmania (in Press).

Birch, C. J. 2011 Media Interview – Radio Australia Pacific Beat PNG's Central Province aims to feed a booming capital. 27th September 2011 http://www.radioaustralia.net.au/pacbeat/201109/s3346276.htm

Birch, C. J. 2011 Interview– ABC Radio, Tasmanian Country Hour on 'Conservation Agriculture' and 'Vegetable Project in PNG' 27th September 2011. http://www.abc.net.au/rural/tas/content/2011/09/s3326935.htm

Palaniappan, G and Birch, C. J. 2011 Papua New Guinea, a stronger value chain. Farming Matters Magazine, The Netherlands.

POSTERS

In this section, posters presented at the meeting and in the Showcase that followed it are included.

Increasing Vegetable Production in Central Province, Papua New Guinea to Supply Port Moresby Markets

Project Leader: Colin Birch, TIA
Participants from TIA/UTAS, NARI, FPDA, PAU, Greenfresh, Central Province Government

Funded by ACIAR

Rigo-Bautama Cooperative farmers meeting with Colin Birch and Richard Doyle, August 2011

Why do the work?

- Population Increase
- Changes in population
- People want temperate vegetables in the market
- People want continuous supply
- Increase farm profitability and household income
- Improve profit to all involved
- Improve sustainability of production.

Japhet Nivi, Mark Boersma and Dickson Benny discussing vegetable trials at Sogeri, August 2011

Philmah Seta, Colin Birch, Dickson Benny and Richard Doyle at NARI, Laloki soil pit August 2011

What work is being done?

- Investigating the supply chain into Port Moresby from Central Province farming areas
- Research on social and economic factors that affect the performance of the value chain
- Assessing land and water resources
- Research on production systems
- Assessing crop varieties
- Research on soil management
  - soil carbon
  - soil erosion
- Research on agronomic practices
  - planting time, plant population, variety
  - water supplies and irrigation
  - soil fertility management

Where is the work being done?

- NARI, Laloki – varieties, irrigation, production system
- PAU – varieties, production system
- Sogeri – demonstration – varieties, production system, value chain
- Rigo-Koiari - demonstration – varieties, production system, value chain, social research
- Tapini - demonstration – varieties, production system, value chain
- All sites – land capability, soil resources, soil fertility, soil management, economic analysis

Part of cultivar and production system trial at PAU, August 2011

Part of variety, irrigation and production system trial at NARI, Laloki, August 2011

Soil and Land Suitability Analysis of key Vegetable Producing Village Cooperatives

Australian Government
Australian Centre for International Agricultural Research

Richard Doyle[A], Mathew Dell[B], Jimmy Maro[B], Colin Birch[A], and Leigh Sparrow[A]

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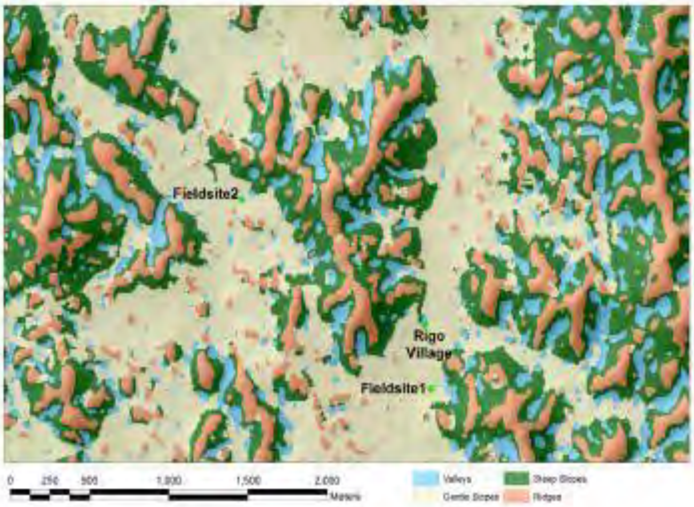
tia

Land suitability analysis has been undertaken for potential vegetable producing areas surrounding Port Moresby, PNG. We have used high resolution radar based imagery to produce 10 m resolution outputs. This will later be combined with an updated geology and soil information (layers) from PNGRIS and other map sources. This analysis will clearly identify areas most suitable for an intensification of agricultural production on a sustainable basis.

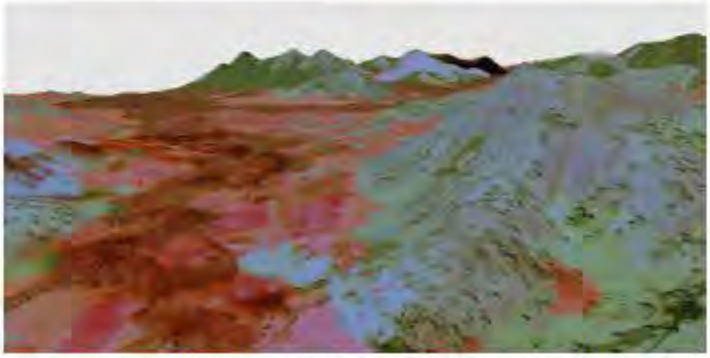
Discussions were held with local coop members on soil and crop management strategies.

Soil profiles are described and sampled for analysis at NARI laboratories in Port Moresby.

Soil profiles from the four trial sites located at A – Tapini, B – PAU, C – NARI Laloki, D – Sogeri



Land identified as suitable for agricultural production based on a lower slope topographic position and mafic rock types on gentle slopes (light yellow) of less than 10 degrees at the Rigo Study Site. Site was ground truthed with soil profile descriptions and inspection of erosion in current gardens.



The above image represents the gentle slopes as red colouring draped over the topography and a Google Earth satellite image – The houses of Rigo Village can be seen in the foreground and the adjacent field site as a red dot.

Increasing Vegetable Production in Central Province, PNG to Supply Port Moresby Markets - Value Chain Component

Project Leader: Colin Birch, TIA

Participants from TIA/UTAS, NARI, FPDA, PAU, Greenfresh, Central Province Government

Funded by ACIAR

tia TASMANIAN INSTITUTE OF AGRICULTURE

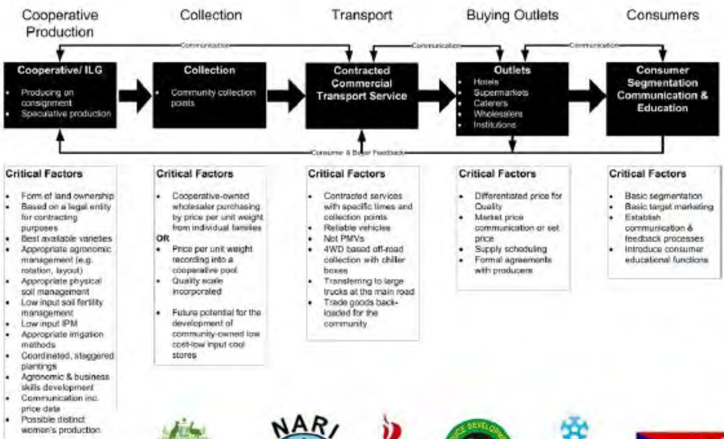
Why do the work?

Value Chain Analysis is needed to understand and overcome three fundamental limitations to the growth of the fresh vegetable industry:

- Lack of critical mass to supply distant and/or larger markets;
- Inability to regularly, consistently and reliably supply a specific market;
- Inability to meet basic quality requirements of formal market consumers.

What work is being done?

- Identified agricultural, logistical and social constraints on the supply of quality vegetables;
- Evaluated potential regions for establishing project value chains;
- Selected **Bautama, Rigo Koiari** and **Tapini** communities and possibly **Sogeri**;
- Mapped the chain, identify opportunities to establish improved value chains;
- Developed a Best Practice Marketing Model.
- Identifying training needs;
- Developing supply.



Australian Government
Australian Centre for International Agricultural Research
NARI
PAU
UNIVERSITY OF CANBERRA
AUSTRALIA'S CAPITAL UNIVERSITY
UNIVERSITY OF TASMANIA

ACIAR VEGETABLE PROJECT

SMCN/2008/008 Increasing vegetable production in Central Province, Papua New Guinea to supply Port Moresby Markets

FRENCH BEAN VARIETY EVALUATION TRIAL - LALOKI

Background

- Six entries were evaluated in August-October 2011: Early Long Pod, Contender, Gourmet's Delight, Dwarf Stringless, Bountiful Butter & Climbing Stringless.
- Data on vegetative & reproductive growth stages, pests & disease infestation and weekly harvest were recorded.

Objectives

- To determine which varieties of tomato perform well under low altitude conditions.

Output (first planting season)

Entry	Late/early maturing (DAP)*	Pest & disease infestation **		No. of pod/ plant	Pod shape	Pod size	Yield (kg/ha)
		Pest	Disease				
Contender	Early (70)	2	2	28	Slender	Small	2890
Gourmet's Delight	Early (73)	3	3	19	Slender	Small	2637
Dwarf Stringless	Late (75)	4	4	10	Short & slender	Small	1481
Bountiful Butter	Late (75)	4	4	6	Short & slender	Small	1481

* DAP = Days after planting

** pest & disease infestation rated on a scale of 1-5 (1- low to 5-highest)

Rust

ACIAR Vegetable Project Team, NARI Southern Regional Centre, Laloki, P O Box 1828 Port Moresby, National Capital District, PNG.
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ACIAR VEGETABLE PROJECT

SMCN/2008/008 Increasing vegetable production in Central Province, Papua New Guinea to supply Port Moresby Markets

TOMATO VARIETY EVALUATION TRIAL - LALOKI

Background

- Six entries were evaluated in August–November 2011: Tropic Boy, Roma, Spring Shine, Money Maker, Grosse Lisse and Tough Boy .
- Data on vegetative & reproductive growth stages, pests & disease infestation and weekly harvest were recorded .

Objectives

- To determine which varieties of tomato perform well under low altitude conditions.

Output (first planting season)

Entry	Late/early maturing (DAT)*	Pest & disease score **		Fruit shape	Fruit size	Fresh wt/fruit (kg)	Yield (kg/ha)
		Pest	Disease				
Tropic Boy	Early (75)	2	2	Deep Globe	Large	0.25	9808
Roma	Early (76)	3	3	Roma	Small	0.11	7033
Spring Shine	Early (75)	4	4	Deep Globe	Medium	0.15	6783
Money Maker	Late (77)	3	3	Deep Globe	Medium	0.19	6609
Grosse Lisse	Late (85)	3	3	Oblate	Large	0.23	6359
Tough Boy	Early (75)	3	3	Deep oblate	Large	0.24	5569

* DAT = Days after transplanting
** pest & disease infestation rated on a scale of 1-5 (1- low to 5-highest)

Tough Boy

Roma

Grosse Lisse

Tropic Boy

Spring Shine

Money Maker

ACIAR VEGETABLE PROJECT

SMCN/2008/008 Increasing vegetable production in Central Province, Papua New Guinea to supply Port Moresby Markets

SWEET PEPPER (CAPSICUM) VARIETY EVALUATION – LALOKI & SOGERI

Background

- Entries Yolo Wonder, California Wonder, Giant Bell, Yellow, SRC-CF 4, SRC-CF 5 and SRC-CF 6 were evaluated in August–November 2011.
- Data on vegetative & reproductive growth stages, pests & disease infestation and weekly harvest were recorded .

Objectives

- To determine which varieties of tomato perform well under low altitude conditions.

Output (first planting season)

Entries	Late/early maturing (DAT)*	Pest & disease infestation **		Fruit shape	Fresh wt/fruit (kg)	Fruit colour	Yield (kg/ha)	
		Pest	Disease				Laloki	Sogeri
SRC-CF 4	Early (71)	3	2	Oblate	0.02	Red	5569	NG
SRC-CF 5	Early (69)	2	2	Bell	0.06	Green-yellow	9808	NG
SRC-CF 6	Early (69)	3	2	Bell	0.05	Yellow	6609	NG
California Wonder	Late (75)	4	4	Bell	0.04	Green	7033	5491
Giant Bell	Early (71)	3	2	Bell	0.042	Green	6783	6790
Yolo Wonder	Late (75)	3	2	Bell	0.045	Green	6359	6416
Yellow	Early (71)	3	2	Bell	0.04	Green	NG***	6663

*DAT= Days after transplanting
** pest & disease infestation rated on a scale of 1-5 (1- low to 5-highest)
***NG = Not grown in that site

SRC-CF 4

Yellow

California Wonder

Yolo Wonder

SRC-CF 6

Giant Bell

SRC-CF 5

ACIAR VEGETABLE PROJECT

SMCN/2008/008 Increasing vegetable production in Central Province, Papua New Guinea to supply Port Moresby Markets

PRODUCTION SYSTEMS TRIAL

Background

•Compare the benefits of three different production systems based on level of inputs.

1. Typical low input system. Based on traditional farmer's knowledge and practice.
2. Improved practice system (low input system). Based on modified improved technologies.
3. High Input / Output system. Based on commercialised farmer's practice.

Objectives

•To determine which production system is most beneficial for vegetable farming.

Expected Output

•Select and recommend the most beneficial production system for vegetable farming.

Land preparation using tractor

Using drip irrigation

Application of commercialised Pesticides

Some high & improved system practices.

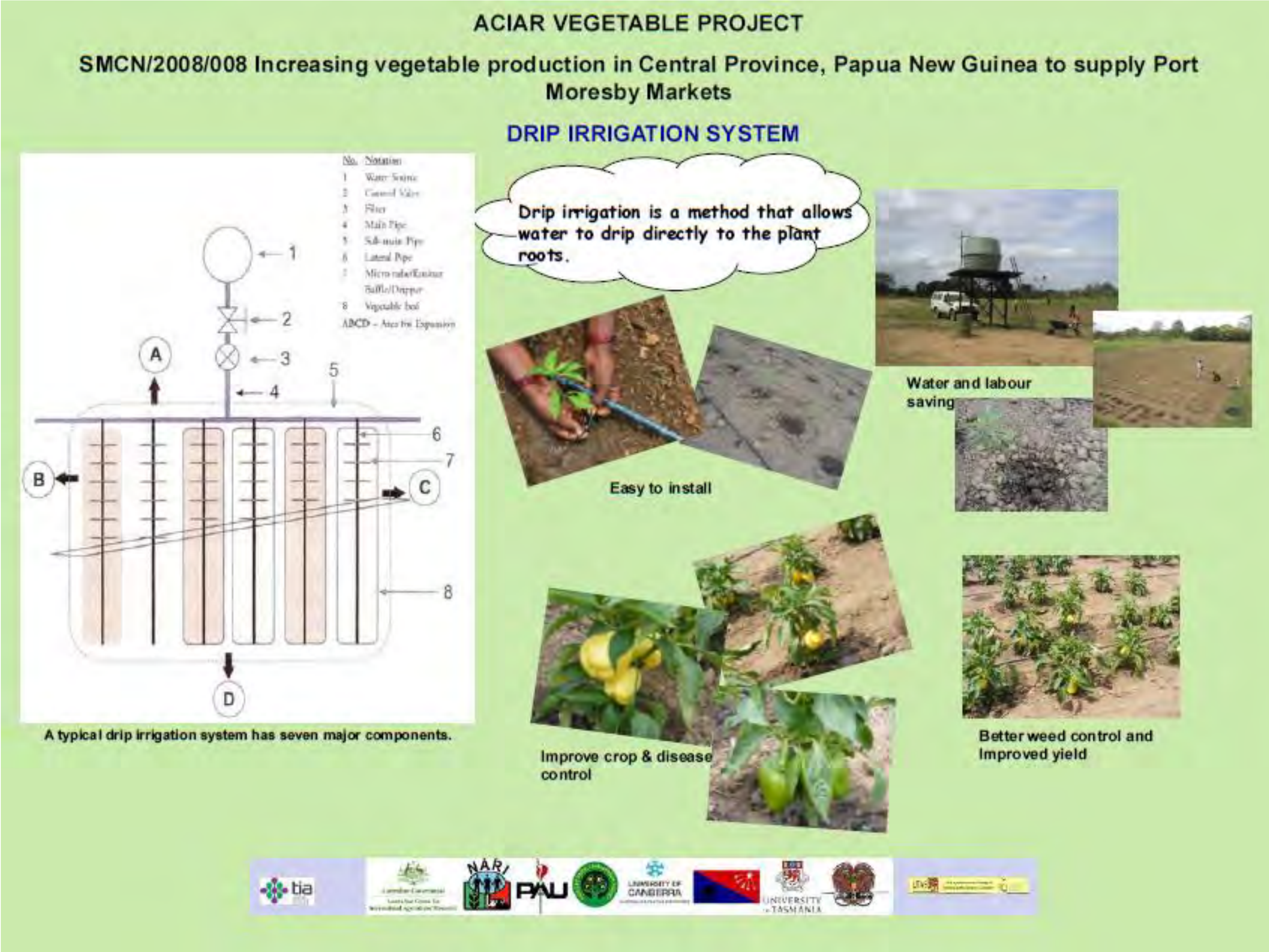
Some low input system practices.

Mulching beds

Land preparation done manually

Drains by raised beds

Watering by hand


ACIAR VEGETABLE PROJECT
SMCN/2008/008 Increasing vegetable production in Central Province, Papua New Guinea to supply Port Moresby Markets
DRIP IRRIGATION SYSTEM
No. Notation
1 Water Source
2 Control Valve
3 Filter
4 Main Pipe
5 Sub-main Pipe
6 Lateral Pipe
8 Vegetable bed
ABCD – Area for Expansion
A
B
C
D
1
2
3
4
5
6
7
8
A typical drip irrigation system has seven major components.
Drip irrigation is a method that allows water to drip directly to the plant roots.
Easy to install
Water and labour saving
Improve crop & disease control
Better weed control and Improved yield
NARI
PAU
UNIVERSITY OF CANBERRA
UNIVERSITY of TASMANIA

Agronomic evaluations for growth and yield performances of Capsicum cultivars in Pacific Adventist University, Papua New Guinea

Japhet Nivi[1], Colin Birch[2] and Mark Boersma[2]
[1] PAU, Private Mail Bag, Boroko NCD, [2] TIA, University of Tasmania

FUNDED BY ACIAR

Key words: Capsicum, Vegetable production, Crop Yield and Quality

Salue, Japhet and Tony working on Capsicum cultivar evaluation plots, Pacific Adventist University, June 2011

Introduction

- Capsicum, (Capsicum *annum*) has high potential to help;
  - stimulate economic independent
  - alleviate poverty
  - improve food security
  - improve standard of living

- To improve capsicum quality and yield production in Central Province several investigations were involved;
  - Agronomic cultivar trial and insect pests' assessment.
  - Production systems evaluation for increasing capsicum yield and quality.
  - This study investigated a total of six potential capsicum cultivars, 2011.

Capsicum evaluation plots PAU, August 2011

Objectives

- evaluated capsicum cultivars for growth and yield performances and;
- To investigated tolerance of capsicum cultivars against local insect pests.

Capsicum after 44 days, PAU

Achievements

- Field preparation and experimentation were completed.
- All the data were collected and performed statistical analysis.
- Scientific report is completed.

Capsicum fruits at before final harvest, PAU 2011

Outcomes to date

- Data analysis produced significant growth and yield among the cultivars.
- Cultivars that had improved performances have been considered.
- Research has identified knowledge, skill, finance and infrastructure constraints improve the research.
- The collaboration between PAU and TIAR team has been remarkably.

Challenges

- Lack of facilities, equipment and research assistance
- Investigating on local pests needs thorough research

Acknowledgments

- The Pacific Adventist University research team would like to thank the UTAS and TIAR ACIAR for their technical and financial support.

Agronomic evaluations for growth and yield of Tomato, Lycopersicum *esculentum* cultivars in Pacific Adventist University, Papua New Guinea

Japhet Nivi
Pacific Adventist University, PMB, Boroko NCD

Funded by ACIAR

Key words: Tomato, Vegetable production, Crop Growth and Yield

Introduction

- Tomato, *Lycopersicum esculentum*, has potential in Central Province, to improve food security in following ways;
  - → improve nutritional values
  - → income generation farmers
  - → improve social livelihood of growers
  - → create employment opportunities in rural areas
  - → expand farmers export to international markets.
- This study investigated six potential tomato cultivars in Pacific Adventist University, Central Province to supply PoM markets.

Objective(s)

- Evaluate tomato cultivars growth and yield performances
- Investigate the tolerance of cultivars against local insect pests.

Achievements

- Field experiments were completed well.
- Data were collected and statistical analysis was performed.
- Scientific paper was written from the research data.

Outcomes to date

- Statistical analysis produces significant effect among cultivar growth and yield.
- Well performing cultivars have been recommended to be further evaluated.
- Identified knowledge and crop management skills to improve the research.
- The collaboration between PAU and TIAR team has been remarkably.

Challenges

- Lack of facilities, proper equipment's and tools.
- More investigate of cultivars against local insect pests and diseases.

Acknowledgements

- The Pacific Adventist University research team would kindly acknowledge UTAS and TIAR ACIAR and other national organisations to technical and financial support.

. Increasing Vegetable Production in Central Province Supply to Port Moresby Markets.

Central Province Division of Agriculture & Livestock

WHO?

The Central Province Division of Agriculture & Livestock through its Goilala, Rigo and Hiri districts Agriculture staff involvement

WHERE?

(i) Goilala District (ii) Rigo District (iii) Hiri District. Tapini (temperate type veges nursery + yield), Rigo (supply chain) Sogeri (yield)

WHAT WAS DONE?

In TAPINI, temperate type veges nursery was established and yield trial was run. The Yield trial is in its 3rd week of being transplanted.

Yield trial plot establishment in Tapini. Local helpers Julian Kailev (i) and Martin Ketava (ii)

Nursery establishment in Tapini by local helpers Tuta Maia(iii) and Jacob Aita (iv). Local materials were used in constructing the nursery.

In RIGO, the supply chain component was run. Selected vegetables seeds were supplied to Rigo Koiari Co-orperative Society in 3 villages, Londairi, Geresi and Garabu.

(i)Rigo Agriculture Co-ordinator with Rigo Koiari Co-operative farmer in the capsicum plot (ii) FPDA rep, Mr. M. Atuai inspecting seedlings in the RKCS nursery ready for transplanting at Lonadairi village nursery (iii) Local informal markets at Kwikila station and NCD provides for farmers to sell products.

KEY CONSIDERATIONS

Tapini, GOILALA (District Agriculture Office area)

The first attempt to establish the nursery was poor as germinations did not take place as expected. The second attempt was successful. Two points in relation to the first failed attempt: (i) The technical DAL staff had not carried out field experiments and for that matter had no prior research experiences. Data collation and daily monitoring of nursery set ups did not take place. For the untrained helpers, in this case who were locals, needed constant direction. (ii) Communication of scientific knowledge to the locals is a complex issue. Generally, transfer of technology (information, techniques, methods and etc) to rural farming communities is a grey area that has eluded the existing agencies responsible. The literacy level of PNG as a whole is generally low. In the target areas, this is expected. The rates of adoption and adaptation of new farming techniques and methods will be interesting to note as the mindsets of generally subsistence farming communities must be changed to embracing the semi- to fully- commercial farming set ups is pre-empted in this work.

RIGO INLAND (Rigo Koiari Corporative Society)

Farmer participatory mode would have been an excellent opportunity to have farmer/expert interaction, and the passing/exchanging of ideas from technical staff/experts to farmers and/or from farmers to technical experts. Local knowledge of farming would normally be important for experts to consider. The French bean was a "new crop" supplied to farmers to the Londairi, Geresi and Girabu villagers. Road network is generally poor. Hence, transport of vegetables to the district and Port Moresby informal markets is the present significant challenge for local organized farming communities.

Increasing Vegetable Production in Central Province, Papua New Guinea to Supply Port Moresby Markets – Action Research Component

Laurie Bonney,[1] Gomathy Palanappian[1], Colin Birch[1], Barbara Chambers[2]
[1] Tasmanian Institute of Agriculture, [2] University of Canberra

Project Leader; Colin Birch, Participants from TIA/UTAS, NARI, FPDA, PAU, Greenfresh, Central Province Government, University of Canberra, Funded by ACIAR

Collaborative action research – designing research questions

Why do the work?

Participatory action research framework was needed:

- to empower stakeholders with scientific knowledge
- to engage stakeholders as partners in research
- to understand the cultural context and adapt methods

Bautama

Rigo Koiari

Identification of agricultural, logistical and social constraints by the Australian research team and stakeholders

Tapini

What work is being done?

- collaborative action research is practiced through consultation of research frameworks and research questions with stakeholders
- Identification of agricultural, logistical and social constraints on the supply of quality vegetables was jointly conducted by the Australian research team and stakeholders at Bautama and Rigo Koiari
- Identification of agricultural, logistical and social constraints on the supply of quality vegetables was conducted by the stakeholders at Tapini
- continuous cycles of action and reflection in progress

Increasing Vegetable Production in Central Province, PNG to Supply Port Moresby Markets - *Women & Youth Component*

Gomathy Palanappian[1] and Barbara Chambers[2]

[1] Tamanian Institute of Agriculture, [2] University of Canberra

Project Leader: Colin Birch, TIA Participants from TIA/UTAS, NARI, FPDA, PAU, Greenfresh, University of Canberra, Central Province Government
Funded by ACIAR

Why do the work?

Women and youth workshop was needed to improve women participation in vegetable production by overcoming the following limitations:

- Lack of technical knowledge for efficient crop production
- Lack of knowledge to manage market and business activities

What work is being done?

- Identified what horticultural jobs women and youth find easy, more difficult and very hard to do in **Bautama** and **Rigo Koiari**.
- Discovered what gets in the way of doing the difficult and hard to do jobs and what resources might make those jobs easier.
- Identified what dreams or ideas women and youth have for their futures.
- Action plan on how to achieve the dreams was completed.
- Training to be developed and delivered.
- Action plan to be reviewed.

Attachment 2A

SMCN/2008/008 Increasing vegetable production in Central Province, PNG for Port Moresby markets

Project Meeting

NARI Southern Region Centre, Laloki

Day 2, 14 March 2012

Planning for 2012 Activities and their Implementation

Introduction

The notes that follow were recorded on Day 2 of the project meeting, which was devoted to planning activities in 2012, preparing for their implementation and planning for the mid-project review to be conducted later in the year. A few key points are:

- the potential impact on visits to PNG and research activities of the elections was acknowledged.
- The Annual report is due in May.
- The mid-term review is to be conducted towards the end of the year, but project review documentation is likely to need to be submitted by September.

The proposed project activities were reviewed by activity as listed in the project proposal documentation and line number in the Excel Spread Sheet (shown on power point) and provided with this document.

***Note: 23rd June is the election date and Dr Bang advised avoiding the Highlands areas of Central Province until after July*.**

1. Planning Activities for 2012

(i) Activity 1.3 Line 6 Develop, Implement Best Practice Chain Management

ACTION ITEM: Laurie Bonney to coordinate the chain activity for this period.

(ii) Activity 1.5 Second generation programs developed and reviewed

Revitalising work on the chain. The key task is freight and getting growers to bring produce to one point to be picked up by a dedicated freight service. The project does not pay for this but FPDA will coordinate with the Central Province Administration (CPA)and liaise with local District Advisors - Murray Kuido from Rigo-Koiari and Kasmiro Bauai (?) from Tapini.

ACTION ITEM: Pus Weisis, FPDA, and Felix Gitai agreed to coordinate the activities.

(iii) Activity 1.5, line 9 - Plan, Develop and implement programs for men

The 'Men and their Sons' workshop is planned for the second week of July. There was some discussion around the criteria for selecting youth participants, ranging from Grade 10 plus youth (those better educated but unemployed) to learn about inputs, costs, making money, agriculture as an activity for life to concentrating on practising farmers. It was resolved that a balance of age and experience was needed, with FPDA, NARI and CPA advising on selection criteria. It was noted that the Men's workshop was about a Training Needs Analysis in order to mirror the Women's workshop focus.

ACTION ITEM: FPDA is to organise this activity, and liaise with PAU (the venue site).

(iv) Activity 1.7, Line 10 Value Chain high input/high value study – to be done in Australia

Laurie Bonney emphasised that Value Chain work is not difficult, just complicated. Pus and Regina are starting new at FPDA, so question of the possibility of Dixon, Philmah and Japhet working with them on some of the trips to help with their induction was raised (and was agreed).

ACTION ITEMS: Clifton Gwabu from NARI will coordinate joint activities.

FPDA needs to be involved with on-farm trials site selection with CPA.

(v) Activity 2.1 Lines 11 and 12 - Field Trials Completion and Write Up

For Tapini the date for trial completion and write up will be extended until the end of July 2012

Analysis of data from 2011 trials not yet finished by NARI. It was agreed that reports should be written by scientists at NARI and PAU

ACTION ITEMS: Scientists at NARI and PAU to draft reports

Reporting would be coordinated and mentored by Mark Boersma, but initial drafting be completed by PNG based project staff.

Japhet and Philmah to finish writing interim summary data reports from Year 1 and send to Mark Boersma by the end of April.

Full Reporting, including Tapini results to be completed by end August 2012

NOTE: Any redesign of experiments to be identified at an early stage, for implementation in 2012 trial period (Note that no redesign of trial appears necessary for Sogeri as it was only the site/site conditions that were problematic)

(vi) Activity 2.1, Line 13 Field trials - site characteristics

ACTION ITEM: Richard Doyle to lead completion of report on soil fertility by the end of April 2012.

(vii) Activity 2.1, Line 14 Shifting of trial sites at Hiri area Sogeri needs to be added to Work Plan.

A new site has been identified near a village (Bisanumu), for security and allocated to NARI for trials.

ACTION ITEM: Agreed that Philmah and Tony (NARI) team with Felix (CPA) and Gus (NARI) to check the site with a DPI officer to help with supervision with local people and report back.

(viii) Activity 2.1 Line 15 In-country planning for 2012 Field Trials

Being done in this meeting

ACTION ITEM: Mark Boersma to coordinate design and implementation with Rosa and Philmah (NARI) , Japhet (PAU), Pus and Gus (FPDA) and Felix (CP), who will be the contacts

(ix) Activity 2.1, Line 16, Report writing, 2012 trials

ACTION ITEMS: Agreed this would be coordinated by Mark Boersma, but initial drafting be completed by PNG based project staff.

Scientists involved commence writing up 2012 trials at time of planning them

(x) Activity 2.2, line 17 Crop adaptation studies

ACTION ITEM: controlled conditions to be done by Honours student/s in Australia, supervised by Mark Boersma, Al Gracie and Colin Birch, as appropriate

(xi) Activity 2.3, Line 18 GIS Studies

These will continue to be supervised from Australia. The deadline for the Soils Conference is the end of June, if Jimmy wishes to write a paper for it.

ACTION ITEM: Jimmy, Richard Doyle and Matt Dell consult re preparation of a paper for the Aust NZ Soils Congress

(xii) Activity 2.4, Line 19 Affordable low input solutions.

ACTION ITEM: Leigh to review information and add to Value Chain work by September 2012

(xiii) Activity 2.5, Line 20 Post harvest

Maintaining quality from farm gate to market e.g. cool box, temperature trials, data loggers is challenging and was to be done initially by February and then August. Felix (CPA) said they had a graduate in Food Science who could be useful here.

ACTION ITEM: Laurie to follow-up with Gus and determine what can be done in a practical and meaningful sense.

(xiv) Activity 3.1, Line 21 Prototype Extension

ACTION ITEM: All project staff to keep this under review and prepare as material becomes available (see also line 19 re activity 2.4 on Low Input Solutions)

(xv) Activity 4.1, Line 22 GIS crop and land suitability to be done by NARI

Jimmy, Richard and Matt have this in hand, outputs expected late in 2012

(xvi) Activity 4.2, Line 23 Review programs for inclusion of Women & Young People

Note: This is contingent on outcomes of work of NARI, FPDA et al in Activity 1.5 above.

Review in July/August of first stage programs for Women and Youth is contingent on FPDA and other partner trainers being able to implement training in May.

ACTION ITEMS: Meeting on Thursday 15/3/12 of Poela Utama (FPDA), Regina (FPDA), Lalen Simeon(PAU), Philmah Seta-Waken (NARI), Roselyn Winston(NARI) with Barbara Chambers to plan first training programs for Rigo-Koiari and Bautama based on a replicating model of pre-training assessment, program planning, design, implementation and assessment/evaluation. This will enable comparative review and make it easier to develop training units into a manual and publish pre- and post-test results, with the aim of producing best practice extension. Gomathy Palaniappan will assist with monitoring and reviewing training in 2012 and work with BC and PNG team for second stage training and review in 2013.

2. Publications

Lines 27-45, Publications: Theimportance of co-authorship on conference papers and journal articles and how this contributed to capacity building for less experienced researchers was emphasised. It was also noted that the downturn in the global economy had affected conferences and funding to attend them so 2013 might be a better year for doing international conference papers.

Publication Plans include:

1. The women and youth team will be writing a paper for the International Journal Development in Practice. The target date for submission is June , Barbara Chambers to coordinate.
2. 2 papers proposed for Aust NZ Soils Conference, December 2012 (one on agronomic studies, one on GIS findings
3. Colin Birch will circulate the anthology of papers already produced.

3. Alternative approach if the Election makes travel to PNG until after July 2012

Lines 48 – 53, Notes 1 – 5. If staff from Australia can't come up to PNG until after July because of elections, then there is a possibility of bringing some people to Australia in joint financial partnership (suggestions in the Excel worksheet)

4. Implementation of Activity Plans and Planning for the Mid-Project Review

1. An in-country coordination committee of partners who will meet on a regular basis at two monthly intervals was agreed. There would be a rotating chair and site and a different person each time responsible for organizing meetings. Lead people in different agencies will be sent the Work Plan. Pus and Gus will be lead persons for FPDA (copy to Robert Lutulele); Rosa and Clifton will be lead persons for NARI (copies to Philmah and Dixon); Felix will be lead person at CPA and Lalen and Japhet at PAU. Rosa from NARI will coordinate the first meeting. This proposal was endorsed by the group. Lead agencies should give Rosa key contact details for their representatives.

2. The mid-term review's purpose is to be supportive of the project.
    2.1 It aims to look at progress to date: what has worked, what hasn't, why it hasn't worked; where to from here.
    2.2 Its main objective is that performance has to be quantified or have an evidential base.
    2.3 The process involves ACIAR setting terms of reference, with some generic benchmarks.
    2.4 The panel's composition will be discussed with the project leader. The point was made that the project leader should ensure an equal balance of science and social science members.
    2.5 The panel provides a draft report to ACIAR for comment (sometimes this is shared with the project leader for comment), then a final and private report is prepared for the lead agency.

21 March 2012

Activities	RESP	Partner R	Jan-12	Feb-12	Mar-12	Apr-12	May-12	Jun-12	Jul-12	Aug-12	Sep-12	Oct-12	Nov-12	Dec-12
							ELECTION - PNG ACIAR							
Mid-Project Review	CB			Visit GK	Preparation					Visit GK - TBC	Preparation		Review	
Annual Review by Partners	CB	All												
Annual Report	CB													
1.3 Develop, implement BP chain management	LB	FPDA				LB in PNG FOR FPDA WORK								
'						Some continue in/supervised from Australia (Note 1)								
1.5 2nd Gen progs developed & reviewed	LB	FPDA				Organisation of VC freight service FPDA								
1.5 Plan, Develop progs for men	BC	FPDA, PAU, CP						MENS WORKSHOP - FPDA TO LEAD, W/SHOP AT PAU PREFEREABLY IN JULY						
1.7 VC high input/high value study	LB				To be done in Australia									
2.1 Field trials - complete Y.1 expt & data analysis	MB	All		2011 TO BE COMPLETED		TAPINI EXPERIMENT TO BE COMPLETE BY END JULY 2012								
2.1 Field trials - report writing	MB	All	2011 EXPT WRITE UPS BY 30APR			TO INCLUDE ALL EXPTS AND COMPLETE BY END AUGUST 2012								
2.1 Field trials - site characterisation, soil analysis etc	RD	All			Supp Report			PAPER/s for SOILS CONF BY JUNE 2012						
2.1 ENGAGE WITH HIRI DARE SOGERI		FPDA, NARI, CP				CENTRAL AND PHILMAH AND GUS								
2.1 Field trials - complete Y.2 expt & data analysis, SITE SELECTION, BISIANUMU	MB	All			In-country Planning	DESIGN MOD and planting etc by PNG partners								
2.1 Report writing - agronomic trials	MB	All				START 2012 WRITE UP								
2.2 Crop adaptation studies - controlled conditions	MB/CB/AG			Honours student to be done in Australia										
2.3 GIS Studies	RD/MD	NARI (JM)			To continue in/supervised from Australia (!PAPER FOR CONF									
2.4 Affordable low input solutions	LS	All												
2.5 Post-harvest	LB	FPDA - GUS/CP FOOD SC		/NARI										
3.1 Prototype extension	All	All		In country planning	To continue in/supervised from Aust (Note 3)					SEE ALSO 2.4				
4.1 GIS - crop & land suitability NARI assessment	RD	NARI (JM)												
4.2 Review progs for inc Women & YP (Contingent on NARI fnds et al 1.5)	BC	All												
Possible Publications														
Economics	CB, LB	CG				Journal, local extension publications, conference (?) (Note 4)								
Agronomy/Soils/NRM/Systems								Nat Soils^^			Agron Conf#			Nat Soils
Value Chain	LB	All												
Gender sociology	BC	All												
13th WC Sociology SCRAPPED ON COST GROUNDS														
Agronomy Conf	LS, RD, CB	All	Paper submission closed											
Soils Conf														
International Development journals (MENTIONED 13/3/12)	BC, GP	All						BC						
NOTE:														

SMCN/2008/008 Increasing Vegetable Production in Central Province, Papua New Guinea to Supply Port Moresby Markets

Vegetables at the Rocklea Markets, Brisbane

ACIAR Project: SMCN/2008/008 Increasing Vegetable Production in Central Province, Papua New Guinea to Supply Port Moresby Markets

Trip Report for 18th June 2012 by Dr Gomathy Palaniappan

Tasmanian Institute of Agricultural Research

Purpose of the Trip

The aim of this trip is to improve market systems in PNG by facilitating the PNG participants from Fresh Produce Development Agency (FPDA) to understand the functioning of the Rocklea markets and a local super market in Brisbane, Australia. This visit was significant as all the participants from FPDA, PNG were women unlike during their previous visit in 2011 October where only men made the visits to the markets in Australia.

Preparation for the trip

The Fresh Produce Development Agency (FPDA) is preparing to take the responsibility of operating the markets in Port Moresby and the building construction for the markets is currently underway. For this reason the FPDA participants:

1. Louise Aitsi Deputy Chairlady,
2. Elizabeth Melchior Fruit Tree Development Officer and
3. Poela Utama Specific Crop Development Officer

were interested in visiting the central markets operating in Australia. This study visit is significant as all the team members were women unlike the previous visit in 2011. In October 2011 the FPDA participants were:

1. Mr Fabian CHOW, (Chairman of the Board of Directors, Fresh Produce Development Agency Limited)
2. Mr Gregory Berry, (Member of the Board of Directors, Fresh Produce Development Agency Limited)
3. Mr Gregory Liripu, (General Manager, Fresh Produce Development Agency Limited)
4. Mr Mewie Launa, OBE, (Divisional Manager for Corporate Affairs, Fresh Produce Development Agency Limited)
5. Mr Lucas Kindiwa, (Divisional Manager for Production and Value Chain Supplies)

The central markets in Australia play a significant role within Australia's horticulture industry as the major distribution point of the nation's fresh fruit, vegetables and flowers. In Australia there are six Central Markets, including Brisbane, with the others located in Sydney, Melbourne, Adelaide, Perth and Newcastle. The FPDA participants chose to study 2 central markets Brisbane and Sydney and so a study to Brisbane markets was organized through the project.

Brisbane's Rocklea market in action

The communications manager, Vanessa Kennedy from the Rocklea Markets, Brisbane was contacted and the purpose of the visit was explained. She responded positively and was happy to host the participants from PNG. A comprehensive set of questions were prepared to interview the wholesalers, growers and staff of the Rocklea markets. An alternate vegetable outlet such as the Woolworths which is a local super market chain was chosen and the comprehensive sets of questions were discussed with the store manager prior to the visit.

A brief history on the Brisbane Market

The first purpose-built fruit and vegetable Market was built in Market Street in 1866 and after years of changing ownership, had closed by 1881. However, Brisbane Municipal Council stepped in four years later, and in 1885 opened the purpose-built Roma Street Markets, tucked beside the rail line and handy river ports, in the heart of the city, to service a growing Brisbane. By 1906, a band of wholesalers, unsatisfied with increasing government regulation and congestion, created a rival market in Turbot Street, and over the years, the two markets operated side by side, creating a Brisbane fruit and vegetable precinct. As the city grew, so did the congestion, and as early as 1936 there was talk of moving the Markets precinct. It wasn't until 1964 that the plan came to fruition, with the Queensland Government stepping in to create the Brisbane Markets site, at Rocklea, where it stands today (Source: Brisbane market's pamphlet).

- During debriefing the FPDA participants made a note that the markets must be built in a location with access to transport and must take measures to avoid congestion.

The PNG participants observed the following from the interviews:

Market operation and regulations:

- The market is divided into different sections for easy operation such as the produce market centre, flowers market, market place, fresh centre etc.
- The market allows the bulk buyers like the fruit and vegetable retailers, secondary wholesalers, restaurants, cafes, food service businesses and exporters, source their fresh produce requirements from the Brisbane Produce Market. These buyers inspect the wide variety and range of products available and compare various grades and prices to ensure they are getting the best produce available at a fair market price on the day.
- There are regulations in place for accessing the markets. For instance a commercial buyer needs to get a market access card to enter the markets during the defined working hours.

- Safety measures are in place like all market users whilst on market need to wear a day/night reflective safety west

- Translating this idea to the PNG market means FPDA must define the purpose of their market whether it is for consumers or for commercial buyers and if it was for both then a mode of operation to accommodate both type of transaction must be planned.
- Market regulations must be developed in order to provide safe access to markets particularly for women to avoid any interference.

Farmers and wholesalers

- Most vegetables are purchased from farmers through the wholesalers and the farmers and wholesalers have relationship built over generations.
- Some vegetables are imported from New Zealand, PNG and other countries. But most vegetables are purchased local.
- Regular supply of vegetables is a must to keep the market profitable. The surplus vegetables are stored in cold storage rooms by the wholesalers. The wholesalers pay for the stalls and storage facilities in the market.
- Good quality vegetables fetches best price and so farmers grade the vegetables and send in best quality. If farmers did not provide good quality vegetables then the wholesaler refuse to buy vegetables from the farmer and as a result the farmer loses business with the wholesaler. If the wholesaler does not give a good price for the farmer than the wholesaler will lose the business with the farmer.
- Low quality vegetables are sold at lower price unless there is a great demand on the vegetables.
- There is an agreement called Horticulture Producer Agreement to protect the interest of both grower and wholesaler.
- There is credit scheme where the farmers and wholesalers secure their transaction.

- Farmers take the risk on the produce during transportation. There is a general understanding between both the farmers and wholesalers. For instance recently the price of tomatoes increased due to bad weather conditions. During such circumstances both farmers and wholesalers share the benefits and consumers are disadvantaged. However when there is surplus production then the consumer is at the advantage as the price goes down. Most farmers produce a variety of produce to deal with such kind of risks.
- Market kitchen – a new venture to process surplus produce is now in place
- Farmers pack the right quantity of produce cartons to maintain the quality of the vegetables during transport

- **This means that FPDA must see that there is eough local production to meet the market needs.**
- **Infrastructure like cold storage rooms must be provided to store vegetables**
- **The market currently under plan in PNG may be for both farmers and wholesalers and to protect the interest of both famers and wholesalers are to be developed.**

- **Quality and quantity of vegetables are both important for the market to function.**
- **Credit scheme is a good method for future transaction in PNG.**

Quality vegetables displayed by wholesalers

Debriefing with FPDA participants

- Do not mix businesses – To be in business it must be focussed on vegetables and fruits only Too many diversifications like allowing stalls to be taken over by other entrepreneurs may severely damage the business.
- Continuous supply of produce – Every action must see that there is continuous supply of vegetables or we can't stay in business
- Packaging – Local material or cartons can be used to maintain the quality of vegetables
- Recycling of cartons – Caution must be taken as any fungus may get spread through the chain
- Cleanliness – Markets need to be kept cleaned Any damaged produce must be removed immediately

- Stall need to be constructed in such a way that the goods can be loaded and unloaded with ease (women bring the produce to the market so this needs to be taken into consideration)
- Water supply is a must in the market for the sellers and buyers in the market
- Toilet facilities and washing facilities must be provided as women will be travelling from remote places to access the market
- Food shop for buyers and sellers in the markets

FPDA participants interviewing wholesalers

Vegetables kept in Cold storage

Woolworth's super market chain

An alternate vegetable outlet such as the Woolworths which is a local super market chain was chosen and the comprehensive sets of questions were discussed with the store manager prior to the visit. We agreed not to take any pictures in the store.

- Vegetables are purchased centrally from farmers and each store would mention their requirements and will be delivered to the store through cold storage transport
- Quality of vegetables are discussed centrally with the farmers
- Farmers take pride in supplying through our chain as we sell mostly the locally grown vegetables. Farmers know that our chain supports them and they see the benefits
- Locally grown vegetables means a lot to the consumers and they are here to support the local growers
- Some vegetables are packed in quantity and some vegetables can be packed by consumers as per their requirements. For instance this store is located at Indooroopilly and the majority of the consumers are students. They prefer to buy small quantities rather than the half Kg packed bags which will best suit families. So we provide choices to the consumers based on the pattern of consumers walking into the store.
- I take account of the sales pattern and decide to promote the vegetables. For instance if we have more stalk to be cleared then we reduce the price of the vegetables so that it can be sold at a faster rate.
- In order to promote our sales we advertise through pamphlets, websites and media

Debriefing with FPDA participants

- A system to monitor the sales of vegetables and fruits need to be developed
- A system to record the pattern of sellers and buyers need to be developed
- Promote our markets through advertisements through pamphlets, websites and media

Appendix 1: WORK BOOK for participants

Improving Market Systems in PNG

SMCN-2008-008 Increasing Vegetable Production in Central Province PNG to Supply Port Moresby Markets

Visit to Rocklea Markets, Brisbane

Australia

This workbook is developed to record the observations during the visit to Rocklea Market in Brisbane and Woolworths Retail outlet in Brisbane.

Date: 18th June 2012

Venue: Brisbane, Australia

Name: Louise Aitsi Deputy Chairlady, Elizabeth Melchior Fruit Tree Development Officer and

Poela Utama Specific Crop Development Officer

Organization: Fresh Produce Development Agency

Objective: To improve marketing systems in PNG

A. **Visit to Rocklea Markets - Discuss their observation**
B. **Visit to Outlet Markets**
C. **Debrief learnings**

A. Visit to Rocklea Markets - Discuss their observation

To understand how the wholesalers work with fruit and vegetable growers.

1.1 Where do you get vegetables from?

1.2 Do you have regular suppliers?

1.3 How do you obtain the quality you want?

1.4 What do you do when the quality is not what was expected?

1.5 If a supplier wants to supply vegetables what must he do?

1.6 What is the volume of supply that a grower supplies to the market?

1.7 What are the terms of agreement with the grower/wholesaler?

1.8 How is the interest of the grower protected?

1.9 How is the interest of the wholesaler protected?

2. To understand how the price for fruit and vegetables is decided.

2.1 How do you determine price?

2.2 Who does the grading of vegetable?

2.3 What happens if the vegetables get damaged during transport or weather conditions?

2.4 Who pays the transporter?

2.5 What supply problems do they have?

3. To understand how the consumer preferences are addressed.

How do you know what the consumer wants?
Is this information shared with the others in the chain? If so with whom and how?
Is the price/demand response the only way they determine what the consumer wants?
Do they ever use other means to determine consumer values?
How do they go about introducing new products into the market?
Vegetables being seasonal how do they manage off season demands?

4. To understand how to manage a market system

4.1 Who manages or runs the market?

4.2 How and when did the market start?

4.3 Is there a government regulation to support the market?

4.4 How do you generate the revenue to mange the expenses in the market?

4.5 What is the waste management system practiced?

4.6 How do you regulate the behaviour in terms of protecting the interest of all actors?

4.7 How do you solve disputes?

5. To understand the challenges in the market system.

5.1 What are the challenges as stallholders in the market and how can this be improved?

5.2 What are the challenges of market operators and how can this be improved?

6. To understand grower's perspectives of marketing through Rocklea Markets

6.1 What vegetables do you grow?

6.2 Where do you sell them and why?

6.3 What do you do to maintain the expected quality?

6.4 What happens if there is crop failure or pest infestation?

6.5 What are the benefits and challenges in marketing your produce?

Other Observations

B. Visit to Woolworth

1. To understand the functioning of the retail outlet

1.1. Where do you get vegetables from?

1.2. Do you have regular suppliers?

1.3. How do you obtain the quality you want?

1.4. What do you do when the quality is not what was expected?

1.5. If a supplier wants to supply vegetables what must he do?

1.6. What is the volume of supply that a grower supplies to you?

1.7. What are the terms of agreement with the grower/wholesaler?

1.8. How is the interest of the grower protected?

1.9. How is the interest of the wholesaler protected?

2. To understand how the price for fruit and vegetables is decided.

2.1 How do you determine price?

2.2 Who does the grading of vegetable?
2.3 Who does the packaging?
2.4 What happens if the vegetables get damaged during transport or weather conditions?
2.5 Who pays the transporter?
2.6 What supply problems do they have?

3. To understand how the consumer preferences are addressed.

How do you know what the consumer wants?

Is this information shared with the others in the chain? If so with whom and how?

How do you attract your consumers? What are the strategies used to attract consumers?

What if the consumer is unhappy with the produce purchased?

Is the price/demand response the only way they determine what the consumer wants?

Do they ever use other means to determine consumer values?

How do they go about introducing new products into the market?

Vegetables being seasonal how do they manage off season demands?

4. To understand why they shelve the vegetables in a certain pattern

4.1 What is the reason for shelving in a certain pattern?

4.2 Why some vegetables are bagged and some are left at the choice of the consumer?

4.3 What value has been added to the vegetables?

5. To understand how to manage a market system

5.1 Who manages or runs the market?

5.2 How and when did the market start?

5.3 Is there a government regulation to support the market?

5.4 How do you generate the revenue to manage the expenses in the market?

5.5 What is the waste management system practiced?

5.6 How do you regulate the behaviour in terms of protecting the interest of all actors?

5.7 How do you solve disputes?

<u>Other Observations</u>

C. Debrief Learnings

APPENDIX 5

TRAINING REPORTS

NOTE: This appendix contains reports on training in PNG as part of the project SMCN/2008/008 Increasing vegetable production in Central Province, Papua New Guinea, for Port Moresby Markets. Some of the material is embedded in Trip reports, and is therefore also contained in Appendix 4 (Trip Reports), which also contains some additional contextual material. Further, some needs data on the needs for training is incorporated in Appendix III (Publications) and is not repeated here.

Report on
Training for Women and Youth

For

Final Project Meeting of SMCN/2008/008 Increasing Vegetable Production in Central Province
9-12 June 2015

Woman and Youth: University of Canberra Sub-Project

The University of Canberra was sub-contracted through Barbara Chambers[1] to examine ways in which women and youth were able to engage with the project aim "To develop efficient and effective value chains in Central Province that are based on sound use of natural resources, to meet growing demand for fresh vegetables in Port of Moresby."

This was to be achieved in conjunction with the following objectives:

OBJECTIVE 1To establish two examples of efficient, effective and sustainable vegetable value chains in Central Province to enhance profitability of enterprises at all stages in the value chain and household income security for chain participants;

OBJECTIVE 4: To identify other areas in Central Province with land resources and climate suited to vegetable production and provide a mechanism to extend project outcome to them.

Having undertaken a prior project ASEM/2009/042 *Improving Women's Business Acumen in PNG: Working with Women Smallholders in Horticulture* it was clear from a situational analysis that engaging women and their daughters in economic activities could only be achieved with the participation and agreement of men. However, because the voices of women may be silenced and their participation minimised in value chain activity, especially marketing, disaggregated sites of engagement were undertaken for data collection in interviews, focus groups, training needs analyses and training workshops. The Central Province Villages districts that were the subject of this sub-project were Rigo-Koiari (Gerabu, Geresi and Londari villages) and the Sogeri Plateau (Bautama and Kerekadi villages). The same techniques and methods were also used in Tapini, Goilala by University of Tasmania colleagues on the project.

The extension of the project activities to April 2015 enabled the completion of the post-training men's survey to examine the implementation of training activities in associated villages and the compilation and revision of a Farmers' Training Manual, the exercises of which formed the basis of the training in farm production, postharvest and financial literacy (to be reported on by Philmah Seta-Waken).

It would be hard to overestimate the demand for training in crop production, marketing and financial literacy expressed by smallholders in the Central Province of PNG. There have been many extension activities for farmers run over the years, but most of have been technically driven, rather than taking an adaptation approach and few have begun with asset based community development using an Appreciative Inquiry method. The results of what communities valued and had aspirations about formed the agenda for the identification of a

[1] The project engaged Professor Chambers at 10% of her time for the duration of the project.

training needs analysis workshop and then training workshops. Workshops were disaggregated for men and women and youth were given a separate focus as part of the small group activities.

In terms of the overall activities, the following table identifies broad activities, outputs, outcomes and projected impacts for this sub-project.

Table 1 Outline of Sub-Project Achievements and Projected Impact

Activities	Outputs	Outcomes	Projected Impact
1.2 Workshop and interviews commenced with women and youth on opportunities and constraints affecting their participation in the value chain	Identification and/or confirmation of impediments to full participation in the supply chain	Planned programs for women and youth based on interview and workshop outcomes	Constraints minimised to greater participation in the value chain.
1.5 Develop and implement programs to increase the participation of women and young people from Central Province in vegetable production and marketing	Programs developed, and implemented in collaboration with Women in Agriculture provincial leaders and FPDA Village Extension Workers (PC)	Improved retention of young people and status of women in production and marketing of vegetables	Engagement of women and youth in mounting their own horticultural training programs in place based context (train the trainer)
1.6 Analysis and reporting on evaluation outcomes of women's and youth participation programs	Youth and women's participation programs evaluated	Recommendations for long term adoption of change found to be acceptable and effective in retention of young people and improving status of women in production and marketing of vegetables	Demand for leadership, governance and conflict resolution training in co-operatives and collaborative village enterprises.
4.2 Review programs to increase the participation of women and youth from the Central Province in vegetable production and marketing	Programs reviewed in terms of adoption of knowledge and technology	Modification and/or extension of successful programs and input to train-the-trainer programs run-by PNG agencies based on a Farmers' Training Manual.	Training in leadership, governance and conflict resolution leading to more stable commitment to and participation in the value chain.

The post-training survey of men's training implementation was carried out in October and November 2014 and January 2015. A comparative analysis of men's and women's training implementation follows.

Comparative Results of Post-Training Evaluation in Sogeri and Rigo-Koiari, Central Province

Table 2 Post-Training Evaluation on Training Expectations and Banking

Post-Training Evaluation	Yes		Partly		No	
1. **Questions** 2. Men=9 3. Women=21	Men	Women	Men	Women	Men	Women
4. The training met my expectations	5	16	4	3*	0	0
5. I have been able to apply the banking knowledge learned	5	12	1	1	3	6
6. I have been able to open a passbook account or obtain a debit card	7	13	0	0	2	6

*Did not participate in the Training Needs Analysis Workshop only the Training Workshop.

Comment:

Overall, there were 21 men trained and 9 respondents to the post-training survey (42%) twelve months later and 31 women trained and 19 respondents to the post-training survey (61%) twelve months later.

For question one, the majority of women (76%) said that training met their expectations and just over half the men (56%). Homemade pesticide training was valued highly by men.

For question two, 5 men (55%) had been able to apply banking knowledge, compared to 12 (57%) for women. Men who said they hadn't been able to apply banking knowledge claimed that either the spouse did the banking or sons looked after the father and he didn't make enough to save.

For question three, the majority of men (78%) had been able to open savings accounts which were specified by men as BSP and Westpac. For men who said no, it was because they use their spouse's account. Over half the women (62%) had been able to open a passbook or debit account, but 6 (32%) had not.

Table 3 Post-Training Evaluation on Business Skills

Post-Training Evaluation	**Yes**		**Partly**		**No**	
Questions Men=9 Women=21	Men	Women	Men	Women	Men	Women
7. I have been able to maintain accounts on my income and expenditure	6	7	1	4	2	8
8. I have referred to the training material provided to guide my business practice	3	13	5	1	1	5
9. I have been able to practice my budgeting skills	6	14	2	1	1	4
10.I have been able to secure micro-credit to assist with crop production	1	4	1	1	7	14

Comment:

For question 4, men who responded yes (67%) said they found it easy; men who responded no said they had insufficient income at the moment. Only 7 (33%) women had been able to maintain accounts on income and expenditure

For question 5, men who responded yes (33%), said training helped them to understand and save better; men who responded partly said it depended on income or they were too busy; the men who responded no said he knew all there was to know about business. On the other hand, 13 (62%) women did use the training material to guide business practice.

For question 6.1, men (67%) who responded yes to short term goals, said they were saving to buy seed and equipment, bride price, building a house or to buy a new water pump; the men who responded partly, said they were saving to buy furniture and household items; the man who responded no, said he would think more about this after he had built his house. Women equally (67%) responded yes to setting short term goals.

For question 6.2, men who responded yes to long term goals, said they wanted to build a new house or buy a vehicle, learn to start a piggery and poultry business, want the family to have a higher living standard or build a hydroponic business; the men who responded partly or no, said they were still working on budgeting or were now retired with sons looking after them. One said it took so much money to hire a tractor (PGK1 square metre to plough and PGK.50 to harrow) for his 25x20 m block, there was no money over to budget. Women who said they were setting long term goals were doing so for their children’s future education and for building a house. One woman’s long term goal was to buy a tractor and a truck.

For question 7, most of the men (78%) responded no saying they either didn’t want or need micro-credit as it was not consistent with prioritising and saving; they had insufficient earnings to apply for credit or did not understand the rules for it (“I am a bit illiterate”). Of the other two men, one said he had PGK 4,000 micro-credit over 18 months from the National Development

Bank for farming and had paid it back at PGK120/month. Only a small number of women (19%) but twice as many as men (11%) had been able to secure micro-credit, but many had not tried to obtain it preferring to save for what they wanted e.g. school fees.

Table 4 Post-Training Evaluation on Production Skills

Post-Training Evaluation	**Yes**		**Partly**		**No**	
Questions	Men	Women	Men	Women	Men	Women
11.I have been able to implement soil management practices	6	13	2	3	1	3
12.I have been able to implement irrigation techniques as shown in my training	2	5	1	1	6	13
13.I have been able to identify and manage weeds that come up in my garden	5	17	3	1	1	1

Comment:

For question 8.1, most of the men (67%) and women (62%) had been able to implement soil management practices shown in training including mulching (although one said sawdust made his plants die), crop rotation and short fallows. The one who said the training in this regard was not applicable commented that he has no need of soil management because he has a big land area and can leave soil fallow.

For question 8.2, where they were asked what the impact of this training had on cropping practices, 2 men and 3 women said it had increased the amount of money they spent on soil management; 3 men and 8 women said it was about the same and 4 men and 10 women said it had decreased the amount of money they spent on soil management. In terms of increased yield, 3 men and 13 women said yes; 3 men and women said the same and 3 men and 5 women that it had decreased yield. For the quality of produce, 4 men and 10 women said it had increased; 4 men and 6 women said it was the same and 1 man said that they had gone back to hand cultivation as tractors were too expensive. In terms of price of produce, 3 men and 7 women said it had increased; 4 men and 11 women said the same, 1 man and 3 women that it had decreased and 1 man that it depends on the weather or the market.

For question 9.1, where they were asked if they had been able to implement irrigation techniques as shown in training, the majority of men (67%) and women (62%) said no either because of committed costs e.g. house building, school fees or that they only used flood irrigations with a water pump. Women also said that new techniques such as drip irrigation were too expensive and furrow irrigation could only work if you had ready access to water. However, one woman from Rigo-Koiari had borrowed money for a tank and pump and was starting to use it for irrigation.

For question 9.2, where they were asked about the impact on cropping practices, 2 male and 5 female respondents said that it had increased the amount of money spent on irrigation, but increased the yield, quality and price of their produce; 3 men said that it had only partly had an effect on these things and 6 men and 13 women said they hadn't used new irrigation techniques so there was no difference in impact.

For question 10, 5 men (56%) and 17 (81%) women said that since training they were able to identify and manage weeds that came up in their gardens; 3 men and 1 woman said they had always been good at this and 1 man and women that they used traditional weed control i.e. removing everything except the crop. In the positive category, men and women identified practices that included leaving weed material on beds to act as mulch; hand weeding those weeds that take up nutrients; and one male said they used paid village labour to do the weeding in return for cooking their meals and paying PGK50/group after produce is sold.

However, compared with men, women said that their changed practices through training had improved yield, quality and price, except they spent more money on their gardens where chemicals were used to control pests and diseases or improved irrigation technology was purchased.

Table 5 Post-Training Evaluation on Pests and Diseases

Post-Training Evaluation	**Yes**		**Partly**		**No**	
Questions	Men	Women	Men	Women	Men	Women
14. I have been able to identify and manage insect pests in my garden	7	17	2	1	0	1
15.I have been able to identify pests and manage diseases affecting the plants in my garden	5	16	2	3	2	0

Comment:

For question 11.1, the majority of men (78 %) and women (81%) agreed that because of training they had been able to identify and manage insect pests in their gardens such as pumpkin, beetle, green vegetable bug, and used chemical control such as Karate.

For question 11.2, of the 7 men and 17 women, 3 (34%) men and 7 (34%) women said this had increased the amount of money spent on the management of insect pests, 1 man and 4 women said the same and 3 men and 10 women that it had decreased. In terms of yield and quality, 5 men and 14 women said it had increased yield, 1 man and 6 women said it was the same and 1 man and 1 woman had seen a decrease. In terms of price, 3 men and 11 women said it had increased the price for their product, 3 men and 6 women said it was the same and I man and 4 women said it had decreased the price. The two male respondents who said training had only partly helped the identification and management of insect pests in their gardens, identified the need for repeat training as they were having problems with spider mites and the diamond backed moth, who had developed a resistance to the chemical they used (DBM?).

For question 12.1, 5 men (56%) and 16 (76%) said that they had been able to identify and manage diseases affecting the plants in their gardens since training, 2 men and 3 women said partly and 2 men said no.

For question 12.2, of those who said yes, 2 men and 4 women thought that identifying and managing diseases meant they were spending more money on their gardens, 3 men and 7 women said about the same and 2 men and 11 women thought less money. In terms of yield, 4 men and 16 women thought that this had increased the yield, 1 man and 4 women the same and 2 men decreased yield. The quality of produce was increased according to 3 men and 16 women, with no response from 5 men and the management of diseases had increased the price according to 5 men and 16 women, with 2 men each saying it had been partly affected or decreased.

Table 6 Post-Training Evaluation on Training Other Villagers

Post-Training Evaluation	**Yes**		**Partly**		**No**	
Questions	Men	Women	Men	Women	Men	Women
13. I have been able to train other men or women in the skills I have learned.	8	12	0	1	1	6
13.1 If yes, how many older mothers?	21	31				
13.2 If yes, how many younger women?	19*	6				
13.3 If yes, how many men?	3	0				

*2 trained young women who were in-laws and 1 trained a married couple

For question 13.1, the majority of men (89%) had trained others in the skills that they had learned during training. Most had trained older mothers and young women and only 3 (younger) men had been trained by them. For instance, older mothers had been trained in business skills, nursery transplanting, crop planting such as measurement and spacing of snake bean, eggplant and fertilizing using NPK and pest control, especially chilli and neem. Only one had been trained in soil management. Younger women had been trained, together with their husbands in one case, in spraying, planting, cultivating, irrigation and pesticide application. The three young men had been trained in pest and disease control, irrigation, use of chemicals and fertilizer and soil management. However, fewer women (57%) had trained others. Feedback from Rigo-Koiari was that older women were interested in training but young women were either not interested or husbands tended to train young wives. Men were not interested in being trained by women. However, in Kerekadi, young women formed a consortium of nine and those who had been trained in turn trained other young women.

Interpretation

It has been argued in previous studies that women are more adept at or interested in acquiring business skills than men. Yet these results indicate that there was little difference between men's and women's application of banking knowledge learned during training and more men than women had opened banking accounts. However, literacy levels may account for the result that double the number of women had referred to training material since training but equal numbers of men and women had been able to practice budgeting skills. Nearly twice as many women as men had secured micro-credit, but the numbers were still very small. In terms of identifying and managing weeds, twice as many women (81%) as men (56%) were able to do this and found a positive connection between weed management and increases in yields, quality and price. Similarly, for the identification and management of pests and diseases, more women (76%) than men (56%) were able to do this and also found positive connections between the identification and management of pests and diseases and increases in yields, quality and price. Both men and women noted that the costs of weed and pest and disease control had increased because of the use of relevant pesticides and chemicals.

Where gender roles are most apparent is in the training of others. Most men trained older mothers and young women in gender and age relevant activities that support agriculture, for instance, business skills, nursery transplanting and pesticide application. Men had been trained in soil management, irrigation, use of chemicals and fertilizer. However, subsequent interviews had revealed that at Rigo-Koiari older mothers found older women more responsive to training than young women and men tended to relax and trust older women to handle smallholder business and agriculture. Men felt that they should train their younger wives. In contrast, Kerekadi, younger women trained other young women and formed loose alliances with shared gardens, crop management and production, marketing and sales. In this community, men tended to be hunters rather than gardeners.

Achievements:

- Identifying community assets, capacities and future goals through interviews and focus group discussions in the districts of Goilala (Tapini), Rigo-Koiari (Gerabu, Geresi and Londari villages) and Segari Plateau (Kerekadi and Bautama) in January and February 2011.
- Conducting Women and their Daughters Workshops to identify Training Capacities and Needs with respect to the Value Chain - Rigo-Koiari and Segari September 2011 and Goilala in June 2013).
- Conduct of a Woman and their Daughters Training Workshop – Rigo-Koiari and Segari in May 2012 and Goilala in August 2013 - in production, postharvest and financial literacy skills.
- Conduct of Men and their Sons Workshop to identify Value Chain Capacities and Needs for Rigo-Koiari and Segari Plateau in September 2012 and for Goilala in June 2013.
- Following the Women's & Girl's Workshop, the Rigo-Koiari women established a new produce chain to a large supermarket in Port Moresby and their Women in Agriculture (WIA) group won the CPL 'Pride of PNG' Award. Men linked with this chain to supply produce to Stop 'N Shop.
- The total value of supply to Stop 'N Shop was about PGK 10,000 per week
- The farmers acknowledge they now have much improved farming and business skills

Failures:

Due to pre-existing factors within the community of Rigo-Koiari, the men's and women's chain to Stop 'N Shop declined because of pre-existing factors such as

- Disputes over charges for the use of equipment for vegetable production and the ownership of key machinery
- Key members of the community, such as the cooperative manager and cooperative organiser both obtained jobs outside the community
- Disputes over charges by coordinator of produce for market led to the decline in the Women in Agriculture chain and drop income to PGK 200 – 300 per week to Stop 'N Shop.

- No understanding of cooperative articles of association and how to hold elections for new office bearers
- No dispute resolution capacities within the community

Due to cultural and traditional factors, the success of the Kerekadi young women's collective in production and marketing fragmented due to such factors as

- Right of leadership based on family based traditional hierarchy within the village. The natural leader whose vision it was to have a collective conflicted with the perceived rights of a women from a family who had traditional leadership authority.
- There was no record of the agreement that had formed the collective and distrust about what had happened to profits from collective marketing activities
- There were no conflict resolution skills in the group for dealing with the 'falling out', as it was described.

Recommendations

- Training in leadership
- Training in conflict resolution
- Training in managing cooperatives and understanding of articles of association
- Maintenance by relevant PNG agencies (FPDA or NARI) in the villages to ensure of implementation and adaptation of previous training in production, marketing and financial literacy skills.

Barbara Chambers

07/06/2015

TRAINING REPORT

WOMEN'S TRAINING

For

RIGO/KOIARI & HIRI VEGETABLE FARMERS FROM PRODUCTION SITES OF THE LOW ALTITUDE AREAS IN CENTRAL PROVINCE

A follow up training on the Needs Analysis Workshop in September 2011 conducted by the Project Team with Barbara Chambers and Gomathy Palaniappan.

Philmah Seta-Waken and Roselyn Winston
NARI ACIAR Vegetable Project Team

SMCN/2008/008 Increasing Vegetable Production in Central Province, Papua New Guinea to Supply Port Moresby Markets

May 14th -18th 2012
NARI Southern Regional Centre, Laloki, Central Province,
Papua New Guinea

Executive Summary

In May 2012, Women Vegetable Farmers in the Rigo/Koiari and Hiri District were trained on Basic Financing, Book Keeping, Crop Management and Post-Harvest Techniques at NARI, SRC, Laloki, PNG. The training was conducted by Project partners; NARI, PAU and FPDA of the ACIAR Funded Vegetable Project for Central Province.

The training was a follow up on a Needs Analysis Workshop (Pictorial Training Needs Assessment Using a Collaborative Problem Solving Method (CPSM)) carried out by Prof Barbara Chambers, Dr Gomathy Palaniapan and Project Partners (NARI, PAU and FPDA) at the Pacific Adventist University, PNG in September 2011.

Before this training could happen, a steering committee representing workshop participants was set up to monitor the Action Plan on the training priorities identified from the Needs Workshop with the project partners making up the Action Committee. A criterion was developed to guide the selection of women, including a range of ages, a little bit of education, capability and willingness to share training with other women in their villages. Depending on the number of villages in each district, two women from 18 villages in Rigo/Koiari and five women from 6 villages in Hiri were expected to attend thus at least 60 women were expected to attend the training. However, a total of 28 women, 14 from Rigo/Koiari and 16 from Hiri were able to attend the training. Due to communication and distances from most villages in the Rigo/Koiari district not all selected women were able to attend the training. Overwhelming, the one week training were appreciated and grasped by the women as most of their training needs identified on Basic Financing, Book Keeping, Crop Management and Post-Harvest Techniques were addressed. The women were also advantaged to have had the training within NARI as scientists of various expertise were available to help them in terms of advice with problems encountered in their various farms. Thus, this training report will focus on NARI's contribution and part in which was played in the "Crop Management Techniques and Irrigation" as a training need identified in the previous workshop.

Background to the Training

In February 2011, group interviews were carried out in the villages of Rigo/Koiari and Bautama (Hiri) to determine what crops they produced using an appreciative inquiry (AI) technique against a Rapid Value Chain Appraisal (RVCA). From their various answers and data collected, the Needs Analysis Workshop was conducted for the women and daughters of Rigo/Koiari and Hiri districts to determine/ identify training needs in horticulture. Overwhelmingly, their training needs were identified as Farm

Production (Crop management and irrigation), Marketing (product readiness and negotiating price) and Business Skills (banking and book keeping).

Thus, we the PNG partners formed an Action Committee composing of Ms Roselyn Winston (NARI), Ms. Philmah Seta-Waken (NARI), Dr Lalen Simeon (PAU), Ms Poela Utama (FPDA), Ms Regina (FPDA) and Mr Gus Maino (FPDA) to address the identified training needs of the participants. All partners were involved in the planning of the training which included allocation of responsibilities, budget, selection of participants, training materials, and approach of training all in liaison with Professor Chambers and Dr Palaniappan. It was decided to conduct the training at NARI SRC, Laloki as it was safe and ideal as it had the requisite facilities especially on the training demonstrations for basic Crop Management and Post-Harvest Techniques. Professor Chambers met with the team in Port Moresby in early March 2012 for the initial planning stages of the training and assisted with advice on training approaches and planning.

This report is NARI's summary of the one week women's training that was conducted in May 2012 by the PNG Partners of the ACIAR Vegetable Project for Central Province, PNG.

NARI's contribution to this training on "Basic Crop Management and Irrigation" will be given in details while report on topics in the training facilitated by PAU and FPDA will be in brief.

Method

Selection criteria

Similar to the workshop prior to this training, the team devised a selection criterion for the women participants. These are some of the criteria of which participants were selected on:

- Two women from each village in Rigo/Koiari district.
- Five women from each village in Hiri District.
- Women who have had a bit of education and can at least read and write.
- Women who are able to understand English and Tokpisin.
- Women who had previous training of some kind.
- Women who are actively involved in vegetable farming.
- Women who are members of an agriculture organization/ association/ cooperative.
- Women who are committed to sharing their learning with other women.
- Ensuring a mix of ages i.e. mothers and daughters/daughters in-law.

Evaluation Surveys

Professor Chambers and Dr Palianappan provided templates for the pre and post evaluation tests. Copies of these especially for Basic Crop Management Techniques and Irrigation given by NARI are n Appendix 2. These Pre and Post Evaluation Surveys were devised according to each facilitator's training curriculum. We were asked to give the participants a Pre- Evaluation Survey before and a Post-Evaluation Survey after the training sessions. To also aid us the facilitators with the training sessions, we also had to draft personal schedules (Appendix 3) for each session we took. The facilitators also had to fill in the Facilitator's Evaluation form (Appendix 4). By the end of the week's training, participants finally filled in an evaluation survey on the whole training (Appendix 5).

Day One – Basic Financing and Book Keeping by PAU

Introduction

The participants registered to start the day. To register, on an information list, they wrote their names, village and district in which they came from and then were given a name tag with their names and a folder containing an exercise book for notes, a biro and a program (Appendix 1) for the week.

Day one of the training officially began by a little opening ceremony in the conference room in the presence of NARI's staff and invited media. Introduction of the training was given by Philmah Seta-Waken. Mrs Rosa Kambuou as NARI's ACIAR Vegetable Project Coordinator introduced the staff of NARI followed by a short speech encouraging the women to learn as much as they could during the training. They were also encouraged to take the opportunity of engaging and discussing issues with NARI scientists as they are privileged to have the training on the research station. With that she officially opened the one week training program.

Basic Financing and Book Keeping

Basic financing and book keeping topics started the training program for the week. Facilitator Ms Belinda Bush took the women through a power point presentation on money value, savings, budgeting, short and long term goals and book keeping. They did simple activities to get them to have a feel of drawing up their budgets in terms of short term and long term goals which took them through the first part of the day.

After lunch, PNG Microfinance Bank came to promote the products they have as their service to little farmers and business people like the women participants. The women had the opportunity to ask questions and also get from them application forms to open personal saving accounts with the bank. Having the bank present was a great compliment after stressing savings and budgeting in the morning.

Dr Simeon will give you a detailed report on this training.

Day Two - Basic Crop Management Techniques and Irrigation by NARI

Training Objectives

The overall purpose of this training was to have these women farmers be able to:

1) Identify six soil management practices and appreciate the importance of soil management.
2) Learn and know about some new irrigation technologies and how they can adopt it in their current farming practices.
3) Identify common weeds, pests and diseases of common vegetables and some of their management practices.

Training on Basic Crop Management Technique and Irrigation was made up of three topics and divided into two parts, theory and practical. The three main topics discussed were:

1. Soil Management Practices;
2. Irrigation (Introduction to Drip Irrigation); and finally
3. Crop Protection.

The first part of the day was focussed on theory (classroom activities) and the second part of the day practical which included field visits of demonstration plots and other field demonstrations as a follow up of the theory discussions.

Session 1: Theory

Each participant was given a Training Manual compiled based on the training needs identified. The Training Manual (Appendix 6) was compiled in such a way to capture the participant's interest with pictures and simple explanations to stress the importance of crop management activities. Most of the participants were familiar with soil management techniques; however, they didn't really know the reason behind doing these activities. Thus, the importance of these techniques was stressed to them hence they could appreciate and apply more of these techniques if they weren't practising them. An introduction to Drip Irrigation technology was a new concept to the participants which they showed very keen interested. Crop Protection was the third topic of discussion. There were quite a few questions and discussions during this last topic of discussion. Slide show presentations on each topic with their objectives were discussed and explanations were also given to compliment the Training Manual.

After each topic was discussed, simple activities in the Training Manual were attempted in groups. The women were put into four groups. Two groups made up of women from Rigo/Koiari and two groups from Hiri. After group discussions and answers, leaders /speakers from each group presented their answers and discussions were made around their answers through sharing from the participants. From their presentations, it was clear that women from the Rigo/Koiari area were more confident and vocal than that of the Hiri group of women. Women from this area are active vegetable farmers than most of the women from the Hiri district. Most women from Tubuseria village of the Hiri District were not active vegetable farmers. For these women, most of what was explained was new to them. The exercises and group discussions were a good learning and helpful experience for them.

Session 2: Practical

In the second part of the day, the participants were taken through the field to observe and see some of the soil management, irrigation and crop protection practices applied at NARI, SRC station. The Crop Protection Team on station took the women through steps on making their own pesticides using natural resources within their means through the Plant Derived Pesticides (PDP) techniques identified by NARI. Plants used were chilli and neem. The team then demonstrated how to apply the pesticides using a knapsack and a bucket and leaves. The women were given a chance to participate, by making their own PDP after the demonstrations by the facilitators. These were new to both groups of women. They were excited of the fact that they can make their own pesticides which were safer instead of spending money on commercialised pesticides. The women were then taken through a tomato plot to identify insects/pests and diseases.

The Agronomy team then took the women through making their own liquid fertilizers using animal manure and plants' remains followed by their application methods. The women were also given the opportunity to make their own liquid fertilizers and apply to crops in the demonstration plots. This also was a new concept to these women farmers, as it was expressed when discussed with them.

Facilitators' Observations

The following are some observations noted during the day's training:

a. Two women group from obviously different ways of livelihood. Women from Rigo/Koiari are active vegetable farmers where most daily income comes from farming. Women from Hiri especially from the Tubeserea village are not active vegetable farmers.
b. Rigo/Koiari group were more knowledgeable about certain concepts in the topics discussed.
c. Women from Kerekadi, Seme, Dagoda, Kore and Vadiri of the Hiri group were also familiar with these concepts as most of them are also active vegetable farmers.
d. While women from Tubuserea village were new to most concepts discussed as most have not farmed in their lives.
e. There was keen interest among all the participants both in classroom and field discussions.
f. Curious questions asked (some I couldn't answer, sought assistance & advice from colleagues).

g. Most participants' appreciated the importance of these "normal/common" farming activities after learning the reasons why these activities are done.
h. Understanding level of participants was not all the same.

Day three - Basic Post-Harvest Techniques by FPDA

Day three was devoted to Post-Harvest Techniques and Marketing led by Ms. Poela Utama and Mr Pus Wesis of FPDA.

The first part of the day was spent in the field where the women farmers were separated into two groups, Rigo/Koiari and Hiri. Each group were given baskets to harvest pachoi, corn and yardlong beans and pack. They were asked to see what each group did, and take note of how each group did harvest and packing. Power point presentations and group discussions were done in the second part of the day.

This is only a summary of day three, Poela and Pus will provide a detailed report on their observations on that day's program.

Day Four – Evaluation of the Training

Finally, the two groups were requested to evaluate the training. We took the first part of the day to go through evaluation survey forms with the women. They filled evaluation forms to tell us if the training had met their expectations, needs, exceeded most of their expectations or failed to meet most of the expectations.

From filled evaluation forms, it can be summarised that the two groups of women agreed that the training met most of their identified needs and exceeded most of their expectations. All the completed Evaluation Surveys such as Pre and Post Evaluation Surveys, Facilitators evaluation and whole training evaluation surveys will be compiled and sent to Dr Palaniappan and Professor Chambers.

In the second part of the day, Brian Bell & Co's Agriculture Section came up to NARI SRC, Laloki to showcase to the women farmer's their agricultural products. The participants were very grateful as a trip to Brian Bell for most women in Rigo/Koiari would have been only once or twice in a year. The women got a chance to ask questions about seeds, chemicals and equipment etc. to the sales team and of course purchase them as well.

Day Five - Graduation

The one week training ended on a high note with a little graduation ceremony. Guests, Ms Emily Flowers ACIAR Country Manager and her assistant Ms Rebecca Bogosia were invited to attend. The program (Appendix 1) began at 9:30am. Dr Lalen Simeon opened the program by welcoming the participants, guests, media and friends and family to the graduation ceremony. This was followed by NARI, SRC Research and Development Coordinator's speech. Mrs Rosa Kambuou gave a little speech as NARI's ACIAR Vegetable Project Coordinator followed by Ms Emily Flowers speech as the ACIAR Country representative and also as the funding body of the project. Certificates were presented to each woman by Ms Emily Flowers and Mr Kelly Ovia (Resource Manager – NARI). A copy of the certificate can be found in Appendix 9. Mr Pus Wesis closed the ceremony with a speech as the FPDA's ACIAR Vegetable Project Leader.

Finally, the women leaders of the two groups thanked the training facilitators with speeches of appreciation. Each women group performed songs and dances as a thank you to the facilitators and guests.

Summary

Overwhelmingly, the participants agreed that training by NARI on Crop Management Techniques and Irrigation had met their expectations and more from the needs identified in the first workshop. All women participants from Rigo/Koiari District are active vegetable farmers. Women from Kerekadi, Seme, Dagoda, Kore and Vadiri of Hiri District are also active vegetable farmers while women from Tubuserea village were all new to vegetable farming. However, both groups agreed that they now appreciate the importance of the techniques they apply and why these activities contribute in improving their vegetable production in terms of soil management, irrigation and crop protection. An introduction to the drip irrigation technology with its many advantages was welcomed by the participants and seeing from their reaction, I won't be surprised that they would be setting up a couple of these in their farms in the near future.

As facilitators, we believe that we have met the objectives of the three topics we have delivered to meet the participants' needs in Basic Crop Management and Irrigation Techniques.

Acknowledgment

The financial support of the Australian Centre for International Agricultural Research is gratefully acknowledged.

As well as the support of PNG partners of the ACIAR Vegetable Project – FPDA and PAU and collaborators The University of Canberra and The University of Queensland in the planning and delivery of the training.

APPENDIX 1

WOMEN'S TRAINING

For

RIGO/KOIARI & BAUTAMA VEGETABLE FARMERS FROM PRODUCTION SITES OF THE LOW ALTITUDE AREAS IN CENTRAL PROVINCE

A follow up training on the Needs Analysis Workshop in September 2011 conducted by the Project Team with Barbara Chambers and Gomathy Palaniappan.

SMCN/2008/008 Increasing vegetable production in Central Province, PNG, for Port Moresby Markets

PROGRAM

DATE: 14TH -18TH May 2012

VENUE: NARI, Southern Regional Centre, Laloki, Central Province, PNG

Day 1: Monday, 14th May 2012

7:30am – 8:00am	Welcome and Introduction (PSW/PU/LS/RW)
8:00am – 8:30am	Opening (Rosa Kambuou- NARI's Project Coordinator)
8:30am – 10:00am	Basic FinancingFacilitated by PAU
10:00am – 12:00pm	Practical Activities
12:00 – 1:00 pm	Lunch
1:00pm – 2.30pm	Cash flow
2:30pm – 4:30pm	Introduction to Microfinance Bank

Day 2: Tuesday, 15th May 2012

NARI: Crop Management – Group 1: Rigo-Koiari Women

8:00 am – 10:00am	Soil Management (PSW)
10:00am – 11:00 am	Irrigation Methods (PSW)
11:00am – 12:00 pm	Crop Protection (PSW)
12:00pm – 1:00pm	Lunch
1:00pm – 4:00pm	Field Visits and Demonstrations Crop Protection (BN/SA) Agronomy (AG) Irrigation (PSW)

Day 3: Wednesday, 16th May 2012

FPDA: Post Harvest – Group 1: Rigo/Koiari Women

8:00am – 10:00am	Harvesting (PU/PW)
10:00am – 12:00pm	Packaging (PU/PW)
12:00pm – 1:00pm	Lunch
1:00pm – 3:00pm	Transporting (PU/PW)
3:00pm – 4:00pm	Marketing (PU/PW)

Day 4: Thursday, 17th May 2012

8:00am – 12:00pm	Evaluation of Training (PSW)
12:00pm – 1:00pm	Lunch
1:00pm – 4:00pm	Brian Bell & Co – Agriculture Section display and promotion

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Day 5: Friday, 18th May 2012

8:00am – 10:00am	Preparation of graduation
10:00am – 12:00pm	Graduation Ceremony
12:00pm – 2:00pm	Travel back home

Graduation Ceremony Program

9:00 am – 9:30am	Arrival of guests
9:30 am – 9:40am	Welcome - Dr Lalen Simeon (PAU)
9:40am – 9:50am	Mr Clifton Gwabu (NARI SRC Research and Development Coordinator)
9:50am – 10:00am	Mrs Rosa Kambuou (NARI ACIAR Vegetable Project Coordinator)
10:00am – 10:10am	Ms Emily Flowers (ACIAR Country Manager)
10:10 – 10:30am	Presentation of certificates – Ms Emily Flowers and Mr Kelly Ovia
10:30am – 10:40am	Closing speech – Mr Pus Wesis (FPDA's ACIAR Vegetable Project Leader)
10:40am – 11:00am	Participant's Leaders thank you speeches – Rigo/Koiari and Hiri Groups
11:00am – 12:00pm	Depart NARI Laloki to nearest bus stops for home

APPENDIX 2

Pre-training Evaluation Survey

Basic Soil management techniques

1. What methods do you use to manage soil in your garden?
2. How did you know these methods?
3. Are you able to follow these methods?
4. Are there any other methods you know about soil management?

Post -training Evaluation Sheet

Basic Soil management techniques

1. Are there any other methods you know about soil management?
2. How did you know these methods?
3. Are you able to follow these methods?
4. Are there any challenges in following the method?

Pre-training Evaluation Sheet

Irrigation

1. What methods do you use to irrigate your garden?
2. How did you know these methods?
3. Are you able to follow these methods?
4. Are there any other methods you know about irrigation?

Post -training Evaluation Sheet

Irrigation

1. Are there any other methods you know about irrigation?
2. How did you know these methods?
3. Are you able to follow these methods?
4. Are there any challenges in following the method?

Pre-training Evaluation Sheet
Crop Protection

1. Name or describe the plants that compete with your main crop in your garden?

2. What do you do with the plants (weeds) that compete with your main crop in your garden?

3. Name or describe the insect pest that damages your crop in your garden?

4. What do you do with the insect pest that damages your crop in your garden?

5. Name or describe the disease that you observed in your crops in your garden?

6. What do you do to cure the disease observed in your crops in your garden?

Post -training Evaluation Sheet

Crop Protection

1. Are there any other weeds/pests/disease you know that affects your garden?

2. How did you know this weed/pest/disease affects your garden?

3. Are you able to follow these methods to manage weed/pest/disease?

4. Are there any challenges in following the method?

APPENDIX 3

Facilitator's Training Schedule

Session 1: **Soil Management** **Date:** **15^{th} -16^{th} May 2012** **Time:** **8:00am – 10:00am**
Venue: **NARI, SRC, Laloki**

Objectives:

At the end of the session participants will be able to:

- Know what soil management is;
- Identify ways to properly manage soil; and
- Appreciate these soil management practices to maintain soil fertility.

Time	Agenda	What is needed
5 minutes	**Introduction** • State objectives • Give house rules	• Presentation saved on computer.
35 minutes	**Knowledge (EXPAIN)** • Using power point presentation to explain Soil Management; and the techniques used to properly manage soil.	• Presentation saved on computer. • Handout of Training Manual - 1 copy per participant. • Flip charts and markers.
40 minutes	**Attitude (ASK)** • Participants to do Activities 1 & 2 in the Training Manual; and • Discussion of answers	• Document the discussion • Observe agreements and discussion
40 minutes	**Skill (SHOW)** • Field visit to see examples of soil management practice. • 2 practical exercises of soil management techniques.	• Demonstration fields • Spades • Rakes • Hoes

Trainer: Philmah Seta-Waken, Project Scientist, NARI SRC, Laloki
Abel Giblin, Research Associate, Agronomy, NARI SRC, Laloki

Session 2: **Irrigation** **Date:** **15th – 16th May 2012** **Time:** **10:00pm – 12:00pm**

Venue: NARI, SRC, Laloki

Objectives:

At the end of the session participants will be able to:

1. Identify different types of irrigation;
2. Know about drip irrigation;
3. Appreciate and apply drip irrigation method in their farms.

Time	**Agenda**	**What is needed**
5 minutes	**Introduction** • State objectives • Give house rules	• Presentation saved on computer.
40 minutes	**Knowledge (EXPAIN)** • Using power point presentation to explain Irrigation; irrigation methods and introduction to drip irrigation.	• Presentation saved on computer. • Handout of Training Manual - 1 copy per participant. • Flip charts and markers.
40 minutes	**Attitude (ASK)** • Participants to do Activities 1 & 2 in the Training Manual; and • Discussion of answers	• Document the discussion • Observe agreements and discussion
40 minutes	**Skill (SHOW)** • Field visit to see examples of drip irrigation set up.	• Demonstration fields • Equipment/connectors etc. to show farmers.

Trainer: Philmah Seta-Waken, Project Scientist, NARI SRC, Laloki

Session 3: **<u>Crop Protection</u>** **Date:** **<u>15th – 16th May 2012</u>** **Time:** **<u>1:00pm – 4:00pm</u>**
Venue: **<u>NARI, SRC, Laloki</u>**

Objectives:

At the end of the session participants will be able to:

- Describe which plants are called weeds;
- Identify ways to control and mange weeds;
- Know what an insect pest is;
- Recognize which insects are pests to a particular crop;
- Identify ways to control and manage insect pests;
- Learn some PDP techniques;
- Define plant disease;
- Describe symptoms of common vegetable plant disease.

Time	Agenda	What is needed
10 minutes	**Introduction** • State objectives • Give house rules	• Presentation saved on computer.
50 minutes	**Knowledge (EXPAIN)** • Using power point presentation to explain Crop Protection; Causal agents – Weeds, insect pests, plant disease, management techniques.	• Presentation saved on computer. • Handout of Training Manual - 1 copy per participant. • Flip charts and markers.
40 minutes	**Attitude (ASK)** • Participants to do Activities 1-5 in the Training Manual; and • Discussion of answers	• Document the discussion • Observe agreements and discussion
1hour 20 minutes	**Skill (SHOW)** • Field visit to see examples of soil management practice. • 2 practical exercises of soil management techniques.	• Demonstration fields • PDP materials for demonstration ○ Chilli, neem seeds, soap, buckets, containers, strainers, water, gloves etc. • Flip charts, markers

Trainer: Philmah Seta-Waken, Project Scientist, NARI SRC, Laloki
Benjamin Niangu, Research Associate, Plant Protection/Entomology, NARI SRC, Laloki
Sharon Agovaua, Research Associate, Plant Protection/Entomology, NARI SRC, Laloki

APPENDIX 4

Facilitator's Reflection on conducting Training

Facilitator: Philmah. Seta-Waken
Organization: NARI
Date of training: Tuesday, 15th May 2012
Name of session: Basic Crop Management Techniques – Soil Management, Irrigation and Plant Protection.

Thank you for organizing the training session. We'd like to hear your reflections on the various aspects of the training, so that we can continually improve on conducting training.

1. **What did I do to conduct training?**

   As a trainer, these are some tasks I did to prepare myself for the training;

   a. Compiled a Training Manual based on the participant's identified needs in "crop management" considering also the target audience when compiling the manual.
   b. Prepared a power point presentation according to the training manual also considering the target audience.
   c. Completed a Training Template to prepare my sessions for the day.
   d. Liaised with colleagues on station to prepare field for demonstrations and other activities for the training.

2. **What did I observe during training?**

   During the training, these were some of my observations.

   i. Two women group from obviously different ways of livelihood.
   j. Rigo/Koiari group were more knowledgeable about certain concepts discussed while the Hiri group were new to most concepts discussed.
   k. All participants of Rigo/Koiari group are actual women farmers while Hiri group women were just being introduced; most have not farmed in their lives.
   l. Keen interest among the participants.
   m. Curious questions asked (some I couldn't answer, sought assistance & advice from colleagues).
   n. Most participant's appreciated the importance of these normal farming activities after learning why these activities where done.
   o. Understanding level of participants were not the same.

3. **What did I learn through conducting training?**
   These are some things I learnt during this training;
   a. Always consider/know your target audience before and while you deliver the training.

b. Understanding level of all participants were not the same.
c. Some of the participants are very practical.
d. Getting participants to discuss openly and share amongst themselves and I helped us all to learn from each other.

4. **Was there anything that I was surprised about?**
   I was surprised about the fact that half of the participants from the Hiri Group of women were not farmers at all. (The criteria drawn up for selection weren't correctly relayed to contact farmers along that area.)

5. **Did I meet my objectives?**
   Yes, I believe I did meet my objectives in the three sessions I conducted.

6. **Were participants responsive to my training?**
   Yes, I found participants to be quite responsive, as I said; they now knew and appreciated why they do the activities they do at their farms especially for the Rigo/Koiari group and the Hiri group learnt some new concepts. An introduction to drip irrigation in one of the sessions got the both groups intrigued.

7. **What did I value most about the training?**
   What I valued most was probably the introduction of drip irrigation for farmer's at their level in which they could easily adapt in their farms if they were serious about it and committed to adopting the idea.

8. **What did I least value about the training?**
   I believe all of what I taught the participants in my sessions was important.

9. **If I have to conduct training in the future what will I do differently?**
   Learning from this training, crop management being a practical area, I would first and foremost arrange properly in advance field demonstrations in whatever topic I will deliver to the participants and involve them in these activities as much as possible.

APPENDIX 5

Training Evaluation

Thank you for attending the training session. We'd like to hear your impression of the various aspects of the training, so that we can continually improve the experience for all participants. Please (X) tick any one of the columns to answer the questions on the form.

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
1. The training met my expectations.					
2. I will be able to apply the knowledge learned.					
3. The training content was relevant to the objectives.					
4. The content was organized and easy to follow.					
5. The materials distributed were useful.					
6. I will refer to the material provided in future.					
7. The trainer was knowledgeable.					
8. The trainer was able to answer my questions					
9. Participation and interaction were encouraged.					
10. Adequate time was provided for questions and discussion.					

11. What was the most valuable information you learned and why?

12. What was not valuable to you and why?

13. Others

APPENDIX 6

INTRODUCTION TO BASIC CROP MANAGEMENT TECHNIQUES
By NARI, Southern Regional Centre Project Team

WOMEN'S TRAINING

For

RIGO/KOIARI & HIRI VEGETABLE FARMERS FROM PRODUCTION SITES OF THE LOW ALTITUDE AREAS IN CENTRAL PROVINCE

A follow up training on the Needs Analysis Workshop in September 2011 conducted by the Project Team with Barbara Chambers and Gomathy Palaniappan.

SMCN/2008/008 Increasing Vegetable Production in Central Province, Papua New Guinea to Supply Port Moresby Markets

May 14th -18th 2012

NARI Southern Regional Centre, Laloki, Central Province,

Papua New Guinea

Table of Contents

Introduction

This manual is part of a series of training conducted by the National Agriculture Research Institute, Southern Regional Centre in conjunction with Fresh Produce Development Agency and the Pacific Adventist University as partners in this ACIAR funded Vegetable Project for the Central Province.

This is a follow up training from a previous Needs Analysis Workshop conducted for these women farmers from the production sites of the low altitude areas of the Central Province from the Rigo/Koiari and Bautama areas in September 2011.

Needs identified by these women farmers were in Farm Production (soil management, crop protection and irrigation), Marketing (product readiness, postharvest and negotiating price) and Business Skills (banking and book-keeping). Hence, NARI SRC- Laloki was nominated to provide training especially on Farm Production needs as identified.

The notes in this manual capture basic information on farm production techniques especially on soil management techniques, crop protection and a basic introduction to drip irrigation. Therefore, these notes are very brief and from the Trainer's personal knowledge and experiences in vegetable farming.

Training Objectives

By the end of this training, these women farmers will be able to:

4) Identify six soil management practices and appreciate the importance of soil management.

5) Learn and know about some new irrigation technologies and how they can adopt it in their current farming practices.

6) Identify common weeds, pests and diseases of common vegetables and some of their management practices.

Topic 1 Soil Management

Objectives

By the end of this topic, you should be able to:

1. Know what soil management is;
2. Identify ways to properly manage your soil; and
3. Appreciate these soil management practices to maintain soil fertility.

Introduction

A soil can lose its ability to support plant growth if it is not looked after (*managed*) properly. This may happen through landslides, flooding and erosion. Soil management means using it wisely so that it can support plant growth.

Soil management practices

Soil management practices include the following:

Mulching

What is mulching?

- Covering of the surface of the bed prepared for planting vegetables with dry grass, leaves, saw dust, food peelings.



Why is mulching good?

- Mulching helps to:
  (1) **Hold back water and keep crops cool** during the dry season.
  (2) **Minimize weed growth.**
  (3) **Preventing soil erosion** by reducing the impact of raindrops on the soil surface and runoff.
  (4) **Improve soil fertility and structure.**

Types of mulches

Mulches can be divided into two types:

1. **Organic mulches-** The most common ingredients of organic mulches are dry grass, leaves and saw-dust and crop by-products like peanut shells, coffee hulls, rice hulls, coconut husks and corn cobs.



2. **Artificial mulches**. These include polyethylene plastics, fibreglass and aluminium foil, sand, stones and gravel.



Crop rotation

What is crop rotation?

Crop rotation is the process whereby a first crop (e.g. peanuts) planted on the land is followed by planting a different crop (e.g. capsicum) on the same land after harvesting the first crop. The diagram below shows an example of crop rotation.

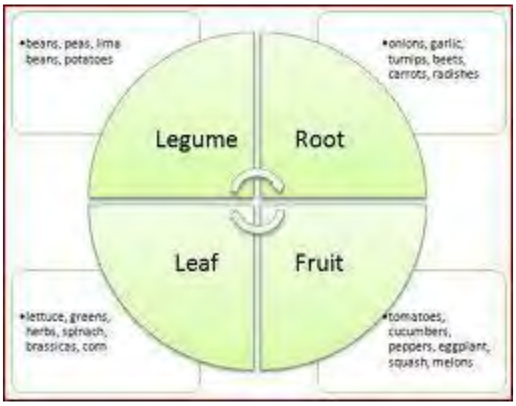


Figure 1: An example of a crop rotation. The non- legume crops (corn and cabbage) will use up nitrogen in the soil while legume crops (peanut and snake bean) will add nitrogen to the soil. After harvesting, the non-legume crops will be rotated as shown by the arrows. Corn and cabbage will use the nitrogen put in the soil by peanut and snake bean respectively.

Why is crop rotation good?

Crop rotation is good because:

(1) Avoiding disease attack on crops in the previous plot.
(2) Adding nitrogen in the soil by growing legume crops.
(3) Prevention of soil erosion by growing dense - foliaged or vined - crops such as snake beans.
(4) Varieties of crops are grown for farmer's use.




Green manuring

What is green manuring?

Green manuring is the process of growing legume plants such as cowpea into well prepared soil until they are leafy (4-6 weeks after planting). The green crop is then harvested before they develop flowers and fruits and buried by ploughing or digging, into the soil

Green Manuring

Why is green manuring good?

To improve the soil:

1. organic matter content;
2. fertility;
3. structure;
4. prevent erosion; and
5. Conserve soil moisture.

Cover cropping

What is cover cropping?

When the bare soil surface is protected by a cover of certain legume plants it is called *cover cropping*. An example is growing legume plants such as *Pueraria or Centrosema* in a plantation of coconut, cocoa, oil palm and rubber. The cover crops should be better established before these plantation crops are mature.


Pueraria


Centrosema

Why is cover cropping good?

Like green manuring, cover crops help to:

1. reduce weed growth,
2. conserves soil moisture,
3. adds nitrogen into the soil,
4. improves soil organic matter content and soil structure; and
5. Prevents soil erosion.



Land fallow

What is land fallow?

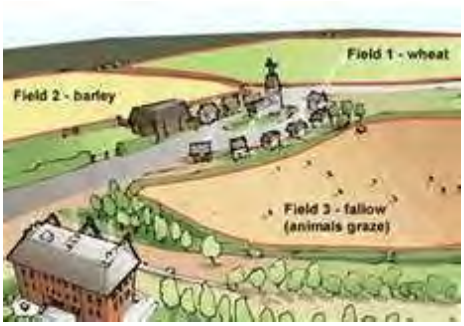
Land fallow is a process where the land is rested from cropping for a period of time, which may be many years. In the past the fallow period used to be 10 to 25 years. Today, this period is in some areas only 3 to 5 years as a result of land pressures due to increases in population.



Why is land fallow good?

Land fallow helps to restore:

1. Organic matter content of the soil,
2. Soil fertility and
3. Soil structure.
4. Prevents soil erosion

Activity 1

1. Think back to your village garden.
   a. Write down 6 types of crops grown.

   b. For each crop tell us if they are mulched and if so with what type of material.

   c. For each crop, what rotation system is used? For example if sweet potato is grown, what is the next crop grown in the same ground?

   d. Is your land left to fallow? How long do you normally fallow your land?

How fertilizers are applied to crops

There are 4 methods of applying fertilizers to crops.

1. Broadcasting Method

The fertilizer is held by the hand or machine and is evenly distributed over the soil surface and then carefully mixed into the soil. This method is easy to use but usually the crops may not utilize fertilizer as it may be out of reach of the roots of the crops. Also the fertilizer is usually applied before the crops are planted and if it rains heavily some loss of the fertilizer may occur by leaching.

2. Placement of fertilizer

The fertilizer is placed as a band to the side of the seedlings, about 10cm from vegetables such as cabbages, tomatoes and capsicum. If seeds are planted the fertilizer is placed in the planting holes then covered with some soil before seeds are added. The placement method is good because fertilizer is given directly to individual plants. However, it requires more time and excess of fertilizer may kill the crops.

3. Foliar (leaf) application

Some fertilizers can be mixed in water and sprayed with machinery (manual or motorized sprayers) onto the leaves of growing crops. This has to be done carefully as too much fertilizer used will injure plants.

4. Fertigation method

In this method the fertilizer is mixed in a tank and a motorized pump is used to pump the fertilizer via an irrigation pipe or fixed irrigation sprayers/sprinklers onto the soil at the base of the crop.

When can you apply fertilizer?

Fertilizers can be applied

1. Before planting (*pre-planting* or *pre-emergence*),
2. At planting and
3. During the growth stages of a crop (*post- planting* or *post-emergence*).

The timing depends on types of crops and fertilizers.

Activity 2

2. Think back to your village garden/farm. Do you use fertilizers? Fill in the table.

Name of crop	**Is fertilizer applied?**	**What type of fertilizer is used?**

3. When (time) do you apply fertilizer?

4. What method do you use to apply fertilizer?

Summary

Appropriate soil management practices should be used where possible to maintain high soil organic matter content to

1. Protect the soil from erosion,
2. Improve the soil properties that will benefit the soil, which in turn will
3. Improve crop growth and bring better yield to the farmer.

Topic 2 Irrigation Techniques

Objectives

By the end of this topic you should be able to:

4. Identify different types of irrigation;
5. Know about drip irrigation;
6. Appreciate and use the drip irrigation method in your farm setting.

Introduction

Like people and animals, plants also need water for its healthy and normal growth. Many farmers rely only on the rainfall to water their crops (gardens). Water for irrigation is very important to successfully grow vegetables all year round even in dry periods without rain. The fertilisers / nutrients in the soil are absorbed into the plant along with the water through its roots in the soil for the plant to grow well and produce more.

Some vegetable require relatively more and frequent water than others. Example, cabbages requires more water than tomatoes, capsicums and watermelons that grows well in drier conditions. A form of irrigation system is a must to successfully grow our vegetables especially in the drier periods when there is no rain.

Types of Irrigation

The type of irrigation system depends on the size of the farm, the source of water (from a water-well, dam or river) and the how much the farmer can afford.

1. Manual – the simplest but less efficient system is watering by hand using buckets and watering cans for irrigation. Water is fetched and applied to plants by hand.
2. Canal or farrow – water pumped (using manual or motorised water pump) and stored in reservoir which is then directed to flow into the open field between the farrows or ridges. May need a water pump to draw water from water well or from a river.
3. Drip – water is pumped into a tank (a reservoir) and then delivered as drips to the plants' base through small and narrow tubes through gravity force. This system is effective when the tubes are not blocked by dirt or build-up of chlorine from the water.
4. Overhead Sprinklers- this system requires sufficient pressure from the water-pump to force water to shoot out of the upright sprinklers as sprays as it rotates.

Drip irrigation

What is drip irrigation?

Drip irrigation/ micro-irrigation is a method that allows a farmer to control the application of water and fertilizer by allowing water to drip slowly near the plant roots through a network of valves, pipes, tubing and emitters. However, drip irrigation is not applicable to all farms.

Advantages of drip irrigation

1. Less water can be used
2. Lower operating pressure means low cost for fuel/petrol for pumping.
3. Water used well because plants can be supplied with water.
4. Water is applied directly to the plant root zone.
5. Reduce weeding
6. Reduce pests/disease infestation
7. Reduce soil erosion
8. Reduce labor




Disadvantages of drip irrigation

1. Higher initial investment
2. Requires regular maintenance and high quality water
3. Tubes may be lifted by wind or displaced.

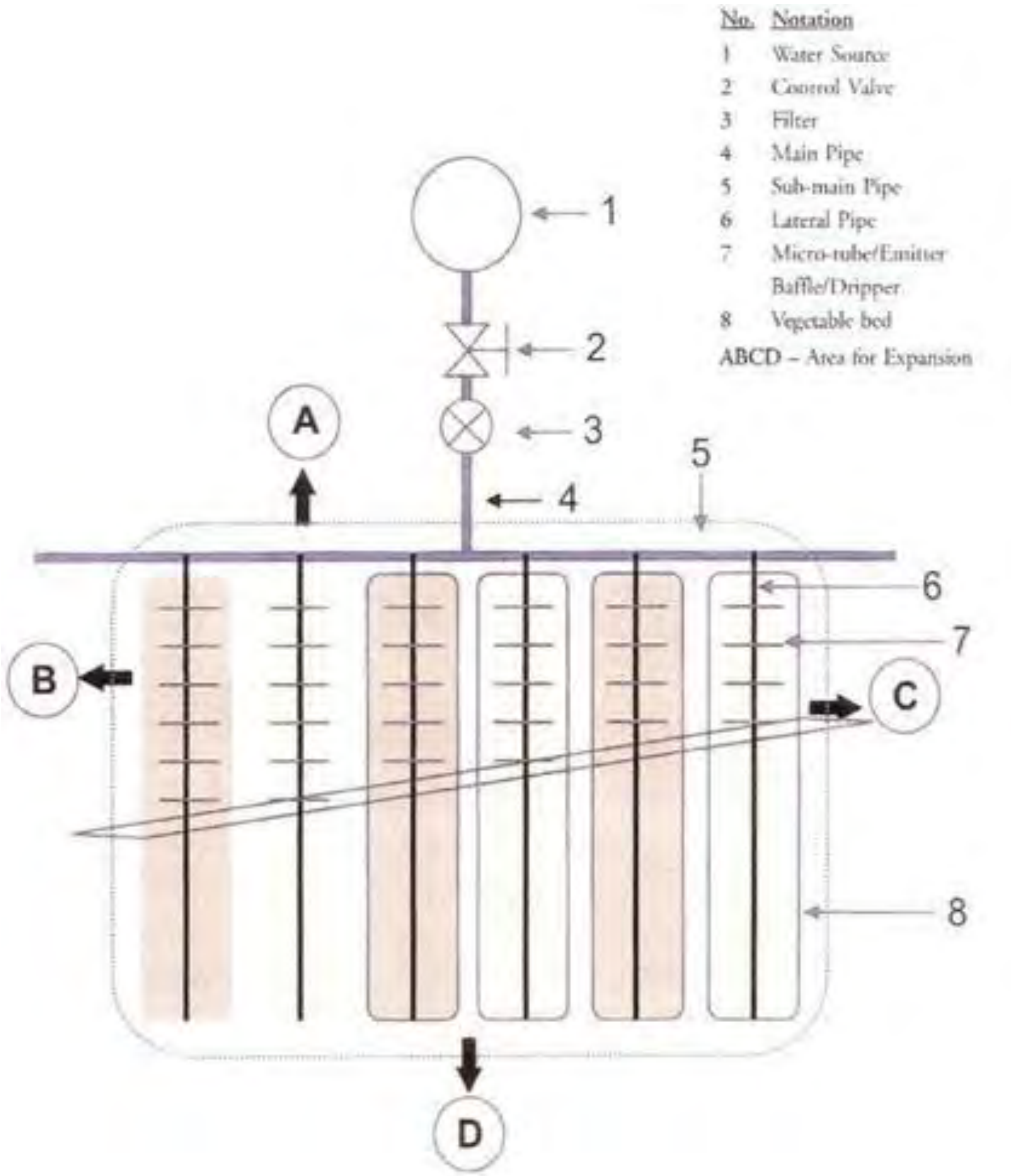


Water source

The water for irrigation can come from wells, streams, ponds, tanks, rain, recycled water from wastewater treatment plants or other sources.


Components of a drip irrigation system

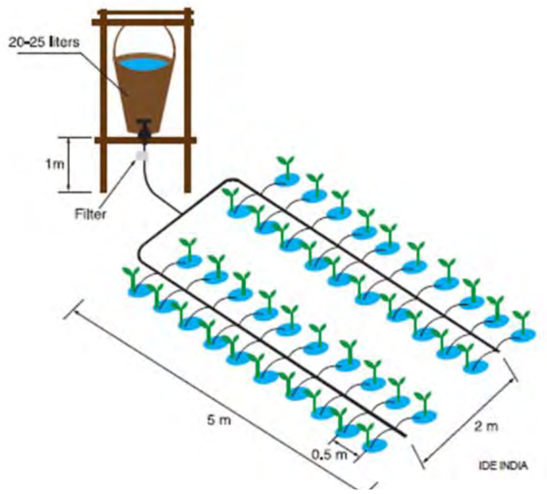
A typical drip irrigation system has seven major components.



Some simple drip irrigation systems

International Development Enterprises (IDE) in India has developed simple, affordable low-cost drip irrigation systems for smallholder vegetable growers. These systems include:

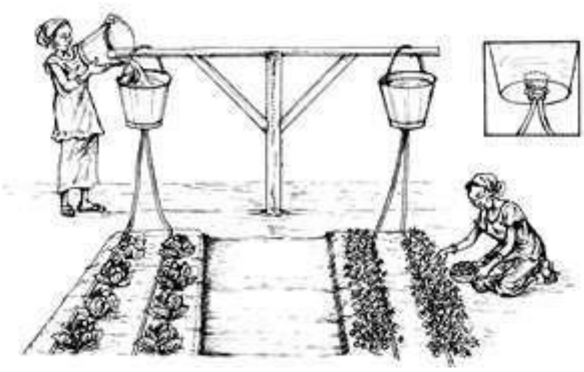
- Bucket Kit
- Family Nutrition Kit
- Drum Kit
- Customized System
- Combo Kit



A simple bucket kit for irrigating a small vegetable garden plot of approximately 20m^2.

Bucket Kit Features

- A pre-assembled kit to irrigate vegetables in home gardens.
- Has a 20-liter bucket with one or two rows of lateral drip lines 5 to 10 meters in length, depending on the space available.
- Can irrigate up to 20 square meters.
- Bucket can be hung from a tree or pole 1 meter high.



Topic 3 Crop Protection

Objectives

By the end of this topic you should be able to:

1. Describe which plants are called weeds;
2. Identify ways to control and mange weeds;
3. Know what an insect pest is;
4. Recognize which insects are pests to a particular crop;
5. Identify ways to control and manage insect pests;
6. Learn some PDP techniques;
7. Define plant disease;
8. Describe symptoms of plant disease.

Introduction

The Crop Protection deals with the agents that cause crop losses and how they are managed to minimise these losses. There are 3 main agents Weeds; Insect pests and Plant diseases.

Weeds

What are weeds?

A weed is a plant that is growing in the wrong place.

For example, volunteer tomatoes, or beans become weeds if they grow in ground that has been planted with a crop of sweet potatoes. Weeds, which interfere with cropping or grazing activities or block waterways, can compete with nutrients in the soil resulting in low crop yields. Some examples of introduced weeds of economic importance to PNG are shown below:






The effects of weeds on crops

Harmful effects of weeds

Weeds directly **compete** with crop plants for light, nutrients and water and this causes a reduction in crop yields. Some weeds can also act as hosts for insect pests and disease agents.


Beneficial effects of weeds

However, in abandoned land, weeds can help reduce soil erosion and add organic matter to the soils when they decompose. Some may also act as a source of food and may have medicinal properties.


Ways to control weeds

1. Physical Control

a. Hand weeding
b. Hoeing and cultivation
c. Mowing and slashing

2. Cultural practices

1. Mulching
2. Cover cropping especially using leguminous crops also helps to reduce weed growth. Cover crops also help to improve soil fertility.

3. Using chemicals

- These chemicals are called herbicides.
- Herbicides are expensive and dangerous to use without proper equipment and training.
- Some herbicides kill the plant by contact with the plant surface and are called contact herbicides.
- Others can be applied to one part of the plant and they are then absorbed and distributed through the plant's vascular system to the whole plant. These, e.g. glyphosate or roundup are called translocated herbicides. However, care must be taken as these can also kill crop plants.
- Manufacturers therefore give strict instructions on the label of the containers as to how and when a particular herbicide can be applied and its potential danger to humans and animals and crops.
- Chemicals do result in a quick kill of weeds and may only be economic if used in large plantation crops such as cocoa, coffee, and oil palm.

Insect Pests

What are insect pests?

Pests refer to mostly the bad insects and their larvae which feed and damage food crops. They include

1. Sucking insects (e.g. aphids, stink bugs, plant hoppers, thrips etc.);
2. Chewing insects (e.g. grasshoppers, caterpillars and beetles etc), leaf rollers (e.g. aibika leaf roller, banana skippers etc.); and
3. Barrowing insects (e.g. taro beetles, sweet potato weevils, red banded caterpillars etc).

Ways to control insect pests

a) **Physical Control**
- Do hand picking and killing them. Possible for small garden only. Best time to hand pick insects are early in the mornings when the sun is not too high on a weekly basis.

b) **Cultural control**
- Cultural Control involves**:**
  - Crop Rotation
  - Planting of repellent crops in the vegetable garden
  - Planting resistant crop varieties.

c) **Biological Control**
- Biological control encourages the use of other natural living organisms (e.g. insects, birds, etc) to control/kill other bad insects. The good insects are called parasites / parasitoids) like spiders, praying mantis, lady bird beetles etc. which feeds on other bad insects which destroys our vegetables.

d) **Chemical Control**
- Using of organic or in-organic pesticides to kill the bad insect pests attacking our vegetables.

e) **Organic pesticides**
- Organic insecticides are naturally derived pesticides made from plants like:
  - Derris (poison root)
  - Tabocco leaf and stalk

- Neem leaves, bark & seeds
- Marigold leaves and stem
- Chili fruits
- Pawpaw leaves

f) Inorganic pesticides

- These are pesticides that are produced using chemicals. They are very effective but are very harmful to the environment and are very costly. There are strict safety measures to follow to avoid poisoning yourself, others and polluting the environment.

- It is best not to use in-organic pesticides in your home garden unless you are sure and know how to safely handle the chemicals and correctly mixing and applying the chemicals to your crops. This is because they are poisonous to humans. However, it is useful on commercial scale farming.
- Examples of insecticides & their mixing rate sold in Didiman stores in PNG include:

Chemicals	**Mixing rates**	**Comments**
Karate	10mls into 10L water	
Thunder	5ml in 1L water	
Confidor		
Othin		
Biefenthrin & Mustang	50ml into 20L water	For taro beetle control

Note: Application of these chemicals requires knapsack sprayers. The application rates defer from chemical to chemical. On every chemical container there should be labels and instruction guides given on the rate for mixing and application (e.g. 10mls into 10L water) and how to apply them.

Activity 1

1. Below are some photos (1 –8) of different insects. Do you see some of these insects in your gardens? If yes, what crops do they attack?

Tomato Hornworm

Corn Earworm


Brown Sting bug


Pumpkin Beetles


Cane Toad


Capsicum Maggots


Giant African Snail

Plant diseases

What is plant disease?

A plant can be defined as diseased if it is not growing well or looks sick compared to a normal healthy plant. We can usually see with our eyes some of the symptoms that plants are not growing well.



What causes plant disease?

Most plant diseases are caused by:

1. Fungi
    - Fungi cause plant tissue to rot, spots on the flowers, leaves and stem.



2. Bacteria
    - Bacteria diseases are similar but the only difference is, it gives off an awful smell.




3. Virus
    - Virus diseases, the symptoms are closely similar to nutritional deficiency.

Mosaic virus

Ways to control diseases

There are three (3) common controls that can be used.

- Cultural control – practice crop rotation, use resistant varieties etc.
- Physical control – preventing excess water e.g. use glass -house.
- Chemical control – use of copper based fungicide chemicals.

Some common diseases in vegetable crops

Wilt diseases

Here the symptom is shown by the leaves, which are no longer erect and turgid but are drooping downwards and are limp.

Photo 9: Capsicum plants showing typical signs of wilting.

Wilt may be caused by not enough water in the plant in which case the plant recovers as soon as water is applied to the soil and taken up by the roots. But if the plant does not recover from the wilting even though there is enough water given it means that the wilting is caused by a disease.

We can test this further by slicing the plant stem. If the tissue is sliced longitudinally (along the stem length) the vascular tissue (which allows water to move from the roots to the leaves) shows a brown streak running along the length; if the tissues are sliced horizontally (or across the stem), the vascular system appears as a brown ring. This browning shows that the wilt is due to a blockage of the vascular system and the disease is known as *vascular wilt disease*.

Leaf blight

The symptoms of leaf blight start from the appearance of tiny brown spots of dead tissue on the green leaves. These enlarge and merge together until the whole leaf is dead.

Early and late symptoms of potato late blight on potato leaves

Under good environmental conditions the disease can spread from one plant to another plant until the entire crop is affected. If the disease starts when plants are young it is called *Early leaf blight*, but if it occurs later when plants are flowering or producing fruit, it is called *late blight*. Leaf blight disease is common on Tomatoes, capsicum, potato crops and taro.

Activity 2

1. Take a walk in the garden and see if any tomatoes are showing signs of wilt. Scrape the top layer of soil and test if the soil is moist or dry.

   If the soil is moist then remove a wilted plant and take a knife and cut open of the stem, horizontally and longitudinally and examine to see if you see any signs of vascular browning.

2. Examine the leaves for brown spots. If the spots are brown with concentric rings that look like a target board of darts - it is called *target spot* and this is indicative of early blight disease.

3. Take a walk amongst some taro plants growing in the field. Examine both young and old leaves. Note if young leaves have any circular brown spots on them. Now examine older leaves and see whether there are huge areas of brown spots or dead tissue due to the merging of a number of dead leaf spots. Examine the under surface of the leaves and check whether there is any white ring around the border of the leaf spot. If so, this is Taro leaf blight disease. It is best to observe this in the early morning.

   Symptoms observed……………………………………………………………...

   Number of plants affected…………………………………………………..

Leaf spots

Sometimes there may be a number of different types of leaf spots on a plant. Some may be regular or round and small; others may be irregular, and others are where the diseased brown dead tissues drop off leaving a hole. More than one disease may occur on the same plant.

Activity 3

1. Examine leaves of bananas growing in the gardens around you.
   (a) Take a leaf showing symptoms and describe the leaf spots you observe by making a drawing of the type of spots present.

   (b) Count the number of different types of spots present and their colour.

   The symptoms help to identify what the cause is.

Ways to control disease

There are a number of simple ways in which the losses caused by plant diseases can be controlled. These are as follows:

- **Using disease –free planting materials** i.e. healthy seeds or cuttings obtained from a healthy crop.
- **Good hygiene**, i.e., Removing and destroying infected material, e.g. cocoa pods with black pod disease by burning; destroying crop residues after the crop is harvested.
- **Crop rotation** by planting a different host crops after the first crop is harvested i.e. beans after sweet potato. Avoid too close spacing when planting corn, peanuts, and taro.
- **Planting cultivars, which are resistant to disease**– e.g. new taro and potato varieties with tolerance to Leaf blight, hybrid cocoa, corn.
- **Managing insect pests** such as aphids which transmit plant viruses
- **Farm quarantine** – stop unnecessary movement of people animal, machines in and out of the farm.
- **Chemicals** -As with herbicides there are chemicals that can be used to control diseases caused by micro-organisms such as fungi. These are called fungicides. However these are also costly and require care in using the right chemical for the right disease. Copper based compounds have been long used to control some diseases like coffee rust but these are generally only used in bigger plantations rather than on smallholder blocks.

Activity 4

1. Do you use any of these practices in your gardens/farms and if so, why?

Summary

Weeds grow in any environment. They are found in gardens, pastures, in water, on trees and in all environments. Weeds compete with crops for water, nutrients and sunlight resulting from loss of yield. Weeds can be controlled by physical, cultural, mechanical, chemical (herbicides) and biological control.

Pests refer to mostly the bad insects and their larvae which feed and damage our vegetables. Insect pests can be controlled by physical, cultural, biological, organic and inorganic pesticides.

Plant diseases are hard to see or recognize at an early stage until the crop has been affected. Observing the visible symptoms indicate there is a plant disease problem. To control crop diseases, some of these include good cultural practices, physical and using chemicals.


Examples of damage caused by fruit fly larvae


STOCK FEED


BRIAN BELL & CO LTD
SAKATA


BELL & CO LTD

Participants
Name List

No	Name	Village	District	Age
1	Mellen Camilus	Kerekadi	Hiri	29
2	Valo Fakepo	Kerekadi	Hiri	46
3	Esther Koroki	Kerekadi	Hiri	29
4	Filo Kidu	Kerekadi	Hiri	36
5	Diresa Karara	Dagoda	Hiri	35
6	Maiva Geita	Seme	Hiri	33
7	Naomi Moia	Kore	Hiri	39
8	Idau B Henao	Vadiri	Hiri	45
9	Hereva Noinoi	Tubuserea	Hiri	58
10	Kila Sibona	Tubuserea	Hiri	20
11	Nancy Kila	Tubuserea	Hiri	62
12	Manega Logona	Tubuserea	Hiri	43
13	Rei Ahuta	Tubuserea	Hiri	54
14	Kila Kamuta	Tubuserea	Hiri	45
15	Hoi Morea	Tubuserea	Hiri	56
16	Gaugu. Keina	Geresi	Rigo/Koiari	53
17	Kariza. Maiga	Geresi	Rigo/Koiari	37
18	Vaburi. Konido	Girabu	Rigo/Koiari	41
19	Lalau. Konido	Girabu	Rigo/Koiari	41
20	Kosina. Komuzo	Kodere	Rigo/Koiari	28
21	Helen. Tabu	Kodere	Rigo/Koiari	39
22	Anna. Samuel	Londairi	Rigo/Koiari	43
23	Levana. Arua	Gea	Rigo/Koiari	39
24	Greisi. Gari	Gea	Rigo/Koiari	31
25	Ragana. Andrew	Vasiri	Rigo/Koiari	24
26	Buana. Mareva	Vasiri	Rigo/Koiari	32
27	Maia. Joshua	Wasuma	Rigo/Koiari	45
28	Joyce. Duna	Wasuma	Rigo/Koiari	34

SMCN/2008/008 Increasing Vegetable Production in Central Province, Papua New Guinea to Supply Port Moresby Markets

Vegetables at the Rocklea Markets, Brisbane

ACIAR Project: SMCN/2008/008 Increasing Vegetable Production in Central Province, Papua New Guinea to Supply Port Moresby Markets

Trip Report for 18th June 2012 by Dr Gomathy Palaniappan

Tasmanian Institute of Agricultural Research

Purpose of the Trip

The aim of this trip is to improve market systems in PNG by facilitating the PNG participants from Fresh Produce Development Agency (FPDA) to understand the functioning of the Rocklea markets and a local super market in Brisbane, Australia. This visit was significant as all the participants from FPDA, PNG were women unlike during their previous visit in 2011 October where only men made the visits to the markets in Australia.

Preparation for the trip

The Fresh Produce Development Agency (FPDA) is preparing to take the responsibility of operating the markets in Port Moresby and the building construction for the markets is currently underway. For this reason the FPDA participants:

1. Louise Aitsi Deputy Chairlady,
2. Elizabeth Melchior Fruit Tree Development Officer and
3. Poela Utama Specific Crop Development Officer

were interested in visiting the central markets operating in Australia. This study visit is significant as all the team members were women unlike the previous visit in 2011. In October 2011 the FPDA participants were:

1. Mr Fabian CHOW, (Chairman of the Board of Directors, Fresh Produce Development Agency Limited)
2. Mr Gregory Berry, (Member of the Board of Directors, Fresh Produce Development Agency Limited)
3. Mr Gregory Liripu, (General Manager, Fresh Produce Development Agency Limited)
4. Mr Mewie Launa, OBE, (Divisional Manager for Corporate Affairs, Fresh Produce Development Agency Limited)
5. Mr Lucas Kindiwa, (Divisional Manager for Production and Value Chain Supplies)

The central markets in Australia play a significant role within Australia's horticulture industry as the major distribution point of the nation's fresh fruit, vegetables and flowers. In Australia there are six Central Markets, including Brisbane, with the others located in Sydney, Melbourne, Adelaide, Perth and Newcastle. The FPDA participants chose to study 2 central markets Brisbane and Sydney and so a study to Brisbane markets was organized through the project.

Brisbane's Rocklea market in action

The communications manager, Vanessa Kennedy from the Rocklea Markets, Brisbane was contacted and the purpose of the visit was explained. She responded positively and was happy to host the participants from PNG. A comprehensive set of questions were prepared to interview the wholesalers, growers and staff of the Rocklea markets. An alternate vegetable outlet such as the Woolworths which is a local super market chain was chosen and the comprehensive sets of questions were discussed with the store manager prior to the visit.

A brief history on the Brisbane Market

The first purpose-built fruit and vegetable Market was built in Market Street in 1866 and after years of changing ownership, had closed by 1881. However, Brisbane Municipal Council stepped in four years later, and in 1885 opened the purpose-built Roma Street Markets, tucked beside the rail line and handy river ports, in the heart of the city, to service a growing Brisbane. By 1906, a band of wholesalers, unsatisfied with increasing government regulation and congestion, created a rival market in Turbot Street, and over the years, the two markets operated side by side, creating a Brisbane fruit and vegetable precinct. As the city grew, so did the congestion, and as early as 1936 there was talk of moving the Markets precinct. It wasn't until 1964 that the plan came to fruition, with the Queensland Government stepping in to create the Brisbane Markets site, at Rocklea, where it stands today (Source: Brisbane market's pamphlet).

- During debriefing the FPDA participants made a note that the markets must be built in a location with access to transport and must take measures to avoid congestion.

The PNG participants observed the following from the interviews:

Market operation and regulations:

- The market is divided into different sections for easy operation such as the produce market centre, flowers market, market place, fresh centre etc.
- The market allows the bulk buyers like the fruit and vegetable retailers, secondary wholesalers, restaurants, cafes, food service businesses and exporters, source their fresh produce requirements from the Brisbane Produce Market. These buyers inspect the wide variety and range of products available and compare various grades and prices to ensure they are getting the best produce available at a fair market price on the day.

- There are regulations in place for accessing the markets. For instance a commercial buyer needs to get a market access card to enter the markets during the defined working hours.
- Safety measures are in place like all market users whilst on market need to wear a day/night reflective safety west

- Translating this idea to the PNG market means FPDA must define the purpose of their market whether it is for consumers or for commercial buyers and if it was for both then a mode of operation to accommodate both type of transaction must be planned.
- Market regulations must be developed in order to provide safe access to markets particularly for women to avoid any interference.

Farmers and wholesalers

- Most vegetables are purchased from farmers through the wholesalers and the farmers and wholesalers have relationship built over generations.
- Some vegetables are imported from New Zealand, PNG and other countries. But most vegetables are purchased local.
- Regular supply of vegetables is a must to keep the market profitable. The surplus vegetables are stored in cold storage rooms by the wholesalers. The wholesalers pay for the stalls and storage facilities in the market.
- Good quality vegetables fetches best price and so farmers grade the vegetables and send in best quality. If farmers did not provide good quality vegetables then the wholesaler refuse to buy vegetables from the farmer and as a result the farmer loses business with the wholesaler. If the wholesaler does not give a good price for the farmer than the wholesaler will lose the business with the farmer.
- Low quality vegetables are sold at lower price unless there is a great demand on the vegetables.
- There is an agreement called Horticulture Producer Agreement to protect the interest of both grower and wholesaler.
- There is credit scheme where the farmers and wholesalers secure their transaction.
- Farmers take the risk on the produce during transportation. There is a general understanding between both the farmers and wholesalers. For instance recently the price of tomatoes increased due to bad weather conditions. During such circumstances both farmers and wholesalers share the benefits and consumers are disadvantaged. However when there is surplus production then the consumer is at the advantage as the price goes down. Most farmers produce a variety of produce to deal with such kind of risks.
- Market kitchen – a new venture to process surplus produce is now in place
- Farmers pack the right quantity of produce cartons to maintain the quality of the vegetables during transport
- This means that FPDA must see that there is eough local production to meet the market needs.
- Infrastructure like cold storage rooms must be provided to store vegetables

- The market currently under plan in PNG may be for both farmers and wholesalers and to protect the interest of both famers and wholesalers are to be developed.
- Quality and quantity of vegetables are both important for the market to function.
- Credit scheme is a good method for future transaction in PNG.

Quality vegetables displayed by wholesalers

Debriefing with FPDA participants

- Do not mix businesses – To be in business it must be focussed on vegetables and fruits only Too many diversifications like allowing stalls to be taken over by other entrepreneurs may severely damage the business.
- Continuous supply of produce – Every action must see that there is continuous supply of vegetables or we can't stay in business
- Packaging – Local material or cartons can be used to maintain the quality of vegetables
- Recycling of cartons – Caution must be taken as any fungus may get spread through the chain
- Cleanliness – Markets need to be kept cleaned Any damaged produce must be removed immediately
- Stall need to be constructed in such a way that the goods can be loaded and unloaded with ease (women bring the produce to the market so this needs to be taken into consideration)
- Water supply is a must in the market for the sellers and buyers in the market
- Toilet facilities and washing facilities must be provided as women will be travelling from remote places to access the market
- Food shop for buyers and sellers in the markets

FPDA participants interviewing wholesalers

Vegetables kept in Cold storage

Woolworth's super market chain

An alternate vegetable outlet such as the Woolworths which is a local super market chain was chosen and the comprehensive sets of questions were discussed with the store manager prior to the visit. We agreed not to take any pictures in the store.

- Vegetables are purchased centrally from farmers and each store would mention their requirements and will be delivered to the store through cold storage transport
- Quality of vegetables are discussed centrally with the farmers
- Farmers take pride in supplying through our chain as we sell mostly the locally grown vegetables. Farmers know that our chain supports them and they see the benefits
- Locally grown vegetables means a lot to the consumers and they are here to support the local growers
- Some vegetables are packed in quantity and some vegetables can be packed by consumers as per their requirements. For instance this store is located at Indooroopilly and the majority of the consumers are students. They prefer to buy small quantities rather than the half Kg packed bags which will best suit families. So we provide choices to the consumers based on the pattern of consumers walking into the store.
- I take account of the sales pattern and decide to promote the vegetables. For instance if we have more stalk to be cleared then we reduce the price of the vegetables so that it can be sold at a faster rate.
- In order to promote our sales we advertise through pamphlets, websites and media

Debriefing with FPDA participants

- A system to monitor the sales of vegetables and fruits need to be developed
- A system to record the pattern of sellers and buyers need to be developed
- Promote our markets through advertisements through pamphlets, websites and media

Appendix 1: WORK BOOK for participants

Improving Market Systems in PNG

SMCN-2008-008 Increasing Vegetable Production in Central Province PNG to Supply Port Moresby Markets

Visit to Rocklea Markets, Brisbane

Australia

This workbook is developed to record the observations during the visit to Rocklea Market in Brisbane and Woolworths Retail outlet in Brisbane.

Date: 18th June 2012

Venue: Brisbane, Australia

Name: Louise Aitsi Deputy Chairlady, Elizabeth Melchior Fruit Tree Development Officer and

Poela Utama Specific Crop Development Officer

Organization: Fresh Produce Development Agency

Objective: To improve marketing systems in PNG

- **A. Visit to Rocklea Markets - Discuss their observation**
- **B. Visit to Outlet Markets**
- **C. Debrief learnings**

A. Visit to Rocklea Markets - Discuss their observation

To understand how the wholesalers work with fruit and vegetable growers.

1.1 Where do you get vegetables from?

1.2 Do you have regular suppliers?

1.3 How do you obtain the quality you want?

1.4 What do you do when the quality is not what was expected?

1.5 If a supplier wants to supply vegetables what must he do?

1.6 What is the volume of supply that a grower supplies to the market?

1.7 What are the terms of agreement with the grower/wholesaler?

1.8 How is the interest of the grower protected?

1.9 How is the interest of the wholesaler protected?

2. To understand how the price for fruit and vegetables is decided.

2.1 How do you determine price?

2.2 Who does the grading of vegetable?

2.3 What happens if the vegetables get damaged during transport or weather conditions?

2.4 Who pays the transporter?

2.5 What supply problems do they have?

3. To understand how the consumer preferences are addressed.

- 3.1. How do you know what the consumer wants?
- 3.2. Is this information shared with the others in the chain? If so with whom and how?
- 3.3. Is the price/demand response the only way they determine what the consumer wants?
- 3.4. Do they ever use other means to determine consumer values?
- 3.5. How do they go about introducing new products into the market?
- 3.6. Vegetables being seasonal how do they manage off season demands?

4. To understand how to manage a market system

- 4.1 Who manages or runs the market?
- 4.2 How and when did the market start?
- 4.3 Is there a government regulation to support the market?

4.4 How do you generate the revenue to mange the expenses in the market?

4.5 What is the waste management system practiced?

4.6 How do you regulate the behaviour in terms of protecting the interest of all actors?

4.7 How do you solve disputes?

5. To understand the challenges in the market system.

5.1 What are the challenges as stallholders in the market and how can this be improved?

5.2 What are the challenges of market operators and how can this be improved?

6. To understand grower's perspectives of marketing through Rocklea Markets

6.1 What vegetables do you grow?

6.2 Where do you sell them and why?

6.3 What do you do to maintain the expected quality?

6.4 What happens if there is crop failure or pest infestation?

6.5 What are the benefits and challenges in marketing your produce?

Other Observations

B. Visit to Woolworth

1. To understand the functioning of the retail outlet

1.1. Where do you get vegetables from?

1.2. Do you have regular suppliers?

1.3. How do you obtain the quality you want?

1.4. What do you do when the quality is not what was expected?

1.5. If a supplier wants to supply vegetables what must he do?

1.6. What is the volume of supply that a grower supplies to you?

1.7. What are the terms of agreement with the grower/wholesaler?

1.8. How is the interest of the grower protected?

1.9. How is the interest of the wholesaler protected?

2. To understand how the price for fruit and vegetables is decided.

2.1 How do you determine price?
2.2 Who does the grading of vegetable?
2.3 Who does the packaging?
2.4 What happens if the vegetables get damaged during transport or weather conditions?

2.5 Who pays the transporter?
2.6 What supply problems do they have?

3. To understand how the consumer preferences are addressed.

3.1. How do you know what the consumer wants?
3.2. Is this information shared with the others in the chain? If so with whom and how?
3.3. How do you attract your consumers? What are the strategies used to attract consumers?
3.4. What if the consumer is unhappy with the produce purchased?
3.5. Is the price/demand response the only way they determine what the consumer wants?
3.6. Do they ever use other means to determine consumer values?
3.7. How do they go about introducing new products into the market?
3.8. Vegetables being seasonal how do they manage off season demands?

4. To understand why they shelve the vegetables in a certain pattern

4.1 What is the reason for shelving in a certain pattern?
4.2 Why some vegetables are bagged and some are left at the choice of the consumer?
4.3 What value has been added to the vegetables?

5. To understand how to manage a market system

5.1 Who manages or runs the market?
5.2 How and when did the market start?
5.3 Is there a government regulation to support the market?
5.4 How do you generate the revenue to manage the expenses in the market?
5.5 What is the waste management system practiced?
5.6 How do you regulate the behaviour in terms of protecting the interest of all actors?
5.7 How do you solve disputes?

Other Observations

C. Debrief Learnings

ACIAR SMCN/2008/008 Increasing Vegetable Production in Central Province, Papua New Guinea to Supply Port Moresby Markets

Report on the Men & Sons Participatory Value Chain Planning Workshop

held at Tapini Station, Goilala District, Central Province, PNG

by
Pus Wesis[1]
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Regina Malie[1]

19th – 20th March 2013

[1]FPDA POM, [2]NARI Laloki, [3]DAL Central Province

Workshop Aim:

To improve our understanding of each players role in the value chain and identify training needs of male smallholders in horticulture in the Tapini Local Level Government (LLG), Central Province of PNG.

Objective 1: To explore people's roles in the horticultural value chain

Objective 2: Training Needs Assessment in Small Village Based Groups

Objective 3: To explore the ideas or dreams that men smallholders have for the future wellbeing of their families and villages

Objective 4: To identify plans or strategies for addressing:

a) Issues in the value chain

b) Training priorities

Introduction:

The Workshop was attended by 30 participants from three communities; Tapini station, Kaitapi Ward and Erume ward of the Tapini Local Level Government (LLG) in Central Province of PNG. The participants had either worked with the Fresh Produce Development Agency (FPDA) in the past and through contacts for demonstration trials for this project or have known the National Agricultural Research Institute (NARI) while a trial was conducted in the first season at the Tapini station. Participants were selected and invited by the Central Provincial Department of Agriculture and Livestock (DAL CP) staff based at Tapini. Some of the participants had considerable previous experience marketing vegetables to the informal markets while others had no experience. Both groups either with marketing or no marketing experience mentioned that due to road infrastructure and transportation to bring vegetables to the Port Moresby markets, most vegetables rotted at the Tapini station.

None of the participants had any prior training or exposure to the concept of value chain management and in general vegetable production. The training was to be conducted with lead facilitators from the donor country however; this was not possible due to family and other reasons. Hence, local staff from project partner organizations conducted the training and imparted the knowledge they had in value chain management.

Again the training was conducted for one and half days as the training facility was shared with Mineral Resources Authority (MRA) who were also conducting trainings for the same participants on small alluvial gold mining.

Approach:

The facilitators were first timers in conducting such trainings in value chain management and system. Hence, the approach used were those developed from Laurie Bonney, Barbara Chambers and Gomathy Palaniappan during the Men and Sons workshop held at Pacific Adventist University (PAU) in September 2012. The three research and development models; Appreciative Inquiry (AI), Rapid Supply Chain Appraisal (RSCA) and Organic Research and Collaborative Development (ORCD) were used.

Appreciative Inquiry (AI), emerging from Participative Action Research, is one of a family of approaches that can complement problem-solving by counterbalancing its self-limiting aspects. AI is an approach for planning and working for change that identifies the best of "what is" as the grounding for pursuing a vision of "what could be."

The Rapid Supply Chain Appraisal Approach (RSCA), an approach which rapidly scoops the performance of the whole supply chain as a dynamic system and by doing so provides a simple framework for analysing the critical parameters of complex chain dynamics.

The Organic Research and Collaborative Development (ORCD) method is an iterative, evolutionary and collaborative approach to solving wicked problems in a Development context. It has strengths in its approach to collaborative planning with a whole supply chain that accommodates potential gender issues as well as explicitly processing both the local knowledge that is so important to capacity-building in the Host Country and the contextual scientific knowledge so important to Donor Agencies.

The three methods outlined above, ORCD, AI and RSCA, all have common roots in Participative Action Research which shares perspective on social research founded on the principles of:

- Participation, collaboration and democracy;
- Iterative learning-doing processes…knowledge-in-action;
- Achieving practical outcomes;
- Emergent, developmental properties.

Therefore, the project methodology below proposes to employ the strengths and methods of these three methods for establishing and developing the value chains in focus for this project.

Methodology:

The method used for the value chain component of this project incorporates the strengths of the three research and development models below and thus is called the 'rapid value chain research and development method:

- Appreciative Inquiry (AI) - a cycle of:

  1. Discovery or appreciation of the best of 'what is';
  2. Dreaming of 'what might be';
  3. Designing what 'should be';
  4. Destiny of how to empower, learn and adjust/improvise.

- *Rapid Supply Chain Appraisal Approach (RSCA):*

  This incorporates four sub-systems found to be critical to a supply chain's operational efficiency and effectiveness:

  - Product integrity;
  - Communication;
  - Value creation;
  - Chain governance.

- Organic Research and Collaborative Development (ORCD) method

  The explicit incorporation of the iterative action research process involving:
  1. Working 'with' the chain participants;
  2. The initial use of non-contextualised scientific knowledge in concert with 'local

knowledge' with the incorporation later of and contextualised scientific knowledge and experience;

3. Pre-planning workshops with women to identify gender issues for incorporation into the later planning stage.

Unifying and adapting these for this ACIAR Project has necessitated the incorporation of more explicit capacity-building processes to develop participant and community knowledge of the value chain management process.

The extension of the ORCD method provides the process framework in which the AI and RSCA methods are unified into a 'rapid value chain research and development method'. This occurs through the design of questions (Table 1) and organisation of responses in the 'rapid value chain development matrix' (Table 2), which was based on the Collaborative Problem Solving Methodology used in the very successful Women's and Daughters Workshop in late 2011 and Men and Sons Workshop in September 2012.

Workshop processes:

The agenda and processes have been detailed in Appendix 1. Briefly, the participants were:

Fig 1: Tapini men and sons discuss their plans within each group

1. Welcomed;
2. Introduced to each other and the facilitators;
3. Received an explanation of the aims and objectives (Appendix 2);
4. Signed an Ethics Consent Form after receiving an explanation of the Ethics Procedures (Appendix 3);
5. Developed their rules of participation (Appendix 4);
6. Explained their expectations for the workshop which were recorded for evaluation at the workshop closure (Appendix 5);
7. Introduced to value chain concepts
8. Participated in 'icebreaker discussions' in village groups – "What do PNG consumers value?" This served to get vigorous discussion going and provided the workshop orientation to delivering the consumer value attributes which creates 'demand pull' and drives all chain processes.
9. Discussed and reported to plenary sessions for each of the questions in the Rapid Value Chain Development Matrix (Table 1)
10. Used the 'poster, stickers and cards method' of identifying training needs and priorities (Tables 2 – 6)
11. Ranking training needs in terms of priorities (Table 8)
12. Evaluated the Workshop in terms of participant objectives (Appendix 4)

From Bonney, Chambers and Palaniappan (2012) report, the implementation of the rapid value chain research and development method employed several tools as described in the following section.

1. **Introducing value chain principles and the icebreaker**

Fig 2: Sylvester Bannon facilitating in a group discussion.

All the workshop participants had no previous exposure to the value chain principles. Therefore, the first part of Session 1 provided a brief, basic explanation with diagrams and contextual examples of the main value chain principles which emphasised, in particular, the role of consumer value in driving demand. After allowing time for questions, this lead into five small group discussion (10 minutes) using each staff as table facilitator and elected leaders reporting of the question: "What do PNG consumers value in fresh vegetable products?" Each group's output was recorded on butcher's paper in English and then reported to the plenary.

Table 1: The Rapid Value Chain Development Matrix of workshop questions

	Appreciative Inquiry Stage	1. Product integrity	2. Communication	3. Value creation	4. Relationships
Day 1	**Discovery or appreciation of the best of 'what is'**	What is it about current arrangements with your Buyer that is working very well?	What information do you currently get about the vegetables that you supply to your Buyer?	Describe why you think your vegetables are better than those from other communities?	What do you know about how your Buyer does business? What would you like your Buyer to know about how you produce vegetables that would help them understand your problems?
Day 2	**Dreaming of 'what might be' (GOALS)**	How could the arrangements with your Buyer be improved to improve the quality of your vegetables when they arrive at the store?	What information from your Buyer would you like to know that would help you improve your growing and supply of vegetables to them? What information do you think they need?	How could you make sure that the vegetables you supply to your Buyer are better than other communities?	What would you like to know about your Buyer that would help you do a better job of supplying them with vegetables?
	Designing what 'should be' (ACTIONS TO ACHIEVE THE GOALS)	What will you do in the coming year to achieve these improved arrangements?	What will you do in the coming year to improve the info you give your Buyer and they give you?	What will you do to produce better veges during the coming year?	What will you do to improve your relationship with your Buyer in the next year?
	How to empower, learn and adjust/improvise	What skills and knowledge do you need to learn to do this? Who do you need to give authority to in your Cooperative for this to happen? What changes to your equipment, facilities & way you work together to make these things happen?			

Participants met in council ward (village-based) groups of 6-7 persons with a table facilitator each which facilitated them discussing their shared views of problems and possible futures:

- Interaction in the small groups was governed by the workshop rules that they had made at the beginning of the workshop (Appendix 5), which emphasised respectful listening to other people's views, the discussion of experiences, similarities and differences, hopes and plans.
- Rotating responsibilities for group leadership and recorders was encouraged but as time passed designating these functions became almost redundant except for the final reporting back to the plenary. Generally, there was a high level of enthusiastic participation generated. Each group leader expressed their appreciation of being invited to participate and indicated it was a first time for such training probably since independence and would definitely change their approach to vegetable growing and marketing.
- At appropriate points during the session, time was given to consider one or several questions from the participants. Presentations from the groups during plenary session received universal attention, some questions and enthusiastic appreciation exhibited through applause. At times, presentations were passionate and somewhat emotional as people described their visions, plans and possible effects on their communities.

This small group approach was interspersed as indicated by the Agenda (Appendix 1) with the alternative participatory tool, the "Pictorial Method of Assessing Value Chain Training Needs" described in the next section. This was highly complementary to the group processes associated with the Matrix:

- On Day 1, after the AI "Discovery or appreciation of the best of 'what is'" phase, the change of activity to using the pictorial method to focus on vegetable growing activities and determine "the similarities and differences between groups" was a logical step;
- On Day 2, considering shared goals, actions required to achieve them and then enabling those plans had a clear link to the pictorial method of determining training needs and priorities.

Table 2, presents the output of the Rapid Value Chain Development Matrix of workshop questions. This will be used to develop the on-going Project Work Plan for each community and, through incorporating the output of the Pictorial Method of Assessing Value Chain Training Needs, will comprise a training plan.

Table 2: Men and their son's responses

Appreciative Inquiry Questions	Group 1 (Guari LLG, Ward 1)	Group 2 (Kataipi ward)	Group 3 (Tapini station)	Group 4 (Erume)	Group 5
What do Tapini farmers value most?	1. Taste 2. Size 3. Quality 4. Appearance 5. Price 6. Freshness 7. Location (LLG)	1. Quality of produce 2. Price 3. Colour 4. Size/shape 5. Taste 6. Freshness 7. Regularity (how often available on market)	**Banana/Sweet Potato** 1. Colour 2. Taste 3. Size 4. Price **Head Cabbage** 1. Price 2. Size 3. Taste 4. Colour	**Sweet Potato** 1. Quality 2. Taste 3. Price **Banana/Peanut** 1. Taste 2. Colour 3. Shape/size Choko tips 1. Freshness 2. Taste 4. Price	**Sweet Potato** 1. Colour (white) **2.** Taste **3.** Shape (long) **4.** Quality **5.** Price **6.** Freshness **7.** Regularity **8.** Cleanliness
What is it about current arrangements with your Buyer that is working very well?	**Open Market** • Middleman available • Takes less time	• No buyer at all in PoM	• No time taken to sell • Buyer available • Constant price	• No time wasted in selling • Buys whole produce without checking • Agreed Price	• Sells all to middleman • Constant Price
What information do you currently get about the vegetables that you supply to your Buyer?	• Quality	• No information hence all vegetables rot	• About good quality • Buyer wants freshness • Proper packaging	• Good quality produce • Freshness	• Quality • Grow highlands variety
Describe why you think your vegetables are better than those from other communities?	• Tastes better • More fresh than highlands • More quantity	• Organically grown • Best quality • Freshness	• Tastes better	• Firm flesh of tuber crops • Vegetables tastes better • More quantity supplied	• Firm tuber flesh • Sweet taste
What do you know about how your Buyer does business? **What would you like your Buyer to know about how you produce vegetables that would help them understand your problems?**	• Very little or no understanding of buyer's business	No knowledge as don't do business in PoM	No or very little knowledge of buyer's business	No or very little understanding of buyer's business	Very little of buyers business. He resells to other retailers
How could the arrangements with your Buyer be improved to improve the quality of your vegetables when they arrive at the store?	• Packaging • Farm extension • Provide transportation	• No idea on what to do. Thinks buyer provides transport to pick produce at Tapini	• Provide transport • Post-harvest training • Pest & disease management	• Provide training • Provide transport • Establish relationship with buyer	• Build relationship • Price agreement • Training
What information from your Buyer would you like to know that would help you improve your growing and supply of vegetables to them?	• Prices of different vegetables	• Quality & Quantity required • Price of produce	• Quantity required • Price to be paid for • Type of vegetables	• Required quality & quantity • Price to be paid	• Price to be paid • Vegetable required
What information do you think they need?	• Quality • Price	• Transport • Price	• Transport • Vegetable type	• Transport requirement • Supply chemicals	• Provide transport • Give training

What will you do in the next year to improve your arrangements for producing and delivering vegetables to your main buyer? (DIFOT)	• Improve quality • Packaging in proper materials	• Grow required vegetables • Maintain quality • Request transport	• Improve transport • Proper packaging for freshness • Supply good quality	• Consistent supply if transport provided	• Supply good quality • Grow required variety • Agree on price
What will you do to improve communications with your main buyer?	• Get mobile number • Become friend • Agree on what to grow and supply	• Meet and come to common understanding	• Get telephone numbers of buyers and research & extension staff • Give some extra quantity of produce	• Meet and discuss requirements • Get contact details	• Get mobile number • Agree on price • Use DPI, NARI & FPDA staff
What will you to do to improve quality, taste, size, shape that your buyer and consumers want?	• Get training • Plant what buyer wants	• Seek technical advice from relevant agencies	• Get some training • Proper packaging • Plant what buyer requires	• Grow vegetables that buyer wants • Get more training	• Proper packaging • Grow variety buyer wants
What could you do to improve your relationships with your main buyer?	• Meet and agree to sign contract	• Supply some extra produce on top of what is required	• Sign agreement • Keep constant contact	• Provide best quality only • Give some extra quantity	• Constant contact • Sign agreement

Pictorial Method of Assessing Value Chain Training Needs

In societies of low literacy and diverse cultures and many languages (dialects), traditional pen and paper modes of assessing training needs are not particularly successful. They demand a high level of resources, whereby research assistants have to administer such assessment one- on-one as an interview with the participant. Using familiar pictures of everyday value chain tasks in a workshop setting facilitates a better understanding of what is required amongst participants and the workshop facilitator has a better chance of moderating comprehension and consistency.

Having this understanding and in this workshop, each group (6 members each) was given a set of poster cards in horticulture, marketing and business similar to the poster cards developed and used for the women and daughters (2011) men and sons (2012) workshops respectively. With the help of a table facilitator, each group was asked to discuss each picture associated with the task in general and then decide which tasks were easy, which were quite difficult and which were very difficult and why this was so. They were then asked to allocate poster cards to one of three stacks based on those assessments. Some groups began their task with difficult tasks and others with easy tasks. Each group presented their findings to the whole workshop by posting the poster cards on the wall under the headings of easy, moderately difficult and most difficult and explaining their ratings. Participants were asked to explain why, what obstacles get in your way? What resources do you have that would make the job easier to do? What other resources do you need to make the job easier to do? (Tables 3 – 10)

Table 3 Training Needs Assessment Recording of Table Facilitators (Group 1a)

From which village is this group? Guari LLG

What is the age range of group members? 21 – 31 (Younger men)

Name of Table facilitator? Dickson Benny

Horticultural Jobs <u>Very Hard</u> to do (List) **1. Soil Preparation H1**	**Why? What obstacles get in your way?** 1. Clearing new land, use spades a hard work	**What resources do you have that would make the job easier to do?** 1. Spades	**What other resources do you need to make the job easier to do?** 1. Tractor
Horticultural Jobs <u>Quite Difficult</u> to do (List) **1. Marketing M3**	**Why? What obstacles get in your way?** 1. Painful sitting in market and too hot during hot sunny day	**What resources do you have that would make the job easier to do?** 1. Many local markets	**What other resources do you need to make the job easier to do?** 1. Sell produce to buyer on contract agreement

Horticultural Jobs <u>Easy</u> to do (List) **1. Harvesting M1**	**Why? What obstacles if any get in your way?** 1. None	**What resources do you have that would make the job even easier to do?** 1. Knives	**What other resources do you need to make the job even easier to do?** 1.Buy more harvesting tools

Table 4 Training Needs Assessment Recording of Table Facilitators (Group 1b)

From which village is this group? Guari LLG

What is the age range of group members? 31 -51 (older men)

Name of Table facilitator? Dickson Benny

Horticultural Jobs <u>Very Hard</u> to do (List) **1. Crop Management H4**	**Why? What obstacles get in your way?** 1. Lack knowledge to control pest and disease problems 2. No spraying equipment	**What resources do you have that would make the job easier to do?** 1.No equipment at all 2.Labour	**What other resources do you need to make the job easier to do?** 1. Spraying equipment and information on what chemicals to use
Horticultural Jobs <u>Quite Difficult</u> to do (List) **1. Irrigation H3**	**Why? What obstacles get in your way?** 1. Hard to make drains	**What resources do you have that would make the job easier to do?** 1. Buckets	**What other resources do you need to make the job easier to do?** 1. Irrigation pump and system
Horticultural Jobs <u>Easy</u> to do (List) **1. Planting H2**	**Why? What obstacles if any get in your way?** 1. None	**What resources do you have that would make the job even easier to do?** 1. Just direct planting	**What other resources do you need to make the job even easier to do?** None

Table 5 Training Needs Assessment Recording of Table Facilitators (Group 2a)

From which village is this group? Kataipi ward

What is the age range of group members? 21-30 (Younger men)

Name of Table facilitator? Pus Wesis

Horticultural Jobs <u>Very Hard</u> to do (List) 1. Transport B3 2. Marketing M3	Why? What obstacles get in your way? B3 - no good road M3 -Labour intensive	What resources do you have that would make the job easier to do? B3 – no vehicles H3 - Mechanisation B2 - General book keeping	What other resources do you need to make the job easier to do?
Horticultural Jobs <u>Quite Difficult</u> to do (List) **1. Irrigation H3** **2. Crop Management H4** **3. Packaging M2**	**Why? What obstacles get in your way?** H3 –accessibility H4 – poor knowledge label M2 – poor knowledge	**What resources do you have that would make the job easier to do?** H3 –rain fed H4 – some knowledge M2 –empty bags	**What other resources do you need to make the job easier to do?** H3 – irrigation pump & system H4 – spraying equipment & pesticides M2 – proper packaging materials
Horticultural Jobs <u>Easy</u> to do (List) **1. Harvesting M1** **2. Planting H2** **3. Book keeping B2** **4. Soil Preparation H1** **5. Banking B1**	**Why? What obstacles if any get in your way?** No obstacles	**What resources do you have that would make the job even easier to do?** Family labour, open market	**What other resources do you need to make the job even easier to do?** Hired labour, contract market

Table 6 Training Needs Assessment Recording of Table Facilitator (Group 2b)

From which village is this group? Kataipi ward

What is the age range of group members? 40+ Older Men

Name of Table facilitator: Pus Wesis

Horticultural Jobs **Very Hard to do (List)**	Why? What obstacles get in your way?	What resources do you have that would make the job easier to do?	What other resources do you need to make the job easier to do?
1.Soil preparation H1 **2. Transport B3** **3. Banking B1**	H1- labour intensive B3- Poor infrastructure B1- Lack knowledge	Family labour Few local transport Bank accessible in a day	Contract labour & simple soil preparation tools Improved road Training in banking & establish agent at Tapini
Horticultural Jobs Quite Difficult to do (List)	**Why? What obstacles get in your way?**	**What resources do you have that would make the job easier to do?**	**What other resources do you need to make the job easier to do?**
1. Crop Management H4 **2. Irrigation H3** **3. Marketing M3**	Lack knowhow Water system too far Poor road condition No market arrangements-sell at open market	Rain fed irrigation	Training on crop management Irrigation pump 7 system Contracted market
Horticultural Jobs Easy to do (List)	**Why? What obstacles if any get in your way?**	**What resources do you have that would make the job even easier to do?**	**What other resources do you need to make the job even easier to do?**
1. Planting H2 **2. Packaging M2** **3. Book keeping B2**	No obstacles	Family labour, empty 50kg feed bags, local knowledge	Training in post-harvest & packaging

Table 7 Training Needs Assessment Recording of Table Facilitators (Group 3a)

From which village is this group? Tapini station

What is the age range of group members? 20-31 (Younger Men)

Name of Table facilitator: Philmah Seta-Waken

Horticultural Jobs <u>Very Hard</u> to do (List)	**Why? What obstacles get in your way?**	**What resources do you have that would make the job easier to do?**	**What other resources do you need to make the job easier to do?**
None	N/A	N/A	N/A
Horticultural Jobs <u>Quite Difficult</u> to do (List)	**Why? What obstacles get in your way?**	**What resources do you have that would make the job easier to do?**	**What other resources do you need to make the job easier to do?**
1. Marketing M3 **2. Book keeping B2** **3. Crop Management H4**	-Time consuming -Poor knowledge	Some knowledge in marketing and book keeping	Need training
Horticultural Jobs <u>Easy</u> to do (List)	**Why? What obstacles if any get in your way?**	**What resources do you have that would make the job even easier to do?**	**What other resources do you need to make the job even easier to do?**
1 Transport B3 **2. Irrigation H3** **3. Planting H2** **4. Packaging M2** **5. Harvesting M1** **6. Soil preparation H1**	No obstacle		

Table 8 Training Needs Assessment Recording of Table Facilitators (Group 3b)

From which village is this group? Tapini station

What is the age range of group members? 32-51 (Older Men)

Name of Table facilitator: Philmah Seta-Waken

Horticultural Jobs <u>Very Hard</u> to do (List)	**Why? What obstacles get in your way?**	**What resources do you have that would make the job easier to do?**	**What other resources do you need to make the job easier to do?**
1. Irrigation H3 **2. Marketing M3** **3. Book keeping B2** **4. Banking B1**	-Problem during dry season - Poor knowledge	Mostly rain fed	-Irrigation system - Training

Horticultural Jobs <u>Quite Difficult</u> to do (List) **1. Transport B3** **2. Packaging M2**	**Why? What obstacles get in your way?** -Poor road, No transport - Poor knowledge	**What resources do you have that would make the job easier to do?** Some knowledge in marketing and book keeping	**What other resources do you need to make the job easier to do?** Need training
Horticultural Jobs <u>Easy</u> to do (List) **1. Crop management H4** **2. Soil preparation H1** **3. Harvesting M1** **4. Planting H2**	**Why? What obstacles if any get in your way?** No obstacle	**What resources do you have that would make the job even easier to do?** NA	**What other resources do you need to make the job even easier to do?** NA

Table 9 Training Needs Assessment Recording of Table Facilitators (Group 4a)

From which village is this group? Erume

What is the age range of group members? 22-32 (Younger Men)

Name of Table facilitator: Regina Malie

Horticultural Jobs **<u>Very Hard</u> to do (List)** **Transport B3**	**Why? What obstacles get in your way?** No transport and poor road	**What resources do you have that would make the job easier to do?**	**What other resources do you need to make the job easier to do?** Improved road
Horticultural Jobs <u>Quite Difficult</u> to do (List) **1. Crop Management H4** **2. Planting H2** **3. Soil preparation H1**	**Why? What obstacles get in your way?** -Poor knowledge	**What resources do you have that would make the job easier to do?** Can perform task if knowledgeable	**What other resources do you need to make the job easier to do?** Require training in all areas

Horticultural Jobs Easy to do (List) 1. Irrigation H3 2. Marketing M3	Why? What obstacles if any get in your way? No obstacle	What resources do you have that would make the job even easier to do? NA	What other resources do you need to make the job even easier to do? NA

Table 10 Training Needs Assessment Recording of Table Facilitators (Group 4b)

From which village is this group? Erume

What is the age range of group members? 35-50 (Older Men)

Name of Table facilitator: Regina Malie

Horticultural Jobs Very Hard to do (List) 1. Book keeping B2 2. Transport B3	Why? What obstacles get in your way? -Lack knowledge -No transport & bad road	What resources do you have that would make the job easier to do?	What other resources do you need to make the job easier to do? Training and buyer provide transport
Horticultural Jobs Quite Difficult to do (List) **1. Packaging M2** **2. Irrigation H3** **3. Crop Management H4**	**Why? What obstacles get in your way?** -Poor knowledge	**What resources do you have that would make the job easier to do?** Use bags to package produce for markets	**What other resources do you need to make the job easier to do?** Training
Horticultural Jobs Easy to do (List) **1. Marketing M3** **2. Planting H2**	**Why? What obstacles if any get in your way?** No obstacle	**What resources do you have that would make the job even easier to do?** NA	**What other resources do you need to make the job even easier to do?** NA

The participants were asked to find similarities and difference between and amongst groups. They responded that in crop management, poor to no knowledge was the most prohibiting factor. In marketing, banking and book-keeping difficulties were evident of lack of skill. Transporting vegetables to Port Moresby markets was seen as a major issue as there are less public motor vehicles (PMV) operating from Tapini and the road infrastructure was also a big problem. Irrigation was also seen to be a very difficult task for one group as they were dependent on rain water. Younger men from group three did not list any very difficult task because they were from the station thus had the advantage than others. Most participants expressed that some difficulties could be addressed however, no to lack of knowhow were seen to be a major contributor. Thus training them in various aspects may solve these problems. Table 11 below shows the comparative rankings for each group.

Table 11 Ranking horticulture task based on difficulty

Groups	Very difficult tasks	Quite difficult tasks	Easy tasks
Group 1a Younger men from Guari LLG (Table facilitator: Dickson Benny)	H1 Soil preparation	M3 Marketing	M1 Harvesting
Group 1b Older men from Guari LLG (Table Facilitator: Dickson Benny)	H4 Crop management	H3 Irrigation	H2 Planting
Group 2a Younger men from Kataipi ward (Table facilitator: Pus Wesis)	B3 Transport M3 Marketing	H3 Irrigation H4 Crop management M2 Packaging	M1 Harvesting H2 Planting B2 Book keeping H1 Soil Preparation B1 Banking
Group 2b Older men from Kataipi ward (Table facilitator: Pus Wesis)	H1 Soil preparation B3 Transport B1 Banking	H4 Crop management H3 Irrigation M3 Marketing	H2 Planting M2 Packaging B2 Book keeping
Group 3a Younger men from Tapini station (Table facilitator: Philmah)	None	M3 Marketing B2 Book keeping H4 Crop management	B3 Transport H3 Irrigation H2 Planting M2 Packaging M1 Harvesting H1 Soil Preparation
Group 3b Older men from Tapini station (Table facilitator: Philmah)	H3 Irrigation M3 Marketing B2 Book keeping B1 Banking	B3 Transport M2 Packaging	H4 Crop management H1 Soil preparation M1 harvesting H2 Planting
Group 4a Younger men from Erume (Table facilitator: Regina Malie)	B3 Transport	H4 Crop management H2 Planting H1 Soil preparation	H3 Irrigation M3 Marketing
Group 4b Older men from Erume (Table facilitator: Regina Malie)	B2 Book keeping B3 Transport	M2 Packaging H3 Irrigation H4 Crop management	M3 Marketing H2 Planting

Colours are used to highlight similarities between groups.

B3 Transport was agreed to be a very difficult task by 2 groups of both younger and older men. But older men from group 3 found it to be quite difficult task. The reason for this is that there are less public motor vehicles (PMVs) operating to serve people from Goilala area. Similarly the road condition made transport a major problem to sell their produce in Port Markets.

H1 Soil Preparation is very difficult task for both young and old men from group 1 and 2 respectively while younger men from group 4 said to be quite difficult. This was basically due to the sloppy landscape which made soil preparation a difficult task.

M3 Marketing was found to be a very difficult task for two groups while the other two groups found it to be quite difficult. It was stated that marketing was difficult as they would not want to waste time and sit in the market in an open sunlight.

H4 Crop management was found by older men from group 1 to be very difficult while group 2 and 4 and younger men from group 3 found it quite difficult task. This responses were based on the fact that none have grown introduced vegetables in a large scale or for market. However, if markets are arranged they will grow introduced vegetables and would surely require training.

B2 Book keeping was a very difficult task for older men from group 3 & 4 while younger men from group 3 found it a quite difficult task. The reasons were that book keeping was thought to be just keeping farm records which some were knowledgeable.

To prioritize the horticultural, marketing and business training needs for the participants of Goilala District for both the younger and older men;

It was explained by the facilitators that red and yellow stars were going to be given out representing the highest preference (red) and second highest preference (yellow) for training for men and green and gold stars were going to be given out representing the highest preference (green) and second highest preference (gold) for training youth. Each group was therefore given 6 stars each to allocate to the areas of horticulture, marketing and business that were rated as very difficult tasks. It was explained that it was a bit like voting in that the method gave every individual member of the group an opportunity to express their individual needs without influence from other members of the group.

Table 12 Training Need Priorities by number of stickers

Older Men (22)	Younger Men (8)
B3 Transport (I)	B3 Transport (I)
B2 Book keeping (II)	H4 Crop Management (II)
H4 Crop Management (III)	H3 Irrigation (III)
B1 Banking (IV)	M3 Marketing (IV)
H1 Soil Preparation	M2 Packaging (V)
H3 Irrigation	H1 Soil Preparation (VI)
M2 Packaging	

Both the older and younger men ranked their first training priority as Transport. However, this may be to do with value chain system of discussing with truck owners for produce to be brought solely on a single day to Port Moresby. Similarly they were advised that the project cannot improve roads. However, if they were keen to produce and supply, they could try for some time. Using this information we could lobby with the government for support to improve their roads or to arrange weekly chattered flights to Tapini to pick their vegetables.

Other areas identified as priorities were Book Keeping, Crop Management, Marketing, Packaging, Soil Preparation and Irrigation. The facilitators explained that based on their training priorities, trainings will be conducted at convenient time and will be invited for the training in due course.

Conclusion

It is fundamental that information given to participants must be in the interest of the farmers as their expectations are high. Further, it was a practice for the facilitators as they were first time trainers in value chain management however, they tried their best to deliver what was to be delivered with the little understanding they had in value chain management. Moreover the training was expected to be more of horticulture rather than identification of value chain or horticultural training needs. Despite the initial mismatch of expectations, there was appreciation of and commitment to the specified workshop objectives. There was a high level of consensus amongst the participants as this was a first time they had attended training in their lifetime.

The methods used in conducting the workshop worked extremely well as their training priorities were identified. The participants also showed interest where questions were raised with each facilitator given chance to respond too. Additionally, each session was taken by the facilitators that had prior experience in the Men and Sons workshop in 2012.

The training priorities identified were transport which is difficult for this project to address. Other priorities were crop management, soil preparation, book keeping, marketing, irrigation and packaging which can be addressed by the partner country staff. Follow up trainings were promised but after the women and daughters workshop were held for the Tapini group. No date was confirmed and this has to be decided by the donor country social research team who have more experienced in value chain management training.

Finally the workshop was conducted in 1 and half days due to problems with venue as there was another training conducted by the Mineral Resources Authority in small alluvial gold mining.

Appendix 1: Overview of Workshop Program

Men and Son's Workshop on the Horticultural Value Chain and Identification of Training Needs in Tapini, Central Province

19-20 March 2013

Aim: To improve our understanding of each players role in the value chain and identify training needs of male smallholders in horticulture in the Goilala District of Central Province.

DAY 1	
Tuesday 19 March **1:00 pm- 1.30 pm**	Welcome note – Acting District Administrator-Goilala District Introductions Expectations of the Workshop Overview and Objectives of the Program
SESSION ONE **1:30 pm –3:00 pm**	**Objective 1:** To explore people's roles in the horticultural value chain (**PW**) - Introduction to value chain concepts - Group discussion of an 'ice-breaker question: "What do PNG communities value"?
3:30 pm – 3:45 pm	Tea Break
SESSION TWO **3:45 pm – 5:00 pm**	**Objective 2**: To explore the ideas or dreams that men smallholders have for the future wellbeing of their families and villages (**PW**) Working in small village-based groups, appoint someone to chair the discussion. Each person talks about their ideas or dreams for the future: a) as an individual b) as a member of a village or larger group, such as a cooperative Your table facilitator will take record the main ideas for a) and b) on butcher's paper for later discussion in the whole group. Sharing those ideas and dreams. What do we notice if anything about the differences between a) and b) dreams?
DAY TWO **Wednesday 20 March** **SESSION THREE** **8:00 am -10:00 am**	**Objective 3:** Training Needs Assessment in Small Village Based Groups (**DB**) Using the pictures provided indicate which activities are most difficult to do, a little difficult to do and easy to do (see attached guidelines and recording sheet for table facilitator) Put Results on Butchers' Paper
10:00 am – 10:20 am	Tea Break

10:20 am – 12:00 pm	Reviewing Small Group Work Displayed on Walls: What are the similarities and differences between groups? Using Post-It Notes, could you add ideas for overcoming these obstacles? (**SB/DB/PW**)
12:00 pm – 1:00 pm	**Lunch**
SESSION 3	
1:00 pm – 1:30 pm	**Objective 4: To identify plans or strategies for addressing a)issues in the value chain (PSW/RM)** Working in small village-based or mixed groups, appoint someone to chair the discussion and present the outcomes. Each group to discuss how they as individual farmers and their village can change/improve the issues identified in the previous session.
1:30 pm – 4:00 pm	**Objective 4 continued: To identify plans or strategies for addressing** **b) training priorities (PSW/RM)** Allocate 3 gold (priority one) and 3 green (priority two) dots by sticking them onto the relevant picture to indicate you priority training needs. Facilitator reviews priorities with the group and identifies 3 areas for priority-one training and 3 areas for priority-two training and records which agency should be given the task of training for each of the priority training areas.
4:00 pm – 4:15 pm	**Afternoon Tea**
4:15 pm – 4:40 pm	Review of workshop activities and Summary/Close up (**PW**)
4:40 pm – 5:00 pm	Evaluation of Workshop (**SB**)

Appendix 2: Actual Workshop Objectives

1. To explore people’s roles in the horticultural value chain

2. Training Needs Assessment in Small Village Based Groups

3. To explore the ideas or dreams that men smallholders have for the future well-being of the families and villages

4. To identify training priorities

The project team of lead and table facilitators agreed that the actual workshop objectives had been met.

Appendix 3: Men and their Sons in Horticulture Workshop Ethics Consent form

1. I agree to participate in the men and their sons in horticulture workshop on the 19th and 20th March 2013.
2. As a part of the process I agree to provide confidential personal information to enable contact for possible future training.
3. I agree to the subsequent publication of workshop photographs that might identify me to others.

Name	Village	Signature	Date

(All 30 signed forms available as hard copies)

Appendix: 4 Rules of Participation

- Hands up and stand up to speak
- Turn off mobiles (silent or vibration)
- Short concise and brief conversation
- No smoking or chewing buai when session is in progress
- Respect each other's opinions

Appendix 5 Expectations of Participants of Men's Workshop

At the commencement of the workshop, the participants were asked their expectations of the workshop and were as follows:

1. Learn new technology
2. Get new ideas
3. Know how to sell produce to buyer in PoM
4. Transportation system
5. Crop husbandry skills
6. Seedling raising in Nursery
7. How to run successful business

At the end of the workshop, they were asked to give their feedback as to whether their objectives were met with the following three questions:

a) like the workshop and met your expectations;

b) were presentations clear and exceeded meeting most of your expectations; or

c) What did you not like/failed to meet most of your expectations?

Responses

a= 23 say met expectations while 7 say partly.

b=24 say most expectations met but new to training and require more time to understand while 6 say some areas met but others not.

c= 8 responded failed because no gardening tools provided, 6 responded failed because no transport provided to and from training, 5 say failed because no assurance to work with them after project ends, 2 say failed because training venue wasn't good, 9 didn't respond.

References

Bonney, L, Chambers, B, Palaniappan, G (2012). Report on the Men & their Sons Participatory Value Chain Planning Workshop 20-12 September 2012, Pacific Adventist University.

Trip Report

Women's Workshop in Tapini, Goilala District, Central Province of PNG

Photograph by Laurie Bonney

Gomathy Palaniappan, Laurie Bonney and Barbara Chambers
SMCN/2008/008Increasing Vegetable Production in Central Province, Papua New Guinea to Supply Port Moresby Markets

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Women and their Daughters in Horticulture

A Pictorial Training Needs Assessment Using a Collaborative Problem Solving Method (CPSM)

Executive Summary

Tapini in Goilala district was selected as one of the project sites as the communities are poor and vulnerable. Like any vulnerable community they are isolated and deprived of services and economic/business opportunities due to poor road conditions. The opportunity to produce vegetables is high with fertile soil, water availability and climatic conditions. In, February 2011, this opportunity was explored further by conducting group interviews in the villages of Tapini with men and women. An appreciative inquiry (AI) technique was employed against a template of Rapid Value Chain Appraisal (RVCA) as a framework to conduct the group interviews. Villagers spoke about their crops, what they were proud of and what they hoped to do in the future. Out of this came a desire for horticultural, business and market training for women and girls, men and boys. Before this could happen, a training needs analysis had to be conducted and it was decided that a workshop should be held using pictorial training needs assessment that was trialed earlier in September 2011 with women and September 2012 with men from Rigo-Koiari and Bautama. The pictorial technique worked well in the cross cultural setting of low level literacy in PNG and participants enjoyed the process. Our previous experience in using the technique allowed us to reflect and improve by amending and trialing the technique while conducting men's workshop on training needs analysis on September 2012. The amendments made to the technique were using pictures representing Tapini community; using 11 themes instead of 10 themes with words related to the theme in Tok Pisin. Criteria developed to guide the selection of women in the earlier workshop including a range of ages and willingness to share training with other women (and men) was followed. The outcome was better than we had hoped with 26 women and their daughters at the workshop, in spite of the workshop being organized in Tapini unlike the other workshops where women and men were transported to PortMoresby from their villages. It is interesting that in spite of men's workshop being conducted earlier in March 2013 in Tapini, there were no expectations raised amongst the women as men did not share any information with the women on the workshop participated. The women representing 3 villages namely Koruava, Kovetapa and Erume attended a two day consultative workshop. Overwhelmingly, their training needs were identified as Business Skills (banking and book-keeping), Horticulture Production (crop management) and Marketing (packaging and marketing). A communication group representing workshop participants was set-up to monitor the Action Plan on training priorities and which will be the key contact point for researchers and trainers for during the year.

Background to the Workshop

From our research in the villages of Tapini in February 2011, villagers talked about the crops they grew, what they were most proud of and what their dreams were for the future. Men and women in Tapini were proud of growing banana, kavkav, green and peanut. They identified that they could do better if they worked as a cooperative to arrange better transport to get to the markets. Men, women and youth dreamt for better markets and storage facilities to store their vegetables. This was probed during the women's workshop. When probed women offered dreams which varied from fulfilling basic community needs like water, electricity, transport; earning better income by getting a better truck for transport, improvements to the road and ensuring a selling space at the market; improving women's role in the society through education, women's rights, women's participation in business, leadership opportunities. For this reason a priority was given to a women's workshop to assess their training needs.

Mr. Weis Pus (FPDA) visited Tapini prior to the workshop and discussed with the community members in regards to their convenience in attending the workshop. Mr. Weis Pus (FPDA), Ms Regina Mali (FPDA), Ms Philmah Seta-Waken(NARI) and Mr. Dickson Benny (NARI) liaised with Laurie Bonney and Gomathy Palaniappan in the planning of the workshop, including allocation of responsibilities, budget and selection of participants. It was decided to conduct the workshop at Tapini, as it was difficult to transport women away from their homes. More over the men's workshop was conducted in Tapini for the same reasons so it was decided to do the same for women. Laurie Bonney had met with the team during March 2013 to conduct men's workshop in Tapini and had briefed the team about Collaborative Problem Solving Methodology (CPSM), table facilitation, recording information and reporting. As the team had gone through a learning experience of conducting the workshop with men, this ensured that the workshop itself worked smoothly.

Goilala District

General Information

Administration

District headquarters: Tapini **Number of LLGs:** 3 - Guari Rural, Tapini Rural, Woitape Rural **Number of wards:** 23

Population

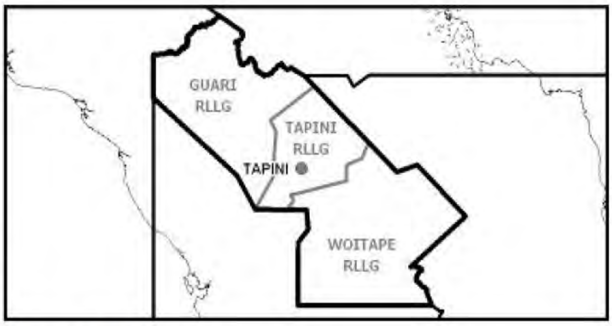
		Male (%)	*Female (%)*
Total	27345	51.9	48.1
< 15 years	11484	53.7	46.3
15-64 years	14980	50.1	49.9
> 65 years	881	58.3	41.7
Citizen households	5464		

Area and population density

Area (km²)	7587
Occupied area (km²)	1684
Population per km²	3.6
Population per km² of occupied area	16.2

Electoral statistics

Eligible voters (2000 Census)	14234
Number of votes cast (2002)	13287
Number of votes cast (2007)	n/a



About Goilala

Goilala District is located in the northern inland area of Central Province, bordering both Morobe and Oro Provinces, and covers the mountains and valleys of the Owen Stanley Ranges.

The district member is Mr. Mathew Poia, of the National Alliance Party. The member between 2002 and 2007 was Mr. Fabienne Savo Inne. Woitape Rural LLG, in this district, is one of only four Local-level Governments in PNG to have a female president.

Incomes are moderate and agricultural potential is high in the lower valleys where transportation to markets is available. The upper valleys have low incomes and low agricultural potential because of their steep slopes and poor weather conditions. There is a gold mining operation at Tolukuma, north of Woitape, however, it has little influence on the incomes of the rural population.

Education

Type and number of schools

Elementary	59
Community	26
Primary	8
Provincial high school	1
Vocational	0

Universal basic education indicators

Net admission rate	10.7%
Gross enrolment rate	57.4%
Net enrolment rate	42.0%

Literacy rate

Total	*Male (%)*	*Female (%)*
24.7	30.3	18.7

Health

Number and population per officer

Medical officers	0	n/a
Nursing officers	4	6836

Number and population per facility

Health centres	7	3906
Aid posts	8	3418

Infrastructure

Road access

The only road in the district is in poor condition and leads from the Hiritano Highway to Tapini. Graded tracks link to Woitape, Guari and other small towns. Parts of the district would require more than eight hours travel to Port Moresby.

Economic Activity

Top agricultural activities of citizen households

	% engaged	*%* engaged for cash*
Food crops	76.2	9.4
Livestock	74.6	20.2
Coffee	70.4	62.7
Betel nut	60.1	26.2
Poultry	32.7	4.1

*of total citizen households

➢ [1] The National Research Institute 2010 viewed August2013 http://www.nri.org.pg

Method

The team decided to use the criteria devised earlier for the selection of women participants for Rigo-Koiari and Bautama given the workshop can only reasonably accommodate 30-35 people. These criteria were:

- women who have had previous training of some kind
- women who are actively involved in horticulture and/or keen to develop their gardens
- women who are members of a women's agricultural organization or association
- women who are committed to sharing their learning with other women
- ensuring a mix of ages i.e. mothers and daughters/daughters in law

Using an action research approach the team reflected on pictorial technique used earlier during the women's and men's workshop during September 2011 and 2012 and amended the pictures used for posters to indentify training needs for horticulture production. For instance the picture on transport was used to identify issues on communication and arrangement for transport so that solutions can be arrived through training. However, participants in the men's workshop conducted in September 2012 needed an explanation on this poster as they interpreted the poster as 'bad roads' and 'bad transport'. This limited the process in terms of agreeing on a common solution for further training. So this poster was replaced with 2 posters one representing communication and arrangement with transporter and another representing transportation. We had 11 posters representing 11 themes to identify training needs instead of the 10 themes used in earlier workshops conducted for women and men from Rigo-Koiari and Bautama. The category on Horticulture production activities had 5 themes instead of 4 themes (soil preparation, planting, irrigation crop management and harvesting). The category on marketing activities had 3 themes (communication with buyers, packaging, and market arrangements). The category on business had 3 themes (banking, book keeping and transport arrangement).

Also, the pictures chosen earlier deliberately avoided images of people in order to comply with the ethics agreement made with the University of Tasmania. In the current workshop the pictures used were chosen with the images of people considering the cultural context as PNG people considered images of their own people on posters with pride. This was confirmed on consultation with the FPDA and NARI staff and some minimum words on Tok Pisin were added to the posters considering the low level of literacy. So, the pictures with minimum words were used so that it might be more self explanatory for the participants to identify the training needs.

Poster – Card for Horticulture: Soil preparation (H1)

A picture of land cleared for agriculture well represented soil preparation. This was adapted with the picture of land cleared with the words stating "Redim graun bilong planim ol kumu" meaning "land preparation".

Photograph by Gomathy Palaniappan

Soil Preparation (H1)

Photograph by Laurie Bonney

Soil Preparation (H1) Revised

Poster – Card for Horticulture: Planting (H2)

The photo below was ranked as priority and the seed poster was adapted with a nursery poster so that participants understood that it was not limited to hybrids. The words "Planim ol kumu" meaning "Ways/how to plant vegetables" enabled participants to explore the various options of planting.

Photograph by Gomathy Palaniappan

Planting (H 2)

Photograph by Laurie Bonney

Planting (H 2) Revised

Poster – Card for Horticulture: Irrigation (H3)

A picture of channel irrigation well represented irrigation techniques. This picture was improved using words "Givim wara lo ol kumu" meaning "Irrigation techniques".

Photograph by Gomathy Palaniappan

Irrigation (H3)

Photograph by Laurie Bonney

Irrigation (H3)

Poster – Card for Horticulture: Crop Management (H4)

The photo below was chosen to represent crop management because the participants need to know how to use chemicals to manage crops in a safe way. This poster was modified by adding pictures of fertilizer bags and words stating "Lukautim ol gaden kaikai" meaning Crop husbandry practices/ crop management.

Photograph by Gomathy Palaniappan

Crop Management (H4)

Photograph by Laurie Bonney

Crop Management (H4)

Poster – Card for Horticulture: Harvesting (H4a)

A picture representing harvesting was included in crop management to emphasize the association with the crop management practices and maturity of crops. The poster had the words "Kamautim ol kumu" meaning harvesting.

Photograph from Post Harvest Manual

Harvesting (M1) Card for Marketing

photograph by Laurie Bonney

Harvesting (H4a) Card for Horticulture

In earlier workshops 'harvesting' theme was categorized as marketing rather than horticulture and was represented as M1. This is because Riogo and Bautma village men and women were concerned about harvesting at the appropriate maturity to meet market needs and transport. In Tapini, men and women were concerned about good crop management practices that would influence maturity and harvest of produce. So, harvesting card was moved from marketing category to horticulture category and was represented as H4a.

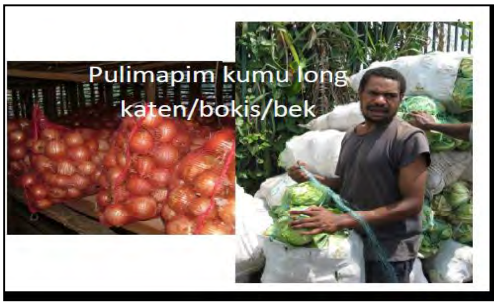
Poster – Card for Marketing: Communication with buyers to find market (M1)
The photo below picture of farmers and buyers around the ginger bilums and bags was chosen to represent Tapini region. Tapini region lacks proper roads and so is isolated from Port Moresby. To overcome the issue, it is important for the growers from Tapini region to communicate with their buyers to make arrangements to sell their produce. The picture below with the statement "Salim ol kumu lo market" means How to find a market/identifying market/market access.

Photograph by Laurie Bonney

Poster – Card for Marketing: Packaging (M2)
This picture below was chosen as the ideal way to pack produce, such as onions, and it showed how to store them correctly. It was thought that storing produce on packing trays will not cause damage to crops and the picture showed what the right packing material was for the onions i.e. the open weave bags are ideal for air circulation. This poster was revised by adding another picture on the current practice of packing more cabbages in a bag to reduce transport cost. The poster was revised to show the contrast between the current practice and the ideal practice. The poster also had the statement "Pulumapim kumu lo katen/bokis/beg" meaning post harvest.

Photograph from Post Harvest Manual

Packaging (M2)



Photograph by Laurie Bonney

Packaging (M2)

Poster – Card for Marketing: Marketing (M3)

The photo below was chosen to represent the current practice of marketing in wet markets. It was thought that it would allow the growers to understand the effect of lack of shelter for the seller and the produce. This was replaced with a photo of selling in the wet market in a shelter with the statement "Salim ol kumu lo market" meaning marketing picture of farmers in the market (Gordon's Market) selling their produce.

Photograph by Gomathy Palaniappan

Marketing (M3)

Photograph by Laurie Bonney

Marketing (M3)

Poster – Card for Business: Banking and Savings (B1)

The picture representing bank was well understood by the participants in the previous workshop and a statement "Putim moni yu kisim long gaden kaikai long benk" meaning banking was added to the picture.

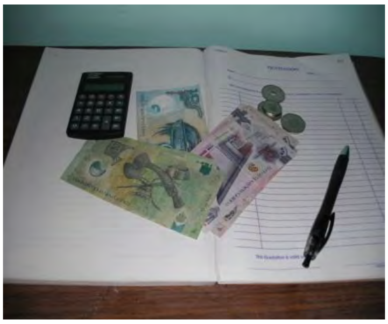
Photograph by Gomathy Palaniappan

Banking and Savings (B1)

Banking and Savings (B1) (revised)

Poster –Card for Business: Book keeping (B2)

The poster for book keeping is appropriate and self explanatory and a statement "Lukautim moni blo gaden kaikai" meaning book keeping/ financial literacy was added to the picture.



Photograph by Gomathy Palaniappan

Banking and Savings (B2)

Banking and Savings (B2) (revised)

Poster –Card for Business: Transport (B3)

The picture below was chosen as the ideal way to transport produce, such as covering the produce to protect from adverse weather. This was replaced with a picture representing current practice, such as transporting produce without covering and passengers sitting on produce. A statement in Tok Pisin “Karim ol kumu lo kar igo lo maket” meaning transportation was added to the revised picture.

Photograph from Post Harvest Manual

Photograph by Laurie Bonney

Transport (B3)

Transport (B3) (revised)

Training in Collaborative Problem Solving Methodology for the Workshop

In Port Moresby during March, the PNG partners from FPDA (Pus Wesis & Regina Malie) and NARI (Philmah Seta-Waken & Dickson Benny) practiced, Collaborative Problem Solving Methodology (CPSM)[3]through conducting the men’s workshop on training needs. Laurie Bonney and Gomathy Palaniappan met with the PNG partners

[3]CPSM (copyright) was developed from Value Management methods by Barbara Chambers and Carole Kayrooz for the Australian Institute for Sustainable Communities, University of Canberra and since 2003, has been modified for several ACIAR projects depending on the cultural context.

from FPDA (Pus Wesis & Regina Malie) and NARI (Philmah Seta-Waken & Dickson Benny) and revisited the Collaborative Problem Solving Methodology before conducting the workshop.

Workshop Program (27 and 28 June, 2013 at Tapini)

Day One (Divergent or Creative Phase)

1. Introductions

The workshop was conducted at Tapini station. A covered space was organised and chairs were arranged in a semi-circle to face the workshop facilitator. Participants rearranged their chairs into circles during small group discussions and returned to their position after completing their tasks. This arrangement ensures that all participants could see the facilitator and it also allowed the facilitator to move around small groups easily.
Gomathy Palaniappan introduced herself as the lead facilitator of the workshop, introduced the speakers Laurie Bonney and Pus Wesis and table facilitators Regina Malie, Philmah Seta-Waken & Dickson Ben. In order to comply with the cultural requirements the facilitation of the workshop was done by the women.

A name tag, an exercise note book and pens was provided to all participants in the workshop. Gomathy Palaniappan explained the consent form in English and was translated by Philmah Seta-Waken in Tok-Pisin. The consent form was obtained to allow the research team to take pictures and document the process. The participants were given 20 minutes to complete the consent form. Table facilitators and participants who could read and write in English helped other participants to complete the form.

Women were seated representing their respective villages Koruava, Kovetap and Erume. At the commencement of the workshop, the participants were asked to form rules for participation and state their expectations of the workshop.

The rules for participation were:

- Respect each other's opinion
- Listen to the speaker

Expectations of the workshop

The facilitator asked the participants what were their expectations of the workshop. The expectations were stated by older mothers as follows:

- Women and daughters to continue agriculture
- Cooking, baking and sewing
- Horticulture practices
- Vegetable nurseries
- Planting vegetables

The participants mentioned cooking, baking and sewing as these were the skills generally taught to women by aid organisations.

2. Overview and Objectives of the Program

The objectives of the workshop were then presented by the facilitator using a PowerPoint presentation.

The overall aim or purpose of the workshop was to identify the training needs of women and youth in horticulture in the central province of PNG.

On the morning of Day One, the first objective is to explore people's roles in the horticultural value chain. This was followed by small village based group discussion "What do PNG communities value"?

In Day One, objective two, will be to find out what dreams or ideas women and youth have for their future wellbeing of their families and villages as an individual and as a member of a larger group, such as cooperative. After presenting their dreams to a larger group the similarities and differences were discussed to understand if their individual dreams were coherent with the dreams of the larger group.

On the morning of Day 2, objective three will be to prioritize the horticultural, marketing and business training needs for the villages of Koruava, Kovetapa and Erume for

i. Youth and

ii. Women.

Followed by the above objective, fourth objective is **individual priorities by voting using golden and silver stars (Youth & Women).**

Finally, on the Day 2, objective five will be to develop an Action Plan which will identify

i. who might conduct training in:

    a) Horticulture

    b) Marketing

    c) Business And

ii. Who should be trained first?

During tea break the participants continued to discuss the issues and a lot of interaction among the women was observed.

3. Training Needs Assessment in Small Village Based Groups

***Objective 1:* T*o* explore people's roles in the horticultural value chain.**

Laurie Bonney began his presentation with a question “How often do you sell your vegetables to the market? Participants replied that they consume what they produce and if they are lucky to get transport then they would get to the Gordon’s market. Laurie then explained the supply chain practiced. Farmers produce vegetables, package, and transport to the markets. The quality is lost and the price of the produce goes down. This is supply chain. If all actors like producers, transporters and wholesalers work together to improve the quality. Farmers play a vital role in producing a good quality vegetable by good practices in the garden and packaging . there should be trust built so that actors in the chain can work together to produce good quality and benefit. Vegetables must be packed honestly and there must not be cheating. Participants agreed that there has been practices where they mixed good and bad quality produce while packaging. Trust and quality is very important in marketing.

Communication

As growers communication is very important. When selling vegetables, feedback communication is very important. Feedback on quality is very important in marketing like the right size, shape etc between you (farmers) and buyers must be maintained. In this project we would advise you to produce quality vegetables to the market. We would provide technical advice, training to improve your business skills, horticulture production skills so that you might benefit by producing quality vegetables to the market. We understand that the roads are in very poor condition and needs to be improved. By means of producing quality vegetables you might be able to justify the need for good roads to your villages. Communication with the buyer will allow you to negotiate price and meet the quality requirements for the market. Relationship with the buyer, middlemen, market must be maintained. DA from Central Province has recognized the problems so there could be some positive outcome in the future.

In continuation of objective 1, small village based group discussion on “What do PNG communities value”?

➢ **Table 1 Small Village based group discussion on "What do PNG Communities Value"?**

	Most Grown Vegetables	Reason
Kovetapa village (Patricia Kauva)	Kumu (greens),Kaukau (sweet potato),Taro (kong Kong), Banana, Avacado, Peanut, Orange, Cabbage, Casava (tapioca), Bean, Spring Onion, Carrot, English potato, Tomato, Corn, Cucumber, Pumpkin	“General reason why we grow these vegetables is Consumption, Sell and earn money and also because of the soil (fertile soil)”.
Madeline Mary Group (Iowa & Loloipia)	Avacado Onions Banana	“Because we make more money from the kilos in the supermarkets” “Because we make it to the big markets and lot of money from the supermarkets” “Make a lot of money

		here, when we get to take it in PMV it gets smashed during transport”
Jacinta – Koruava village	Peanuts Taro Banaana Greens Sweet potatoes	“grows fast, sell fast, harvest fast” “grows fast, sell fast, harvest fast” “grows good because of fertile soil, sells fast” “grows wild and good in area and grows fast” “staple food grows fast and good and sells fast & eat & feed family”

Objective 2: This was followed by small village based group discussion “What do PNG communities value”?

Women were requested to form groups based on their ages as older mothers and young mothers. Each individual were asked to talk about their dreams for their future or ideas women and youth have for their future wellbeing of their families and villages as an individual and as a member of a larger group, such as cooperative.

➢ **Table 2 Dreams or ideas women and youth have for their future wellbeing of their families and villages**

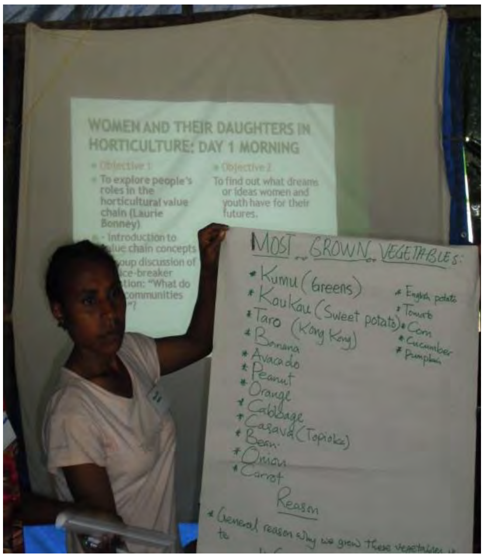
Village	Dreams in the communities	Individual dreams
Group 1 Young Mothers	➢ We need light ➢ Water supplies ➢ Road transport ➢ Good leadership ➢ Women rights	➢ Woman in sports ➢ Woman in education ➢ Woman in business ➢ Woman in agriculture activities ➢ Women rights ➢ Violence (Stop violence) ➢ Women in good leadership ➢ Women must get to health service
Group 2	➢ Must build a big market here in the station	➢ Must own myself a vehicle

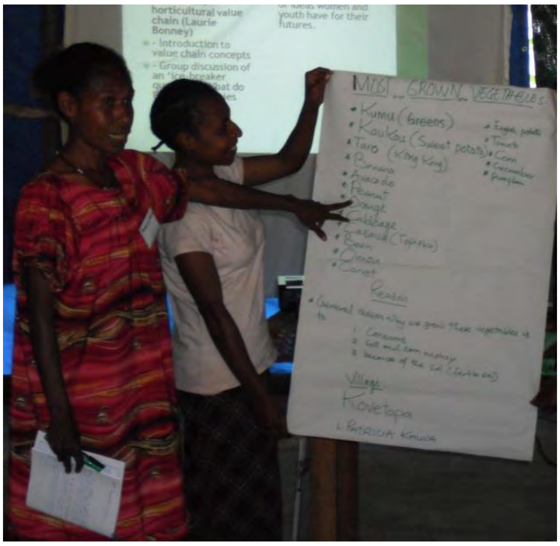
Young mothers	➢ Do up the roads so people can go and sell their produce ➢ Some colleges, vocational schools should be built in the district ➢ Power/water supplies going to our community ➢ Form a women's cooperative group to produce vegetables and sell out the market ➢ To build a coffee mill to mill their coffee here	➢ Must build a permanent house ➢ My child must go to school and use a computer ➢ I must own a trade that my children will benefit ➢ Live in good house so that children will go to school and will go to different places ➢ Must own a truck to sell vegetables and buy goods and do black marketing (trading)
Group 3 Middle Age mothers	➢ Highway feeder the roads should be sealed ➢ We should have transport to and from PMV ➢ We should have power lights to our houses ➢ We really want to educate our children they are our future leaders	
Group 4 Middle Age mothers	➢ Education – We left our villages and came to the station to educate our children ➢ Growing crops- Hard to transport to PMV Some are fortunate to get to PMV to sell others are unfortunate ➢ We expect our leaders to help us in some ways to transport our vegetables to PMV ➢ Find markets for us to sell our produce ➢ We want these kind of workshops to help us plant harvest and sell produce	

The dreams discussed by Tapini women

In essence, the well being of the home and the community was high on the agenda of the older mothers and younger mothers. It is interesting to note this similarity in Tapini women and Rigo-Koiari and Bautama. The younger mothers stated their individual dreams whereas the older mothers could not differentiate their individual dreams from their community dreams. Access to roads and transport were the most important dreams of both older and younger mothers. Followed by transport, children's education, electricity for domestic purpose, were dreams stated by older mothers. Younger mothers stated electricity, water supply, and children's education as dreams for their community. Some younger mothers had attended gender awareness workshop and so deviated quite markedly stating 'no' to women violence, more rights to women, encouraging women leaders as their individual needs. It should be noted that women rarely discuss these issues. When young mothers from Group 1 emphasized about gender equity rest of the participants agreed that they need to stop violence against women. One of the older women mentioned that lack of electricity was one of the causes for sexual violence against women. Younger mothers were interested in trade and business which is similar to the dreams of young mothers from Rigo-Koiari and Bautama. This shows that young women had individuated and career oriented dreams in spite of aid and religious institutions training the women in stereotype skills like cooking, baking and sewing. Young mothers also dreamt of owning individual house and vehicles.

At the end of Day One, the facilitator summarized Day One activities and thanked the women for their participation and knowledge sharing. The women were provided with ingredients like rice and protein for dinner that evening and the activities for Day Two was foreshadowed.





Village based women presenting what they value most in their communities

Day Two (Convergent phase or Judgment Phase)

In the workshop facilitator recapped activities from yesterday and outlined the activities for the day.

Mr. Pus Wesis from FPDA delivered the principles of value chain to the women participants. He emphasized that they need to take initiatives to produce consistently to meet market needs. He acknowledged that transport is a problem for Tapini people but stated that they need to prove to the Government that it was profitable to provide infrastructure to Tapini by means of producing good quality produce.

Objective 3: This objective was addressed by two different activities where participants were organized representing their villages to prioritize their needs (activity a) and later participants were organized as groups of young mothers and older mothers to prioritize their individual needs through voting.

a)prioritize the horticultural, marketing and business training needs for the villages of Koruava, Kovetapa and Erume.

b)prioritize the horticultural, marketing and business training needs for young mothers and older mothers of Koruava, Kovetapa and Erume.

Objective 3: a) prioritize the horticultural, marketing and business training needs for the villages of Koruava, Kovetapa and Erume.

In the workshop, in day two each village based group namely Koruava, Kovetapa and Erume were given a set of poster cards in horticulture, marketing and business. With the help of a group facilitator, each group was asked to discuss each picture and then decide which tasks were easy, which were quite difficult and which were very difficult and why this was so. They were then asked to allocate poster cards to one of three stacks based on those assessments.

Each group presented their findings to the whole workshop by posting the poster cards on the wall under the headings of easy, moderately difficult and most difficult and explaining their ratings. The facilitator asked the workshop to find similarities and difference between and amongst groups. Table 3 below shows the rankings for each group.

➢ **Table 3 Ranking horticulture task based on difficulty**

	Very Difficult tasks	**Quite Difficult tasks**	**Easy tasks**
Jacinta Koruava group (10 women, Regina Malie group facilitator)	B2 Book Keeping B1 Banking (Training support required for B1 and B2) B3 Transport M1Communication with buyers to find market (so far there has been no communication) H4 Crop management (identification of pest and diseases is difficult Also the price for inputs like fertilizer is very expensive)	M2 Packaging M3 Marketing (over supply so difficult to find markets)	H1 Soil Preparation (men's job) H4a Harvesting H2 Planting H3 Irrigation (natural ie. Rainfed) Family labour to complete above activities
Madline Erume	H4 Crop management	M2 Packaging	H1 Soil Preparation

group (4 women, Philmah Seta Waken group facilitator)	B2 Book Keeping (Don't know how much we earn) B1 Banking (security issues regarding keeping money)	M3 Marketing B3 Transport (Many times produce is wasted as we don't have transport)	H3 Irrigation H2 Planting H4a Harvesting M1Communication with buyers to find market
Patricia Kovetapa group (12 women, group facilitator	H4 Crop management (Don't know how to get right chemicals) B2 Book Keeping (literacy level is low) B1 Banking	M1Communication with buyers to find market (No proper communication) H3 Irrigation H1 Soil Preparation (No proper tools) H2 Planting B3 Transport (problems)	M2 Packaging H4a Harvesting M3 Marketing

B2 Book Keeping – Women agreed that they did not have any understanding on the cash flow and profits. As a result they did not know how much they earned and could not decide how to improve their current situation. They agreed that they did not have any resources and would prefer training to improve their skills.
All groups agreed that book keeping was the most difficult task.

B1 Banking - Women agreed that they did not know how to operate an account with a bank. Women mentioned that they were at risk by holding cash and so wanted to save the money in a safe place. They identified bank in Tapini as a local resource to open a bank account (which was not in operation during that time) and information on banking would be helpful to improve their situation.
All groups agreed that banking was the most difficult task.

H4 Crop management - Women agreed that they did not know how to identify pest and diseases. They also mentioned that the price for inputs like fertilizer being very expensive. It was also agreed that they bought introduced seeds from shops and did not know how they would respond to fertilizers or pest.
All groups agreed that crop management was the most difficult task.

B3 Transport – Tapini villages are located approximately 125 Km away from Port Morseby and the roads are in very poor condition that it would take 9 to 10 hours to travel to Port Morseby from Tapini. For these reasons, women agreed that they did not have reliable transport and had to depend on the public motor vehicles (PMVs). If the PMV vehicle broke down they will not get to the market and the produce is eaten, given away or thrown away. (On our way to Tapini we saw women walking back to their villages as the PMV vehicle broke down and they stated that they ate some of the produce and threw the rest in the river as it was too heavy to carry the bags back to the village.) There is no guarantee that PMV s would arrive or reach Port Morseby.

Road to Tapini from Port Morseby

The chance to get to the market in time is unlikely. There is no storage facility to store their produce to address the risk of non availability of transport. Participants agreed that storage facility would help them to increase the shelf life of their produce until they organized transport. Participants struggled to identify their own resources as an alternative to PMV vehicles and fixing roads.
All groups agreed that transport was a difficult task and were trying hard to find alternate resources (One group agreed that transport was a very difficult task and two groups agreed that it was quite difficult).

M2 Packaging is quite a difficult task as appropriate packaging for vegetables varies and it is hard to maintain quality. Mostly we use the same material for packing all produce and it is difficult as there is a need to take it to a longer distance from the field before getting it to the transport site. Banana leaves and bilums were the local resources commonly used for packing. Participants were concerned regarding any additional expenses on packaging material.
Two groups agreed that packaging was quite a difficult task and one group disagreed.

M3 Marketing was considered as quite a difficult task by two groups and was considered easy by one group. They all agreed that the reason marketing was difficult was because of oversupply of produce to local Tapini market and no good roads to transport to other markets in Port Morseby. No proper space for marketing in Port Morseby (Gordons market) was also agreed among participants.

H3 Irrigation was agreed to be easy by two groups and a quite a difficult task by one groups. The groups that found easy stated that they had regular rainfall and so did not require irrigation arrangements. The group that stated difficult mentioned the requirement of irrigation during dry seasons.

H1 Soil Preparation, H2 Planting, H4 harvesting was agreed to be easy by two groups and a quite a difficult task by one group. The groups that found easy stated that they had family labour to manage the tasks. The group that mentioned quite difficult stated that proper tools will be helpful to perform the task efficiently.

Objective 3: b) prioritize the horticultural, marketing and business training needs for young mothers and older mothers of Koruava, Kovetapa and Erume.

It was explained that gold and silver stars were going to be given out representing the highest preference **(gold)** and second highest preference **(silver)** for training: 6 each for younger mothers in each of the areas of horticulture, marketing and business were provided. It was explained that they had two sets of stars – gold and silver - to allocate to each of the areas. It was a bit like voting in that the method gave every individual member of the group an opportunity to express their individual needs without influence from other members of the group.

In order to differentiate the older mothers from the youth and/or younger mothers, the older mothers were provided with **pink** adhesive stickers, representing the highest preference and **blue** adhesive stickers representing the second preference. The older mothers of Erume village identified and ranked their highest training need as soil preparation, marketing and crop management. The younger mothers of Erume showed no similarity in the preference and ranking of training needs with their older mothers. Their highest preferred training needs were banking and book keeping as shown in the table below.
The older mothers of Koruava village identified and ranked their highest training need as marketing, book keeping and soil preparation. The younger mothers of Koruava showed some similarity in the preference and ranking of training needs with their older mothers. Their highest preferred training needs were book keeping, crop management, communication with buyers, soil preparation and harvesting as shown in the table below. Amongst all the groups, the younger mothers of Koruva village preferred tasks on all three categories (horticulture, marketing and business).

The older mothers and younger mothers of Kovetapa village had identified similar training needs of different order of preference. The older mothers ranked their highest training need as crop management, book keeping and banking and the younger mothers ranked their highest training need as banking, book keeping and crop management.

Erume village was quite different in terms of their priority training needs for both older and younger mothers. Koruava and Kovetapa villages were similar in terms of their priority training needs for both older and younger mothers.
All three villages were observed to be at the same level of management in regards to their training needs.

➢ **Table 4 Training Needs Priorities by number of stars**

Women participants	Erume	Koruava	Kovetapa
Older Mothers	Soil preparation (I)	Marketing (I)	crop management (I)
	Marketing (II)	Book keeping (II)	Book keeping (II)
	crop management (III)	Soil Preparation (III)	Banking (III)
Young mothers	Book keeping (I)	Banking (I)	Banking (I)
	Banking (II)	Book keeping (II)	Book keeping (II)
		crop management (III)	crop management (III)
		Communication with buyers (IV)	
		Soil Preparation (V)	
		Harvesting (VI)	

The facilitator then posed the question, as a matter of priority which group should be trained first – younger or older mothers – and why? Majority of the participants agreed that as banking and book keeping emerged to be the highest ranked training that requires literacy to acquire the skills. It was agreed that literacy will be the criteria for selecting participants and so many younger mothers who had higher levels of literacy were encouraged to attend the training by older mothers. This was combined with the criteria of individuals willing to train others as two important criteria for selecting participants. It was agreed that 10 participants representing each of the three villages, both younger mothers and older mothers in total 30 participants will be transported from Tapini to Port Morseby to attend training for 5 days.

Objective 4: Identifying local resources – What potential do your communities have to help you with the training needs identified?

Women actively engaged in discussion and began identifying resource person who can assist them with some tasks. Patricia from Kovetapa was chosen to provide assistance to open and operate bank accounts. We learned that Patricia had a savings account in the bank and was willing to help women secure their money in banks. Some women were willing to get trained on gender based violence where they were informed on women's safety, protection from abuse and harassment working in cooperation with men. Pest management practices followed by some women in their gardens was willingly shared with the rest of the participants like using wood ashes at the base of plants, soil heating to sterilize soils from pest and spraying extract from tobacco leaves by soaking them in water overnight.

4. Where to from here

At the end of the session, the facilitator asked how we can make sure that the Action Plan is implemented. A steering committee was suggested and the workshop decided who would be on it to liaise with the research team and to ensure that the workshop outcomes were achieved. Jacinta from Koruava village, Patricia from Kovetapa village and Medline from Erume village were nominated by members of their respective villages.

5. Evaluation of Workshop in small groups

Finally, the groups were requested to evaluate the workshops and report to the large group about whether the workshop met most of their expectations, exceeded most of their expectations or failed to meet most of their expectations.
All the groups agreed that the workshop met most of their expectations. Individual comments were as follow:

- "Very Good workshop and happy to be trained in the priorities listed".
- "Interesting workshop and we learned from the workshop".
- "Expected to be trained in cooking, sewing and baking but realised that the trainers had come to identify the needs. Very happy this has taken place".
- "Thanks for everyone that came here to find what we want".

Gomathy Palaniappan thanked the participants for their time and participation in the workshop. She mentioned that Pus Wesis from FPDA will contact the steering committee members for training.

The leaders of the group thanked the workshop facilitator, table facilitators and the Australian and PNG research team for the workshop.

Post Workshop Reflection and Debriefing with PNG partners - 30th May 2013

- The objectives of the workshop were well explained by FPDA staff to the participants of Tapini.
- Venue: Workshop was organized in Tapini. Australian Research team and PNG team had to stay overnight at Tapini. Arrangements regarding accommodation were made with great difficulty. The participants were very impressed with the effort taken by the Australian Research team and PNG team to travel up to Tapini to conduct the workshop.
- FPDA and NARI did a wonderful job transporting the Australian Research team and PNG team from Port Moresby. NARI provided workshop materials and stationery. Ms Philmah Seta-Waken and Ms Regina Malie did an outstanding job translating for the workshop as necessary.
- Gomathy Palaniappan was thanked for her role as workshop facilitator. Gomathy Palaniappan agreed to write the report.
- All research staff undertook table facilitation in a very competent manner and demonstrated their understanding of the CPSM workshop method and objectives of the workshop. It was agreed that the prior workshop in Tapini conducted for men by the PNG research team helped them to improve their understanding on the CPSM workshop method.
- The evaluation of the workshop was outstanding, although it may well be that as this is the first workshop for most of the women, the sheer novelty of being asked for their opinion, sharing knowledge and taking time out from everyday tasks, both Australian and PNG research team taking the effort to travel and stay at their place (Tapini) may well have skewed the feedback in our favour.
- It is now clear that PNG research partners can conduct subsequent workshops using the CPSM method.

Appendix 1: Workshop Daily Program

Women and daughter's Workshop on the Horticultural Value Chain and Identification of Training Needs in Tapini, Central Province

28th and 29th May 2013

Aim: To improve our understanding of each players role in the value chain and identify training needs of male smallholders in horticulture in the Goilala District of Central Province.

DAY 1 **Tuesday**	Welcome note **Gomathy Palaniappan**
SESSION ONE	Introductions Expectations of the Workshop Overview and Objectives of the Program **Objective 1: To explore people's roles in the horticultural value chain (Laurie Bonney)** - Introduction to value chain concepts - Group discussion of an 'ice-breaker question: "What do PNG communities value"?
	Tea Break
SESSION TWO	**Objective 2: To explore the ideas or dreams that women smallholders have for the future wellbeing of their families and villages (Gomathy Palaniappan)** Working in small village-based groups, appoint someone to chair the discussion. Each person talks about their ideas or dreams for the future: a) as an individual b) as a member of a village or larger group, such as a cooperative Your table facilitator will take record the main ideas for a) and b) on butcher's paper for later discussion in the whole group. Sharing those ideas and dreams. What do we notice if anything about the differences between a) and b) dreams?
DAY TWO	

Wednesday **SESSION THREE**	**Objective 3: a)Training Needs Assessment in Small Village Based Groups (Gomathy Palaniappan)** Using the pictures provided indicate which activities are most difficult to do, a little difficult to do and easy to do (see attached guidelines and recording sheet for table facilitator) Put Results on Butchers' Paper Tea Break Reviewing Small Group Work Displayed on Walls: What are the similarities and differences between groups? Using Post-It Notes, could you add ideas for overcoming these obstacles? (**Gomathy Palaniappan)**
SESSION 3	**Lunch** **Objective 3: b)To identify individual priorities by voting using golden and silver stars (Youth & Women)** Allocate 3 gold (priority one) and 3 silver (priority two) dots by sticking them onto the relevant picture to indicate you priority training needs. Facilitator reviews priorities with the group and identifies 3 areas for priority-one training and 3 areas for priority-two training and records which agency should be given the task of training for each of the priority training areas. **Objective 4: Identifying local resources – What potential do your communities have to help you with the training needs identified?** **Afternoon Tea** Where to from here Evaluation of Workshop Review of workshop activities and Summary/Close up

Thank You from the ACIAR Team:

Gomathy Palaniappan, Workshop Facilitator
Laurie Bonney, Value Chain Expert
Ms Philmah Seta-Waken Ms Regina Malie Mr Pus Wesis Mr Dickson Benny

Appendix 2: Guidelines for Table facilitators for Training Needs Assessment Recording

From which village is this group? ________________________________

What is the age range of group members? _________________________

Name of Table facilitator: _______________________________________

Horticultural Jobs <u>Very</u> <u>Hard</u> to do (List)	Why? What obstacles get in your way?	What resources do you have that would make the job easier to do?	What other resources do you need to make the job easier to do?
Horticultural Jobs <u>Quite Difficult</u> to do (List)	**Why? What obstacles get in your way?**	**What resources do you have that would make the job easier to do?**	**What other resources do you need to make the job easier to do?**
Horticultural Jobs <u>Easy</u> to do (List)	**Why? What obstacles if any get in your way?**	**What resources do you have that would make the job even easier to do?**	**What other resources do you need to make the job even easier to do?**

Appendix 3. Women and their Daughters in Horticulture Workshop Ethics Consent form

1. I agree to participate in the women and their daughters in horticulture workshop on the May 2013.
2. As a part of the process I agree to provide confidential personal information to enable contact for possible future training.
3. I agree to the subsequent publication of workshop photographs that might identify me to others.

Name	Age	Education	Village	Signature	Date

(All 30 signed forms available as hard copies)

TRIP REPORT

August 2013

Increasing Vegetable Production in Central Province, Papua New Guinea to Supply Port Moresby Markets

SMCN/2008/008

Barbara Chambers

University of Canberra

Poela Utama, Post-Harvest Training of Tapini Women

Table of Contents

Objectives of Field Trip to the Central Province

1. To monitor and evaluate the training of Tapini women
2. 1. To gather a socio-demographic profile of women from the village of Tapini

These objectives are related to the final milestones of the project:

Milestone11: Review programs to increase participation of women and youth from the Central Province in vegetable production and marketing
Milestone 12: Analysis and reporting evaluation outcomes of women's and youth participation programs.

1. Background

Over the life of the project, an Organic Research and Collaborative Development model, based on Action Research, had been followed (Spriggs and Chambers, 2011)[3]. The explicit incorporation of the iterative action research process involved:

5. Working 'with' the chain participants;
6. The initial use of non-contextualised scientific knowledge in concert with 'local knowledge' with the incorporation later of and contextualised scientific knowledge and experience;
7. Pre-planning workshops with women and men to identify gender issues for incorporation into the later planning stage.

Interviews and focus group discussions had been conducted with women, men and youth from Rigo-Koiari, Bautama and Tapini. Questions were based on techniques of Appreciative Inquiry and Rapid Supply Chain Appraisal

- *Rapid Supply Chain Appraisal Approach (RSCA):*

This incorporates four sub-systems found to be critical to a supply chain's operational efficiency

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[3] John Spriggs and Barbara Chambers, Organic Research and Collaborative Development (ORCD) of Horticultural Supply Chains in the Asia-Pacific, **Stewart Postharvest Review 2011, 2:2**

An international refereed journal, published online 01 September 2011 doi: 10.2212/spr.2011.2.2

and effectiveness:

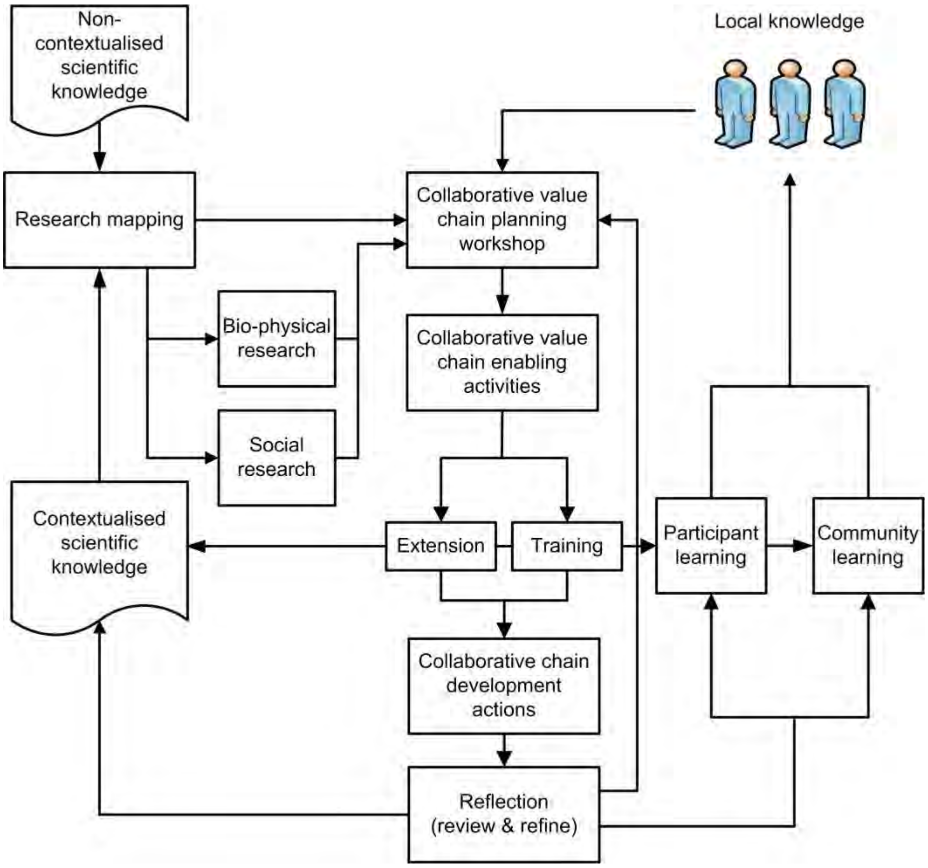
1. Product integrity;
2. Communication;
3. Value creation;
4. Chain governance.

- *Appreciative Inquiry (AI)* - a cycle of:

1. Discovery or appreciation of the best of 'what is';
2. Dreaming of 'what might be';
3. Designing what 'should be';
4. Destiny of how to empower, learn and adjust/improvise.

Unifying and adapting these for this ACIAR Project has necessitated the incorporation of more explicit capacity-building processes to develop participant and community knowledge of the value chain management process. The process sequencing and relationships are reflected in Figure 1.

Figure 1: A rapid value chain research and development method



Source: derived from Chambers and Spriggs (2009) and Reason and Bradbury (2001)

This extension of the ORCD method provides the process framework in which the AI and RSCA methods are unified into a 'rapid value chain research and development method'. For a complete description of this methodology, see the *Report on the Men and their Sons Participatory Value Chain Workshop* by Laurie Bonney, Barbara Chambers and Gomathy Palaniappan, 20 – 21

September 2012. The workshop was based on the Collaborative Problem Solving Methodology used in the very successful Women's and Daughters Workshop in late 2011. Women from this workshop had been followed up nine months later to see if they had adopted training in crop production, business and marketing. Results from this evaluation were contained in two publications: A trip report by Barbara Chambers for 28 February to 15 March 2013 detailing post post-evaluation results from initial women's training and demonstrating wide-spread adoption and a paper given to the ACIAR Socioeconomic Forum in June 2013[4]. The next set of workshops to identify value chain training needs and subsequent training was conducted with Tapini men, women and youth in August 2013. At this point, it was decided timely and necessary to monitor and evaluate the final women's training program

2. To monitor and evaluate the training of Tapini women

It was decided to undertake a monitoring and evaluation role of the Tapini Women's Training by modifying an *Expert Observer Rating Tool* (see Appendix 1). There were four modules in the areas of basic financial literacy, crop management, post-harvest and marketing. With regard to the process of monitoring and evaluation, the permission of trainers was asked for and given.

Context: Before the training began, I asked how many young women were here. Eleven out of eighteen were below 25 years of age and two had done the Women's Training Needs Assessment Workshop in 2011 (Maria and Agnes).

Needs of Tapini Women: At the beginning of the session, I conducted a small group exercise on what were the needs of villagers.

Group 1 said they need help with techniques – because we only use our tubun way of planting (with sticks) and need NARIs assistance to improve our practice; logistics - because we have major problems with transporting our crops; and materials- fork, knife, 'shape'.

Group 2 said they need help with training – post harvest, marketing, crop protection and mulching; transport – terrible roads, no PMV to transport goods; and working tools – spade, fork, watering cans.

Group 3 said they need help with roads, shade cloth and training. At Tapini Station, young people live there and older people live in the villages.

The women rated their training needs as first, to improve production through understanding crop management; second, marketing – where to and how to sell produce and third, transportation and roads – because they live in a mountainous region (which is beyond the project objectives, although was contextually important).

Module 1- Business and Financial Literacy (August 12): The module was an all-day session covering financial literacy, practical activities and cash flow.

[4] Philmah Seta-Waken, Barbara Chambers, Gomathy Palaniappan and Colin Birch, *Impact of Training on horticultural practice adoption by women smallholders in Central Province, PNG*, ACIAR Socioeconomic Forum, 5-6. June 2013, *in press.*

The first session was on income and expenditure, record keeping and household cash flow. At the outset, a pre-test was given that was clear and unambiguous (Appendix 2). A power-point presentation was given as an overview of the module and print materials handed out on income and expenditure. There was a variety of activities from whole group instruction to small group and paired work, with individuals able to ask and respond to questions of the facilitator.

After giving an overview of the training, an exercise on income generating activities was given on determining profit and loss. At this point it might have helped participants if the trainer had frequently asked them if they had questions, or stopped to clarify words, as there were fairly complex concepts involved, such as 'depreciation'. The example chosen for an income generating activity was peanuts. A detailed list of income (from sale of buai, cabbage crops, pig meat, chickens, contract work, wages, etc) was compiled against expenditure (school fees, family needs, bride price, bail, compensation, PMV fare, utilities, rent of houses in the city). This was highly interactive and engaging for participants where they were involved in *problem-solving activities*. *Proof and evidence* were involved as they tested their knowledge of production and therefore came out with realistic plans. The trainer constantly tested the group asking which is the best activity for income (prioritise and put in more resources); which is the most expensive (prioritise between needs and wants, with school fees being given as a need). At this stage the Bank of South Pacific (BSP) guest speakers came in to observe the group.

Awareness of Cultural Context is an important trainer attribute. Tok Pisin was used during instruction and participants were encouraged to use Tok Plas in their small group work. In terms of culturally appropriate learning style, there was some 'learning by doing', which is a preferred learning style of people in the Central Province but perhaps using role play or other simulation game would have enhanced the experience and broken up the reliance on text based materials.

Overall, the facilitator was confident, posing problems and involving the group in problem solutions. Possibly paying more attention to younger, more silent participants would have enhanced engagement. The material on income and expenditure was worked through very thoroughly.

The synthesis rating on *Design, Implementation, Discipline Content and Culture and Equity* was that the session was reflective of best practice. More attention could have been paid to peer learning and smaller group activities. Content was clear, the conceptual level was appropriate and handouts were provided, but the teaching-learning style was a little too instructive, rather than interactive. However, when basic information has to be taught first, the materials were certainly foundational. The facilitator was 'expert' in content and materials were well prepared.

The BSP presentation after lunch was lively and interactive, probably because the motivation to learn about banking was very high. It was difficult to ascertain participant ability to roll-out training and to determine fully the preferred cultural learning style of participants in this first training session. With some modification to include more interactive and creative methods in the module, it could be used with other groups in the Central Province.

Module 2 - Crop Management (August 13): The module was an all day session. Soil Management, Crop Rotation and Fallowing and Irrigation were the main topics covered.

A pre-test was handed out that needed some clarification (Appendix 3). Some definitions were not understood e.g. 'yield'. Although the facilitator stressed that people should respond based on their current practice, it is possible that there was confusion between 'what is' and 'what ought to be'. It would also be difficult to determine the impact of the module on people's attitudes and future behaviour (see Appendix 3).

The major instructional resources were a manual, hand out materials, outdoor resources and technology (power-point presentation). The handout/manual was very professional: there were clear objectives, scaffolding of concepts and pictures illustrating examples. Participants' activities were structured to include whole group, small groups, paired and individual activities. The use of technology was explored by a demonstration on using pesticides and an emphasis that although natural pesticides were endorsed (tobacco leaves and chilli in water; neem seed and bark), people had to protect their bodies and avoid handling pesticides by hand. There were formal presentations by the facilitator and by participants – a group activity on identifying plant pests – problem-solving activities (practical activities for women to do in their gardens) and proof and evidence activities – accounting for damage to plants e.g. virus, bacteria or fungus. Taking women into the field to demonstrate vegetable trials, drip irrigation and composting was very effective and the hands-on building of a 'barni compos' was appreciated by all the women and evidence that they will be able to replicate this practice back in their villages.

Participants' knowledge was assessed by a pre- and post-test and questions and answers demonstrating interactive and peer group learning. In terms of awareness of cultural context, Tok Pisin and Tok Plas languages and hands-on/demonstration was used on pest and disease management and irrigation and composting. Overall, there were varied methods of engagement in learning activities, highly interactive, including a colourful and motivating power-point presentation.

The synthesis rating on *Design, Implementation, Discipline Content and Culture and Equity* was that the session was at the higher end of best practice. The interactive, change of pace and varied learning methods. The facilitator was flexible in meeting learners' needs and very cued in to Tapini women smallholders in terms of knowledge of their area and cultural issues and preferred ways of learning. The material was very well organised, as were the demonstrations. There are therefore strong reasons for confidence in the ability of trainees to roll-out crop production and management amongst their communities. Tok Pisin or English is the preferred language to enhance networking and understanding. This program could be replicated easily with other smallholder groups in the Central Province.

Module 3 - Post Harvest Training (August 14): This was a half day module that started with a pre-test. It was apparent that the way the test had been constructed (see Appendix 4) it would not be readily apparent what impact the module had had in the post-test. The same answer could be given and unless the response went from e) none of the above, to b, c or d (positive interventions) no positive impact could be demonstrated. That and physical exercises to get people moving after the previous morning's activity. The facilitator showed empathy by inquiring where people came from and what language they spoke. It became apparent that when people were describing their country that the 3 LLGs were important, but there was little background information prior to the course about what this might mean.

The synthesis rating on *Design, Implementation, Discipline Content and Culture and Equity* was that the module reflected best practice. A variety of instructional materials were used – print, hands-on and power-point. These were very clear with pictures and simple text explaining each image. Images from the Central Province as distinct from other areas of PNG might have assisted in greater recognition of crops on the part of participants, but nevertheless, the pictures on harvesting, packaging, transport were well received Activities were variously constructed from small group exercises to interactive group questions and answers. Tok Pisin was spoken and small group activities enabled women to use their own language.

Module 4 – Marketing (August 14): The previous pre-test covered post-harvest and marketing, so the same comments apply. The marketing presentation was thoroughly researched but pitched at too high a level for participants. It was more academic than extension. Areas covered were useful differentiations, for example, the 6 Ps of Marketing: People, Plan, Product, Place, Price and Promotion. The power-point presentation was not well done as the slides w

The synthesis rating on *Design, Implementation, Discipline Content and Culture and Equity* was that the module was below best practice. It could be improved by more interactive and small group activities. The posters handed out to participants were very colourful and useful, showing crops for marketing and pointing out quality differentiations in produce for market. The facilitator did talk in Tok Pisin as well as English, used plenty of examples and encouraged the development of a marketing plan. It is unclear whether women will be able to put a marketing plan in place and highly unlikely that they would be able to replicate this module back in the village for other women.

Showcasing - Marketing Agents (August 15): Several agencies involved with retail and wholesale marketing gave lively presentations. Stop N Shop supermarket, the Pacific Adventist Farm Manager, who runs markets at PAU, Island Breeze Ltd, which enables transportation of produce in difficult terrain such as Tapini, BSP Rural gave a promotional power-point presentation and set up a display and Brian Bell set up a display on rural products. All of these presentations were valued by women.

3. To gather a socio-demographic profile of women from the village of Tapini

In August 2013, a training program was mounted for Tapini women at NARI, Laloki. Prior to this, participants were asked to complete a socio-demographic profile. A summary of their responses appears below.

- No of participants : 18 women
- Average age in years is 30 and range is 17-59
- Most of them speak in Tok pisin and Tauwade. Few speak Motu and Kunimaipa
- Average number of household members is 7 and age ranges between 3-18
- Their main source of income is from selling crops grown in their gardens. They own on average 2 soccer field sized gardens. Gardens are on customary land
- Most of them grow peanuts, kaukau, taro, banana and corn, while pumpkin, cabbage, yam, beans, cucumber and tomato are also grown by some participants. One participant was growing oranges.
- Most of them have community affiliations like church group, sports group or NGO group.

- All participants use local seeds and do not buy them. Seeds are planted manually (they do not use tools or tractors for preparing the soil). Many different varieties are grown (for instance, 8 varieties of kaukau are used). They use their old gardens for sources of seeds. No irrigation facility is available. Rain is the only source of water.
- The planting and harvesting time is usually in the dry season. Growing times for crops vary:
    - Choko is grown throughout the year,
    - Kaukau is grown 3-4 times a year,
    - Peanut is grown 3 times a year,
    - Banana is grown 3-5 times a year and
    - Corn is grown once per year.
- Farmers are aware of damage to crops. None of them use any kind of fertiliser or insecticides, but mulching is used by some. They are unaware of managing insects and damaged crops and have not sought help to identify damage or to treat it. Most of them uproot the damaged plant and throw or bury them.
- Distances to local markets vary from an hour to 2 days, and most people walk carrying bags of produce, because the villagers are so wide-spread. In a vehicle, it takes people at least 6 hours by PMV on average to get to Gordons' market in Port Moresby.. Most cash crops are sold retail in the main market in Port Moresby and one sells to a supermarket. The main buyers are residents of Port Moresby Bags are used to transport produce, usually 50 kg.
- Some of the damaged produce like kaukau and peanuts are used by householders in feeding the animals and unsold produce is used by them. However, vegetables like choko are just left in the fields.
- Although there is significant variation, the average transport cost of a 50kg bag is K50 The cost of harvesting is born by the family and not quantified, nor to a large extent is the post-harvest work. Packaging costs are estimated at K 10 – K40. The cost for market space is roughly K3. The average cost of storing the product overnight might be K4 per night and K3 for unloading it. Other, unspecified costs averaged K9.
- Participants were asked for production cost and return for one crop. Most picked peanuts or kaukau. All the participants sell their home grown fruits and vegetables in the local as well as far off (4-6 hrs. of travelling) markets in Port Moresby. The major cost involved is travelling as the cost of traveling for two persons is K160, which destroys their profits. Gross annual income was estimated at K492 and while there was some nominal profit, most suffered a loss in selling their produce.
- None of the women keep farm records and none have training in farm recording.

4.Conclusion

The elevation of Tapini and poor road conditions means that some women have to walk for up to two days and minimally one hour to get to the local market and up to six hours to get from the Tapini station to the Port Moresby market. Settlement is scattered.They do not possess many tools for gardening, so cultivation is done by hand. Training has been minimal so there is little knowledge of controlling pests and diseases and fertilizing plants. During training on crop production, women were very engaged by the hands on process of building a 'barni compos' even though they did practice mulching the soil and said they would replicate this construction when they got home. They do not have access to the means of irrigation, relying on rainfall. Women were aware of the cost of transport of produce to market but appeared unaware of the overall loss of profit once expenditure was taken into account. None of them kept farm records or practices household budgeting prior to training.

The training that met best practice standards was first, crop production; second business and book-keeping; third post-harvest and fourth, marketing. The main recommendations for improving training are:

1. Mixed methods of learning, from formal instruction to group work and practical, simulations and hands-on activities
2. More interactive dialogue through questions and answers between trainer and trainee
3. Handouts that are colourful, dominated by pictures showing best practice in business, crop production, postharvest and marketing.
4. Manuals that simply describe the training and writtin in either Tok Pisin or Tok Plas
5. Clear and unambiguous pre- and post-tests that demonstrate the impact of training on people's perceptions of learning and at a later stage, actual behavioural change.

5.Appendices

Appendix 1

Expert Observer Rating Tool[5]

Training Session Observation Protocol

Background Information

Observer: ________________________________

Date of Observation: ________________________

Men's or Women's Workshop: M ( ) W ( )

Duration of Observation:

__ 1 hour __ half day

__ 2 hours __ whole day

Other, please specify

____

Total Number of Attendees:

____

Name of Presenter(s) and area of expertise:

____

____

____

[5] Adapted from Weiss, Iris, 1997 Local Systemic Change Observation Protocol and Appendix A: Sample Observation Instrument, User-Friendly Handbook for Mixed Method Evaluations, Division of Research, Evaluation and Communication, National Science Foundation, (http://www.ehr.nsf.gov/EHR/REC/pubs/NSF97-153/start.htm).

Section One: Context Background and Activities

This section provides a brief overview of the session being observed.

I. Session Context

In a few sentences, describe the session you observed. Include: (a) whether the observation covered a partial or complete session, (b) whether there were multiple break-out sessions, and (c) where this session fits in the project's sequence of training sessions for those in attendance.

II. Session Focus

Indicate the **major intended purpose(s)** of this session, based on information provided by the project staff.

III. Training Session Activities
(Check all the activities— and related issues (such as resources)—you observed and describe them when relevant)

A. Indicate the <u>major instructional resource(s)</u> used in this training session.

___ Print materials

___ Hands-on materials

___ Outdoor resources

___ Technology/audio-visual resources

___ Other instructional resources. (Please specify.)

B. Indicate the <u>major way(s)</u> in which participant activities were structured.

___ As a whole group

___ As small groups

___ As pairs

___ As individuals

C. Indicate the <u>major activities</u> of presenters and participants in this session. (Check to indicate applicability.)

___ Formal presentations by presenter/facilitator: **(describe focus)**

___ Formal presentations by participants: **(describe focus)**

___ Hands-on/investigative/research/field activities: **(describe)**

___ Problem-solving activities: **(describe)**

___ Proof and evidence: **(describe)**

___ Explored technology use: **(describe focus)**

___ Assessed participants' knowledge and/or skills: **(describe approach)**

___ Interactive and/or Group or Peer Learning: **(describe method and frequency with respect to other methods of learning)**

___ Demonstrated awareness of cultural context **(describe language used – Tok Pisin, ToK Plas, English – and if culturally appropriate or preferred way of learning style was employed)**

___ Other activities: **(Please specify)**

D. Comments: Please provide any additional information you consider necessary to capture the activities or context of this training session. Include comments on any feature of the session that is so salient that you need to get it "on the table" right away to help explain your ratings.

Section Two: Ratings

In Section One of this form, you documented what occurred in the session. In this section, you are asked to use that information—as well as any other pertinent observations you may have—to rate each of a number of key indicators from 1 (not at all) to 5 (to a great extent) in four different categories by circling the appropriate response.

Please note that any one session is not likely to provide evidence for every single indicator. Therefore:

- Use 6 (Don't know) when there is not enough evidence for you to make a judgment.
- Use 7 (N/A, meaning Not Applicable) when you consider the indicator inappropriate given the purpose and context of the session.
- Similarly, there may be entire rating categories that are not applicable to a particular session.

Note that you may list any additional indicators you consider important in capturing the essence of this session and rate these as well.

Using your observations and opinions

- Use your "Ratings of Key Indicators" (Part A) to inform your "Synthesis Ratings" (Part B).
- Indicate in "Supporting Evidence for Synthesis Ratings" (Part C) what factors were most influential in determining your synthesis ratings.
- Section Two concludes with ratings of the likely impact of the training session and a capsule description of it.

I. Design

A. Ratings of Key Indicators

	Not at all				To a great extent	Don't know	N/A
1. The strategies in this session were appropriate for accomplishing the training session's purposes.	1	2	3	4	5	6	7
2. The session effectively built on participants' knowledge of content, teaching, learning, and/or the need for change process	1	2	3	4	5	6	7
3. The instructional strategies and activities used in this section reflected attention to participants':							
a. Experience, preparedness, and learning styles	1	2	3	4	5	6	7
b. Access to resources	1	2	3	4	5	6	7
4. The session's design reflected careful planning and organization	1	2	3	4	5	6	7
5. The session's design encouraged a collaborative approach to learning	1	2	3	4	5	6	7

6. The session's design incorporated tasks, roles, and interactions consistent with a spirit of investigation	1	2	3	4	5	6	7
7. The session's design appropriately balanced attention paid to multiple goals	1	2	3	4	5	6	7
8. Adequate time and structure were provided for reflection	1	2	3	4	5	6	7
9. Adequate time and structure were provided for participants to share experiences and insights	1	2	3	4	5	6	7

B. Synthesis Rating

1	2	3	4	5
Session design was <u>not at all reflective</u> of Best Practices for practitioner development				Session design was <u>extremely reflective</u> of Best Practices for practitioner development

C. Supporting Evidence for Synthesis Rating

II. Implementation

A. Ratings of Key Indicators

	Not at all				To a great extent	Don't know	N/A
1. The session effectively incorporated instructional strategies appropriate for training session purposes and the needs of adult learners	1	2	3	4	5	6	7
2. The session effectively modeled questioning strategies that are likely to enhance the development of conceptual understanding (e.g., emphasis on higher-order questions, appropriate use of "wait time," identifying perceptions and misconceptions)	1	2	3	4	5	6	7
3. The pace of the session was appropriate for training session purposes and the needs of adult learners	1	2	3	4	5	6	7
4. The session modeled culturally appropriate learning styles	1	2	3	4	5	6	7
5. The presenter(s)' background, experience, and/or expertise enhanced the quality of the session	1	2	3	4	5	6	7
6. The presenter(s)' management style/strategies enhanced the quality of the session	1	2	3	4	5	6	7
7. ___Other, please specify ________________________________	1	2	3	4	5		

B. Synthesis Rating

1	2	3	4	5
Implementation of the session was not at all reflective of Best Practices for practitioner development				Implementation of the session was extremely reflective of Best Practices for practitioner development

C. Supporting Evidence for Synthesis Rating

____

____

____

III. Discipline Content (e.g. Horticulture and Agronomy, Supply Chain, Marketing, Business, etc)

A. Ratings of Key Indicators

	Not at all				To a great extent	Don't know	N/A
1. Discipline content was appropriate for purposes of the training session and participants' backgrounds	1	2	3	4	5	6	7
2. The content was sound and appropriately presented/ explored	1	2	3	4	5	6	7
3. Facilitator displayed an understanding of concepts (e.g., in his/her dialogue with participants)	1	2	3	4	5	6	7

4. Content area was portrayed by a dynamic body of knowledge continually enriched by conjecture, investigation, analysis, and proof/justification	1	2	3	4	5	6	7
5. Depth and breadth of attention to disciplinary content was appropriate for session purposes and the needs of adult learners	1	2	3	4	5	6	7
6. Appropriate connections were made to other areas other disciplines and/or to real world contexts	1	2	3	4	5	6	7
7. Degree of closure or resolution of conceptual understanding was appropriate for session purposes and the needs of adult learners	1	2	3	4	5	6	7

B. Synthesis Rating

1	2	3	4	5
Disciplinary content of the session was <u>not at all reflective</u> of Best Practices for practitioner development				Disciplinary content of the session <u>was extremely reflective</u> of Best Practices for practitioner development

C. Supporting Evidence for Synthesis Rating

IV. Culture/Equity

A. Ratings of Key Indicators

	Not at all				To a great extent	Don't know	N/A
1. Active involvement of all the participants was encouraged and valued	1	2	3	4	5	6	7
2. There was a climate of respect for participants' experiences, ideas, and contributions	1	2	3	4	5	6	7
3. Interactions reflected collaborative working relationships among participants	1	2	3	4`	5	6	7
4. Interactions reflected collaborative working relationships between facilitator(s) and participants	1	2	3	4	5	6	7
5. The presenter'(s) language and behavior clearly demonstrated sensitivity to variations in participants':							
a. Experience and/or preparedness	1	2	3	4	5	6	7
b. Access to resources	1	2	3	4	5	6	7
c. Gender, race/ethnicity, and/or culture	1	2	3	4	5	6	7
6. Opportunities were taken to recognize and challenge stereotypes and biases that became evident during the training session	1	2	3	4	5	6	7
7. Participants were intellectually engaged with important ideas relevant to the focus of the session	1	2	3	4	5	6	7

8. Faculty/Practitioner participants were encouraged to generate ideas, questions, conjectures, and propositions	1	2	3	4	5	6	7
9. Investigation and risk-taking were valued	1	2	3	4	5	6	7
10. Intellectual rigor, constructive criticism, and the challenging of ideas were valued	1	2	3	4	5	6	7
11. Other (specify) ______________________	1	2	3	4	5		

[1]Use 1, "Not at all," when you have considerable evidence of insensitivity or inequitable behavior; 3, when there are no examples either way; and 5, "To a great extent," when there is considerable evidence of proactive efforts to achieve equity.

B. Synthesis Rating

1	2	3	4	5
Culture of the session interferes with engagement of participants as members of a learning community				Culture of the session facilitates engagement of participants as members of a learning community

C. Supporting Evidence for Synthesis Rating

V. Overall Ratings of the Session

While the impact of a single training session may well be limited in scope, it is important to judge whether it is helping move participants in the desired direction. For ratings in the section below, consider all available information (i.e., your previous ratings of design, implementation, content, and culture/equity; related interviews, and your knowledge of the overall training session program) as you assess the likely impact of this session. Feel free to elaborate on ratings with comments in the space provided.

Likely Impact on Participants' Capacity for Implementing Training and Capacity to Teach Others

Consider the likely impact of this session on the participants' capacity to implement training and/or teach others. Circle the response that best describes your overall assessment of the *likely effect* of this session in each of the following areas.

___ not applicable. (The session did not focus on teaching other villagers new knowledge, skills or attitudes and/or implementation strategies)

	Not at all				To a great extent	Don't know	N/A
1. Participants' ability to identify and understand important issues of horticulture	1	2	3	4	5	6	7
2. Participants' understanding of horticulture as a dynamic body of knowledge generated and enriched by investigation	1	2	3	4	5	6	7
3. Participants' understanding of how they and other villagers learn	1	2	3	4	5	6	7
4. Participants' ability to plan/implement exemplary horticultural practices	1	2	3	4	5	6	7
5. Participants' ability to implement exemplary instructional materials if teaching others	1	2	3	4	5	6	7
6. Participants' self-confidence in instruction	1	2	3	4	5	6	7
7. Pro-activeness of participants in addressing							

their training session needs	1	2	3	4	5	6	7
8. Professional networking among participants with regard to Horticultural practices	1	2	3	4	5	6	7

Comments (optional):

Appendix 2

Pre-test on business skills

Dear participant the questions below help us understand your current practice on book keeping. We request all participants to read through the questions and circle **one answer** for each question. The information will be used to for improving training modules for future participants.

1. I differentiate needs and wants. Yes/No
2. I prioritise my needs. Yes/No
3. I save my extra money. Yes/No
4. I have a business plan. Yes/No
5. I keep record of my receipts (income) and expenses (cash book). Yes/No
6. I borrow money to meet my business needs. Yes/No
7. I borrow money to meet my family needs. Yes/No
8. I borrow money to meet customary. Yes/No
9. I plan my repayment for the borrowed money. Yes/No
10. I have made profits through my business. Yes/No

Post-test on Business Skills

Dear participant the questions below help us understand your current view of book keeping. We request all participants to read through the questions and circle **one answer** for each question. The information will be used to for improving training modules for future participants.

I was taught in the training:

1. Needs are more important than wants. True/False
2. You must not prioritize needs. True/False
3. Record keeping of payments is good. True/False
4. Record keeping of receipts is not good. True/False
5. Cash flow is not important for business. True/False
6. Business plans are good for future. True/False
7. Money cannot be made to work. True/False
8. Business requires cash flow. True/False
9. Household income does not include receipts. True/False
10. Household expense includes payment. True/False

Appendix 3 Pre-and Post-Test on Farm Production

Dear participant the questions below helps us understand your current practice on farm production. We request all participants to read through the questions and circle **one answer** for each question. The information will be used to for improving training modules for future participants.

1. I look after my soil because it is a) usual practice b) good for soil c) to support plant growth d) to manage nutrients in soil e) none of the above
2. I prepare my soil with tractor before planting a) usual practice b) less labour c) removes weeds d) supports plant growth e) none of the above
3. I grow different crops in my garden a) usual practice b) to feed family c) to manage nutrients in soil d) to avoid disease spread e) none of the above
4. I cover the soil with crops or organic material a) usual practice b) to avoid soil loss c) to retain moisture in soil d) to avoid weeds e) none of the above
5. I apply purchased fertilizers during different stages of crops a) usual practice b) to support plant growth c) to increase yield d) to improve size/quality of vegetables e) none of the above
6. I apply organic manure during different stages of crops a) usual practice b) to support plant growth c) to increase yield d) to increase size of vegetables e) none of the above
7. I water the crops through canal or furrow a) usual practice b) efficient to irrigate crops c) less weed d) to increase size of vegetables e) none of the above
8. I remove unwanted crops growing with my main crop a) usual practice b) main crops can grow better c) unwanted crops compete for nutrients d) to increase yield e) none of the above
9. I manage insects in my garden through methods like biological, chemical or cultural a) usual practice b) protect crops c) to reduce insect damage d) to increase yield e) none of the above
10. I manage disease infestation in my garden through methods like physical, chemical or cultural a) usual practice b) protect crops c) to reduce damage d) to increase yield e) none of the above

Women building a ‘barni compos’

Women learning about pesticide safety

Appendix 4 Pre- and Post-Test on Post-Harvest Practices

Dear participant the questions below help us understand your current practice on post-harvest practices. We request all participants to read through the questions and circle **one answer** for each question. The information will be used to for improving training modules for future participants.

1. I harvest my produce at the right maturity. a) usual practice b) better quality c) better price d) reduce damage e) none of the above

2. I pack produce using right package material. a) usual practice b) better quality c) better price d) reduce damage e) none of the above

3. I organize good handling and transport. a) usual practice b) better quality c) better price d) reduce damage e) none of the above

4. I select good variety crop. a) usual practice b) better quality produce c) better price d) reduce damage during transport e) none of the above

5. I manage the crop from pest and disease. a) usual practice b) better quality produce c) better price d) reduce damage during transport e) none of the above

6. I grade my produce to suit market. a) usual practice b) better quality produce c) better price d) reduce damage during transport e) none of the above

7. I have built trust with my buyers. a) usual practice b) pack only good quality c) produce available for pick up d) good price e) none of the above

8. I sell to the wet markets because it is a) usual practice b) better price c) all grades of produce can be sold d) good price e) none of the above

Tapini Women's Graduation

Appendix 7: Socio-demographic Survey of Tapini Women

Code	Age	Contact no	Off Farm Work	Address	Dialect/language Spoken
T001	41	71470658	Gardener	Ward-10, Tapini	Tauwade
T002	42	73600105		Ward-10, Jowa, Tapini	Kunimaipa, Tok Pisin
T003	19	72248598		Casmironari, Tapini	Tauwade
T004	23	73926326		Ward 4, Tapini	Tauwade, Pigin
T005	19	72238737		Ward 10, Tapini	Pinis, Tauwade
T006	23			Ward 10, Tapini	Tok Pisin, Tauwade
T007	59	72248598	C/Councillor Iva	Evanari, Tapini	Tauwade, Pigin, Motu
T008	52	72868791		Ward 5, Tapini	Pisin, Motu, Tauwade
T009	41			Ward 4, Guria	Kunimaipa
T010	28			Ward4, Aiwara	Tok pigin, Tauwade
T011	17	72301698		Erume 6	Pidgin, Kunimaipa
T012	17	72740405		Ward 4, Guari (Torula)	Kunimaipa, Tok pigin, Mo
T013	17	70568161	Guria	Ward 3, Guria	Kunimaipa
T014	22	71440454		Ward 3, Sopu	Tok pigin, Tauwade
T015	20			Ward 3, Sopu	Tok pigin, Tauwade
T016	27	72587033		Ivani	Pisin, Tauwade
T017	25	70043249		Ward 5, Tapini, Kataip	Tok pigin
T018	50	72757109		Ward 6, Tapini	Kunimaipa
	Average age in years is 30 and range is 17-59	!4 participants has conact telephone no			Most of them speak in Tok pisin and Tauwade.6 can speak in Kunimaipa while one can speak in Motu

Code	No. of household members	Main Source of Income	Land tenure (specify)	Total land area farmed
T001	7	Farming, marketing	Customary land	One field
T002	6	Farming, marketing	Customary land	2 Soccer field size
T003	5	Farming, marketing	Customary land	2 Soccer field size
T004	4	Selling goods in the m	Customary land	1 Soccer field size
T005	8	Farming, marketing	Customary land	1 Soccer field size
T006		Farming, marketing	Customary land	2 Soccer field size
T007	5	Farming, marketing	Customary land	2 Soccer field size
T008	3	Sells food stuff at mar	Customary land	2 Soccer field size
T009	9	Marketing	Customary land	2 Soccer field size
T010	3	Selling goods in the m	Customary land	2 Soccer field size
T011	8	From my dad, Salary	Customary land	3 Soccer field size
T012	7	From dad's salary	Customary land	2-3 Soccer field size
T013	8	Farming, marketing	Customary land	1 Soccer field size
T014	7	Marketing	Customary land	1 Soccer field size
T015	7	Farming	Customary land	1 Soccer field size
T016	10	Marketing	Customary land	2 Soccer field size
T017	7	Selling goods in the m	Customary land	1 Soccer field size
T018	4	Farming, marketing	Customary land	2 Soccer field size
	Average number of household members is 7 and ranges between 3-18	Their main source of income is from selling crops grown on their field. Only 2 participants told their main source was their father's salary	Customary land	They own an average of 2 soccer field sized land area

Code	Crops Grown	Community affiliation	Sources of farm information
T001	Kaukau, Banana, Taro, Corn, Peanut	Church group	Learned from parents
T002	Kaukau, Peanut, Sugar cane, Cabbage, Onion, Carrot	NGO group	Parents, babu
T003	Kaukau, yam, pumpkin, banana, taso scoko	Sports group	Parents
T004	Kaukau, yam, banana, taro	Youth group	Parents/ Nari
T005	Kaukau, Banana, Taro, abika, Scoko, pumpkin, Tomato	Sports group	Parents, Scholl, Nari
T006	Kaukau, taro, banana, Sugar cane, onion, chilli, scoko,	Sports group	Parents, Scholl, Nari
T007	Kaukau, taro, yam, corn, pumpkin, sugar cane, banana,	Church group	Parents
T008	Sweet potato, corn, banana, taro, cucumber, pumpkin, bean,	church group, TALAI C	Parents, missionaries, DD ma n
T009	Potato, taro, banana, cabbage, tomato, corn	Youth group	Parents
T010	Taro, kaukau, corn, banana, pumpkin	Youth group	Parents and Nari
T011	Kaukau, Taro, banana, corn, peiote	Sports group	
T012	Kaukau, banana, taro, corn, peanut, tomato, carrot , beans	Community children lea	Parents and grand parents
T013	Yam, banana, kaukau, taro, corn	Sports group, Church	Marketing
T014	Kaukau, corn, peanut, cucumbers, bean, yam, taro,	None	Parents
T015	Kaukau, corn, taro, yam	None	Parents
T016	Banana, taro, corn, peanut	None	Parents and grand parents
T017	Kaukau, taro, corn, green yam	None	Parents and Nari
T018	Kaukau, taro, yam, beans, corn, pumpkin	SDA Church group	Parents, babu
	This list is made based on all the responses given by the participants.Most of them grow peanuts, kaukau, pawpaw, taro, banana and corn while pumpkin, sweet potato cabbage, yam, beans, cucumber, tomato are also grown by some participants. Orange, carrots and aibika are mentioned by one participant.	5 - Church group, 5 - Sports group, 3-Youth Group, 4- No affiliation, 1-NGO. 2 - Affiliated to more than one group	Parents

Code	What type of vegetable crops did you grow	what varieties of vegetables did you grow	Where did you buy Seeds	How much the seed costs
T001	Kaukau, Banana, Taro, Corn, Pea	2	Local	Nothing
T002	Kaukau, Peanut, Sugar cane, Cab	Kaukau 2, Pawpaw 2, Ta	Local seeds	Nothing
T003	Kaukau, yam, pumpkin, banana, t	Kaukau 8, Taso 2, banan	Local seeds	Nothing
T004	Kaukau, yam, banana, taro	Taro 2, Corn 3, Pumpkin	Local seeds	Nothing
T005	Kaukau, Banana, Taro, abika, Sc	kaukau 8, Taro 2, Banana	Local seeds	Nothing
T006	Kaukau, taro, banana, Sugar cane	kaukau 8, Taro 2, Banana	Local seeds	Nothing
T007	Kaukau, taro, yam, corn, pumpki	Corn 3types, kaukau 7 ty	Local seeds	Nothing
T008	Carrots, onion like shallots, celery	Corn 3, Kaukau 6, pawpa	Local seeds	Nothing
T009	Potato, taro, banana, cabbage, tom	9 types	Local seeds	Nothing
T010	Taro, kaukau, corn, banana, pum	Kaukau 6, Taro 2, Pawpa	Local seeds	Nothing
T011	Kaukau, Taro, banana, corn, peio	Kaukau 7, Taro 6, Banan	Local seeds	Nothing
T012	Kaukau, banana, taro, corn, peanu	Kaukau 10, Taro 5, bana	Local seeds	Nothing
T013	Yam, banana, kaukau, taro, corn	Kaukau 9, corn 3, banana	Local seeds	Nothing
T014	Kaukau, corn, peanut, cucumbers	More than 10	Local seeds	Nothing
T015	Kaukau, corn, taro, yam	More than 10	Local seeds	Nothing
T016	Banana, taro, corn, peanut	More than 10	Local seeds	Nothing
T017	Kaukau, taro, corn, green yam	Kaukau 6, corn 3, taro 3 k	Local seeds	Nothing
T018	Kaukau, taro, yam, beans, corn, p	Kaukau 5, yam 4	Local seeds	Nothing
	This list is made based on all the responses given by the participants.Most of them grow peanuts, kaukau, pawpaw, taro, banana and corn while pumpkin, sweet potato cabbage, yam, beans, cucumber, tomato are also grown by some participants. Orange, carrots and aibika are mentioned by one participant.	Not vey clear about the responses. After compiling all the data, the vaieties could be more than 5.	Local seeds	Nothing

Code	What month of the year do you usually plant these vegetables	Why the chosen month	How did you prepare your seeding	How did you prepare the land for planting	If yes, how many times did you plough and harrow the field	Did you have any provision for irrigation
T001	Dry season			Men prepare land		No
T002	July-Aug, Sept-, during dry season		Dry seeding, trans	We use manpower		No
T003	Dry season		transplanting from	Manually prepared	NA	No
T004	Dry season	If we plant during wet seas	Dry seeds are dire	Manually prepared	NA	No
T005	Dry season		Transplanting from	Manpower	NA	No
T006	Dry season	it is the right time to pants	Transplanting fro	Manpower	NA	NA
T007	When the garde	NA	Transplanting suc	Manually prepared	NA	NA
T008	We plant in dry	To avoid washing of soil, P	Transplanting of s	Cut down bushes 3	NA	NA
T009	Dry season	It wont grow during the ra	Drying the seeds, u	We use stick to pla	NA	NA
T010	Dry season	It wont grow during the ra	Dry seeds are dire	Manually prepared	NA	NA
T011	Dry season July - Sep				NA	NA
T012	Dry season July - Sep		Transplanting of s	Manually prepared	NA	NA
T013	Dry season	It wont grow during the ra	Transplanting of s	We use stick to plan	NA	NA
T014	Dry season	It wont grow during the ra	Transplanting of s	Manually prepared	NA	NA
T015	Dry season	It wont grow during the rai	Transplanting of s	Manually prepared	NA	NA
T016	Dry season	It wont grow during the ra	NA	We use stick to plan	NA	NA
T017	Dry season	NA	Seeds directly	Manually planting	NA	NA
T018	Dry season, eve	NA	Direct planting, dr	Manpower	NA	NA
	Dry Season	To avoid washing of soil, Plant seed will not grow well	Seeds from the old garden directly plant in to the new garden	Manually	NA	NA

Code	What is the source of irrigation water	Did you apply fertiliser	How much of fertiliser	What kind of fertiliser	What damage did you observe in your crop
T001	Rain	No, Mulching			holes on leaves, holes in fruits
T002	Rain	NA	NA	NA	holes on leaves
T003	Rain	NA	NA	NA	yellowing, holes on leaves, curling of lea
T004	Rain	NA	NA	Na	yellowing, holes on leaves, curling of lea v
T005	Rain	NA	NA	NA	yellowing, holes on leaves, curling of lea
T006	Rain	No, Mulch	NA	NA	holes on leaves, curling of leaves, wittin g
T007	Rain	NA	NA	NA	yellowing, holes on leaves, curling of lea
T008	Rain	NA	NA	NA	holes on leaves, curling of leaves, holes
T009	Rain	NA	NA	NA	holes on leaves, holes in fruits
T010	Rain	NA	NA	NA	yellowing, holes on leaves, curling of lea v
T011	Rain	NA	NA	NA	holes on leaves, holes in fruits
T012	Rain	NA	NA	NA	holes on leaves, holes in fruits
T013	Rain	NA	NA	NA	yellowing, holes on leaves, witting, hole
T014	Rain	NA	NA	NA	holes on leaves, curling of leaves, holes
T015	Rain	NA	NA	NA	holes on leaves, curling of leaves, holes
T016	Rain	NA	NA	NA	yellowing, holes on leaves, curling of lea v
T017	Rain	NA	NA	NA	yellowing, holes on leaves, curling of lea
T018	Rain	NA	NA	NA	yellowing, holes on leaves, curling of lea v
	Rain Water	NA	NA	NA	yellowing, holes on leaves, curling of leaves, witting, holes in fruits

Code	What did you do to protect your crops from insect damage and disease	Did you seek help for treating damage in your crops	Did you apply any chemical pesticides?		
			Type	Qty	Frequency
T001		No	NA	NA	NA
T002	Put ashes, pick insects and kill them, upr	No	NA	NA	NA
T003	None	No	NA	NA	NA
T004	None	No	NA	NA	NA
T005	Take them out and kill or throw them aw	No	NA	NA	NA
T006	Take them out and kill them	No	NA	NA	NA
T007	If it is near the house we throw ashes to t	No	NA	NA	NA
T008	Pick insects to kill, use local ways of stop	No	NA	NA	NA
T009	Sometimes take it out and throw them	No	NA	NA	NA
T010	No idea how to protect	No	NA	NA	NA
T011	Remove the damage crop and bury it	No	NA	NA	NA
T012	Remove the damage crop and bury it	No	NA	NA	NA
T013	Sometimes take it out and throw them	No	NA	NA	NA
T014	We pull it out and throw them	No	NA	NA	NA
T015	We pull it out and throw them	No	NA	NA	NA
T016	Sometimes take it out and throw them	No	NA	NA	NA
T017	None	No	NA	NA	NA
T018	Put ashes, kill insects	No	NA	NA	NA
	Most of them pull out the damaged crop and thow or bury them. Only 2 put ashes to control damage. 5 participants do not take any action	No	NA	NA	NA

Code	Did you apply any chemical pesticides in your crop					
	Type	Qty	Frequency	Type	Qty	Frequency
T001	NA	NA	NA	NA	NA	NA
T002	NA	NA	NA	NA	NA	NA
T003	NA	NA	NA	NA	NA	NA
T004	NA	NA	NA	NA	NA	NA
T005	NA	NA	NA	NA	NA	NA
T006	NA	NA	NA	NA	NA	NA
T007	NA	NA	NA	NA	NA	NA
T008	NA	NA	NA	NA	NA	NA
T009	NA	NA	NA	NA	NA	NA
T010	NA	NA	NA	NA	NA	NA
T011	NA	NA	NA	NA	NA	NA
T012	NA	NA	NA	NA	NA	NA
T013	NA	NA	NA	NA	NA	NA
T014	NA	NA	NA	NA	NA	NA
T015	NA	NA	NA	NA	NA	NA
T016	NA	NA	NA	NA	NA	NA
T017	NA	NA	NA	NA	NA	NA
T018	NA	NA	NA	NA	NA	NA
	NA	NA	NA	NA	NA	NA

Code	Where	Distance	Mode of transport	Packaging
T001	Tapini	6 -10min	Walk	Woven bag
T002	Tapini	1-2 days	Walking	Woven bag
T003	Tapini	1 day	Walking	Woven bag
T004	Tapini	6 hrs	Walking	Woven bag
T005	Tapini	1 day	Walking	Woven bag
T006	Tapini	1 day	Walking	Woven bag
T007	Tapini	Few yards	Walking	Woven bag
T008	Local Market	3-4 hrs	Walking	Woven bag
T009	Bauai		Walking	Woven bag
T010	Tapini	1 day	Walking	Woven bag
T011	Tapini	1 day	PMV	Bag
T012	Foodland	4-5 hrs	PMV	Woven bag
T013	Tapini	1 day	Walking	Woven bag
T014	Tapini station	2 days	Walking	Woven bag
T015	Tapini station	2 days	Walking	Woven bag
T016	Tapini	3 hr	Walking	Woven bag
T017	Tapini	1 day	Walking	Woven bag
T018	Tapini	1 day	Walking	Woven bag
	All the participants sell their home grown fruits and vegetables in the local as well far off (4-6 hrs. of travelling) markets. Five people sell their crops to 4-5 different markets. Nine particiapnts sell their goods at 3 different markets. All participants except one sell their goods at 2 diiferent markets. The local market is Tapinin which is a walking distance, whereas other markets are located far off, 4-5 hrs of drive in PMV			

Code	Wholesale or retail	Buyer	Mode of payment	Where	Distance	Mode of transport
T001	Retail	Local Res	Cash	Manu	one day	PMV
T002	Retail	Local Resi	Cash	Gordon's marke	4 hrs	PMV
T003	Retail	Local Resi	Cash	Gordens marke	half way	PMV
T004	Retail	Local Resi	Cash	Gorbons marke	6 hrs	PMV
T005	Retail	Local Resi	Cash	Gondens marke	1 and half day	Truck
T006	Retail	Local Resi	Cash	Gurbons marke	1 and half day	Truck, PMV
T007	Retail	Local Resi	Cash	Goden's	half way	PMV
T008	Retail	Local Res	Cash	Moresby	5-6 hrs	PMV
T009	Retail	Local Resi	Cash	Guria		
T010	Retail	Local Res	Cash	Gordons market	6 hrs	PMV
T011	Retail	Residents	Cash	Gerechu	1 day	PMV
T012	Retail	Local Res	Cash			
T013	Retail	Local Resi	Cash	Gordons marke	half way	PMV
T014	Retail	Local Resi	Cash	Gordons marke	4 hrs	PMV
T015	Retail	Local Resi	Cash	Gordons marke	9 hr	PMV
T016	Retail	Local Resi	Cash	Gerechu	Highway	PMV
T017	Retail	Local Res	Cash	Gordons market	6 hrs	PMV
T018	Retail	Local Res	Cash	Gordons market	4 hrs	PMV

Where did you sell your vegetables

Code	Packaging	Wholesale or retail	Buyer	Mode of payment	Where	Distance	Mode of transport
T001	50Kg bags	Retail	residents of M	Cash			
T002	50Kg bags	Retail	Residents of P	Cash			
T003	Bag	Retail	Residents of C	Cash	Gerehu	Halfway	PMV
T004	Bags and boxes	Retail	Black market b	Cash			
T005	Woven bags	Retail	Residents of G	Cash	Mumket	1 and half day	Truck Woven
T006	bags	Retail	Residents of G	Cash	Manu mark	1 and half day	Truck, PMV
T007	Bags 50 kg	Retail	Black market b	Cash	Manu mark	Halfway	PMV
T008	Bags 50 kg	Retail	Gordons, Any	Cash	Super marke	5-10 min	Car, bus, taxi
T009		Retail	Tapini Station	Cash			
T010	Bags 50 kg	Wholesale		Cash			
T011	Bags	Retail	Jaika	Cash	Makw	Half day	PMV
T012		Retail		Cash			
T013	Bag	Retail	Residents	Cash	Gerehu	Halfway	PMV
T014	Bags 50 kg						
T015	Bags 50 kg						
T016	Bags 50 kg	Retail	Black market	Cash	Gordens	Highway	PMV
T017	Bag or box	Retail	Black market b	Cash	Manu mark	6 hrs	PMV
T018	Bags 50 kg	Retail	Pom residents	Cash			

Code	Packaging	Wholesale or retail	Buyer	Mode of payment	Where	Distance	Mode of transport	Packaging
T001								
T002								
T003	bag	Retail	Retailer	Cash	Manu	Halfway	PMV	Bag
T004								
T005	Woven bags	Retail	Residents of A	Cash				
T006	Woven bags	Retail	Residents of A	Cash				
T007	Woven bags, ba	Retail	Retailer	Cash	Gerchu	Halfway	PMV	Woven bags,
T008	Bags 50 kg							
T009								
T010								
T011	Bags	Retail	Jaika	Cash	Subama	Half day	PMV	Bags
T012								
T013	Bags	Retail	Retailer	Cash	Mamu	Halfway	PMV	Bags
T014								
T015								
T016	Bags 50 kg	Retail	Retailer	Cash	Koki	Highway	PMV	Bags 50 kg
T017	Woven bags	Retail	Black market	Cash				
T018								

Code	Wholesale or retail	Buyer	Mode of payment	Where	Distance	Mode of transport	Packaging	Wholesale or retail
T001								
T002								
T003	Retail	Retailer	Cash	Sabama	Halfway	PMV	Bag	Retail
T004								
T005								
T006								
T007	Retail	Retailer	Cash	Koki	Halfway	PMV	Woven bags, ba	Retail
T008								
T009								
T010								
T011	Retail	Jaika	Cash					
T012								
T013	Retail	Retailer	Cash	Sabama	Halfway	PMV	Bag	Retail
T014								
T015								
T016	Retail	Retailer	Cash	Manu	Highway	PMV	Bags 50 kg	Retail
T017								
T018								

Code	Buyer	Mode of payment	Did you keep farm record	If yes, what type of record	Did you have training in farm recording	Who conducted the training	Crop
T001			no		no		Peanut
T002			no		no		Peanut
T003	Retailer	Cash	no		no		Peanut
T004			no		no		Peanut
T005			No		No		Peanut
T006			No		No		Peanut
T007	Retailer	Cash	No		No		Peanut
T008			No		No		Peanut
T009			No		No		Peanut
T010			No		No		Peanut
T011			No		No		Peanut
T012			No		No		Tapioca
T013	Retailer	Cash	No		No		Peanut
T014			No		No		Peanut
T015			No		No		Peanut
T016	Retailer	Cash	No		No		Peanut
T017			No		No		Peanut
T018			No		No		Peanut
			No		No		kaukau is 3-4 times, peanut is 3 times a year, corn is one time and banana is 3-5 times a year, choko, taro and pawpaw any time of the year, potato 2-3 times a year, orange all year around

Code	Start of harvest	Frequency	Duration	Indicators of harvesting	Crop	Start of harvest	Frequency	Duration
T001	March	4 times in a year	4 times	Dry leaves	Choko	any time	round the year	all year
T002	March	3 times	3 times	Dry leaves	Choko	any time	10 times	all year
T003	March	3 times	2 months	Dry leaves	Choko	any time	10 times	all year
T004	March	3 times	1 year	Dry leaves	Banana	any time	5 times	all year
T005	March	3 times	2 months	Dry leaves	Scoko	any time	10 times	all year
T006	March	3 times	2 months	Dry leaves	Choko	any time	10 times	all year
T007	March	3 times			Kaukau	June	2 times	all year
T008	March	3 times	All year	Dry leaves	Chocko	any time	any time	all year
T009	March	1 time	4 months	Leaves turn bı	Taro	May	3 times	
T010	March	3 times		Dry leaves	Choko	any time		all year
T011	March	3 times	2 months	Dry leaves	Choko	any time	10 times	all year
T012	April	4 times	2 months	Dry leaves	Taro	any time	4 times	1 month
T013		2 times		Dry leaves	Choko	any time	10 times	all year
T014	March	3 times		Dry leaves	Choko	any time	10 times	all year
T015					Choko		10 times	
T016		3 times		Dry leaves	Corn			
T017	March				Choko	any time	10 times	all year
T018	March	3 times		Dry leaves	Choko	any time	10 times	all year

Code	Indicators of harvesting	Crop	Start of harvest	Frequency	Duration
T001	Plenty of shoots	Taro	Jan	3 times	every year
T002	New shoots	Round cabbage	March	10 times	5 times
T003	Plenty of new shoots				
T004	Yellow	Choko	any time	more than 20 times	all year
T005	Plenty of new shoot	Banana	Aug	1 time	7 months
T006	Plenty of new shoots	Banana	Aug	1 time	7 months
T007		Pawpaw	June July	2 times	
T008	Plenty of new shoots				
T009		Choko	any time	10 times	all year
T010		Banana	any time		1 month
T011	Plenty of new shoots				
T012	Leaves turn brown	Corn		1 time	4 months
T013	Plenty of new shoot	Potato		2-3 times	
T014	Plenty of new shoots	Potato	Aug-Sept	2-3 times	
T015		Pawpaw			
T016		Kaukau	any time		all year
T017	Plenty of new shoot	Taro	any time	12 times	all year
T018					

When did you harvest your vegetable

Code	Indicators of harvesting	Crop	Start of harvest	Frequency	Duration	Indicators of harvesting	Crop
T001	Dry leaves	Banana	July	3 times	every year	Dry leaves	Kaukau
T002							
T003							
T004	new shoots grow	Corn	Feb	once	half a year	Dry leaves	
T005	Dry leaves	Kaukau	Aug	1 in 4 moths	1 year	Carrying flo	Taro
T006	Dry leaves	Taro	July	2 times	9 months	Dry leaves	Crop
T007							
T008							
T009		Kaukau	any time			leaves turn big	
T010							
T011							
T012	White flower turn brown						
T013	Young shoots growing						
T014	Young shoots growing						
T015		Kaukau					
T016	Young shoots gro	Pawpaw	any time		all year		
T017		Pawpaw	1 month		14 days		Orange
T018							

Code	Start of harvest	Frequency	Duration	Indicators of harvesting	Crop	Start of harvest	Frequency
T001	April	5 times	every year	Dry leaves			
T002							
T003							
T004							
T005	Aug	2 times	9 months	Dry leaves	Corn	March	1 time
T006	March	1 time	4 months	Yellow leaves			
T007							
T008							
T009							
T010							
T011							
T012							
T013							
T014							
T015							
T016							
T017	1 year	12 months	all year				
T018							

Code	Duration	Indicators of harvesting	Crop	Start of harvest	Frequency	Duration	Indicators of harvesting
T001							
T002							
T003							
T004							
T005	4 months	Leaves yellow					
T006							
T007							
T008							
T009							
T010							
T011							
T012							
T013							
T014							
T015							
T016							
T017							
T018							

Code	Vegetable	Home consumption	Leave in the field without harvesting	Feed for animals	Others	Vegetable
T001	Kaukau	yes	no	yes		Choko
T002	Peanut	yes	no	no	yes	Kaukau
T003	Peanut	yes	no	yes		Taso
T004	Peanut	yes	no	no	Market	Kaukau
T005	Peanut	yes	no	no	yes	Kaukau
T006	Peanut	yes	no	no	yes	Kaukau
T007	Kaukau	yes	no	yes		Peanuts
T008	Kaukau	yes	no	yes		Banana
T009	Peanut	yes	yes	yes		Kaukau
T010	Peanut	yes	no	no	Leaves some fo	Kaukau
T011	Peanut	yes	no	yes	yes	Taro
T012	Pawpaw	no	yes	yes		Kaukau
T013	Carrots	yes	yes	yes	yes	Cabbage
T014	Taro	yes	no	yes		Cabbage
T015	Pawpaw	yes	no	yes		Kaukau
T016	Kaukau	yes	yes	yes	yes	Pawpaw
T017	Peanut	yes	yes	yes		Choko
T018	Kaukau	yes	yes	yes	yes	Taro
	Damaged Aibika, Banana, Cabbage, Carrots, Choko, Corn, Kaukau, Kaukau, Pawpaw, Pawpaw, Peanut, Potato, Pumpkin, Taro are consumed at home. Cabbage, choko, pawpaw, kaukau, taro are also kept in the field. Same type of crops are alsoused to feed the animal. Only one particiapnt sell the damaged good at the market apart from using at home, feeding animals.					

What did you do with damaged and unsold v

Code	Home consumption	Leave in the field without harvesting	Feed for animals	Others	Vegetable	Home consumption	Leave in the field without harvesting
T001	no	yes	no		Taro	yes	yes
T002	yes	yes	yes	yes	Pumpkin	yes	yes
T003	yes	yes	no	yes	Banana	yes	yes
T004	yes	yes	yes	Market	Taro	yes	no
T005	yes	yes	yes	yes	Taro	yes	no
T006	yes	yes	yes	yes	Taro	yes	yes
T007	yes	no	yes	no			
T008	yes	no	yes				
T009	yes	yes	yes		Pumpkin	yes	yes
T010	yes	no	yes	Selling	Choko	yes	yes
T011	yes	yes	yes	yes	Pawpaw	yes	yes
T012	yes	yes	yes		Aibika	no	no
T013	yes	yes	no	yes	Banana	yes	yes
T014	yes	no	no		Potato	yes	no
T015	yes	no	no		Taro	yes	no
T016	yes	no	no		Banana	yes	no
T017	yes	no	yes		Taro	yes	no
T018	yes	yes	yes	yes	Pumpkin	yes	yes

egetables

Code	Feed for animals	Others	Vegetable	Home consumption	Leave in the field without harvesting	Feed for animals	Others
T001	no		Banana	yes	no	yes	
T002	no	yes	Taro	yes	yes	yes	yes
T003	yes	yes	Pawpaw	yes	yes	yes	yes
T004	yes	Market	Cabbage	yes	yes	yes	Market
T005	no	yes	Banana	yes	no	no	yes
T006	no	yes	Banana	yes	no	no	yes
T007							
T008							
T009	yes						
T010	yes	Selling	Banana	yes	no	no	Selling
T011		yes	Choko	yes	yes	yes	yes
T012	no						
T013	yes	yes	Taro	yes	yes	no	yes
T014	yes		Peanut	yes	no	no	
T015	yes		Cabbage	yes	no	no	
T016	yes		Taro	yes	no	no	
T017	yes		Kaukau	yes	yes	yes	
T018	yes	yes	Corn	yes	yes	yes	yes

Code						Land preparat	
	Vegetable	Home consumption	Leave in the field without harvesting	Feed for animals	Others	Hiring tractor	Purchase of tools
T001	Peanuts	yes	no	no		No	NA
T002	Corn	yes	no	yes	yes	150	NA
T003	Choko	yes	yes	yes	yes	NA K 70 total with	NA
T004	Banana	yes	yes	yes	Market	Land preparation K	NA
T005	pawpaw	yes	yes	yes	yes	Land preparation K	NA
T006	pawpaw	yes	yes	yes	yes	Land preparation K	NA
T007						Land preparation K	NA
T008						NA	NA
T009						NA	NA
T010	Taro	yes	yes	yes	Selling	1600	NA
T011	Banana	yes	yes	no	yes	Land preparation K	NA
T012						Land preparation K	NA
T013	Kaukau	yes	yes	yes	yes	NA	NA
T014	Sugar cane	yes	no	yes		Land preparation K	NA
T015	Yam	yes	no	yes		Land preparation K	NA
T016						Land preparation K	NA
T017	Corn	yes	no	yes		20	NA
T018	Peanuts	yes	yes	yes	yes	Land preparation K	NA
						Only one particpants given a cost of K150.	NA

Code	ion		Seeds		Weeding		Irrigati	
	Maintenance cost of tools	Other costs	Seed cost	Other costs	Costs	Other costs	Motor pump cost	Fuel cost
T001	NA	NA	Local Seeds	NA	25	NA	NA	NA
T002	NA	NA	Local Seeds	NA	150	NA	NA	NA
T003	NA	NA	Local Seeds	NA	NA	NA	NA	NA
T004	NA	NA	Local Seeds	NA	NA	NA	NA	NA
T005	NA	NA	Local Seeds	NA	NA	10	NA	NA
T006	NA	NA	Local Seeds	NA	NA	NA	NA	NA
T007	NA	NA	Local Seeds	NA	NA	NA	NA	NA
T008	NA	Family su	Local Seeds	NA	NA	NA	NA	NA
T009	NA	NA	Local Seeds	NA	NA	NA	NA	NA
T010	NA	NA	Local Seeds	NA	NA	NA	NA	NA
T011	NA	NA	Local Seeds	NA	NA	NA	NA	NA
T012	NA	40	Local Seeds	NA	100	70	NA	NA
T013	NA	NA	Local Seeds	NA	NA	NA	NA	NA
T014	NA	NA	Local Seeds	NA	1.5	NA	NA	NA
T015	NA	NA	Local Seeds	NA	NA	NA	NA	NA
T016	NA	NA	Local Seeds	NA	NA	NA	NA	NA
T017	NA	NA	Local Seeds	NA	NA	NA	NA	NA
T018	NA	NA	Local Seeds	NA	K150 Family	NA	NA	NA
	NA	NA	Local Seeds	NA	NA	NA	NA	NA

Code	ion cost		Fertiliser	Pest/Disease		Harvest cost	Pos
	Purchase of tools	Other costs		Management cost	Other cost	Cost	Sorting
T001	NA	NA	NA	NA	NA	Family support, No cost	Done by family members
T002	NA	NA	NA	NA	NA	200	200
T003	NA	NA	NA	NA	NA	NA	NA
T004	NA	NA	NA	NA	NA	250	NA
T005	NA	NA	NA	NA	NA	80	NA
T006	NA	NA	NA	NA	NA	50	NA
T007	NA	NA	NA	NA	NA	Family support	NA
T008	NA	NA	NA	NA	NA	Family support	NA
T009	NA	NA	NA	NA	NA	200	The owner will s
T010	NA	NA	NA	NA	NA	150	NA
T011	NA	NA	NA	NA	NA	Family	NA
T012	NA	NA	NA	NA	NA	40-50	NA
T013	NA	NA	NA	NA	NA	NA	80
T014	NA	NA	NA	NA	NA	20	NA
T015	NA	NA	NA	NA	NA		NA
T016	NA	NA	NA	NA	NA		NA
T017	NA	NA	NA	NA	NA		NA
T018	NA	NA	NA	NA	NA	200	NA
	NA	NA	NA	NA	NA	K150-200	NA

Code	t harvest activities		Marketing				
	Packaging	Other costs	Transport cost for products	Transport cost for person	Cost for space in market	Cost for storing products	Cost for unloading produce at the market
T001	Done by family members	25	60	160	2	5	2
T002	40	40	20	80	6	5	2
T003	10	10	20 per bag	80 per person =	2	5 per night	2
T004	20		60	160	2	5	2
T005	10	10	40	80	2	2	2
T006	30	10	40	80	2	2	2
T007	20	20	20	80	2	5	2
T008	20	NA	K20 for 50kg b a	80 for adults an	2	5	2
T009	20	40	40	160	2	5	5
T010	5	40	40	160	6	5	2
T011	10	10	20	80	2	5	2
T012	2bags x20 or 30		20	160	2	2	3
T013	1	1	4	8	2	2	2
T014	40	2	3 bags K60	160	2	5	5
T015	40	2	60	2	5	5	1
T016	NA	NA	2	160	2	5	2
T017	NA	10	20	80	2	2	4
T018			20	80	6	5	2
	K10-40	K10-30	Average is K30	K160 for two person	Average cost is K3	Average cost is K4	Average cost is K3

Code			Comments		
	Other costs	Other costs		How much is your gross income	How much is your total expenses
T001	1	10	Data is for peanuts	600	260
T002	No profit 1	10	Peanut	600	624
T003	1 for toilet use	10 for food		320	250
T004	3	3	Kaukau	240 3 Kaukau ba	577
T005	1	1	Kaukau	270	200
T006	1	10		270	200
T007	1	2		NA	NA
T008	10	1			
T009	2		Total K50	200	100
T010	1	0.5		2 bags = K140	359
T011	10	10	Peanut	320	250
T012	2	10		954	541
T013	1	1	Total K200	80	27
T014	100	0.5		900	3360
T015		0.5		900	3360
T016	2	10		100	3360
T017	5	3		4	380
T018	1	10		600	624
	Average cost is K9	Average cost is K5		Average income is K492	Average expenses is K1487 with 3 unusual value of K3360. The major cost involved is travelling as the cost of traveling for two persons is K160 which destroys their profits. Most of them showed nominal profit or loss by selling the goods.

Men participants Training August 5- 9, 2013

August 2013

Increasing Vegetable Production in Central Province, Papua New Guinea to Supply Port Moresby Markets

SMCN/2008/008

Gomathy Palaniappan

Tasmanian Institute of Agriculture

Objective

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3. Background

Over the life of the project, an Organic Research and Collaborative Development model, based on

Action Research, had been followed (Spriggs and Chambers, 2011)[6]. The explicit incorporation of the iterative action research process involved:

6. Working 'with' the chain participants;
7. The initial use of non-contextualised scientific knowledge in concert with 'local knowledge' with the incorporation later of and contextualised scientific knowledge and experience;
8. Pre-planning workshops with women and men to identify gender issues for incorporation into the later planning stage.

Interviews and focus group discussions had been conducted with women, men and youth from Rigo-Koiari, Bautama and Tapini. Questions were based on techniques of Appreciative Inquiry and Rapid Supply Chain Appraisal

- *Rapid Supply Chain Appraisal Approach (RSCA):*

  This incorporates four sub-systems found to be critical to a supply chain's operational efficiency and effectiveness:

  1. Product integrity;
  2. Communication;
  3. Value creation;
  4. Chain governance.

- *Appreciative Inquiry (AI)* - a cycle of:

  5. Discovery or appreciation of the best of 'what is';
  6. Dreaming of 'what might be';
  7. Designing what 'should be';

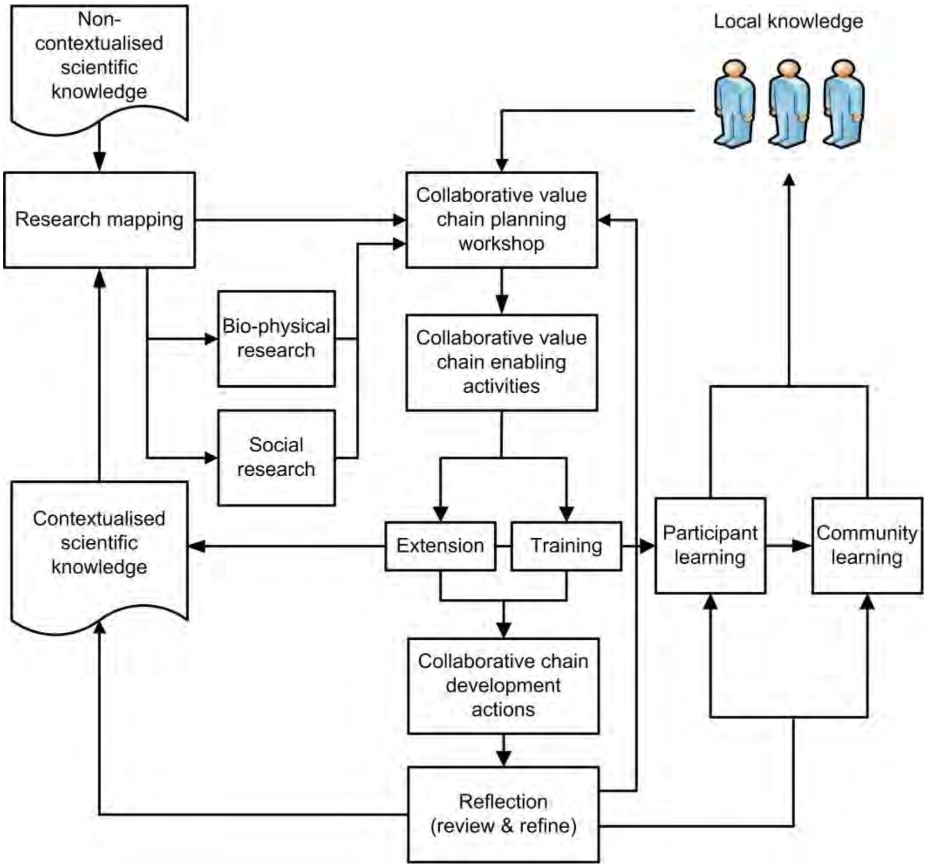
  8. Destiny of how to empower, learn and adjust/improvise.

Unifying and adapting these for this ACIAR Project has necessitated the incorporation of more explicit capacity-building processes to develop participant and community knowledge of the value chain management process. The process sequencing and relationships are reflected in Figure 1.

[6] John Spriggs and Barbara Chambers, Organic Research and Collaborative Development (ORCD) of Horticultural Supply Chains in the Asia-Pacific, **Stewart Postharvest Review 2011, 2:2**

An international refereed journal, published online 01 September 2011 doi: 10.2212/spr.2011.2.2

Figure 2: A rapid value chain research and development method



Source: derived from Chambers and Spriggs (2009) and Reason and Bradbury (2001)

This extension of the ORCD method provides the process framework in which the AI and RSCA methods are unified into a 'rapid value chain research and development method'. For a complete description of this methodology, see the *Report on the Men and their Sons Participatory Value Chain Workshop* by Laurie Bonney, Barbara Chambers and Gomathy Palaniappan, 20 – 21 September 2012. The next set of workshop to identify value chain training needs and subsequent training was conducted with Tapini men and youth in March 2013. A training programme was planned for men from Rigo-Koiari and Tapini to meet the training needs identified earlier in the workshops presented in Table 1.

Table 1 . Training priorities of workshop participants separated by age into 'younger' and 'older' groups, by village

Older men from:	*Bautama*	*Rigo-Koiari & Sogeri*	*Tapini*
	Soil preparation (1)	Soil preparation (1)	B3 Transport (1)
	Bookkeeping (2)	Bookkeeping (2)	B2 Book keeping (2)
	Transport (3)	Transport (3)	H4 Crop Management (3)

	Crop management (4)	Crop management (4)	B1 Banking (4)
			H1 Soil Preparation (5)
			H3 Irrigation (6)
			M2 Packaging (7)
Younger men:	*Majority of participants were from Bautama*		*Tapini*
	Banking (1)		B3 Transport (1)
	Crop management (2)		H4 Crop Management (2)
	Bookkeeping (3)		H3 Irrigation (3)
	Transport (4)		M3 Marketing (4)
	Soil preparation (5)		M2 Packaging (5)
	Planting (6)		H1 Soil Preparation (6)

At this point, it was decided timely and necessary to monitor and evaluate the final men's training program.

There were 28 male participants from Rigo/Koiari especially farmers affiliated to the Rigo/Koiar Cooperative Association, Sogeri and Goilala registered to start the first week (August 05 – 09) of training.

4. To monitor and evaluate the training of Rigo-Koiari and Tapini Men

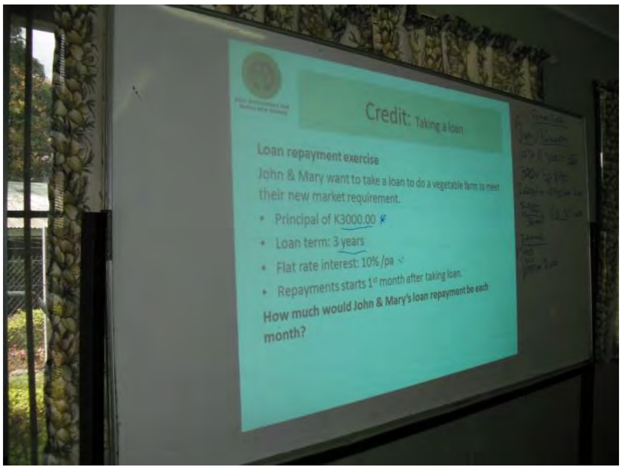
It was decided to undertake a monitoring and evaluation role of the Rigo-Koiari and Tapini men's Training by modifying an *Expert Observer Rating Tool* (see Appendix 1). There were four modules in the areas of basic financial literacy, crop management, post-harvest and marketing. With regard to the process of monitoring and evaluation, the permission of trainers was asked for and given.

2.1 Module 1- Business and Financial Literacy (August 5): The module was an all-day session covering financial literacy, practical activities and cash flow.

The first session was on income and expenditure, record keeping and household cash flow. At the outset, a pre-test was given that was clear and unambiguous (Appendix 2). A power-point presentation was given as an overview of the module and print materials handed out on income and expenditure. There was a variety of activities from whole group instruction to small group and paired work, with individuals able to ask and respond to questions of the facilitator.

Mode of delivery:

Lecture Mode*:* The trainer prepared and delivered the content well. The trainer must take into account the literacy level of participants to engage them while using power points as they got disengaged when introduced to new terms. It might have helped if the trainer handed in printed material in native language so that the participants could learn better. The trainer encouraged participants to raise questions and encouraged active learning rather passive learning.



Financial training delivered through power point presentation

Activity: Problem solving and Purposeful talk to examine and evaluate issues

Whole Group method:

After giving an overview of the training, an exercise to understand where the income was coming from, where it was spent and distinguish between needs and wants was completed on the power-point. The discussion was made in a large group with men from Rigo-Koiari and Tapini without enough time for acquaintance. It might have helped if the trainer had planned the activity for small village based group discussions. However some participants were out spoken and mentioned beer and gamble as wants rather than needs.

A table on House hold Income and Expense was developed as whole group activity.

Household Income and Expense

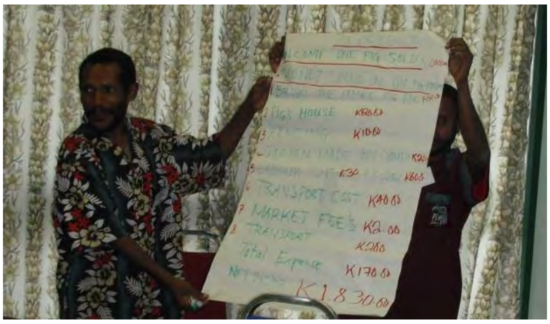
1	Pig	1	School fees - Need
2	Garden Produce	2	Bride Price - Wants
3	Betel Nut	3	Transport fare - Need
4	Fish	4	Funeral -Need
5	Coffee	5	Beer - Wants
6	Fuel	6	Gamble - Wants
7	Bride Price	7	Clothes – Need/Plenty Wants
8	Compensation	8	Food -Need
9	Work Contract	9	Production cost - Need
		10	Hospital - Needs
		11	Social Expenses - Wants
		12	Flex cards – Need/Wants

Village based small group method:

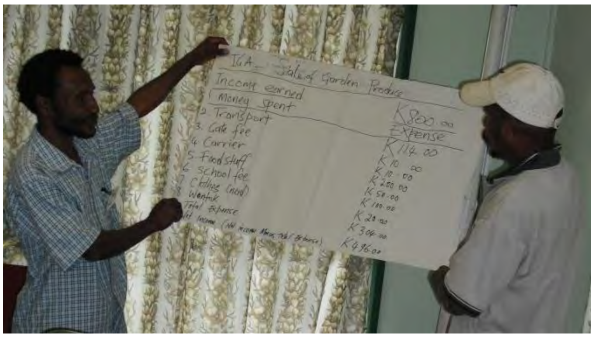
Exercise 1: Small village based groups from Rigo, Tapini, Hiri, Sogeri were given exercises on Income Generation Activity. Participants were asked to choose a farm activity that they thought was remunerative to them. Each group worked on writing cash flow for an income giving activity.

During Cash flow on income generating activity the Tapini group presented their case study on Pig. The Rigo group mentioned that their costs on rearing pigs are less as they let the pig feed on the bush or garden and also use family labour which was different to Tapini group where they have to buy pig feed as not enough feed was available on land (bush). The trainer gave little opportunity for learning between small village based groups.

Rigo Cash flow on Income Generating activity on Watermelon



Tapini Cash flow on Income Generating activity on Pig



Sogeri Cash flow on Income Generating activity from Garden

Exercise 2: Small village based groups from Rigo, Tapini, Hiri, Sogeri were given exercises on Savings. Participants were asked to explain the purpose of savings. All groups mentioned that the purpose of saving was to manage unexpected income, unexpected disaster, school fees, security, and emergency situation. The informal methods to save money mentioned were house, and wontok and the risk involved in this method was stealing, fire and insecurity. The formal methods of saving money are bank and the benefit is the interest that can be gained by saving money. The risks involved in the formal method of saving money in the bank are no interest, deductions on administration and money withdrawals from the bank.

Participants experience real life situation:

At this stage the Bank of South Pacific (BSP) guest speakers came in to observe the group. Bank of South Pacific (BSP) guest speakers explained different options to operate their bank accounts. Mobile Phone baking system was explained to participants. Majority of participants were hesitant to open an account before they experienced the real life situation of speaking with guest speakers from the bank. After, the experience, some participants opened their bank account. This demonstrated change in attitude after experiencing real life situation. The picture below shows president, Rigo-Koiari cooperative opening an account with BSP.

Nationwide Micro Bank guest speaker joined the group and briefed about their service to farmers and small business people. The business and financial literacy taught in the previous modes of instruction enhanced by participant's real life situation.

Awareness of Cultural Context: Awareness of Cultural Context is an important trainer attribute. The trainer used communication as a tool to impact the participants' behavior and attitude towards training and the trainer. Trainer communicated in Tok Pisin and also used English where ever necessary. Participants were encouraged to use Tok Plas in their small group work and presentations. In terms of culturally appropriate learning style, there was some 'learning by doing' in order to engage participants in active learning, so that participants take responsibility in learning. Using role play or other simulation game would have enhanced the experience and broken up the reliance on text based materials. Being a woman trainer, training men participants, the trainer was respected for her experience and knowledge. The trainer on the other hand respected every participant. Overall, the facilitator was confident, posing problems and involving the group in problem solutions. Possibly paying more attention to younger, more silent participants would have enhanced engagement. The material on income and expenditure was worked through very thoroughly.

The synthesis rating on *Design, Implementation, Discipline Content and Culture and Equity* was that the session was of best practice. Reflective exercises worked well at the basic level and higher level concepts like credit and loan need to be taught using other methods like games or role plays. The session was delivered well with prior preparation of the content. The facilitators need to simplify the content according to the experience and knowledge of participants.

Module 2 - Crop Management (August 6):

The second session was on Soil Management, Crop Rotation, Fallowing, Irrigation, Manuring and Crop Protection. At the outset, a pre-test was given that was clear and unambiguous (Appendix 2). A power-point presentation was given as an overview of the module and printed manual was handed out to participants. There was a variety of activities from whole group instruction to small group and paired work, with individuals able to ask and respond to questions of the facilitator.

Mode:

Lecture: The session began with formal presentation by the trainer using a power point. The trainer prepared and delivered the content well. The trainer must take into account the experience of farmers to engage them while using power points as they got disengaged when introduced to new practices like drip irrigation and crop protection. The trainer demonstrated low cost irrigation models in the field . The trainer encouraged participants to raise questions and encouraged active learning rather passive learning.

The major instructional resources were a manual, hand out materials, outdoor resources and technology (power-point presentation). The handout/manual was very professional: there were clear objectives, scaffolding of concepts and pictures illustrating examples (Appendix).

Participants' activities were structured to include whole group, small groups, paired and individual activities

Village based small group method:

> Exercise 1: Small village based groups from Rigo, Tapini, Hiri, Sogeri were given exercises on crops grown, mulch, weeds, rotation and fallow. Participants were asked to list the crops grown and reflect on their current practices in regards to mulch, rotation and fallow. The trainer gave opportunity for learning between small village based groups.

Tapini				Hiri/Sogeri				Rigo Koiari			
Vegetables	Mulch	Rotation	Fallow	Vegetables	Mulch	Rotation	Fallow	Vegetables	Mulch	Rotation	Fallow
Kaukau	weeds	No	3-4	Peanut		KauKau-Peanut	2-3	Yam	weeds	Intercrop	2-3
Taro	Yes	No	3-4	Pakchoi			2-3	Taro	weeds	Intercrop	2-3
Banana	Yes	Yes	3-4	Pineapple			2-3	Pineapple	NA	Intercrop	2-3
Cucumber	No	No	3-4	Corn			2-3	Banana	NA	Intercrop	2-3

Pumpkin	No	-	3-4	Bean			2-3	Tapioca	Dry weeds NA	Intercrop	2-3
Corn	No	No	3-4	KauKau			2-3	KauKau	NA	Intercrop	2-3

Demonstrations:

Chillies as pesticide - The use of technology was explored by a demonstration on using pesticides and an emphasis that although natural pesticides were endorsed (tobacco leaves and chilli in water; neem seed and bark), people had to protect their bodies and avoid handling pesticides by hand. A guest speaker from NARI delivered the demonstration. There were formal presentations by the facilitator and by participants – a group activity on identifying plant pests – problem-solving activities (practical activities for men to do in their gardens) and proof and evidence activities – accounting for damage to plants e.g. virus, bacteria or fungus. The participants were actively engaged in the demonstration and they experienced hands on learning.

Biological control of pest -Training of Rigo-Koiari and Tapini men

Posters on biological control were displayed for participants at the demonstration site

Taking men into the field to demonstrate vegetable trials, drip irrigation and composting was very effective and the hands-on building of a ‘barni compos’ was appreciated by all the men and evidence that they will be able to replicate this practice back in their villages. The composite was made by the participants with the instructions from another guest speaker from NARI. The participants observed the status of composite on the last day.

Composite making by men participants

Men participants were taken on a field trip to demonstrate a low cost method for irrigation. Participants were given opportunity to observe, raise questions and to interact with the trainers.

Demonstration on Irrigation

Participants' knowledge was assessed by a pre- and post-test and questions and answers demonstrating interactive and peer group learning. In terms of awareness of cultural context, Tok Pisin and Tok Plas languages and hands-on/demonstration was used on pest and disease management and irrigation and composting. Overall, there were varied methods of engagement in learning activities, highly interactive, including a colourful and motivating power-point presentation.

The synthesis rating on *Design, Implementation, Discipline Content and Culture and Equity* was that the session was at the higher end of best practice. The interactive, change of pace and varied learning methods. The facilitator was flexible in meeting learners' needs and very cued in to participants in terms of knowledge of their area and cultural issues and preferred ways of learning. The material was very well organised, as were the demonstrations. There are therefore strong reasons for confidence in the ability of trainees to roll-out crop production and management amongst their communities. Tok Pisin or English is the preferred language to enhance networking and understanding. This program could be replicated easily with other smallholder groups in the Central Province.

Module 3 - Post Harvest Training (August 7): This was a full day module that started with a pre-test. The facilitator showed was easily recognized by participants.

Mode of delivery:

***Lecture Mode**:* The trainer prepared and delivered the content well. It might have helped if the trainer handed in printed material in native language so that the participants could learn better. The trainer encouraged participants to raise questions and encouraged active learning rather passive learning.

Whole group method:

Exercise 1: Participants were encouraged to tell their views on the differences between Super market and Wet Market.

Super Market	Wet Market
High Price	Low Price
High Quality	Grade Good and Bad and can sell
Buy in Kgs	Whereas sell in pieces

Exercise 2. Participants were encouraged to tell their views on what they practiced to attract consumers.

1. Keep produce fresh (by sprinkling water}
2. Arrange and grade visibly so consumer can see difference
3. Keep the place clean and tidy
4. Present yourself well to impress customer
5. Keep talking to to get attention
6. Good quality
7. Nominal price
8.

Physical exercises to get people moving after the previous morning's activity maintained the enthusiasm of participants. The trainer could have improved the session if they had planned for field visit to demonstrate participants on the maturity for harvest and packaging rather than pictorial presentation.

The synthesis rating on *Design, Implementation, Discipline Content and Culture and Equity* was that the module reflected best practice. A variety of instructional materials were used – print and power-point. These were very clear with pictures and simple text explaining each image. The pictures on harvesting, packaging, transport were well received. Activities were variously constructed from small group exercises to interactive group questions and answers. Tok Pisin was spoken and small group activities enabled men to use their own language.

Marketing: The marketing presentation was delivered on the next day as the posters did not arrive on time.

Module 4 - Marketing (August 8):

Several agencies involved with retail and wholesale marketing gave lively presentations. Island Breeze Ltd, the Pacific Adventist Farm Manager, who runs markets at PAU, which enables transportation of produce and Brian Bell set up a display on rural products. All of these presentations were valued by men.

The synthesis rating on *Design, Implementation, Discipline Content and Culture and Equity* was that the module was left to the guest speakers to provide insights in regards to marketing. It could be improved by interlinking the presentations by the trainer in order to address the objective of training in marketing.

The posters handed out to participants were very colourful and useful, showing crops for marketing and pointing out quality differentiations in produce for market. The facilitator did talk in Tok Pisin as well as English, used plenty of examples and encouraged the development of a marketing plan. It would have been helpful if the participants were engaged in developing a plan for marketing their produce with continuous feedback and support.

3.Conclusion

The men from Rigo/Koiari and Sogeri men have marketing opportunities but also have challenges in meeting local competitions. The elevation of Tapini and poor road conditions means that the marketing opportunity can be established by initiatives from the community. Participants were interested in garden tools and purchased from Brian Bell's dispaly . Training has improved their knowledge on crop management and business and finance literacy. During training on crop production, men were very engaged by the hands on process of building a 'barni compos' even though they did practice mulching the soil and said they would replicate this construction when they got home. Men agreed to keep record on the cost and benefit to understand and plan for the future. They agreed that all the profit obtained during the crops season must not be spent but some amount need to be saved to re-invest in their business.

The training that met best practice standards was first, crop production; second business and book-keeping; third post-harvest and fourth, marketing. The main recommendations for improving training are:

1. Mixed methods of learning, from formal instruction to group work and practical, simulations and hands-on activities
2. More interactive dialogue through questions and answers between trainer and trainee
3. Handouts that are colourful, dominated by pictures showing best practice in business, crop production, postharvest and marketing.
4. Manuals that simply describe the training and writtin in either Tok Pisin or Tok Plas
5. All training modules although developed independently by trainers must fit in well with the main objective so that participants can have a holistic view.

4.Appendices

Appendix 1

Expert Observer Rating Tool[7]

Training Session Observation Protocol

Background Information

Observer: ______________________________

Date of Observation: ______________________

Men's or Women's Workshop: M ( ) W ( )

Duration of Observation:

__ 1 hour __ half day

__ 2 hours __ whole day

Other, please specify

____

Total Number of Attendees:

____

Name of Presenter(s) and area of expertise:

____
____
____

Section One: Context Background and Activities

This section provides a brief overview of the session being observed.

I. Session Context

In a few sentences, describe the session you observed. Include: (a) whether the observation covered a partial or complete session, (b) whether there were multiple break-out sessions, and (c) where this session fits in the project's sequence of training sessions for those in attendance.

____
____
____
____
____

[7] Adapted from Weiss, Iris, 1997 Local Systemic Change Observation Protocol and Appendix A: Sample Observation Instrument, User-Friendly Handbook for Mixed Method Evaluations, Division of Research, Evaluation and Communication, National Science Foundation, (http://www.ehr.nsf.gov/EHR/REC/pubs/NSF97-153/start.htm).

II. Session Focus

Indicate the **major intended purpose(s)** of this session, based on information provided by the project staff.

____
____
____

III. Training Session Activities
(Check all the activities— and related issues (such as resources)—you observed and describe them when relevant)

A. Indicate the major instructional resource(s) used in this training session.

___ Print materials

___ Hands-on materials

___ Outdoor resources

___ Technology/audio-visual resources

___ Other instructional resources. (Please specify.)
____

____

B. Indicate the major way(s) in which participant activities were structured.

___ As a whole group

___ As small groups

___ As pairs

___ As individuals

C. Indicate the major activities of presenters and participants in this session. (Check to indicate applicability.)

___ Formal presentations by presenter/facilitator: **(describe focus)**

____
____
____

___ Formal presentations by participants: **(describe focus)**

___ Hands-on/investigative/research/field activities: **(describe)**

___ Problem-solving activities: **(describe)**

___ Proof and evidence: **(describe)**

___ Explored technology use: **(describe focus)**

___ Assessed participants' knowledge and/or skills: **(describe approach)**

___ Interactive and/or Group or Peer Learning: **(describe method and frequency with respect to other methods of learning)**

___ Demonstrated awareness of cultural context **(describe language used – Tok Pisin, ToK Plas, English – and if culturally appropriate or preferred way of learning style was employed)**

___ Other activities: **(Please specify)**

____
____
____

D. Comments: Please provide any additional information you consider necessary to capture the activities or context of this training session. Include comments on any feature of the session that is so salient that you need to get it "on the table" right away to help explain your ratings.

____
____
____
____
____
____
____

Section Two: Ratings

In Section One of this form, you documented what occurred in the session. In this section, you are asked to use that information—as well as any other pertinent observations you may have—to rate each of a number of key indicators from 1 (not at all) to 5 (to a great extent) in four different categories by circling the appropriate response.

Please note that any one session is not likely to provide evidence for every single indicator. Therefore:

- Use 6 (Don't know) when there is not enough evidence for you to make a judgment.
- Use 7 (N/A, meaning Not Applicable) when you consider the indicator inappropriate given the purpose and context of the session.
- Similarly, there may be entire rating categories that are not applicable to a particular session.

Note that you may list any additional indicators you consider important in capturing the essence of this session and rate these as well.

Using your observations and opinions

- Use your "Ratings of Key Indicators" (Part A) to inform your "Synthesis Ratings" (Part B).
- Indicate in "Supporting Evidence for Synthesis Ratings" (Part C) what factors were most influential in determining your synthesis ratings.
- Section Two concludes with ratings of the likely impact of the training session and a capsule description of it.

I. Design

A. Ratings of Key Indicators

	Not at all				To a great extent	Don't know	N/A
1. The strategies in this session were appropriate for accomplishing the training	1	2	3	4	5	6	7

	Not at all				To a great extent	Don't know	N/A
session's purposes.							
2. The session effectively built on participants' knowledge of content, teaching, learning, and/or the need for change process	1	2	3	4	5	6	7
3. The instructional strategies and activities used in this section reflected attention to participants':							
a. Experience, preparedness, and learning styles	1	2	3	4	5	6	7
b. Access to resources	1	2	3	4	5	6	7
4. The session's design reflected careful planning and organization	1	2	3	4	5	6	7
5. The session's design encouraged a collaborative approach to learning	1	2	3	4	5	6	7
6. The session's design incorporated tasks, roles, and interactions consistent with a spirit of investigation	1	2	3	4	5	6	7
7. The session's design appropriately balanced attention paid to multiple goals	1	2	3	4	5	6	7
8. Adequate time and structure were provided for reflection	1	2	3	4	5	6	7
9. Adequate time and structure were provided for participants to share experiences and insights	1	2	3	4	5	6	7

B. Synthesis Rating

1	2	3	4	5
Session design was not at all reflective of Best Practices for practitioner development				Session design was extremely reflective of Best Practices for practitioner development

C. Supporting Evidence for Synthesis Rating

II. Implementation

A. Ratings of Key Indicators

	Not at all				To a great extent	Don't know	N/A
1. The session effectively incorporated instructional strategies appropriate for training session purposes and the needs of adult learners	1	2	3	4	5	6	7
2. The session effectively modeled questioning strategies that are likely to enhance the development of conceptual understanding (e.g., emphasis on higher-order questions, appropriate use of "wait time," identifying perceptions and misconceptions)	1	2	3	4	5	6	7
3. The pace of the session was appropriate for training session purposes and the needs of adult learners	1	2	3	4	5	6	7

4. The session modeled culturally appropriate learning styles	1	2	3	4	5	6	7
5. The presenter(s)' background, experience, and/or expertise enhanced the quality of the session	1	2	3	4	5	6	7
6. The presenter(s)' management style/strategies enhanced the quality of the session	1	2	3	4	5	6	7
7. ___Other, please specify ______________________________	1	2	3	4	5		

B. Synthesis Rating

1	2	3	4	5
Implementation of the session was not at all reflective of Best Practices for practitioner development				Implementation of the session was extremely reflective of Best Practices for practitioner development

C. Supporting Evidence for Synthesis Rating

____

____

____

III. Discipline Content (e.g. Horticulture and Agronomy, Supply Chain, Marketing, Business, etc)

A. Ratings of Key Indicators

	Not at all				To a great extent	Don't know	N/A
1. Discipline content was appropriate for purposes of the training session and participants' backgrounds	1	2	3	4	5	6	7
2. The content was sound and appropriately presented/ explored	1	2	3	4	5	6	7
3. Facilitator displayed an understanding of concepts (e.g., in his/her dialogue with participants)	1	2	3	4	5	6	7
4. Content area was portrayed by a dynamic body of knowledge continually enriched by conjecture, investigation, analysis, and proof/justification	1	2	3	4	5	6	7
5. Depth and breadth of attention to disciplinary content was appropriate for session purposes and the needs of adult learners	1	2	3	4	5	6	7
6. Appropriate connections were made to other areas other disciplines and/or to real world contexts	1	2	3	4	5	6	7
7. Degree of closure or resolution of conceptual understanding was appropriate for session purposes and the needs of adult learners	1	2	3	4	5	6	7

B. Synthesis Rating

1	2	3	4	5
Disciplinary content of the session was <u>not at all reflective</u> of Best Practices for practitioner development				Disciplinary content of the session <u>was extremely reflective</u> of Best Practices for practitioner development

C. Supporting Evidence for Synthesis Rating

IV. Culture/Equity

A. Ratings of Key Indicators

	Not at all				To a great extent	Don't know	N/A
1. Active involvement of all the participants was encouraged and valued	1	2	3	4	5	6	7
2. There was a climate of respect for participants' experiences, ideas, and contributions	1	2	3	4	5	6	7
3. Interactions reflected collaborative working relationships among participants	1	2	3	4`	5	6	7
4. Interactions reflected collaborative working relationships between facilitator(s) and participants	1	2	3	4	5	6	7
5. The presenter'(s) language and behavior clearly demonstrated sensitivity to variations in participants':							
a. Experience and/or preparedness	1	2	3	4	5	6	7
b. Access to resources	1	2	3	4	5	6	7
c. Gender, race/ethnicity, and/or culture	1	2	3	4	5	6	7

6. Opportunities were taken to recognize and challenge stereotypes and biases that became evident during the training session	1	2	3	4	5	6	7
7. Participants were intellectually engaged with important ideas relevant to the focus of the session	1	2	3	4	5	6	7
8. Faculty/Practitioner participants were encouraged to generate ideas, questions, conjectures, and propositions	1	2	3	4	5	6	7
9. Investigation and risk-taking were valued	1	2	3	4	5	6	7
10. Intellectual rigor, constructive criticism, and the challenging of ideas were valued	1	2	3	4	5	6	7
11. Other (specify) ________________	1	2	3	4	5		

[1]Use 1, "Not at all," when you have considerable evidence of insensitivity or inequitable behavior; 3, when there are no examples either way; and 5, "To a great extent," when there is considerable evidence of proactive efforts to achieve equity.

B. Synthesis Rating

1	2	3	4	5
Culture of the session <u>interferes with engagement</u> of participants as members of a learning community				Culture of the session <u>facilitates engagement</u> of participants as members of a learning community

C. Supporting Evidence for Synthesis Rating

____

____

V. Overall Ratings of the Session

While the impact of a single training session may well be limited in scope, it is important to judge whether it is helping move participants in the desired direction. For ratings in the section below, consider all available information (i.e., your previous ratings of design, implementation, content, and culture/equity; related interviews, and your knowledge of the overall training session program) as you assess the likely impact of this session. Feel free to elaborate on ratings with comments in the space provided.

Likely Impact on Participants' Capacity for Implementing Training and Capacity to Teach Others

Consider the likely impact of this session on the participants' capacity to implement training and/or teach others. Circle the response that best describes your overall assessment of the *likely effect* of this session in each of the following areas.

___ not applicable. (The session did not focus on teaching other villagers new knowledge, skills or attitudes and/or implementation strategies)

	Not at all				To a great extent	Don't know	N/A
1. Participants' ability to identify and understand important issues of horticulture	1	2	3	4	5	6	7
2. Participants' understanding of horticulture as a dynamic body of knowledge generated and enriched by investigation	1	2	3	4	5	6	7
3. Participants' understanding of how they and other villagers learn	1	2	3	4	5	6	7
4. Participants' ability to plan/implement exemplary horticultural practices	1	2	3	4	5	6	7
5. Participants' ability to implement exemplary instructional materials if teaching others	1	2	3	4	5	6	7
6. Participants' self-confidence in instruction	1	2	3	4	5	6	7

7. Pro-activeness of participants in addressing their training session needs	1	2	3	4	5	6	7
8. Professional networking among participants with regard to Horticultural practices	1	2	3	4	5	6	7

Comments (optional):

Appendix 2

Module 1: BOOK KEEPING

Unit 1.1 :	Introduction
Learning Outcome	Trainees should know what financial literacy is and appreciate the importance of money in today's world.
Training Aids	Pens, Markers, Butcher paper
Durations	30 minutes
Activities	1. Trainer explains what financial literacy is. 2. Ask a participant to tell a typical story of how they exchanged and traded goods and services (barter system) before the arrival of money. 3. Trainer then links the story to money and why money is important in today's society.
Unit 1.2 :	**Household Income and Expense Summary**
Learning Outcome	After Unit 1.2, trainees will be able to • Understand where their household income comes from and • Understand where it is spent • Distinguish between wants and needs
Training Aids	Pens, Markers, Butcher papers, workbook, calculators
Durations	1 hour

Activities	• Trainer explains what household incomes and expenses are.
	• Get the participants into groups of 5 people each and ask them to use butcher paper to list down incomes and expenses of their household.
	• Ask them to rank the income & expense by kina value with the highest as 1 and down.
	• A group's spokesperson to present to the big group and explain why a particular cost or income is the highest income or spending. Trainer to explain further to emphasise the importance and draw conclusion.
	  • Participants can then distinguish between needs & wants.
	  • Spending must be prioritised for needs first over wants.

Unit 1.3 :	Record Keeping / Book Keeping
Learning Outcome	After Unit 1.3, trainees will be able to • Know the importance of record keeping • Know the different types of records (financial and physical records) • Know how to keep records of receipts (income) and payments (expenses) (cash books) in a month NB: Link the cashbook to cash flows
Training Aids	Pens, Markers, Butcher papers, workbook, calculators
Durations	1 hour
Activities	1. Trainer explains to the trainees, the importance of record keeping 2. Get the trainees to do an exercise on cash book recording for

	payments (money going out through expenses for household) and receipts (money coming in as income for the household) in a month.
Unit 1.4 :	**Determining Project Profit and Loss**
Learning Outcome	After Unit 1.4, trainees will be able to • know and understand the formula for calculating profit or loss for an enterprise • calculate the profits of their business activities
Training Aids	Pens, Markers, Butcher papers, workbook, calculators
Durations	1 hour
Activities	1. Before the trainees do an exercise on profit and loss, the trainer should do an example on the board together with the group. 2. Trainees to identify and list all their income generating activities, enterprises that they are involved in occasionally. The trainer then asks the trainees to calculate profit for all their IGAs
Unit 1.5 :	**Household Cash Flow**
Learning Outcome	After Unit 1.5, trainees will be able to • Know what cash flow is and its importance in businesses • Develop their own cash flow budget for their household in periods that are suitable, whether, monthly, quarterly, half yearly or yearly. • Understand the cash flows within the household in the given time period.
Training Aids	Pens, Markers, Butcher papers, workbook, calculators
Durations	1 hour
Activities	1. Show an example of a household cash flow statement for John and Mary on a prepared butcher paper. 2. Ask the trainees to do their own household cash flow statement or budget for the next three months. NB: Advice the trainees that it is the net income from each of the IGAs that would be used in the household cash flow budget. The household cash flow budget excludes the expanses used for farm operations or their business operations. A more detail cash flow exercise will be covered in Module 2, preparing cash flows for loans will include total expenses and income for the farming family.

Module 2: Savings & Credits (making money work)

Unit 2.1 :	**Introduction**
Learning Outcome	• This module will show you how to MAKE MONEY WORK by saving money, using credit, repaying loans, and having money to spend when you need it. • The module will show you how to develop a BUSINESS PLAN that can be used for loan applications.

Training Aids	Pens, Markers, Butcher paper
Durations	30 minutes
Activities	Write down in your workbook (in the table below): 1. Where money comes from and what money is used for within your family household; then 2. Other places that money can come from and other ways money is used. **Discuss these questions:** 3. Are there times when you have not had enough money to pay for your needs? 4. Are there any times when you have had more money than you need? 5. What did you do with the extra money?
Unit 2.2 :	**Saving: Making your own money work for you.**
Learning Outcome	After Unit 2.2, trainees will be able to answer these four questions: • Why should we save—what are savings used for? • Where can we save? • How can we save? • How can we keep records of savings?
Training Aids	Pens, Markers, Butcher papers, workbook, calculators
Durations	1 hour
Activities	1. In your workbooks write down **three** reasons why saving would help you and your family. 2. In pairs. Discuss the reasons you have written and compare them with your partner's reasons. 3. Pick the most important reasons from your lists. Write these reasons in your trainee workbook. 4. Ask volunteer to give out the reasons of savings in class Then; 5. Ask Trainees to identify the examples of formal and informal savings. 6. Trainees then list down two advantages and two disadvantages of formal savings and two advantages and two disadvantages of informal savings. **Role play on savings** (details in note book) 7. Trainees to give advice on how best the couple can save better.
Unit 2.3 :	**Credit: Taking a Loan**
Learning Outcome	By the end of Unit 2.3, trainees will be able to: • Explain the difference between formal and informal credit. • Explain the language (words) used by formal lenders. • Calculate the repayments for a loan. *Credit is borrowed money or money we owe. We call a loan 'credit'*
Training Aids	Pens, Markers, Butcher papers, workbook, calculators
Durations	1 hour
Activities	1. Explain to the trainees the two types of credit (formal & informal). 2. Ask the trainees if they have ever taken a loan? 3. Ask the trainees to work in pairs or three people to discuss the advantages and disadvantage of formal and informal loans 4. Do an example to show the differences between the formal and informal on the board together in class.

	5. Give a glossary of the terms used in obtaining loans 6. Do loan repayment exercise in class as detailed in the training notes
Unit 2.4 :	**Savings and Credit: Where to go**
Learning Outcome	By the end of Unit 2.4, trainees will know; • How to make wise decisions on where to go to save and to borrow money.
Training Aids	Pens, Markers, Butcher papers, workbook, calculators
Durations	1 hour
Activities	1. Explain to the trainees what WAUP is? Refer to the training notes. 2. DO an exercise on making decisions on where to go? 3. The trainees should be adequately informed of the best options of obtaining loans. 4. Inform the trainees the different types of lending or financial institutions and their back ground information. NB: Prior to this unit, the trainer should do a research on the current financial institutions and their products & services to adequately inform the trainees.

Unit 2.5 :	**Credit: Is Credit the right choice?**
Learning Outcome	In this unit you will learn how to confidently decide whether taking a loan (credit) is the right choice for you and your family.
Training Aids	Pens, Markers, Butcher papers, workbook, calculators
Durations	1 hour
Activities	**Exercise** 1. Ask the trainees to think of 4 things that they could borrow money for. 2. Ask them to write them in their workbook in the space provided. 3. Discuss with trainees the types of things they might borrow money for. **Role Play on character:** John & Mary who decide to take up a loan (Detail in training notes). Ask questions as detailed in training notes to further explain to the trainees.
Unit 2.6 :	**Credit: Applying for a loan**
Learning Outcome	By the end of Unit 6, trainees will: • Know what records to keep helping you make a loan application. • Know how a cash flow is prepared from cash book records. **Some of this is revision from the Basic Record Keeping and household cash flow session.**
Training Aids	Pens, Markers, Butcher papers, workbook, calculators
Durations	1 ½ hours
Activities	1. Explain to the trainees the requirements of a loan. 2. **Role Play on Character** John who decides to take a loan from one of the financial institution. The details of the role play are in the training notes. 3. Ask the trainees what they have learnt form the role play?

	4. Explain to the trainees how they should keep records necessary for loan application. 5. Explain to the trainees how they can prepare cash flow budgets for loan applications. 6. Show an example of cash flow budgets 7. Get the trainees to prepare a cash flow budget for John & Mary based on the story in the training notes. 8. At the conclusion of the cash flow budget, ask the trainees to answer questions and discuss answers.
Unit 2.7 :	**Preparing a balance sheet : necessary for loan**
Learning Outcome	After Unit 2.7, trainees will be able to • Know their status of business; where money is obtained to start a business and where money is spent on. • Understand the terms, assets, liabilities & equity in balance sheet.
Training Aids	Pens, Markers, Butcher papers, workbook, calculators
Durations	1 hour
Activities	1. Explain what balance sheet is and its importance in business. 2. List down all assets and liabilities of the business or household. 3. Give an example of John & Mary's farm of what they own, and owe in their farm business. 4. Get the trainees to do a balance sheet for John and Mary's farm for the period ending 2012. 5. Get trainees for feedback on what they understood.
Unit 2.8 :	**The Business Plan**
Learning Outcome	By the end of Unit 2.8, trainees will know how to prepare a 'business plan' that will help them to plan a proposed new business or the development of an existing business
Training Aids	Pens, Markers, Butcher papers, workbook, calculators
Durations	2 hours
Activities	1. Explain to the trainees what business plan is. 2. Show the trainees the simple business plan format 3. Explain and go through the format with the trainees each sections of the business plan. 4. Get the trainees to develop a business idea and develop their business plan for loan applications. Give an example of the business to the trainees to follow as guide to developing their own business plan.

Appendix 3

Pre-test on business skills

Dear participant the questions below help us understand your current practice on book keeping. We request all participants to read through the questions and circle **one answer** for each question. The information will be used to for improving training modules for future participants.

11. I differentiate needs and wants. Yes/No

12. I prioritise my needs. Yes/No

13. I save my extra money. Yes/No

14. I have a business plan. Yes/No

15. I keep record of my receipts (income) and expenses (cash book). Yes/No

16. I borrow money to meet my business needs. Yes/No

17. I borrow money to meet my family needs. Yes/No

18. I borrow money to meet customary. Yes/No

19. I plan my repayment for the borrowed money. Yes/No

20. I have made profits through my business. Yes/No

Post-test on Business Skills

Dear participant the questions below help us understand your current view of book keeping. We request all participants to read through the questions and circle **one answer** for each question. The information will be used to for improving training modules for future participants.

I was taught in the training:

11. Needs are more important than wants. True/False

12. You must not prioritize needs. True/False

13. Record keeping of payments is good. True/False

14. Record keeping of receipts is not good. True/False

15. Cash flow is not important for business. True/False
16. Business plans are good for future. True/False
17. Money cannot be made to work. True/False
18. Business requires cash flow. True/False
19. Household income does not include receipts. True/False
20. Household expense includes payment. True/False

Appendix 3 Pre-and Post-Test on Farm Production

Dear participant the questions below helps us understand your current practice on farm production. We request all participants to read through the questions and circle **one answer** for each question. The information will be used to for improving training modules for future participants.

11. I look after my soil because it is a) usual practice b) good for soil c) to support plant growth d) to manage nutrients in soil e) none of the above
12. I prepare my soil with tractor before planting a) usual practice b) less labour c) removes weeds d) supports plant growth e) none of the above
13. I grow different crops in my garden a) usual practice b) to feed family c) to manage nutrients in soil d) to avoid disease spread e) none of the above
14. I cover the soil with crops or organic material a) usual practice b) to avoid soil loss c) to retain moisture in soil d) to avoid weeds e) none of the above
15. I apply purchased fertilizers during different stages of crops a) usual practice b) to support plant growth c) to increase yield d) to improve size/quality of vegetables e) none of the above
16. I apply organic manure during different stages of crops a) usual practice b) to support plant growth c) to increase yield d) to increase size of vegetables e) none of the above
17. I water the crops through canal or furrow a) usual practice b) efficient to irrigate crops c) less weed d) to increase size of vegetables e) none of the above
18. I remove unwanted crops growing with my main crop a) usual practice b) main crops can grow better c) unwanted crops compete for nutrients d) to increase yield e) none of the above
19. I manage insects in my garden through methods like biological, chemical or cultural a) usual practice b) protect crops c) to reduce insect damage d) to increase yield e) none of the above
20. I manage disease infestation in my garden through methods like physical, chemical or cultural a) usual practice b) protect crops c) to reduce damage d) to increase yield e) none of the above

Appendix 4 Pre- and Post-Test on Post-Harvest Practices

Dear participant the questions below help us understand your current practice on post-harvest practices. We request all participants to read through the questions and circle **one answer** for each question. The information will be used to for improving training modules for future participants.

9. I harvest my produce at the right maturity. a) usual practice b) better quality c) better price d) reduce damage e) none of the above

10. I pack produce using right package material. a) usual practice b) better quality c) better price d) reduce damage e) none of the above

11. I organize good handling and transport. a) usual practice b) better quality c) better price d) reduce damage e) none of the above

12. I select good variety crop. a) usual practice b) better quality produce c) better price d) reduce damage during transport e) none of the above

13. I manage the crop from pest and disease. a) usual practice b) better quality produce c) better price d) reduce damage during transport e) none of the above

14. I grade my produce to suit market. a) usual practice b) better quality produce c) better price d) reduce damage during transport e) none of the above

15. I have built trust with my buyers. a) usual practice b) pack only good quality c) produce available for pick up d) good price e) none of the above

16. I sell to the wet markets because it is a) usual practice b) better price c) all grades of produce can be sold d) good price e) none of the above

Appendix 6: A Temperate (Tasmanian) Broccoli Value Chain Analysis

Summary Report (Redacted for Confidentiality)

Introduction

ACIAR Project *SMCN/2008/008 Increasing Vegetable Production in Central Province, Papua New Guinea to Supply Port Moresby Markets* has a component of Objective 1, the Value Chain activity, which involves a "Value chain analyses of Australian high input, high value horticultural chains" (Objective 1.5).

This is a proposal to conduct this value chain analysis (VCA) of a new Coy A supply chain for broccoli into 24 high quality grocers in NSW.

Aims

The Project aimed to:

1. Validate the commercial partners views about what it is the consumer values (with respect to fresh broccoli);
2. Identify opportunities for the improvement the efficiency and effectiveness of the value chain;
3. Strengthen the commercial relationship between the chain partners;
4. Raise the conscious competence of primary chain partners re providing consumers with value (people development outcome);
5. Identify the benefits and costs of undertaking value chain analysis;
6. Provide comparative data and learning to inform the development of specialised locally produced high value vegetable products for the PNG market;
7. Contribute to modeling of targeted marketing suited to export development by Tasmanian/Australian vegetable chains.

Methodology

The methodology used included:

- Two consumer focus groups conducted by an independent consumer research company in Sydney;
- Face-to-face surveys conducted with 73 Coy B customers as well as consumer behavioural observations were held at the *Suburb A*, *Suburb B* and *Suburb C* stores;
- Data were collected from temperature and G-force data loggers placed in broccoli shipments for comparison with similar data collected from vegetable shipments from Tapini in Goilala District, PNG. Unfortunately, some Tasmanian data was lost when a broccoli shipment containing data loggers went astray. This will be repeated early in the 2014 broccoli season for completeness of the data set;
- Data from a value chain analysis using convergent interviews with managers and staff involved in the broccoli chain, as well as process observations and other data drawn from a recent lean process analysis project conducted by a third party specialist consulting firm.

This data were analysed using NVivo computer-aided qualitative data analysis software to generate important 'themes' relevant to the research aims. These were the basis for the Final Report to the value chain partners. Separate Consumer Research and Logistics Reports were also submitted.

It should be noted that, due to the prior in-depth, lean manufacturing analysis of the broccoli chain processes, this report focuses largely on the chain governance, relationships and communications aspects.

Findings

The findings of this research project have suggested that the main foci for the development by Coy A and Coy B should be:

1. Investing in broadening Coy A's base of capable, reliable contracted broccoli suppliers will enable the company to meet Coy B's desire for more cool climate broccoli;
2. Freight services across Bass Strait are absolutely constraining to future industry growth due to scale issues and the seasonal competition between tourist services and fresh produce; the latter being due to the higher profit yield of tourism services;
3. Leveraging the level of trust and common interest that already exists between the two companies to undertake more co-innovation and NPD of broccoli and broadening out the relationship to the supply of other high quality, 'cool climate' vegetables;
4. Significant future development of the relationship will require a change in the mindsets and culture in both companies. This will require courage and care to not disrupt core business;
5. More systematic and formalised communication and collaborative innovation has the potential to reap benefits for both parties through improving the quality, range and marketing of broccoli products;
6. Developing more closely integrated strategy, cultures and communications has the potential to facilitate the above;
7. There is potential to improve the marketing of broccoli through improving systematic consumer research, education and provenance branding;

Conclusions relevant to comparative PNG fresh produce value chains

1. Strategic alignment encompassing vision, goals, values, attitudes and behaviours is essential to effective value chain collaboration and co-innovation to solve shared problems;
2. Trustworthy behaviour to build trusting, long term relationships is the foundation of value chain development;
3. Appropriate just-in-time education and training is essential for employees/farmers involved in the chain;
4. The cool chain starts at harvest in the field as soon as possible post-harvest. Despite infrastructural differences between Australian cool chains and PNG, smallholders in PNG can reduce fresh produce losses by appropriate post-harvest handling;
5. Appropriate packaging is a critical element for the post-harvest handling of broccoli. The ubiquitous PNG white poly bag will not suffice for the transport of broccoli from Tapini. This is supported by best practice transport of broccoli from the PNG Highlands;
6. Dedicated fresh produce transport is a critical element for maintaining the high quality of broccoli.

Soil Resources in Central Province, PNG

Report to ACIAR

Richard Doyle, Leigh Sparrow and Morris Oromu

August 2015

Overview

This report details soil profile information for all the key trial sites and some of the community gardens used for ACIAR's Vegetable Production and Value Chain Research Project for Central Province PNG. Various temperate vegetable variety trials were conducted on a range of soil and altitudinal situations in the Central Province; described here as 1) Coastal Lowlands (Laloki and Rigo) 2) Sogeri Plateau (ca 500 – 600 m) and 3) Highlands (Goilala/Tapini, ca 1000m) for cultivars of tomatoes, French beans, capsicum, broccoli and cabbage. Soil profile morphological field descriptions and chemical data are provided here, as Appendices to this report, along with images of the key profiles and descriptions of the landforms and soil formation settings and processes. These data were also used to aid in the ground-truthing of the GIS mapping of Prime Agricultural Lands (Land Capability Classes 1 – 3) see Dell and Doyle (2015).

Soil horizon samples were collected from 12 Soil Profiles, typically half-a-dozen samples, and submitted to the NARI analytical laboratories in Port Moresby for full chemical and limited physical analysis e.g., particle size. Collaboration with the NARI laboratory on methods and joint presentation of data at conferences was also an outcome of the project.

Review and re-presentation of earlier soil profiles analysed by CSIRO Soil Division in the period from 1960-80s was also undertaken along with comments on the general state of the soil resources and their management issues facing Central Province (Bleeker and Healy, 1980)

Plate 1 Hill slopes on the peri-urban fringes of Port Moresby where squatter's gardens produce vegetables for sale in the local markets but put huge pressure on the soil and water resources, here generating severe sheet and rill erosion due to cultivation up and down slopes.

Coastal Lowland Soil Resources

Soils at 1) Pacific Adventist University, 2) NARI Laloki Research Station and 3) Rigo-Kwikila

Three areas of the coastal lowlands where examined in total this included two profiles on young alluvial landforms of the Laloki River, two on colluvial slopes form mafic terrains and one on a flood plain near Kwikila. Many other brief soil profile observations recording soil depth and basic soil morphology were also noted in road and stream cuttings. Our detailed profiles descriptions and analysis were restricted to areas identified as Prime Agricultural Lands and generally those being used for variety and systems trials or their neighbouring environments.

Pacific Adventist University

At Pacific Adventist University (PAU) the trial sites and gardens were located on the lower component of a gently sloping colluvial fan (see Plate 2B) and on the first terrace of a tributary stream to the Laloki River. The local hill slopes are formed from siliceous schists and phyllites (see Plate 2B and 2C). The soils on the gently sloping colluvial fans are typically dark cracking clays overlying mottled light grey clays indicating a shallow water-table in the area (see Plates 2A and 2B). These soil required lateral open drains to remove subsurface lateral flow of groundwater (see Plates 2B and C).

Plate 2 A- Soil profile from clayey colluvium, B – Trial site at PAU with soil profile exposed in drain with high water table, C – Local site showing the colluvial fan and surrounding steeper hills of schist and phyllite.

The PAU trial site (ACIAR Soil Profile 1) has moderate agricultural suitability due to the soil reactive clays, the lower slope angles and the good soil structure which will limit the erosion potential. However, potential soil compaction and high soil stickiness are likely to be issues along with a high water table, particularly in the wet season (ca 60 cm). The soil has a neutral to alkaline pH trend with moderate exchangeable calcium levels (>8 cmol+/kg) but very high exchangeable magnesium level (>16 cmol+/kg). Indeed there was three times more exchangeable magnesium than calcium in the topsoil leading to blossom-end-rot in the tomatoes during our trials. Exchange potassium status is moderate (0.31 cmol+/kg) in the topsoils but declines sharply below. There is a moderate topsoil carbon (3.74%) level but only low to moderate total N levels (0.23%). These both decline rapidly with depth. We measured very high available manganese (DTPA) in the topsoil (28 mg/kg).

Other soils of the PAU property include extensive areas of alluvial soils formed on the floodplain of the Laloki River and the main commercial farm gardens are on this soil type. These soils are silty clays with uniform profiles and are moderately fertility but prone to compaction, shallow water tables and formation of plough pans (ACIAR Soil Profile 2, Plate 3). Overall the land use potential of the PAU property is in the moderate class. Potential land use limitations include flooding, compaction and soil organic matter decline and associated nitrogen depletion. We noted a saturated soil surface and indications of subsoil compaction in several profiles while the water table was as shallow at 85 cm in another pit.

The pH is relatively uniform with depth and ranges only 6.8 – 6.9 and this is due to high nutrient cation status with exchangeable Ca ranging from 16 – 24 cmol+/kg, exchangeable Mg also high at 5 – 10 and exchangeable K also high at 0.5 – 0.3 cmol+/kg in the upper 50 cm.

Plate 3 Pacific Adventist University Farm and fertile alluvial soil (ACIAR Soil Profile 2) developed in fine-textured over-bank deposits, water table at 1 m. These soils are heavily cropped, irrigated and fertilised to produce a wide range of fruits and vegetables for sale in the PAU market. They have suffered SOM and N decline due to regular cultivation.

Plate 4 Japhet Nivi at the second of the Pacific Adventist University field trial sites, note possible Mn toxicity in the bean leave in right-hand photograph although soil available Mn was only 10 – 15 mg/kg in this soil type.

NARI's Laloki Research Station

The NARI lowland trial site is located on the lowest terrace of the Laloki River at the NARI Lowland Research Station near Port Moresby (see Plate 5A). The soil profile is derived from fine-textured alluvium and would be highly susceptible to regular inundation from the adjacent streams. The soil also appears to be very susceptible to compaction with the zone 20 – 40 cm appearing very compact and duller in soil colour in the pit face, suggesting water perching (see Plate 5B). The silty clay textures in several horizons mean the soil has very high plasticity making soil smearing and compaction an issue if cultivated when at or above field capacity. The existing compaction is most probably due to excessive cultivation and declining soil organic carbon levels. These were $\leq$1.4 % in the near surface horizons. NARI soil test data indicate the soil pH is favourable at 5.9 – 6.1 in the upper profile with very good exchangeable calcium (14 – 20 cmol+/kg) magnesium (5 – 6 cmol+/kg) and potassium (0.4 cmol+/kg) levels and moderate CEC 24 – 30 cmol+/kg. High Olsen P (due to fertilisation) but low total N and high DTPA extractable Mn are features of this profile.

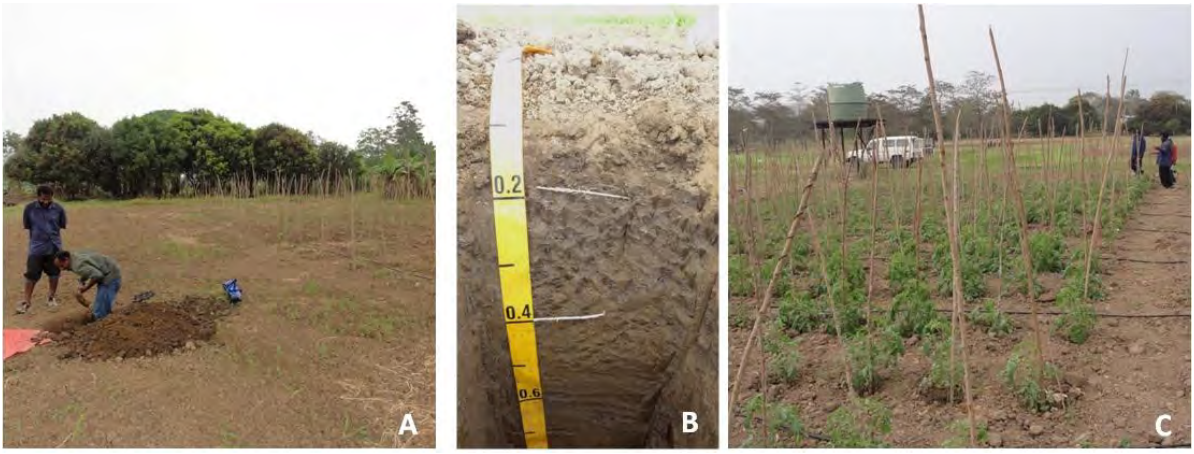


Plate 5 A – NARI Laloki alluvial soil pit location and trail site with stream channel marked by tree line, B – Alluvial soil profile (ACIAR Soil Profile 3) formed from silty light clays of alluvial origin, note distinct compaction zone at 20 – 40 cm a key land use issue on this soil type, C – Trial showing pressure based micro-drip irrigation set-up with water tank and tower in background. Note this system is being trailed at a smaller scale by NARI for small holder adoption.

Soil Resources at Rigo – Kwikila District

Two gardens were visited in the Rigo district and auger soil profile descriptions were undertaken. Both where dark reactive clay soils (Vertosols) from mafic to mixed parent materials, one colluvial (Plate 6) the other alluvial in nature (Plate 7). At the colluvial site there were issues with rill soil erosion occurring due to long cultivated slopes and moderate slope angles, while at the alluvial site soil compaction and inundation are both potential hazards (Plate 6). These issues were discussed with the small holders and the district cooperative manager.

Vertosols are heavy clayey soils with cracking and self-mulching properties. The reactivity of their clays leads to high plasticity and stickiness and proneness to smearing and compaction. When dry water entry is rapid via open cracks but swelling associated with wetness greatly reduces drainage in the wet season and run-off and erosion can result (Plate 6).

The both Rigo Vertosols examined have slightly acidic topsoils pH values (range 6.6 – 6.3) and neutral to slightly alkaline subsoils (6.6 – 7.3). They also have very high calcium (14 – 34 cmol+/kg) and extremely high magnesium levels (16 - 23 cmol+/kg). Exchangeable K is also high being >0.5

cmol+/kg in topsoils. The reactive clays also means these soils have very high cation exchange capacities which are all greater than 42 cmol+/kg. Soil organic carbon is moderate at 2.9 – 3.7% in the topsoils but decreases sharply with depth. However total nitrogen is low at ~0.2% in the topsoils resulting in high C/N ratios and reflecting a resistance nature of the soil organic matter. Unfortunately Olsen P values are also on the lower side at <9 mg/kg meaning N and P will be the primary limiting nutrients in these soil types with most other nutrients in the moderate to high range. However the low Ca/Mg ratio may hinder uptake of both Ca and K, a regular feature of these reactive clay soils.

Plate 6 Vertosols at Rigo 1 (ACIAR Soil Profile 4) formed from mafic colluvium on gentle slope, unfortunately the tillage up and down the slope and the considerable length of the beds has led to minor rill erosion shown in right-hand photograph.

Plate 7 Vertosols at Rigo 2 (ACIAR Soil Profile 5) formed from mixed alluvium on a floodplain. Note very coarse mouldboard ploughed field, sample taken on the side of this field.

Soils of the lower Highlands (Sogeri Plateau)

The Sogeri plateau is highly incised elevated region of andesitic - basaltic pebbly to boulder agglomerate, called the Astrolabe Formation (Cumming, 1969). The dominant soil type are Red Ferrosols, but Red – Brown Dermosols also occur. These iron oxide dominated clayey soils (Ferrosols) are known to fix phosphorus and exhibit low subsoil pH values which also cause aluminium and potentially manganese toxicity. However the soils are relatively deep and well structured. Gardens are often on steep to very steep slopes nestled amongst forested remnants (Plate 8). However despite cut-off drains and in-field drains soil erosion was noted in several ginger fields (Plate 9).

Plate 8 Gardens on steep slopes at Sogeri.

During the project two trial sites where used. The first trial site was located at lower elevation, approximately 450 m adjacent to the Sogeri High School (but unfortunately suffered vandalism) on a gently undulating foot slope colluvium which mantels the lower river terrace of the Browns River. The soil was reddish brown in colour and well-structured but with common manganese segregations all of which suggest formation from mafic dominated parent materials like basalts and associated volcaniclastic materials.

Plate 9 Red Ferrosols soils on basaltic conglomerates (left) and ginger planting on steep slopes at Upper Sorgeri (centre) and erosion on the side of this ginger garden (right).

The high iron oxide content commonly causes high soil phosphorus fixation. This is supported by the very low Olsen P values (8.4 mg/kg) in the topsoil of ACIAR SP6 (at Lower Sogeri) and ranging only 3.5 – 2.9 mg/kg Olsen P on the NARI trial site which also had lower pH (5.1 – 4.9) than the fully analysed profile (to side of trial plots). Otherwise the soil has good organic carbon (2.95 - 3.76 %), moderate total nitrogen (0.28%) and moderate cation exchange capacity (14 - 20 cmol(+)/kg). The base cations levels were also at good levels, with calcium and magnesium each ranging approx. 5 – 9 cmol+/kg, while potassium also at good levels in the topsoil (>0.5 cmol+/kg) and to 35 cm depth (>02. cmol+/kg). Moderate DPTA extractable Mn (20 mg/kg) was measured in the lower topsoil.

Plate 10 A – Sogeri Plateau soil pit location and trail site (behind), B – Soil profile formed from mafic material, probably alluvium C – Trial site behind pit, cultivated but not planted.

NARI ran trials at Vasikila Upper Sogeri with bean and capsicum variety trials where the soil was initially treated with lime and animal manures and this appears to have improved crop growth, although Mn toxicity may have been an issue in the French beans.

Plate 11 Left - Soil profile ACIAR SP 7 at Vasikila and Right - the NARI Systems Trials in preparation.

The soil profile at the base of the Vasikila Systems Trial (ACIAR SP7) exhibited strong structure in a light clay textured and otherwise uniform reddish brown soil profile. The soil pH while moderately acidic in the topsoil (5.3 – 4.5 in upper 16 cm) was extremely acidic below this (<4.1 below 16 cm). The exchangeable cations were dominated by calcium (7.3 cmol+/kg) in topsoil but this declines rapidly to be only 0.7 cmol+/kg below 60 cm. Exchangeable Mg was 2.1 cmol+/kg in the topsoil but dropped off sharply below while exchangeable K decreased from only 0.25 cmol+/kg in the topsoil to <0.05 below only 16 cm. Total organic carbon levels were very good at 4.14% in the topsoil decreasing slightly to 3.62% at 8 – 16 cm and then progressively decreasing with depth. Total N was moderate at 0.32% in the upper 8 cm and declining to 0.25% at 8 – 16 cm and declining rapidly with depth. Thus the key nutritional issues for this soil are it low pH, especially in the subsoil and the low available P levels (<4 Olsen P) and their fixation. There was significant exchangeable Al in the subsoils being >0.52 cmol+/kg below 16 cm which will limit root growth.

A rope and washer irrigation system was set-up on site to demonstrate their operation to the local small-holders and to irrigate the systems trials. The system lifts water from a dam about 4 m in height into the storage tank from which it is then gravity fed to micro-irrigation set-up on systems trials in addition to 44 gallon drums for hand watering of cultivar trials.


Plate 12 View of the NARI micro-irrigation system with rope and washer pulley-pump system, storage tanks and irrigation pipes and dripper pipes at the field trial site at Vasikila Upper Sogeri.

Highland Soils (Goilala)

The soils in the Tapini region of the Goilala District ranged from very deep, multilayered, colluvial soils to isolated areas of shallower rocky soils on spurs and steeper slopes. The topography is dominated by steep to very steep sloping valley sides with deeply incised rivers and streams (see Plate 13). The landscape reflects powerful streams, which are bouldery, high rates of uplift and an intensive tropical weathering environment (Plate 13 and 14). In the Tapini area there is an abundance of slope deposits and colluvial soils ranging from silty clays to gravelly sandy loams making the soils and regolith far thicker that might have been anticipated (Plate 15).

The Owen Stanley Metamorphic Complex, which underlies the area, is comprised of a thick sequence of fine-grained marine sediments. Rock types include slate and phyllite of pelitic (clayey), psammitic (sandy) and lesser volcanic origin, as well as marble, conglomerate and spilite; metamorphic quartz veins are also common (Pieters, 1978; Pigram and Davies, 1987). Soil parent rocks include dominantly dark shales, greywacke and mafic/dark phyllites with minor calcareous sandstone, minor limestone and basalt. This provides a mixed mineralogy of mafic, siliceous and calcareous parent materials for soil formation. The soil depth was generally much greater than might have been expected based on the steepness of the terrain and the rainfall (see Plate 15). However the high rate of weathering, the fractured nature of much of the bedrock materials and the dense forest cover appear to be providing a sufficiently quasi-stable environment to result in many quite deep and multilayered colluvial soils (see Plate 15).

Plate 13 View of local gardens on steep slopes in the Goilala District. Left shows new areas are being prepared for planting (8^{o} 21′ 57″ S and 146^{o} 58′ 37″ E, 1250 m ASL). Right shows local traditional "slash and burn" gardens on very steep slopes. New areas are being prepared for planting in September-October. Note use of cleared logs lain across the slope to reduce soil erosion.

Gardens included crops such as bananas, taro, kau-kau, cabbages, pawpaw, peanuts, corn, guava, mango and breadfruits and others. Pig and chicken raising also seemed common. However despite the broad range of garden foods child malnutrition seemed to be prevenient in several local villages as indicated by children with distended belly's which are typical of high carbohydrate and low protein diet, however most adults looked moderately healthy.

Plate 14 A - Steep terrain on the road up to Tapini village in the Goilala District; B - Deeply incised streams on route to Tapini, C - Tapini village, airfield and trial site (indicated by circle)

Soil conservation measures noted in many gardens to involve the use of tree trunks across the steep slopes to hinder water flow and trap soil and thus reduce sheet and rill erosion (Plates 13 and 15). Other erosion mitigating tactics included water cut-off drains placed above the gardens and internal drains/furrows running directly downslope within the gardens.

Plate 15 Deep colluvial soils are common on the hillsides on the road to Tapini (A), food gardens are created by slash and burn on deep colluvial soils (B), deep colluvial soils at Tapini village

Soil Types in the Tapini Area

Soil profile description ACIAR SP8 was undertaken on the trial site at the Tapini DAL station which is adjacent to the airfield on a relatively flattish site (see Plate 17B). The soil is developed in mixed pebbly fine-textured colluvium derived from mixed fine-grained sedimentary and mafic igneous sources. The soil profile texture is dominated by silty clay loams and silty clays. The strong yellowish brown hues of the subsoil suggest a mix of mafic and sedimentary shale parent rocks may be dominant at the site. The topsoil is moderately thick but with only moderate amounts of soil organic matter (2.2 – 2.3% to 20 cm) and low levels of total nitrogen (ca 0.2%).

Plate 16 Typical gravelly colluvium derived soil on the Tapini airstrip. Right shows NARI/FPDA field trial site at Tapini with cabbages and lettuce rows visible.

The land suitability maps produced using PNGRIS (Dell and Doyle 2015) showed the best agricultural land in the Tapini district occur as strips of land indicated as suitable along the wider stream valleys, however flooding and possibly unmapped occurrences of very stony and boulder soils would greatly limit the total area available for vegetable cropping. The other areas depicted include W-S-E facing ridgelines and spurs which again may have access limitations while better sites include benches and gentler foot and toe slopes. The bench like feature at Tapini itself which forms an excellent production area along with providing the local airfield (refer to Plate 14C) and may be a key reason for the location of both the mission and airfield which established Tapini as a local centre.

The colluvial soil at the Tapini DAL trial site (ACIAR SP8, Plate 17B) has good soil pH levels being 6.2 in the upper 25 cm and increasing to neutral values below this. The base saturation is also moderate (50 – 70%) indicating only moderate leaching. While there are low levels of exchangeable magnesium throughout (<1.2 cmol+/kg) the other nutrient cations are at moderate levels (Ca >8 and K >0.7 cmol+/kg) in the topsoil. This site has high levels of Olsen P (~40 mg/kg) and the high topsoil exchangeable K both reflect fertilisation histories as a government field station. Very low organic carbon (<1.7%) and total nitrogen (<0.14%) levels are reflect oxidation of soil organic matter due to a long cropping history.

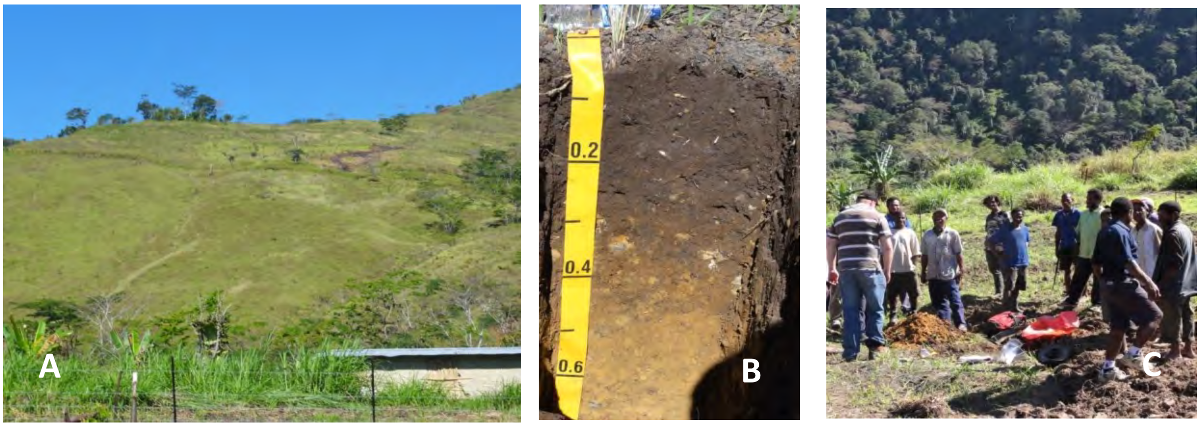


Plate 17 A – Slopes adjacent to the site showing hummocky surface indicating active mass movement, B – Soil profile at the Tapini DPI station (ACIAR SP8), note 30 cm thick topsoil, the angular stones and gravels dispersed throughout indicate a colluvial origin for the materials. C – Local agriculturists, small holders and the agricultural science teacher visiting the site, note forest cover on surrounding slopes.

Yellow brown fine-textured silty clay colluvial soils derived from shales on the surrounding slopes occur above the township adjacent to the Catholic Church (Plate 18). The soil chemical data for soil profile ACIAR SP9 indicate low soil pH levels (5.7) which decrease with depth (<4.5 below 45cm) and correlates with low base saturation levels (56 – 41% in topsoils but <35% in subsoils) and hence moderate to strong leaching. Thus aluminium toxicity, as measured at >0.5 cmol+/kg at 50 cm, may be an issue on these soils despite moderate exchangeable calcium measured at 8.2 cmol+/kg in topsoil but <3.5 in B1 – B21 horizons. Moderate exchangeable magnesium (~2 – 3 cmol+/kg) and very high exchangeable potassium levels (>1 cmol+/kg) occur in upper profile, probably form the mica in the shales. This site has low topsoil Olsen P levels (<10 mg/kg) but moderate subsoil levels (>15 mg/kg) suggesting that these soil parent materials may have some phosphorus bearing minerals. Organic carbon levels are low (~1.5) but the total nitrogen moderate (0.22%) giving a low C/N ratio. This may reflect moderate to heavy use as a catholic mission garden in the past.


Plate 18 Soil profile (ACIAR SP9) developed on deep fine-textured colluvium exposed in road cutting just above Tapini Village close to the Catholic Church. Probably derived from slates and shales of the Owen Staley Complex.

Moderately deep stony sandy clay loam soils occur above sandstone on the slopes to the southwest of Tapini. The soil chemical data for these soils (ACIAR SP10, see Plate 19 and Figure 2) indicate strongly acidic topsoils but neutral subsoils. This is matched by low base saturation in the topsoil horizons and high base saturation in the subsoil, both suggest leaching is a significant process in this environment. The lower topsoil pH mean aluminium toxicity may be an issue despite moderate exchangeable calcium levels. Both exchangeable Mg and K are low (<1 and <0.16 cmol+/kg) in this this profile. This site has moderate levels topsoil Olsen P (>15 mg/kg). Organic carbon and total nitrogen are moderate to good (>3 and 0.35%) resulting in a low-moderate C/N ratio. The high organic carbon levels than the two former Tapini soils probably reflects the recent clearance for a food gardens (see Plate 20).


Plate 19 Soil Profile ACIAR SP10 and surrounds indicate moderately deep boulder rich colluvial soil profile exposed in road cutting. Soil is derived from sandy facies of the Owen Stanley Complex. Note new garden being prepared at the site via slash and burn methods.

Very deep reactive clay soils were also noted on the higher slopes near the upper ridgeline above the Tapini village (Plate 20). The soil chemical data for soil profile ACIAR SP11 (see Figure 2 and Plate 20) indicate acidic topsoils (pH 5.3 – 5.2) and slightly acidic subsoils (pH 5.8 – 5.9). This is very unusual given the high base saturation (ca 90 – 100%) in the profile and the high exchangeable calcium (20 – 30 cmol+/kg) and magnesium (>16 cmol+/kg) levels throughout. The high CEC (>40 cmol+/kg) indicates very reactive clays which is supported by the cracking, slicken-sides and plastic clays in the profile. Exchangeable K is moderate in the topsoil (>0.5 cmol+/kg) but declines rapidly with depth. This site also has moderate levels topsoil Olsen P (ca 15 mg/kg) but this drops to less than 2.5 mg/kg in the rest of the profile. Organic carbon and total nitrogen are high (>5.5% and 0.45% in A1) resulting in a low-moderate C/N ratio.

Plate 20 Soil profile (ACIAR SP11) - Deep fine textured colluvial soil (Vertosol) exposed in road cutting. Soil probable forms from debris from the pelitic phyllites (clayey sediments) of the Owen Stanley Complex.

Soils have also developed on alluvial deposits as see near Tapini High School e.g., ACIAR SP12 (Plate 21). A broad alluvial flood plain and associated over bank deposit has formed on top of the large debris flow which underlies the village and airfield. The extent of the flood plain, its preservation and the depth of the sediment result from the partial impoundment of streams descending the local hillsides. In effect they have had their stream profiles interrupted by this large debris flow deposit lying across their natural stream path. Thus alluvium now overlies the debris flow deposit. The soil profile examined on the alluvium is 940 m above sea level and indicated significant gleying (anerobic environment) as shown by the pale grey mottled subsoils of silty clay texture (Plate 21). The absences of coarse fragments support the interpretation as over-bank type alluvial deposits.

Plate 21 Left - Soil profile (ACIAR SP12) a deep fine-textured, mottled (waterlogged) alluvial soil profile exposed in stream bank near Tapini High School. Right - Stream-channel with SP12 exposed on far right-side of airfield near high school (faint buildings in distance).

The alluvial soil (Hydrosol) is moderately acid (ranging 5.6 – 6.2 in upper 50 cm) with good exchangeable calcium levels (>8 cmol+/kg) but very low exchangeable magnesium (<0.5 in upper 50 cm) and potassium levels (<0.12 in upper 50 cm). Olsen P is also very low (<4 throughout) but the organic carbon if moderately good (2.9% in topsoil) and total nitrogen low - moderate at 0.22%. The soil has moderate to high CEC (mostly >20 cmol+/kg) and would thus respond well to additions of Mg, P and K. However it will be limited by the apparent waterlogging and potential flooding hazards.

Overall the soil chemical data indicate most of the Tapini area topsoils are acidic however soil pH typically increases with depth, ACIAR SP8 being a noted exception. The base saturation percentage, another indicator of leaching, mimics the pH tends, the clayey profile (SP10) having a very high BS percentage perhaps due to high exchangeable Mg level and reactive clay minerals. In general the soils all have moderate to high exchangeable calcium and CEC levels suggesting base rich parent materials of medium to fine textures. Exchangeable Mg is variable, very high in the clayey soils and moderate to low elsewhere while exchangeable K is high in three of the topsoils but is lower in the sandier and alluvial soil profiles. Topsoil carbon is generally 3% or less, the turf-mat at ACIAR SP11 being a noted exception and total nitrogen mimics this trend with topsoil C/N ratios typically <12. Olsen P is quite variable, high in the former DAL trial site, perhaps due to prior fertiliser applications, but otherwise low to very low in the unfertilised soil profiles though the slate/shale parent rocks may contain some natural reserves.

Soils in the Kovetapa subarea

Very deep stony to bouldery colluvial soil profiles are exposed in the road cuttings on the short track up from Tapini to Kovetapa Village (Plate 22). These soils support the notion most soils in this landscape are derived from slope deposits derived from the various facies of the Owen Stanley Complex, and range from shallow to extremely deep. At Kovetapa a large landslide has blocked the road and a large gully has developed due to the water flow diversions at 8.34498°S and 146.99749° E. The landslide occurred in 2012 and has blocked the road ever since. The soils on the route were photographed and were 3 – 5 m deep and composed of stony colluvium. The bedrock was a type of jointed greywacke with in places slicken-sides.

Plate 22 Left - deep layered colluvial soils near Kovetapa village. These soils support productive gardens and show rapid weathering, forest cover and active slopes lead to thick multi-layered soils. Centre photograph indicates a deep bouldery landslide deposit near the village – land sliding is a key and regular process in soil formation in these landscapes. Right shows these very deep but gravel colluvial soils are extremely common in the area.

Major Landslide forming Tapinin Village and Airstrip

Our studies indicate the entire Tapini village and airfield are located on a large debris flow deposit, or series of deposits, sourced from the surrounding slopes (see upper-right side of Plate 23-left). Topographic images of Tapini indicate the neighbouring hills and likely source area of the debris flow(s) as see in Plate 23-left. The Google earth topographic map below illustrates this geomorphic feature very well (see Figure 1). The flow has an elevated semi-circular rim and is approximately 100 m deep and there is a 320 m descent from the debris flow's rim to the valley floor below.

Smaller and more recent landslides, having occurred within the last few years, were reported by the neighbouring villages, e.g. Kovetapa (8.34498 ^{O} E, 146.99749^{O} E). All the soils examined on the slopes in the area form from shallow to very deep colluvial or slope deposit materials. Several profiles contained slicken-sides and lenticular soil structures which are features of reactive fine earth materials. Other tell-tale features included rumpled landscapes and diverted stream lines.

Plate 23 Left - View from the rim of the Tapini landslide, a debris flow deposit, looking toward the hilly source areas. Note the quartz boulders from the debris deposit (probably not *in situ*). Right – looking from source areas directly down and along the approximate direction of the landslide.

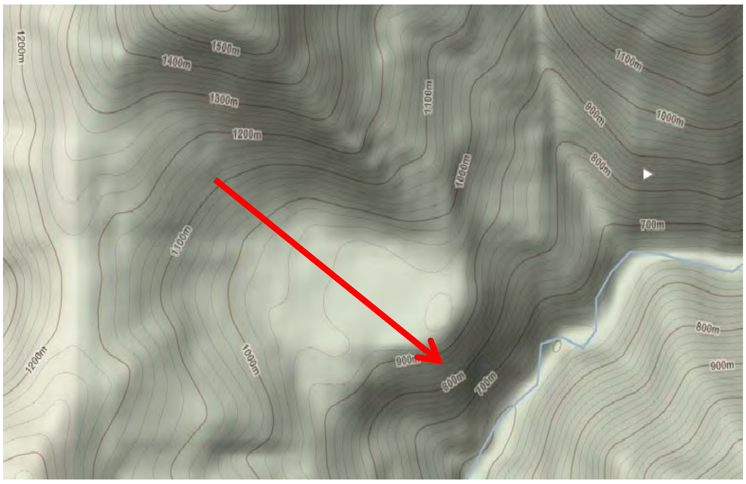


Figure 1 Google topographic image of the Tapini landslide deposit on which the village and airfield are located. Arrow marks likely path of the debris flow, flattish area in centre of image makes up the bulk of the deposit. Note the elevated rim of the deposit suggesting semifluid flow.

On the lower side slopes below the airfield (8.36036^{o} S and 146.99177^{o} E) show clear evidence of the debris flow deposit is exposed in a 20 m + thick section show distinct slip planes and stratigraphy in the debris (Plate 24).

Plate 24 Very deep layered stony colluvial/debris flow section near the hydroelectric turbine shed shows at least three deposits with clear slip-plane visible between upper two units.

Large blocks of limestone (fizzed with battery acid) with layers of calcareous sandstone noted at the base of the hill slope behind the primary school (shown in Plate 25). These blocks probably originate from a visible cliff face near the top of the mountain. Clearly they indicate a potential hazard to the school and hospital.

Plate 25 Left - Large blocks of limestone and calcareous sandstone which have fallen from exposed cliffs above (centre). Right - View down the Tapini airfield toward the rim of the landslide, note Primary School buildings on the left. High school students are cutting grass in the stream channel, the stream is piped under airfield and the alluvial soil (ACIAR SP12 was described on the right-hand-side middle-distance of photograph.

Soil Chemistry *(Note - for all graphs X-axis is soil profile depth in cm)*

All soil profile chemical data are presented in Appendix 2 including the data from the random samples taken across trial plots prior to treatments at Laloki (2 sets of data), Sogeri (upper and lower trials) and Tapini. Data for the Sogeri Systems Trials is also presented.

<u>Soil pH and cations</u>

The soil acidity was more pronounced in the highlands area, the upper Sogeri Ferrosol being the most acidic and confirming that these soil types will have limitations of both aluminium toxicity and P fixation, a fact born out in our field trials (Figure 2). The other acidic soil is the Tapini soil derived from mudstone (at the Church) and again it proved to have higher exchangeable Al levels (cmol+/kg). Small amounts of exchangeable Al also occurred in the Lower Sogeri Ferrosol and the acidic Tapini alluvial soils (Figure 2). The overall message it that pH generally increases with depth and most soils in the lowlands have only slightly acidic topsoils increasing to neutral pH values with depth indicating little need for lime. This is supported by the exchangeable Ca data with all Vertosols and the alluvial lowland soils having high exchangeable Ca values (>15 cmol+/kg) and indeed it is only the Sogrei Ferrosols and one of the Tapini soils with values <5 cmol(+)/kg, though at values still in the sufficient range (Figure 3).

These data support the idea calcium is in abundance in many of the Central Province parent materials and is only lost to leaching in high rainfall areas and particularly in more intensively weathered soils such as Ferrosols. CSIRO data from earlier PNG soil surveys support this finding (Figures 4 and 5) Their data form three basic soil groupings 1) soils with high levels of exchangeable Ca i.e., >25 cmol+/kg throughout, which are the more reactive clayey soils namely V**<u>ert</u>**isols and M**<u>oll</u>**isols (US Taxonomy), 2) an intermediate group of soils with Ca in the 5 – 15 cmol+/kg range such as the younger soils (**<u>Ent</u>**isols, Inc**<u>ept</u>**isols, but also **<u>Alf</u>**isols) and those more leached and weathered highland soils (**<u>Ox</u>**isols and **<u>Ult</u>**isols) with<5 cmol+/kg Ca in the upper profile and declining rapidly with depth.

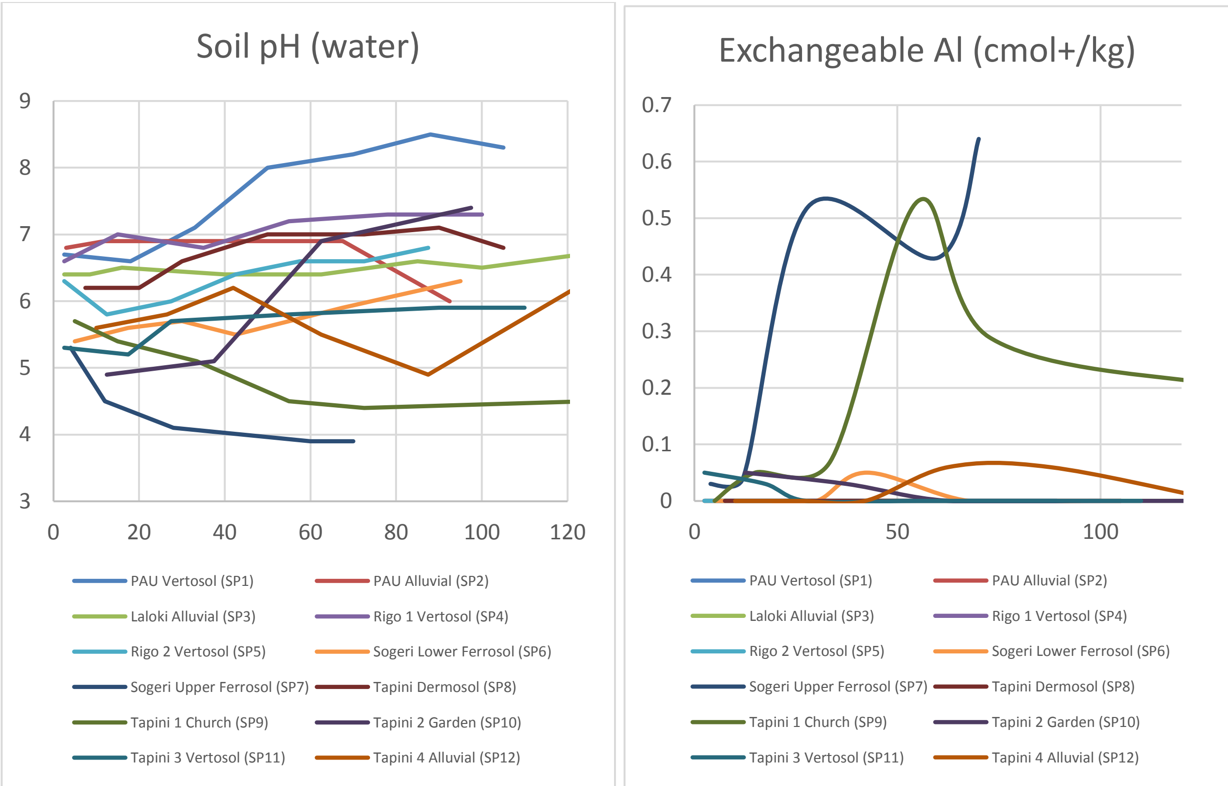


Figure 2 Soil pH in water and exchangeable Al for 12 ACIAR Soil Profiles (depth in cm on X-axis)

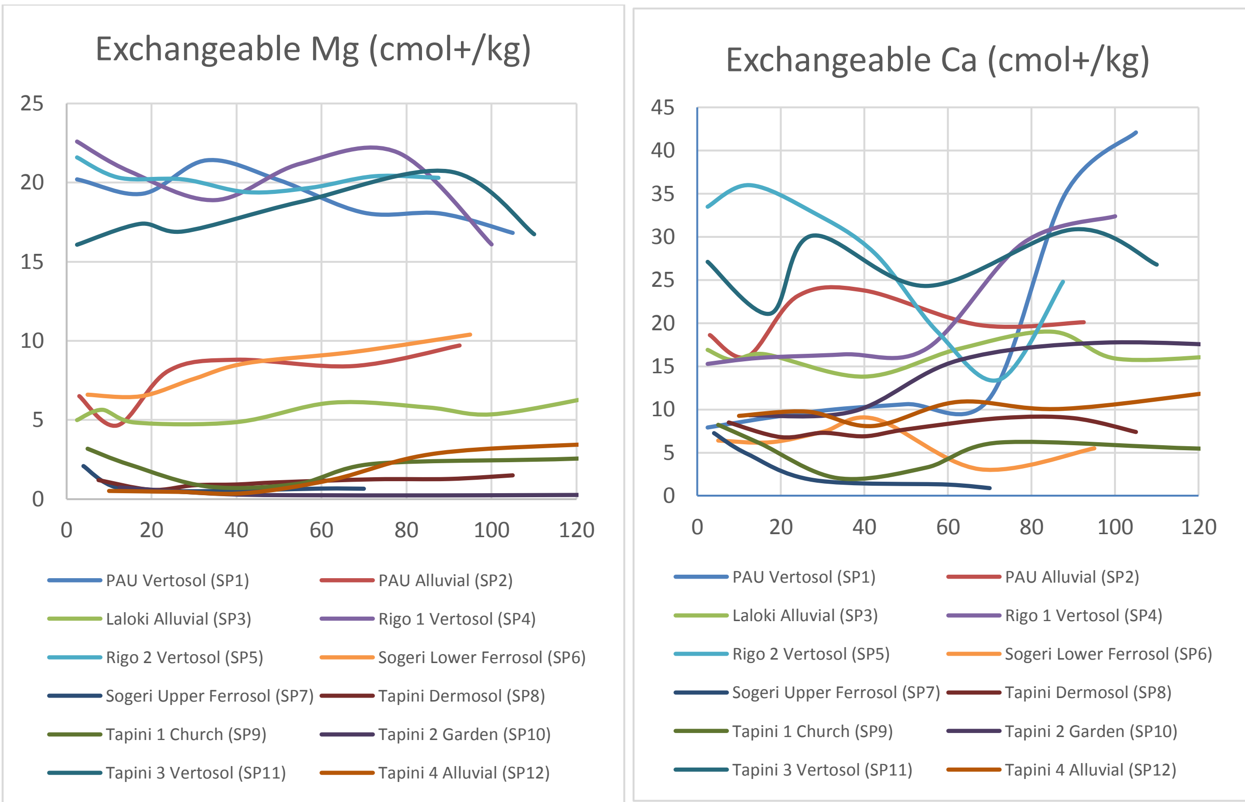


Figure 3 Exchangeable Ca and Mg data for the 12 ACIAR profiles (depth in cm on x-axis).

This clustering of soils is further supported by the CSIRO Base Saturation (%) data showing soils falling into three main clusters (Figure 5), those with 1) base saturation >80% again mainly V**ert**isols and M**oll**isols (US Taxonomy), 2) those with base saturation in a range of approximately 50 – 70%, mostly Inc**ept**isols and **Alf**isols and 3) those with <30% and declining rapidly with depth (**Ox**isols and **Ult**isols). The latter group of acidic and leached soils will be more depended on soil organic matter levels and hence regular migratory slash-and-burn agriculture than those less leached soils.

Exchangeable magnesium (cmol+/kg) is very high in all Vertosols and indeed the only Tapini soil type with much Mg was a Vertosol as all other Tapini soils are quite low in this cation (see Figure 3) while the alluvial lowland soils all have intermediate to high levels of exchangeable Mg which generally increase with depth. Several Vertosols have a very low Ca/Mg ratio (<1) and this seems to be affecting uptake of Ca, despite good levels in the soils, as shown in tomato trials by the expression of blossom-end-rot, this high Mg may also be affecting K uptake.

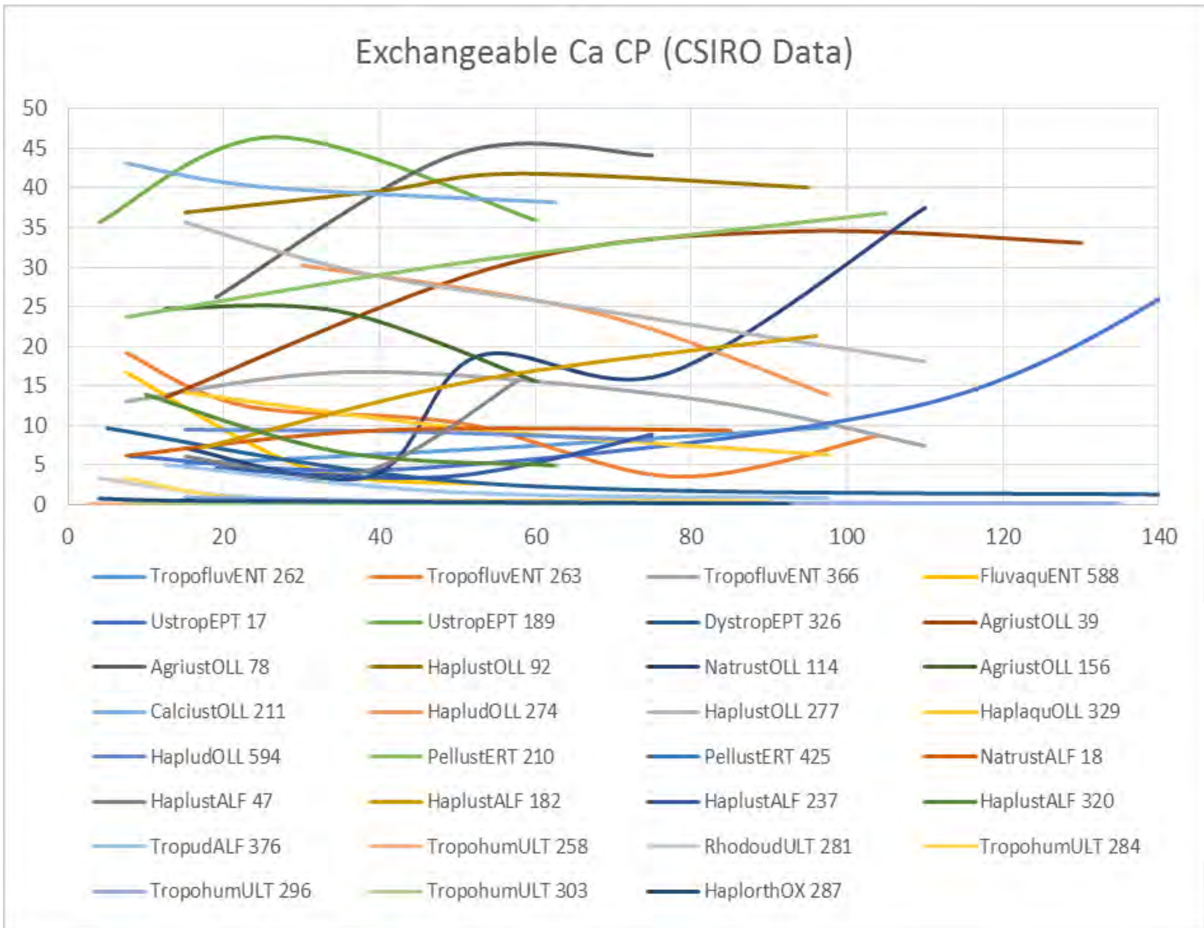


Figure 4 Exchangeable Ca data for 31 CSIRO Central Province (CP) soil profiles. We only plotted those with data for three or more soil horizons (depth in cm on X-axis).

Soil Carbon and Nitrogen

Soil organic matter and nitrogen are strongly linked showing similar declines with depth (Figure 6). Soil carbon was extremely high in the grassland turf/topsoil of the Tapini Vertosol otherwise most topsoils only have moderate levels organic carbon (3 – 4%) which tended to decrease steadily with depth and a group of heavily cropped soils at the research/farm stations all of which had quite low carbon levels (all <1.7% C) reflecting sustained use and oxidative losses of carbon and consequently nitrogen. One notable feature was that recently cleared garden topsoils had the highest total N values (all > 0.3%) namely Tapini Vertosol (burnt from former grassland), Upper Sogeri cleared for our trial and a recently cleared garden (former forest) at Tapini on sandstone. The research stations and commercial farms (PAU) again had the lowest total N values (all < 0.15%) reflecting sustained tillage and disturbance while all other soils where intermediate in N levels (~ 0.2%).

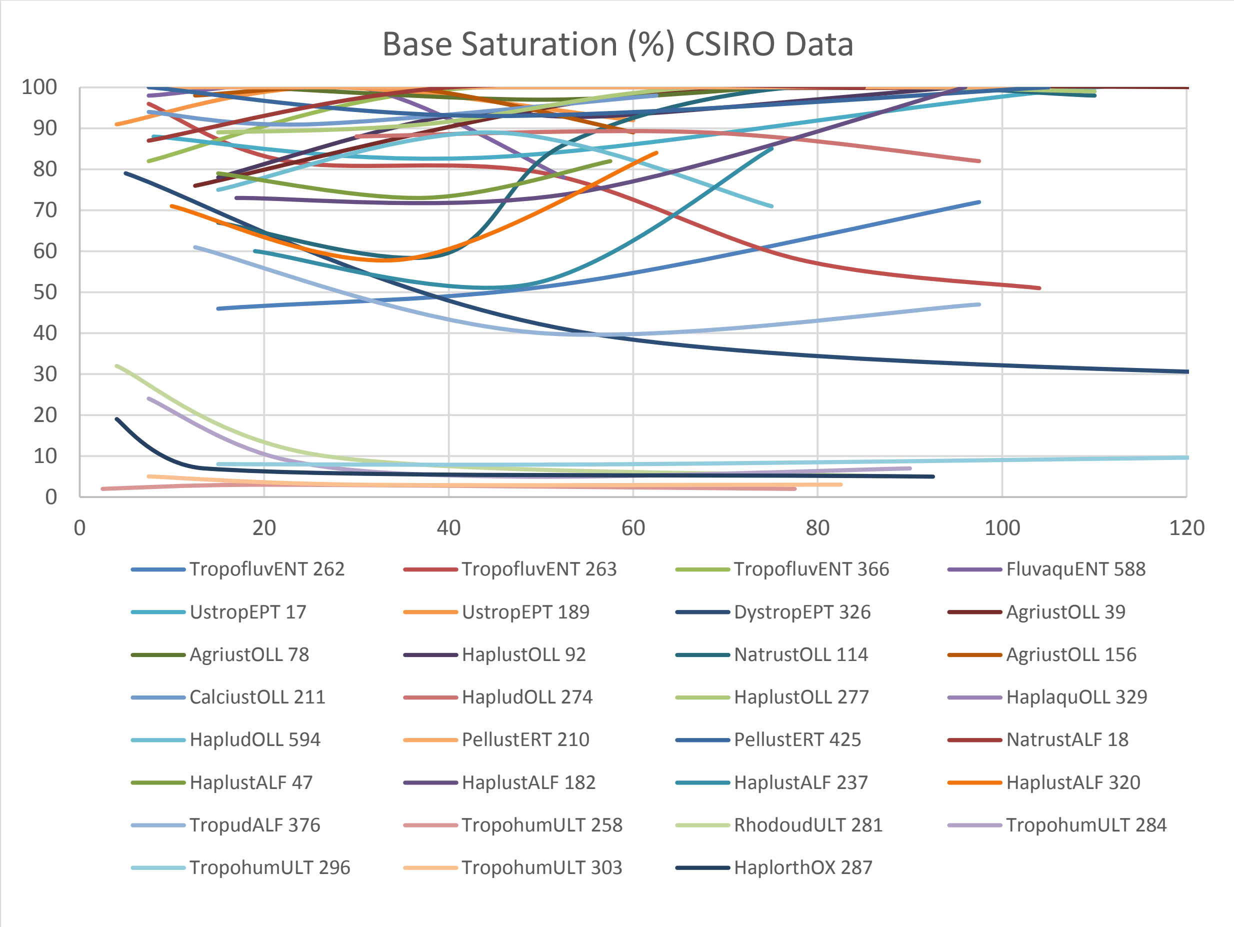


Figure 5 Base saturation data for the 31 CSIRO Central Province soil profiles with data for three or more soil horizons (depth in cm on X-axis).

Soil P and K values

The three research stations/farms have the highest Olsen P levels (>25 mg/kg in upper 20 cm) probably due to fertiliser applications for research trials and commercial crops (Figure 7). All the Vertosols and one sandstone soil in general also have good available P levels (15 – 25 mg/kg in upper 20 cm) followed by all other soils. The Ferrosols, alluvial and mudstone soils had the lowest levels of Olsen P (all <5 mg/kg).

Exchangeable potassium is in general quite high (>0.4 cmol+/kg) and decreases rapidly with depth in all soils (Figure 7). The lowest values are in the sandier soils and the acid soils (Ferrosols and alluvial soils in high rainfall areas).

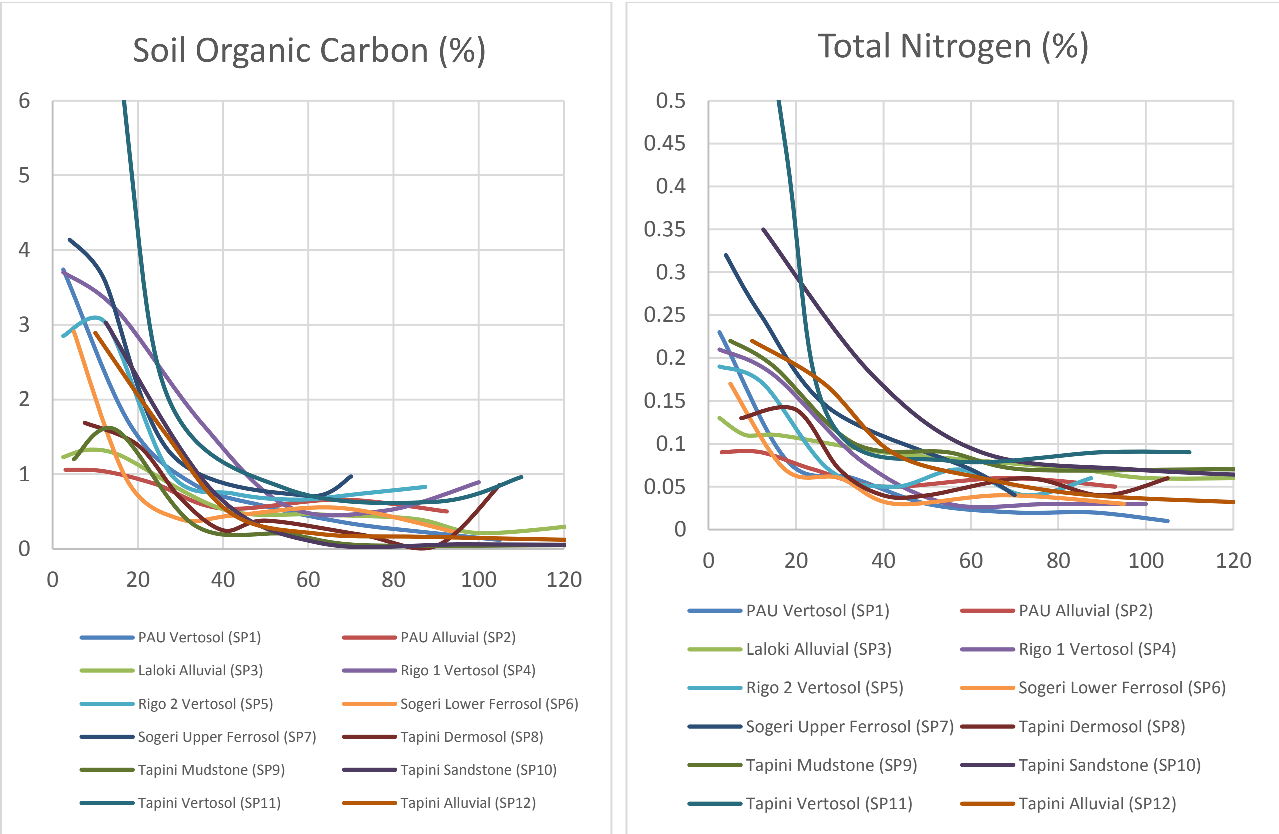


Figure 6 Soil organic carbon and nitrogen in 12 ACIAR soil profiles (depth in cm on x-axis).

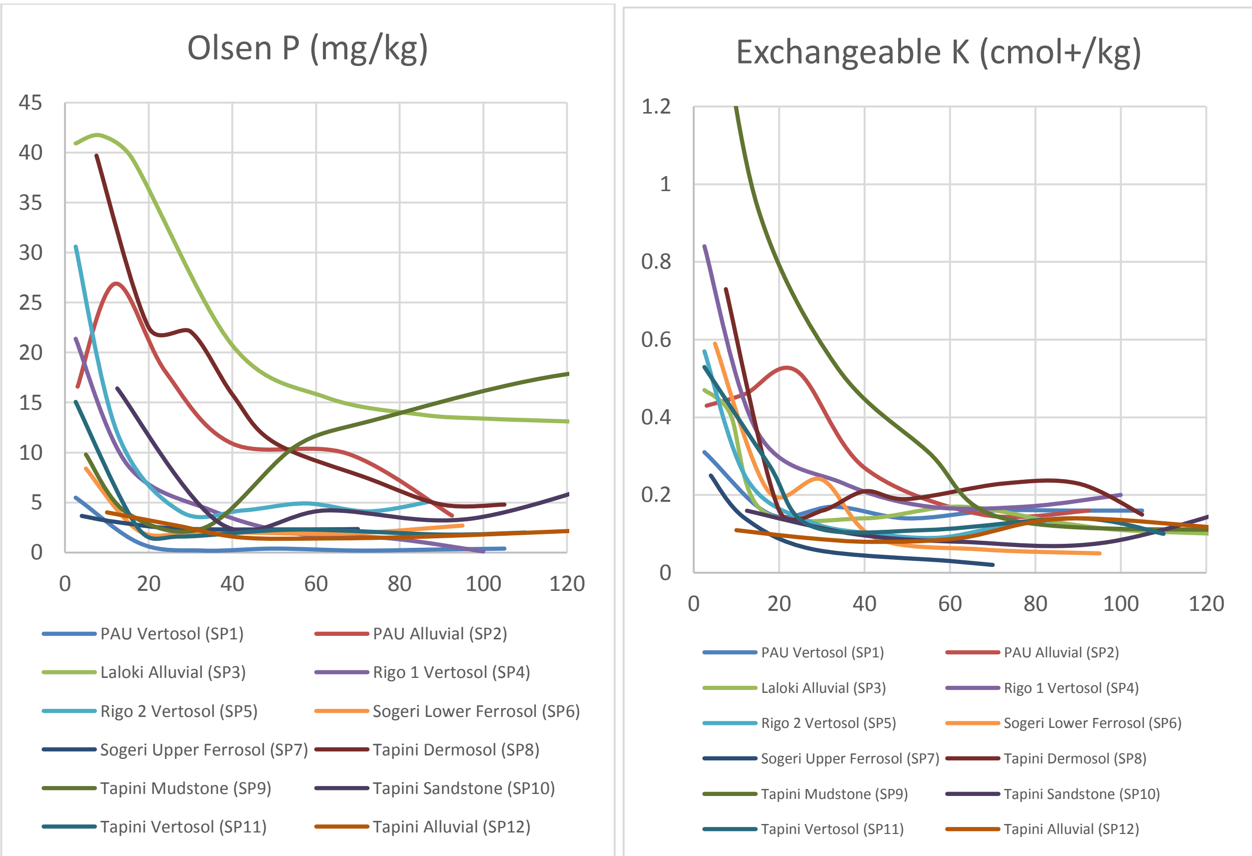


Figure 7 Olsen P and exchangeable K levels in 12 ACIAR soil profiles (depth in cm on x-axis).

Clay content and type

In general the soils studied all had reasonable clay contents, indeed all soils have at least one horizon with >30% clay (Figure 8). The clay contents tended to increase with depth and the Ferrosols and Vertosols had the highest levels of subsoil clay, in the latter being reactive clay as indicated by high CECs while the former having low reactive clays and hence lower CEC values. These differences in cation exchange capacity are very apparent in the Vertosols which all have very high CEC (>45 cmol+/kg) and the Ferrosols which show the reverse pattern (15 – 30 cmol+/kg). However overall the soil profiles studied exhibited moderate of higher capacity to retain cation nutrients and this in part explains the general moderate to high fertility and pH of the soils studied. This reflects the abundance of mafic, fine textured, mixed and also calcareous soil parent materials in the region.

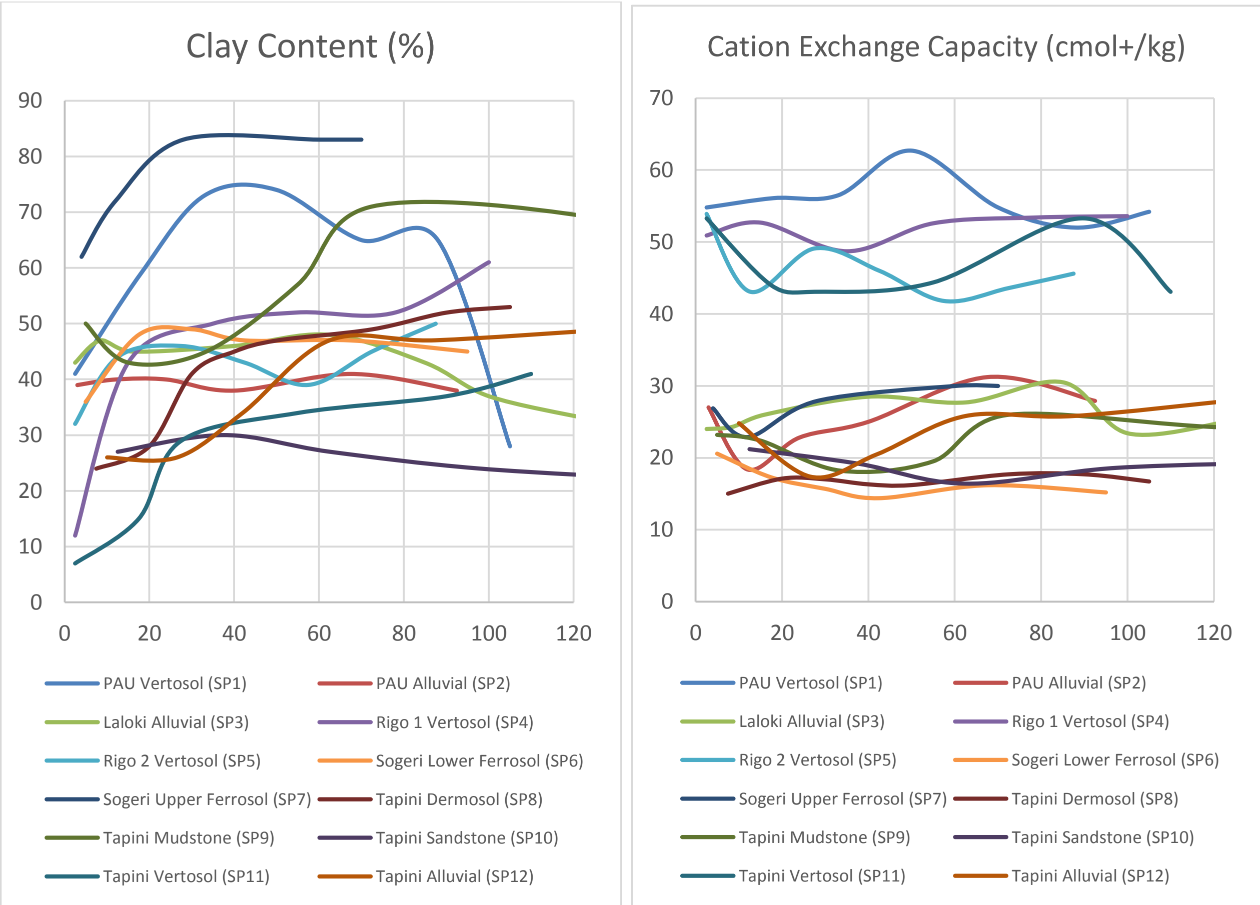


Figure 8 Clay contents and cation exchange capacity (cmol+/kg) in 12 ACIAR soil profiles (depth in cm on x-axis).

Summary

The hill soils of the Tapini area are commonly moderately deep to very deep despite the generally steep terrain and high rainfall. While there are limited areas of gently sloping to flat ground, the hill slopes, however steep, seem to present few limitations to tradition "slash and burn" agricultural gardens. Indeed logs cut during bush clearing are commonly lain across the slopes to trap soil and prevent active erosion, we also noted this in the Sogeri highlands. The range of food crops grown is very diverse and it seems the mixture of soil parent materials in the area have provided moderate natural fertility. Earlier analysis of the soils at the Tapini DPI station indicated high P status but low levels of organic carbon and hence total N.

The generally striking depth of the soils and regolith in the highlands seems to suggest a naturally higher rate of weathering and deposition of debris regolith than of erosion and transport. This suggests while the environment is characterised by steep slopes and high rainfall which favour erosion and transport this is countered by the thick forest cover, small and irregular soil disturbance by traditional gardens and the rapid weathering and hence regolith and soil formation. The weak and fractured nature of many of the parent rocks, and commonly shaly nature, no doubt also leads to rapid development of a weathered regolith mantle that can supply earthy materials to the mid and lower slopes. However, even on the few ridgelines investigated soil thickness appeared adequate for traditional gardens.

Plate 26 Martin our field assistant and Dr Leigh Sparrow on the rim of the Tapini landslide (airfield) with the Tapini river valley behind them draining toward the south coast of Papua.

In the lowlands the higher land capability soils we examined were dominated by alluvial and lower slope colluvial profiles derived from mixed mafic, calcareous and siliceous parent rocks. This led to an array of moderately deep and fertile soil types. Their key limitations being loss of carbon and nitrogen following extended cultivated use in all soils; and in the Vetolsols imbalances due to very high exchangeable magnesium levels and in the Ferrosols subsoil acidity and associated aluminium toxicity. Other soil management issues included; 1) on alluvial soils, subsoil waterlogging and associated soil compaction following tillage when wet and 2) sheet, rill and gully erosion on sloping colluvial soil types where excessive down-slope bed length, excessive slope angle especially on weakly structured soils and/or lack of soil cover (mulch/crop) on soils when exposed to intense rain storms.

GIS based mapping of Prime Agricultural Lands (PAL)

Elsewhere we report the approach taken to produce maps of arable agricultural land (PAL) using both PNGRIS and newer terrain based data sets from Radar and Shuttle sources (Dell and Doyle, 2015).

In brief various data layers on soils, geology, landforms, population, climate and inundation in PNGRIS (http://gis.mortonblacketer.com.au/upngis/research.htm, Bryan and Sherman, 2007) were used to produce mapped outputs and presented to NARI and FPDA officers for use in selecting research and development sites.

We combined several soil and landform layers to identify most suitable land for arable cropping (PAL) in the various regions under investigation. This essentially came down to utilising the PNGRIS derived soils and topographic layers and selecting the best classes in each of the mapped layers.

These 3rd Edition PNGRIS layers were;

1) Inherent Fertility
    a. Soil Field Texture – Classes "moderate to fine"
    b. Cation Exchange Capacity – Classes "moderate to high"
    c. Anion Fixation – Class "low"
2) General Fertility
    a. Available Phosphorus – Classes "moderate to high"
    b. Exchangeable Potassium – Classes "moderate to high"
    c. Base Saturation – Classes "moderate to high"
    d. Total Nitrogen – Classes "moderate to high'
3) Stoniness – Classes "not to moderately stony or rocky"
4) Soil Drainage – Classes "imperfect or better drainage class"
5) Soil depth – Class "solum >60 cm"

However, these land class rules did vary a little based on region, on the Sogeri Plateau for example we relaxed the "Anion Fixation" class.

We then combined these soil classes with areas based on lower slope classes, generally less than 20 degrees, in hindsight too steep, and W-S-E aspects using the PNGRIS topographic classes. The areas meeting all these criteria were then indicated on the satellite base for each region. The type of land and the size and distribution of the areas depicted in each map are discussed below.

In this initial land mapping of the most suitable land area the amount of land identified in each area is; Kwikila 99 sq/km, Sogeri 92 sq/km, Tapini 40 sq/km, Laloki – Browns River area 66 sq/km. These values suggest there is no shortage of suitable land in the regions, however further analysis and ground truthing is required.

The next steps in Prime Agricultural Land mapping involved use of higher resolution Radar and Space Shuttle Topographic data (30 m resolution) and these outputs are fully reported in Dell and Doyle (2015).

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APPENDICIES

Appendix 1: Soil Profile Descriptions

ACIAR PNG Soil Profile 1 – Pacific Adventist University – Grey Vertosol (Japhet Nivi Trial)

Site:	Block E, Pacific Adventist University
Lat./ Long./Elevation	9^0 24' 47.42" S, 147^0 16' 13.44" E, @ 43 m Alt.
Aust Soil Classification:	Grey Vertosol
Date/Describer	31/08/2011 / Richard Doyle UTAS and ACIAR
Description Type:	Cutting with auger boring below 60 cm
Drainage/Permeability	Imperfectly drained soil/Slowly permeable soil profile
Site Run off:	Slow rate of run-off, due to flattish site and permeable soil
Landform Element:	Very gentle (1 – 3% slope at soil pit)
Element Type:	Lower slope (broad colluvial fan)
Geomorphic Agent:	Gravity (colluvial deposition from surrounding moderate – steep slopes)
Element Type/Pattern	Foot slope, very gentle (1 – 3% slope angle - terrain within 300 m)
Pattern Relief Class/Type	Very low (9 – 30 m), Low Hills
Land Surface:	5%, sloping N
Land Disturbance:	Cultivated, rain fed
Surface/micro relief:	Self-mulching/cracking; normal gilgai; Soft when moist, but firm when dry
Soil Erosion:	No evidence of surface soil erosion, but mass movement is a feature of this landscape
Surface stone/outcrops:	Very few course gravels (20 – 60 mm), no rock outcrops
Geological setting:	Mixed substrate, not parent material. Deep colluvium derived soil
Substrate:	Silty/clay sized, amorphous, mixed rock origins. Black clay, ASC Vertosol, water table approx 3 – 5 m
Vegetation:	Kuni Grass – but adjacent to bean and tomato trial

A11	0 – 10 cm	Black (10YR 2/1); medium clay; dry; strongly developed very fine (2 – 5 mm) polyhedral structure; plus strongly developed medium-course (20 – 50 mm) polyhedral structure; moderately sticky; moderately plastic; firm moist strength; strong dry strength; rough ped fabric; fine cracks; many fine (1 – 2 mm) roots; clear smooth boundary;
A12	10 – 25 cm	Black (10YR 2/1); medium clay; slightly moist; strongly developed fine (5 – 10 mm) polyhedral structure; plus strongly developed medium-course (20 – 50 mm) polyhedral structure; moderately sticky; moderately plastic; very firm moist strength; fine cracks; few (2 – 10%) strong rock, sub-rounded dispersed medium gravels (6 – 20 mm); common fine (1 – 2 mm) roots; clear smooth boundary;
B21g	25 – 40 cm	Dark grey (10YR 4/1); few fine (<5 mm) prominent red (2.5YR 4/8) mottles; light medium clay; moist; moderately developed fine (5 – 10 mm) angular blocky structure; plus moderately developed medium (10 – 20 mm) angular blocky structure; moderately sticky; moderately plastic; firm moist soil strength; few (<10%) faint organic humus cutans, very dark grey (10YR 3/1), lining pores/cracks; few very fine (<1 mm) roots; gradual smooth boundary;
B22g	40 – 60 cm	Greyish brown (2.5Y 5/2); few fine (<5 mm) prominent yellowish red (5YR 4/8) mottles; light medium clay; wet; weakly developed fine (5 – 10 mm)

		angular blocky structure; plus weakly developed medium (10 – 20 mm) angular blocky structure; moderately sticky; moderately plastic; firm moist soil strength; smooth ped fabric; faint slicken-sides; few fine (<2 mm) carbonate nodules; few very fine (<1 mm) roots; clear smooth boundary;
C1g	60 – 80 cm	Greyish brown (2.5Y 5/2); medium clay; wet; massive structure; moderately sticky; moderately plastic; firm moist soil strength; smooth ped fabric; faint slicken-sides; common medium (2 – 6 mm) carbonate nodules; no roots; diffuse boundary;
C2g	80 – 95 cm	Light brownish grey (2.5Y 6/2); few fine (<5 mm) distinct gleyed (10GY 5/) mottles; medium clay; wet; massive structure; moderately sticky; moderately plastic; firm moist soil strength; earthy fabric; many medium (2 – 6 mm) carbonate nodules; no roots; diffuse boundary;
C3g	95 – 115+ cm	Yellow (5Y 7/8); common fine (<5 mm) distinct (10GY 5/) mottles; medium clay; moist; massive structure; moderately sticky; moderately plastic; firm moist soil strength; earthy fabric; many medium (2 – 6 mm) carbonate nodules; no roots;

ACIAR PNG Soil Profile 2 - Pacific Adventist University – Alluvial Grey Tenosol

Site:	Farm Blocks - Pacific Adventist University
Lat./ Long.	9.40856^0 S, 147.27097^0 E
Auts. Soil Classification	Grey Dermosol (Alluvial soil)
Date/Describer	4/02/2014 / Richard Doyle UTAS and ACIAR
Description Type:	Soil Pit
Drainage/Permeability	Imperfectly drained soil/Slowly permeable soil profile
Site Run off:	Slow rate of run-off, due to flat site and moderately permeable soil
Landform Element Slope:	Level (<1%)
Element Type:	Valley Flat or Floodplain of tributary to Laloki River
Geomorphic Agent:	Overbank alluvium – water transported sediments
Element Type/Pattern	Alluvial deposits on flat floodplain
Pattern Relief Class/Type	Low (0 – 9 m)
Land Surface:	0 – 1 % slope
Land Disturbance:	Cultivated, irrigated
Soil Erosion:	No evidence of surface soil erosion
Surface stone/outcrops:	None and no rock outcrops or bedrock
Geological setting:	Deep fine overbank alluvium
Substrate:	Silty/clay sized, amorphous, mixed rock origins.
Water table:	Approx. at 1 m
Vegetation:	Paw-paw garden

A11	0 – 6 cm	Very dark greyish brown (10YR 3/2); silty light clay; moist; strongly developed very fine (20 – 50 mm) polyhedral structure parting to strongly developed medium-course (10 – 20 mm) polyhedral structure; slightly sticky; moderately plastic; firm moist strength; common fine roots; clear smooth boundary;

A12	6 – 18 cm	Silty medium clay; strongly developed very fine (20 – 50 mm) polyhedral structure parting to strongly developed medium-course (10 – 20 mm) polyhedral structure; firm to very firm moist; moderately sticky; strongly plastic;
A3	18 – 30 cm	Silty light clay; moderately developed very fine (20 – 50 mm) platy structure parting to moderately developed medium-course (10 – 20 mm) polyhedral structure; slightly sticky; moderately plastic; gradual smooth boundary;
B21g	30 – 50 cm	Dark greyish brown (2.5Y 4/2), fine sandy light clay; moderately developed 30 – 50 mm platy to lenticular structure plus strong 2 – 5 mm polyhedral structure; slightly sticky and moderately plastic; very few fine roots; gradual smooth boundary;
B22	50 – 85 cm	Light medium clay; strongly developed 10 – 20 mm polyhedral plus strongly developed 2 – 5 mm polyhedral structure ; moderately sticky; spongy and slightly subplastic; moderately plastic; gradual smooth boundary;
BC	85 – 100 cm	Water table struck at 105 cm (but rose to 90 cm in 1 h); fine sandy light clay; moderately sticky; strongly plastic; very few fine roots;

ACIAR PNG Soil Profile 3 – NARI Laloki Station Trial Site – Alluvial Grey Tenosol

Site:	NARI Trial site, Laloki
Lat./Long./Elevation	9^0 22' 21.32" S, 147^0 15' 00.88" E, 26 m elevation
Date/Describer	31/08/2011 / Richard Doyle UTAS and ACIAR
Description Type:	Soil pit to 80 cm and auger below
Drainage/Permeability	Imperfectly drained soil/Slowly permeable soil profile
Site Run off:	Slow rate of run-off, due to flat site and slowly permeable soil
Landform Element:	Level (<1% slope at soil pit)
Element Type:	Flat, alluvial plain
Geomorphic Agent:	Over bank stream
Element Type/Pattern	Level, flood plain
Pattern Relief Class/Type	Extremely Low (<9 m), alluvial plain
Land Surface:	1%, sloping S
Land Disturbance:	Cultivated, rain fed
Condition Soil Surface:	Hard setting, No micro relief
Soil Erosion:	No evidence of surface soil erosion.
Inundation:	> once per year, for 1-20 days, at 300 mm – 1 m depth
Surface stone/outcrops:	None
Geological setting:	Alluvium, unknown underlying substrate
Substrate:	Silty/clay sized, amorphous, massive, weak silt
Vegetation:	Signal grass

A11	0 – 5 cm	Dark greyish brown (10YR 4/2, moist); pale brown (10YR 6/3, dry); silty clay loam; slightly sticky; moderately plastic; dry; moderately developed medium-course (20 – 50 mm) polyhedral structure; plus moderately developed very fine (2 – 5 mm) polyhedral structure; clear irregular boundary;

A12	5 – 12 cm	Dark greyish brown (10YR 4/2, moist); pale brown (10YR 6/3, dry); silty light clay; slightly sticky; moderately plastic; slightly moist; moderately developed medium-course (20 – 50 mm) polyhedral structure; plus moderately developed very fine (2 – 5 mm) polyhedral structure; clear wavy boundary;
B11	12 – 30 cm	Very dark greyish brown (10YR 3/2, moist); silty light clay; slightly sticky; very plastic; slightly moist; moderately developed course-very course (100 – 200 mm) prismatic structure, plus massive structure; clear smooth boundary;
B12	30 – 50 cm	Brown (10YR 4/3); many medium (5 – 15 mm) faint dark grey (10YR 4/1) mottles; silty light clay; moderately sticky; very plastic; moist; strongly developed medium-course (20 – 50 mm) polyhedral structure; parting to strongly developed very fine (2 – 5 mm) angular blocky structure; gradual smooth boundary;
B21	50 – 75 cm	Dark greyish brown (10YR 4/2); common medium (5 – 15 mm) faint dark yellowish brown (10YR 4/4) mottles; silty medium clay; moderately sticky; very plastic; moist; strongly developed medium-course (20 – 50 mm) polyhedral structure; parting to strongly developed very fine (2 – 5 mm) angular blocky structure; gradual smooth boundary;
B22	75 – 95 cm	Dark greyish brown (10YR 4/2); common medium (5 – 15 mm) faint dark yellowish brown (10YR 4/4) mottles; silty light clay; moderately sticky; very plastic; moist; gradual smooth;
B31	95 – 105 cm	Dark greyish brown (10YR 4/2); silty light clay; moderately sticky; very plastic;
B32	105 – 140+ cm	Dark greyish brown (10YR 4/2); fine sandy light clay; moderately sticky; moderately plastic; gradual smooth boundary

ACIAR PNG Soil Profile 4 – Rigo 1 – Colluvial Black Vertosol

Site:	Rigo – Kwikila Cooperative (supplying vegetables to PoM) supermarkets)
Lat./Long./Elevation:	09^{o} 22.484' S, 147^{o}13.655' E, 87 m elevation
Date/Describer:	2/09/2011 / Richard Doyle UTAS and ACIAR
Description Type:	Auger
Drainage/Permeability	Moderately drained/Moderate to slow permeability
Site Run off:	Slow rate of run-off, gentle slope
Landform Element:	Gentle (3-10%)
Element Type:	Waning lower slope
Geomorphic Agent:	Colluvium
Element Type/Pattern	Footslope
Land Surface:	3.5%, sloping N
Land Disturbance:	Cultivated, irrigated
Condition Soil Surface:	Cracking
Soil Erosion:	Minor, sheet erosion
State of Erosion:	Stabilised, 5cm deep 1 cm wide
Inundation:	No inundation
Surface stone/outcrops:	None

Geological setting:	Colluvial soil, underlying clay, unknown geology
Substrate:	Silt/clay sized particles, clay substrate, ASC Vertosol
Vegetation:	Cultivated for vegetables (capsicum, tomatoes, melons, bok choi etc), adjacent hills possess *Eucalyptus sp.* and open savannah.

A11	0 – 5 cm	Black (10 YR 2/1); silty light clay; dry; strongly developed fine (5-10mm) polyhedral structure; plus strongly developed very fine (2-5mm) polyhedral structure; slightly sticky; firm moist strength; very firm dry strength; rough ped fabric; fine cracks; common fine (1-2mm) roots; abrupt boundary;
A12	5 – 25 cm	Black (10 YR 2/1); silty light medium clay; slightly moist; strongly developed fine (5-10mm) polyhedral structure; plus strongly developed medium-course (20-50mm) polyhedral structure; slightly sticky; firm moist strength; rough ped fabric; fine cracks; common fine (1-2mm) roots; diffuse boundary;
A13	25 - 45 cm	Black (10 YR 2/1); silty light medium clay; moderately developed medium (10-20mm) polyhedral structure; slightly sticky; very firm moist strength; rough ped fabric; few very fine (<1mm) roots; gradual smooth boundary;
B21	45 – 65 cm	Very dark greyish brownish (10 YR 3/2); light medium clay; moderately developed medium (10-20mm) polyhedral structure; slightly sticky; very firm moist soil strength; rough ped fabric; few fine (<2mm) carbonate nodules; few very fine (<1mm) roots; diffuse boundary;
B22	65 – 90 cm	Brownish black (2.5 Y 3/1); medium clay; massive; slightly sticky; very firm moist soil strength; earthy ped fabric; few fine (<2mm) carbonate nodules; few dispersed weak angular fine gravels (2-6mm); no roots; diffuse boundary;
B23	90 – 110 cm	Very dark grey (2.5 Y 3/1); medium clay; massive; slightly sticky; firm moist soil strength; earthy ped fabric; few fine (<2mm) carbonate nodules; few dispersed weak angular fine gravels (2-6mm); no roots;

ACIAR PNG Soil Profile 5 – Rigo 2 – Alluvial Black Vertosol

Site: Rigo – Kwikila region (cooperative supplying vegetables to PoM supermarkets)

Lat./Long./Elevation:	09° 46.609' S, 147°41.572' E, 50 m elevation
Date/Describer:	1/09/2011 / Richard Doyle UTAS and ACIAR
Description Type:	Auger
Drainage/Permeability	Imperfect - Moderately drained/Slow permeability
Site Run off:	Very slow rate of run-off
Landform Element:	Flat (0 – 2 %)
Element Type:	Overbank fine clayey alluvium
Geomorphic Agent:	Alluvium
Element Type/Pattern	Floodplain
Land Surface:	0 – 1 %, sloping N
Land Disturbance:	Cultivated grassland
Condition Soil Surface:	Cracking
Soil Erosion:	Nil

Inundation: Inundation – frequency unknown, probably every 1 – 5 years
Surface stone/outcrops: None
Geological setting: Alluvial soil, underlying clay, in river valley
Substrate: Silt/clay sized particles, clay substrate, ASC Vertosol
Vegetation: Recently cultivated grassland or open savannah of kuni grass and rushes

A11 0 – 5 cm Black (10 YR 2/1); silty light clay; dry; strongly developed fine (5-10mm) polyhedral structure; plus strongly developed very fine (2-5mm) polyhedral structure; moderately sticky; moderately plastic; weak moist strength; firm dry strength; fine cracks; many fine (1-2mm) roots; abrupt boundary;

A12 5 – 20 cm Black (10 YR 2/1); silty light medium clay; slightly moist; strongly developed fine (5-10mm) polyhedral structure; plus strongly developed medium-course (20-50mm) polyhedral structure; very sticky; weak moist strength; rough ped fabric; fine cracks; common fine (1 – 2 mm) roots; gradual boundary;

B1 20 – 35 cm Very dark grey (10 YR 3/1); silty medium clay; appears massive in auger; massive parting to moderately structured very fine granular structure (in auger = estimate); very sticky; very plastic; firm moist strength; few very fine (<1mm) roots; gradual smooth boundary;

B21 35 – 50 cm Very dark greyish brown (10 YR 3/2); silty medium clay; appears massive in auger; massive parting to moderately structured very fine granular structure (in auger = estimate); very sticky; very plastic; very firm moist strength; few very fine (<1mm) roots; gradual smooth boundary;

B22 50 – 65 cm Very dark greyish brown (2.5 Y 3/2); silty medium clay; appears massive in auger; massive parting to moderately structured very fine granular structure (in auger = estimate); very sticky; very plastic; very firm moist strength; few very fine (<1mm) roots; gradual smooth boundary;

B23 65 – 80 cm Very dark grey (2.5 Y 3/1); silty medium clay; appears massive in auger; massive parting to moderately structured very fine granular structure (in auger = estimate); very sticky; very plastic; very firm moist strength; few very fine (<1mm) roots; gradual smooth boundary;

BC 80 – 95+ cm Very dark grey (2.5 Y 3/1); silty medium clay; appears massive in auger; massive parting to moderately structured very fine granular structure (in auger = estimate); very sticky; very plastic; very firm moist strength; no roots;

ACIAR PNG Soil Profile 6 – Sogeri High School – Brown Ferrosol

Site: Sogeri High School, Sogeri, Central Province
Lat./Long./Elevation 9^0 25’ 02.15” S, 147^0 25’ 38.65” E, 470 m
Date/Describer 2/09/2011 / Richard Doyle UTAS and ACIAR
Description Type: Soil pit to 80 cm and auger below
Drainage/Permeability Moderate drainage

Site Run off:	Slow to moderate rate of run-off, due to flat site and good drainage
Landform Element:	Level (<1% slope at soil pit)
Element Type:	Flat, Terrace plain – cover of colluvium from adjacent slopes
Geomorphic Agent:	Over bank stream – plus colluvial cover (?)
Element Type/Pattern	Level – very gently sloping, Terrace plain
Pattern Relief Class/Type	Extremely Low (<9 m)
Land Surface:	1%, sloping N
Land Disturbance:	Cultivated, irrigated
Condition Soil Surface:	Cracking, Mild micro relief of normal gilgai
Soil Erosion:	No evidence of surface soil erosion.
Inundation:	> once per year, for 1-20 days, at 100 - 300mm depth
Surface stone/outcrops:	None
Geological setting:	Alluvium of mafic origin
Substrate:	Silt/clay sized particles, sandy clay substrate
Vegetation:	Grasses, *Panicum maximum* and *Digitaria bothriochloa*

A1	0 – 10 cm	Dark brown (7.5YR 3/3); light clay; slightly moist; strongly developed medium-course (20 – 50 mm) polyhedral structure; parting to strongly developed very fine (2 – 5 mm) polyhedral structure; slightly sticky; moderately plastic; firm moist strength; many fine (1 – 2 mm) roots; clear smooth boundary;
A3	10 – 25 cm	Brown (7.5YR 4/3); fine sandy light clay; moist; strongly developed medium-course (20 – 50 mm) polyhedral structure; parting to strongly developed fine (5 – 10 mm) polyhedral structure; slightly sticky; moderately plastic; firm moist strength; common (10 – 50%) distinct mangans (N 1/0); common fine (1 – 2 mm) roots; gradual smooth boundary;
B1	25 – 35 cm	Brown (7.5YR 4/4); sandy clay loam; moist; moderately developed medium – course (20 – 50 mm) polyhedral structure; parting to strongly developed very fine (2 – 5 mm) polyhedral structure; slightly sticky; moderately plastic; firm moist strength; common (10 – 50%) distinct mangan mottles (N 1/0); few very fine (<1 mm) roots; clear wavy boundary;
B21	35 - 50 cm	Strong brown (7.5YR 5/6); many medium (5 – 15 mm) faint brown (7.5YR 5/3) mottles; clay loam, sandy; moist; massive structure; parting to moderately developed medium (10 – 20 mm) angular blocky structure; slightly sticky; moderately plastic; firm moist strength; common (10 – 50%) distinct mangans (N 1/0); few very fine (<1 mm) roots; diffuse boundary;
B22	50 – 85 cm	Brown (7.5YR 5/2); many medium (5 – 15 mm) distinct strong brown (7.5YR 5/6 mottles); sandy light clay; moist; massive structure; parting to weakly developed medium (10 – 20 mm) angular blocky structure; slightly sticky; moderately plastic; firm moist strength; common (10 – 50%) prominent mangans (N 1/0); few very fine (<1 mm) roots; diffuse boundary;
B3	85 – 120 cm	Strong brown (7.5YR 5/6); common medium (5 – 15 mm) distinct brown (7.5YR 5/2) mottles; sandy light clay; moist; massive structure; slightly

sticky; moderately plastic; strength; few (<10%) distinct mangans (N 1/0); no roots; undefined lower boundary;

ACIAR Soil Profile 7 – Upper Sogeri Plateau at Vasikila – Red Ferrosol

Site location:	Upper Sogeri, 9^0 22’ 57.67” S, 147^0 26’ 45.73” E, 530 m
Date/Describer	19/09/2012 / Richard Doyle UTAS and ACIAR
Description Type:	Soil pit to 80 cm
Drainage/Permeability	Well drained
Site Run off:	Moderate rate of run-off, due good drainage
Landform Element:	Gentle slope (<10% slope at soil pit)
Element Type:	Lower slope in dissected hill country
Geomorphic Agent:	Colluvial toeslope
Element Type/Pattern	lower toeslope – 5 m from slow moving billabong
Pattern Relief Class/Type	Dissected valleys in basaltic terrain
Land Surface:	5%, sloping SE
Land Disturbance:	Cultivated, and now micro-drip irrigated
Condition Soil Surface:	Minor cracking
Soil Erosion:	Minor evidence of surface soil erosion
Inundation:	Unknown but possible for lower site
Surface stone/outcrops:	None – soils from very deeply weathered materials
Geological setting:	Colluvium of mafic origin – basaltic
Substrate:	Silt/clay sized particles, sandy clay substrate
Vegetation:	Bare – cultivated, cleared from grasses like kuni

A1	0 – 8 cm	Very dark brown (7.5YR 2.5/2 M, 7.5YR4/2 D); light clay; slightly moist; strongly developed medium (10 – 20 mm) polyhedral structure; parting to strongly developed very fine (2 – 5 mm) polyhedral structure; slightly sticky; moderately plastic; firm moist strength; many fine (1 – 2 mm) roots; few earthworms; clear smooth boundary;
A3	8 – 16 cm	Dark brown (7.5YR 3/2 M, 7.5YR 4/3 D); light clay; moist; strongly developed medium (10 – 20 mm) polyhedral structure; parting to strongly developed fine (5 – 10 mm) polyhedral structure; slightly sticky; moderately plastic; firm moist strength; common fine (1 – 2 mm) roots; few earthworms; gradual smooth boundary;
B1	16 – 40 cm	Reddish brown (5YR 4/3, 7.5YR 4/4 D); light medium clay; moist; moderately developed medium (10 – 20 mm) polyhedral structure; parting to strongly developed very fine (2 – 5 mm) polyhedral structure; slightly sticky; moderately plastic; firm moist strength; few very fine (<1 mm) roots; gradual smooth boundary;
B21	40 - 60 cm	Reddish brown (5YR 4/4, 7.5YR 5/6 D); light medium clay; moist; moderately developed medium (10 – 20 mm) polyhedral structure; parting to strongly developed very fine (2 – 5 mm) polyhedral structure; slightly sticky; moderately plastic; firm moist strength – very firm in face and to dig; very few very fine (<1 mm) roots; diffuse boundary;
B22	60 - 80 cm	Reddish brown (5YR 4/4 M, 7.5YR 5/6 D); light medium clay; moist; strongly developed very fine (2 – 5 mm) polyhedral structure; slightly sticky; moderately

plastic; firm moist strength – very firm in face and to dig; very few very fine (<1 mm) roots; diffuse boundary;

ACIAR PNG Soil Profile 8 – Tapini DPI Station – Colluvial Brown Dermosol

Site:	Adjacent to Ex-DPI Station at Tapini, adjacent to airstrip
Lat./Long./Elevation:	8^0 21' 29.75" S, 146^0 59' 24.63" E, 960 m
Date/Describer	30/08/2011 / Richard Doyle UTAS and ACIAR
Description Type:	Soil pit to 80 cm and auger below
Drainage/Permeability	Moderately well drained soil/Moderately permeable soil profile
Site Run off:	Slow rate of run-off, due to flattish site and permeable soil
Landform Element:	Very gentle (1-3% slope at soil pit)
Element Type:	Flat (broad bench in landscape – perhaps formed by limestone outcrops)
Geomorphic Agent:	Gravity (colluvial deposition from surrounding moderate – steep slopes)
Element Type/Pattern	Bench (sloping)/Moderate (10 - 32% slope angle - terrain within 300 m)
Pattern Relief Class/Type	High (90 – 300 m), Hills
Land Surface:	5%, sloping WSW
Land Disturbance:	Cultivated, rain fed
Condition Soil Surface:	Soft when moist, but firm when dry
Soil Erosion:	No evidence of surface soil erosion, but mass movement is a feature of this landscape
Surface stone/outcrops:	Very few medium gravels (6 – 20 mm), no rock outcrops
Geological setting:	Shale and limestone above site, meta-sedimentary fragments in pit
Substrate:	Silty/clay sized, amorphous, massive, weak colluviums, shale derived?
Vegetation:	Kuni grasses, Kaukau and nut grass, all as weeds in cultivate field

A11	0 – 15 cm	Black (7.5YR 2.5/1); silty clay loam; moderately structured very fine (2 – 5 mm) polyhedral structure plus moderately well-developed fine (5 – 10 mm) polyhedral structure; non-sticky; weak moist strength; very firm dry strength; earthy fabric; few (2 – 10%) weak, sub-angular, dispersed medium gravels (6 – 20 mm) of shale; common fine (1 – 2 mm) roots; non water repellent; gradual smooth boundary;
A12	15 – 25 cm	Very dark grey (7.5YR 3/1); silty clay loam; moderately structured very fine (2 – 5 mm) polyhedral structure plus moderately well-developed fine (5 – 10 mm) polyhedral structure; non-sticky; weak moist strength; very firm dry strength; earthy fabric; few (2 – 10%) moderately weak, sub-angular, dispersed medium gravels (6 – 20 mm) of shale; common fine (1 – 2 mm) roots; non water repellent; gradual smooth boundary;
AB	25 – 35 cm	Dark reddish brown (5YR 3/2); silty light clay; moderately developed medium (10 – 20 mm) angular blocky structure; parting to moderately well-developed fine (5 – 10 mm) angular blocky structure; slightly sticky; weak moist strength; very firm dry strength; earth fabric; common (10 – 20%) weak rock, sub-angular stratified coarse gravels (20 – 60 mm) of shale; few fine (1 – 2 mm) roots; non water repellent; clear smooth boundary;
B21	35 – 45 cm	Brown (7.5YR 4/4); silty light clay; moderately developed fine (5 – 10 mm) angular blocky structure; parting to moderately well-developed very fine (2

		– 5 mm) angular blocky structure; slightly sticky; weak moist strength; earth fabric; few (5 – 10%) moderately weak rock, sub-angular dispersed medium gravels (6 – 20 mm) of shale; few fine (1 – 2 mm) roots; non water repellent; gradual smooth boundary;
B22	45 – 65 cm	Yellowish brown (10YR 5/6); silty light medium clay; moderately developed medium (10 – 20 mm) angular blocky structure; slightly sticky; weak moist strength; earth fabric; very few (<2%) weak sub-angular dispersed medium gravels (6 – 20 mm) of shale; no roots; non water repellent; gradual smooth boundary;
B23	65 – 80 cm	Yellowish brown (10YR 5/6); silty medium clay; moderately developed medium (10 – 20 mm) angular blocky structure; slightly sticky; weak moist strength; earth fabric; very few (<2%) moderately weak sub-angular dispersed medium gravels (6 – 20 mm) of shale; no roots; non water repellent; gradual smooth boundary;
B24	80 – 100 cm	Yellowish brown (10YR 5/6); silty medium clay; weakly developed fine (5 - 10 mm) angular blocky structure; slightly sticky; weak moist strength; earth fabric; few (2 – 10 %) strong sub-angular dispersed medium gravels (6 – 20 mm) of shale; no roots; non water repellent; gradual smooth boundary;
B25	100 – 110 cm+	Yellowish brown (10YR 5/6); very few medium (5 – 15 mm) distinct 2.5Y 6/2 mottles; silty medium clay; weakly developed fine (5 – 10 mm) angular blocky structure; slightly sticky; weak moist strength; earth fabric; few (2 – 10 %) moderately weak sub-angular dispersed medium gravels (6 – 20 mm) of shale; no roots; non water repellent

ACIAR PNG Soil Profile 9 – Tapini Mudstone (colluvium) at Catholic Church – Brown Dermosol

Location – Tapini TPS1 Lat/Long 8.35950° S, 146.98470° E, 970 m elevation
Date/Describer – 11/9/2013 in road cut, RBD and LAS
Drainage/Run-off/Permeability – Moderate drainage/Rapid run-off/Slow permeability
Landform – Steep (32-56%) mid slope, aggraded by mass movement process on a landslide
Landform Pattern – Low local relief (30-90 m), hill, ENE aspect,
Land Surface – Soft, mounding and rumpled = land sliding, severe mass movement 2 -3 m deep, but stabilised
Vegetation – Banana, avocado, guava, breadfruit, corn, kaw-kaw, peanut, taro, mango, elephant grass
Parent Material – No rock outcrops, no surface stones, silt/clay sized fragmental possibly calcareous mudstone

A11	0 – 10 cm	Slightly moist; Brown (10YR 4/3); light clay; strongly developed 10-20 mm polyhedral structure plus strongly developed 5-10 mm polyhedral structure; moderately sticky; very plastic; very few weak angular 2-6 mm coarse fragments; many 2-5 mm roots; clear smooth boundary;
A12	10 - 22 cm	Dry; Brown (10YR 4/3); silty light clay; strongly developed 20-50 mm polyhedral structure plus strongly developed 10-20 mm polyhedral structure; moderately sticky; very plastic; very few weak angular 2-6 mm coarse fragments; many medium roots; clear smooth boundary;

B1 22 - 45 cm Dry; dark yellowish brown (10YR 4/4); light clay; moderately developed 20-50 mm polyhedral structure plus moderately developed 5-10 mm polyhedral structure; moderately sticky; very plastic; very few weak angular 6-20 mm coarse fragments; common 1-2 mm roots; gradual smooth boundary;

B21 45 – 65 cm Dry, yellowish brown (10YR 5/6); -light clay; strongly developed 50-100 mm polyhedral structure plus strongly developed 10-20 mm polyhedral structure; moderately sticky; moderately plastic; few weak sub-angular 6-20 mm coarse fragments; common 2-5 mm roots; gradual smooth boundary;

B22 65 – 100 cm Slightly moist, yellowish brown (10YR 5/6); light clay; strongly developed 100-200 mm lenticular structure plus strongly developed 20-50 mm lenticular structure; moderately sticky; moderately plastic; common weak sub-angular 20-60 mm coarse fragments; many 2-5 mm roots; diffuse boundary;

B23 100 – 150 cm Slightly moist, dark yellowish brown (10YR 4/6); silty light clay; strongly developed 100-200 mm lenticular structure plus strongly developed 20-50 mm lenticular structure; moderately sticky; moderately plastic; common distinct mangans and slicken-sides; common weak sub-angular 20-60 mm coarse fragments; few 1-2 mm roots; diffuse boundary

BC 150 – 200 cm+ Slightly moist, yellowish brown (10YR 5/8); silty light clay; strongly developed 50-100 mm polyhedral structure plus strongly developed 10-20 mm polyhedral structure; moderately sticky; moderately plastic; common distinct mangans; common 2-6 mm carbonate soft segregations; many very weak sub-angular 6-20 mm coarse fragments; few 1-2 mm roots; slight effervescence;

ACIAR PNG Soil Profile 10 – Tapini/Jolo R – New Garden on Sandstone Colluvium – Brown Tenosol

Location – Tapini on road to Jolo River, 8.33478° S and 146.97014 ° E, Elevation 940 m
Date/Describer – 11/9/2013 in road cut, RBD and LAS
Drainage/Run-off/Permeability – Well drained/Rapid run-off/High permeability
Landform – Steep (32-56%) mid slope, aggraded by mass movement process on hill slope
Landform Pattern – High relief (90-300 m), hills, WNW aspect,
Land Surface – Moderate mass movement 3 - 4 m deep but stabilised, common boulders at surface
Vegetation – Breadfruit, rain trees, palm trees, wild banana, wild cava
Parent Material – No rock outcrops, silt/clay sized fragmental, platy, phylite bedrock noted below site

A1 0 – 25 cm Slightly moist, very dark grey (10YR 3/1); humic silty clay loam; strongly developed 20-50 mm polyhedral structure parting to strongly developed 10-20 mm polyhedral structure; slightly sticky; moderately plastic; very few moderately weak angular dispersed 6-20 mm coarse fragments of phyilite and sandstone; common 1-2 mm roots; clear smooth boundary;

A3 25 - 50 cm Slightly moist, very dark grey (10YR 3/1); fine sandy clay loam; strongly developed 20-50 mm polyhedral structure parting to strongly developed 5-10 mm polyhedral structure; slightly sticky; moderately plastic; common strong angular dispersed 200-600 mm coarse fragments of sandstone; few 1-2 mm roots; clear smooth boundary;

B1 50 - 75 cm Slightly moist, olive brown (2.5Y 4/3); sandy loam; single grained; non sticky; slightly plastic; many moderately weak angular dispersed 60-200 mm coarse fragments of sandstone and phylite; few 1-2 mm roots; clear smooth boundary; few 1-2 mm roots; gradual smooth boundary;

BC 75 – 120 cm Slightly moist, light olive brown (2.5Y 5/3); sandy clay loam; single grained; slightly sticky; slightly plastic; abundant moderately weak angular dispersed 60-200 mm coarse fragments of sandstone and phylite; common 1-2 mm roots; diffuse boundary;

C 120 cm+ Slightly moist, light olive brown (2.5Y 5/3); light sandy clay loam; single grained; non sticky; non plastic; abundant moderately weak angular dispersed 60-200 mm coarse fragments of sandstone and phylite; few 1-2 mm roots;

ACIAR PNG Soil Profile 11 – Tapini Ridgeline – Colluvial Brown Vertosol

Location – Tapini TPS3 Lat/Long 8.35965^{o} S and 146.97890^{o} E, Elevation 1170 m
Date/Describer – 11/9/2013 in road cut, RBD and LAS
Drainage/Run-off/Permeability – Moderately well drained/Rapid run-off/Moderately permeability
Landform – Steep (32-56%) upper slope, wanning, aggraded by mass movement process on hill slope
Landform Pattern – Low local relief (30-90 m), hills, NE aspect,
Land Surface – Cracking, moderate mass movement >2 m deep but stabilised, few stones at surface
Vegetation –Rain trees, banana, bread fruit, elephant grass, molasses grass, Desmodium spp, rats-tail grass
Parent Material – No rock outcrops, silt/clay sized fragmental, with few highly weathered basaltic fragments, soil clays probably from pelitic phyllites and or mafic rocks.

O1 0 – 5 cm Slightly moist; black (10YR 2/1); Peaty loam; non sticky; slightly plastic; abundant <1 mm roots; abrupt smooth boundary;

A1 5 – 20 cm Slightly moist; very dark grey (10YR 3/1); humic clay loam; strongly developed 10-20 mm polyhedral structure parting to strongly developed 2-5 mm polyhedral structure; non sticky; slightly plastic; very few weak sub-angular dispersed 6-20 mm basaltic coarse fragments; many 1-2 mm roots; clear smooth boundary;

A3 20 – 35 cm Slightly moist; very dark greyish brown (10YR 3/2); medium clay; strongly developed 50-100 mm polyhedral structure parting to strongly developed 10-20 mm polyhedral structure; slightly sticky; moderately plastic; few weak angular dispersed 20-60 mm basaltic coarse fragments; common 1-2 mm roots; gradual smooth boundary;

B2 35 – 75 cm Dry; brown (10YR 4/3); gritty medium clay; strongly developed 20-50 mm polyhedral structure parting to strongly developed 10-20 mm polyhedral structure; slightly sticky; moderately plastic; common distinct slicken-sides; common weak angular dispersed 20-60 mm basaltic coarse fragments; common 1-2 mm roots; clear smooth boundary;

BC 75 – 105 cm Slightly moist; brown (10YR 4/3); gritty medium clay; strongly developed 20-50 mm angular blocky structure parting to strongly developed 10-20 mm angular blocky structure; slightly sticky; moderately plastic; common distinct slicken-sides; abundant moderately weak angular stratified 60-200 mm basaltic coarse fragments; common 1-2 mm roots; abrupt smooth boundary;

Rw 105 – 200 cm + Slightly moist; profuse strong angular stratified 600-2000 mm basaltic coarse fragments; common 1-2 mm roots;

G Between bedrock – Dark greyish brown (2.5Y 4/2); medium clay; moderately sticky; very plastic;

ACIAR PNG Soil Profile 12 - Tapini Alluvial Soil – Redoxic Hydrosol

Alluvial Soil – Tapini High School, gleyed fine-textured alluvial profile in stream section

Location – Tapini Soil Profile TSP4, Grid Reference 8.35702^{o} S and 146.99138^{o} E, Elevation 905 m
Date/Describer – 13/9/2013 by RBD and LAS
Drainage/Run-off/Permeability – Very poor drainage/Slow run-off/Slow permeability
Landform – Very gentle, open depression, wanning, aggregated, overbank stream, valley flat
Landform Pattern – Very low relief, alluvial plain, <5% slope, completely cleared, firm surface, no micro-relief
Land Surface – Some stream bank erosion, no coarse fragments, no rock outcrops, water table at 2 m
Vegetation – Cabbage tree, kaw-kaw, corn, pumpkin, lemon tree, banana, red berries, kikuya
Parent Material – Alluvium, silty/clay sized, bedded, weak strength, kaolinised

A11 0 – 20 cm Dry, dark greyish brown (2.5Y 4/2); silty clay loam; strongly developed 20-50 mm polyhedral structure plus strongly developed 5-10 mm polyhedral structure; slightly sticky; moderately plastic; common 1-2 mm roots; clear smooth boundary;

A12 20 - 33 cm Dry, dark greyish brown (2.5Y 4/2); silty clay loam; strongly developed 20-50 mm polyhedral structure plus strongly developed 5-10 mm polyhedral structure; slightly sticky; moderately plastic; common 1-2 mm roots; abrupt smooth boundary;

G 33 - 50 cm Dry, light olive grey (5Y 6/2) with common 5-15 mm distinct 7.5YR 5/6 mottles; silty light clay; massive; slightly sticky; moderately plastic; many fine macropores; common 1-2 mm roots; clear smooth boundary;

B2g 50 – 70 cm Dry, light grey (5Y 7/2) with common 5-15 mm distinct 10YR 5/8 mottles; silty light clay; strongly developed 50-100 mm prismatic structure; slightly sticky; moderately plastic; common distinct organic coatings of 10YR 5/2; few 1-2 mm roots; clear smooth boundary;

Cg1 75 - 110 cm Dry, light grey (5Y 7/2) with few 15-30 mm prominent 10YR 5/8 mottles; silty light clay; strongly developed 100-200 mm prismatic structure; slightly sticky; moderately plastic; common faint organic coatings of 10YR 5/2; few 1-2 mm roots; diffuse boundary;

Cg2 110 – 150 cm Moist, light grey (10Y 7/) with few 15-30 mm prominent 10YR 6/8 mottles; silty light medium clay; massive; slightly sticky; moderately plastic; few 1-2 mm roots;

Appendix 2: Soil Chemical and Physical Data

Lowland Soils Profile Chemical Data

	pH	EC	SOC	N	C/N	Ca	Mg	K	Na	Al	CEC	Base Sat	Ca/Mg	Olsen P	Mn	Fe	Zn	Cu	Sand	Silt	Clay
	water	mS/cm	%	%			Cmol(+)/kg					%	ratio			mg/kg			%	%	%
ACIAR PNG SP1 - PAU Japhet Nivi's Trial Site - Colluvial Grey Vertosol																					
0 - 10	6.7		3.74	0.23	16	7.9	20.2	0.31	0.17	0	55	52	0.4	5.5	28	1	1	1	39	20	41
10 - 25	6.6		1.68	0.08	21	9.1	19.3	0.15	0.22	0	56	51	0.5	0.9	13	1	1	1	23	18	59
25 - 40	7.1		0.87	0.06	15	10.0	21.4	0.17	0.36	0	57	57	0.5	0.2	5	1	1	1	16	11	73
40 - 60	8		0.57	0.03	19	10.6	20.2	0.14	0.32	0	63	50	0.5	0.4					15	11	74
60 - 80	8.2		0.34	0.02	17	11.3	18.1	0.16	0.29	0	55	54	0.6	0.2					20	15	65
80 - 95	8.5		0.22	0.02	11	34.9	18.1	0.16	0.30	0	52	103	1.9	0.3					18	17	65
95 - 115	8.3		0.12	0.01	12	42.1	16.8	0.16	0.36	0	54	110	2.5	0.4					35	37	65
ACIAR PNG SP2 - PAU Commercial Gardens - Alluvial Grey Tenosol																					
0 - 6	6.8	37.3	1.06	0.09	12	18.6	6.5	0.43	0.10	0	27	95	2.9	16.6	8	1	1	2	36	25	39
6 - 18	6.9	34	1.04	0.09	12	16.1	4.7	0.46	0.10	0	18	116	3.5	26.9	12	2	1	2	33	27	40
18 - 30	6.9	29.9	0.87	0.07	12	23.2	8.1	0.52	0.11	0	23	140	2.9	18.1	14	2	1	3	33	27	40
30 - 50	6.9	22.4	0.54	0.05	11	23.8	8.8	0.27	0.14	0	25	132	2.7	10.9	11	2	1	3	20	42	38
50 - 85	6.9	22.7	0.66	0.06	11	19.8	8.4	0.15	0.15	0	31	91	2.4	9.9	8	1	1	2	31	28	41
85 - 100+	6.9	20.7	0.5	0.05	10	20.1	9.7	0.11	0.16	0	28	108	2.1	3.7	9	1	1	2	37	25	38
ACIAR PNG SP 3 - Laloki Research Trials - Alluvial Grey Tenosol																					
0 - 5	6.4		1.23	0.13	9	16.9	5.0	0.47	0.16	0	24	94	3.4	40.9	36	2	1	1	18	39	43
5 - 12	6.4		1.33	0.11	12	15.7	5.7	0.41	0.16	0	24	90	2.8	41.7	22	2	1	1	7	46	47
12 - 30	6.5		1.25	0.11	11	16.4	4.9	0.16	0.14	0	26	83	3.4	39.0	28	2	1	1	11	44	45
30 - 50	6.4		0.53	0.09	6	13.8	4.9	0.14	0.20	0	29	67	2.8	20.7					23	31	46
50 - 75	6.4		0.46	0.08	6	17.0	6.1	0.17	0.19	0	28	85	2.8	15.5					17	35	48
75 - 95	6.6		0.4	0.07	6	19.0	5.8	0.13	0.20	0	31	82	3.3	13.8					21	36	43
95 - 105	6.5		0.21	0.06	4	15.9	6.1	0.11	0.21	0	23	95	2.6	13.4					30	33	37
105+	6.7		0.31	0.06	5	16.1	6.4	0.10	0.21	0	25	91	2.5	13.1					36	31	33

	pH	EC	SOC	N	C/N	Ca	Mg	K	Na	Al	CEC	Base Sat	Ca/Mg	Olsen P	Mn	Fe	Zn	Cu	Sand	Silt	Clay
	water	mS/cm	%	%		———	Cmol(+)/kg			———	——	%	ratio	———	———	mg/kg	———	———	%	%	%
Topsoils - Laloki Trial Plots 2011 - Soil Data																					
0 - 15	6.1		1.4	0.19	7		3.9	0.5			16			34.1							
0 - 15	5.9		1.44	0.14	10		4.1	0.5			17			35.1							
Subsoils - Laloki Trial Plots 2011 - Soil Data																					
15 - 30	6		1.55	0.14	11		4.1	0.47			17			34.1							
15 - 30	6.1		1.43	0.15	10		4.2	0.46			15			36.3							
Topsoils - Laloki Trial Plots 2013 - Soil Data																					
0 - 15	5.9		1.74	0.18	13	10.4	5.6	0.4	0.19		18	92	1.9	34.1							
0 - 15	5.8		1.21	0.13	11	12.9	5.5	0.5	0.08		18	108	2.4	35.1							
ACIAR PNG SP4 - Rigo 1 Grassland to 1st Garden) - Colluvial Blak Vertosol																					
0 - 5	6.6		3.7	0.21	18	15.3	22.6	0.85	0.36	0	51	77	0.7	21.4	25	1	1	1	53	35	11
5 - 25	7		3.2	0.18	18	16.0	20.7	0.36	0.52	0	53	71	0.8	8.7	9	1	1	1	37	20	43
25 - 45	6.8		1.68	0.08	21	16.4	18.9	0.23	0.66	0	49	74	0.9	4.2	15	1	1	1	28	22	50
45 - 65	7.2		0.57	0.03	19	17.1	21.2	0.17	0.68	0	53	74	0.8	1.9					24	24	52
65 - 90	7.3		0.51	0.03	17	29.3	21.9	0.17	0.63	0	53	97	1.3	1.4					24	24	52
90 - 110	7.3		0.89	0.03	30	32.4	16.1	0.20	0.64	0	54	92	2.0	0.1					19	20	61
ACIAR PNG SP5 - Rigo 2 Grassland to garden - Alluvial Black Vertosol																					
0 - 5	6.3		2.85	0.19	15	33.5	21.6	0.57	0.40	0	54	104	1.6	30.6	5	3	1	1	46	22	32
5 - 20	5.8		3.02	0.17	18	36.0	20.3	0.24	0.60	0	43	133	1.8	11.9	9	10	1	1	32	24	44
20 - 35	6		1.02	0.07	15	32.9	20.2	0.13	0.73	0	49	110	1.6	4.1	3	4	1	1	23	31	46
35 - 50	6.4		0.74	0.05	15	28.1	19.4	0.10	0.79	0	46	105	1.4	4.2					24	33	43
50 - 65	6.6		0.66	0.07	9	19.0	19.7	0.09	0.83	0	42	95	1.0	4.9					33	28	39
65 - 80	6.6		0.74	0.04	19	13.5	20.4	0.12	0.81	0	44	80	0.7	4.1					24	31	45
80 - 95+	6.8		0.83	0.06	14	24.8	20.3	0.14	0.78	0	46	101	1.2	5.1					17	33	50

Sogeri Plateau Soils Chemical Profile Data

	pH	*EC*	*SOC*	*N*	*C/N*	*Ca*	*Mg*	*K*	*Na*	*Al*	*CEC*	*Base Sat*	*Ca/Mg*	*Olsen P*	*Mn*	*Fe*	*Zn*	*Cu*	*Sand*	*Silt*	*Clay*
	water	*mS/cm*	*%*	*%*			*Cmol(+)/kg*					*%*	*ratio*			*mg/kg*			*%*	*%*	*%*
ACIAR PNG SP6 - Sogeri High School - Colluvial/Alluvial Brown Ferrosol/Dermosol																					
0 - 10	5.4		2.91	0.17	17	6.4	6.6	0.59	0.10	0	21	66	1.0	8.4	4	2	1	1	42	22	36
10 - 25	5.6		0.92	0.07	13	6.2	6.5	0.21	0.06	0	17	75	1.0	2.2	20	1	1	1	26	26	48
25 - 35	5.7		0.4	0.06	7	7.4	7.6	0.24	0.11	0	16	98	1.0	2.0	12	1	1	1	31	20	49
35 - 50	5.5		0.45	0.03	15	8.9	8.6	0.09	0.13	0.05	14	123	1.0	2.0					33	20	47
50 - 85	5.9		0.55	0.04	14	3.1	9.3	0.06	0.18	0	16	78	0.3	1.9					38	15	47
85 - 120	6.3		0.22	0.03	7	5.5	10.4	0.05	0.28	0	15	107	0.5	2.7					36	19	45
Topsoils - Sogeri High School Trial Plots Soil Data																					
0 - 15	5.1		2.95	0.28	11		4.58	0.2			24			3.5							
0 - 15	4.9		3.76	0.28	13		4.25	0.2			22			2.9							
Subsoils - Sogeri High School Trial Plots Soil Data																					
15 - 30	5.2		1.55	0.15	10		3.95	0.10			25			2.9							
15 - 30	6		1.51	0.14	11		3.87	0.10			17			1.8							
ACIAR PNG SP7 - Upper Sogeri Upper (grassland to trial) - Red Ferrosol																					
0 - 8	5.3		4.14	0.32	13	7.3	2.1	0.25	0.04	0.03	27	36	3.5	3.7	6	3	1	1	15	23	62
8 - 16	4.5		3.62	0.25	14	4.8	0.7	0.14	0.03	0.04	23	25	6.7	3.1	29	2	1	1	9	19	72
16 - 40	4.1		1.26	0.14	9	1.8	0.5	0.06	0.05	0.52	28	9	3.6	2.4	7	1	1	1	2	15	83
40 - 60	3.9		0.71	0.07	10	1.3	0.7	0.03	0.04	0.43	83	2	1.9	2.3					3	14	83
60 - 80+	3.9		0.97	0.04	24	0.9	0.7	0.02	0.04	0.64	103	2	1.3	2.3					2	15	83
Topsoils (0 - 15 cm) - Upper Sogeri System Trials Data																					
Inputs	*pH*		*SOC*	*TN*	*C/N*	*Ca*	*Mg*	*K*	*Na*		*CEC*	*BS%*	*Ca/Mg*	*Olsen P*							
Traditional	5.63		2.23	0.17	13	4.64	1.06	0.21	0.03		24	25	7.53	4.39							
Moderate	5.93		1.91	0.14	14	7.00	1.46	0.26	0.04		23	38	4.62	5.42							
High	5.80		2.31	0.16	14	5.56	1.52	0.25	0.04		26	28	3.77	2.88							
Control	4.70		1.78	0.31	6	2.10	1.07	0.18	0.07		21	16	3.77	4.10							
Subsoils (15 - 30 cm) - Upper Sogeri System Trials Data																					
Inputs	*pH*		*SOC*	*TN*	*C/N*	*Ca*	*Mg*	*K*	*Na*		*CEC*	*BS%*	*Ca/Mg*	*Olsen P*							
Traditional	5.60		2.24	0.17	13	4.06	0.87	0.19	0.03		25	21	5	2.37							
Moderate	5.90		2.35	0.15	16	7.23	0.91	0.16	0.04		25	33	8	4.47							
High	5.70		1.58	0.13	12	5.69	1.87	0.31	0.05		23	35	3	5.63							

Tapini Highlands (Goilala) Soils Chemical Profile Data

	pH	*EC*	*SOC*	*N*	*C/N*	*Ca*	*Mg*	*K*	*Na*	*Al*	*CEC*	*Base Sat*	*Ca/Mg*	*Olsen P*	*Mn*	*Fe*	*Zn*	*Cu*	*Sand*	*Silt*	*Clay*
	water	*mS/cm*	*%*	*%*			*Cmol(+)/kg*					*%*	*ratio*			*mg/kg*			*%*	*%*	*%*
ACIAR PNG SP8 Tapini DAL Research Station (tillage history) - Colluvial Brown Dermosol																					
0-15	6.2		1.69	0.13	13	8.5	1.2	0.73	0.06	0	15	70	7.1	39.7	30	2	1	1	37	39	24
15-25	6.2		1.39	0.14	10	6.8	0.6	0.16	0.05	0	18	43	11.7	22.5	35	2	1	1	32	40	28
25-35	6.6		0.68	0.07	10	7.3	0.9	0.16	0.11	0	17	50	8.4	22.1	19	1	1	1	27	32	41
35-45	6.8		0.25	0.04	6	6.9	0.9	0.21	0.10	0	16	50	7.5	15.8					24	31	45
45-65	7		0.38	0.04	10	7.7	1.1	0.19	0.06	0	16	56	7.3	11.0					24	29	47
65-80	7		0.19	0.06	3	9.0	1.3	0.23	0.09	0	18	60	7.2	7.4					24	27	49
80-100	7.1		0.04	0.04	1	9.0	1.3	0.23	0.11	0	18	60	7.1	4.8					21	27	52
100-110+	6.8		0.86	0.06	14	7.4	1.5	0.15	0.09	0	17	55	4.9	4.8					24	23	53
Topsoils - Tapini DAL Trial Plots Soil Data																					
0 - 15	5.1		2.95	0.28	11		4.58	0.2			24			3.5							
0 - 15	4.9		3.76	0.28	13		4.25	0.2			22			2.9							
Subsoils - Tapini DAL Trial Plots Soil Data																					
15 - 30	5.2		1.55	0.15	10		3.95	0.10			25			2.9							
15 - 30	6		1.51	0.14	11		3.87	0.10			17			1.8							
ACIAR PNG SP9 - Tapini Catholic Church - Slate-Mudstone Brown Dermosol																					
0 - 10	5.7	0.03	1.2	0.22	5	8.2	3.2	1.55	0.04	0	23	56	2.6	9.8	23	1	1	1	27	23	50
10 - 22	5.4	0.09	1.59	0.19	8	6.1	2.2	0.94	0.05	0	22	41	2.8	3.9	4	2	1	1	27	30	43
22 - 45	5.1	0.04	0.31	0.1	3	2.1	0.8	0.53	0.02	0	18	19	2.6	2.5	15	1	1	1	26	29	45
45 - 65	4.5	0.01	0.2	0.09	2	3.3	1.0	0.31	0.06	0.53	20	24	3.4	10.6					18	25	57
65 - 100	4.4	0.01	0.05	0.07	1	6.2	2.2	0.14	0.07	0.29	26	33	2.8	13.1					14	15	71
100 - 150	4.5	0.03	0.05	0.07	1	5.4	2.6	0.11	0.06	0.21	24	34	2.1	18.1					14	17	69
150 - 200	4.7	0.01	0.05	0.06	1	5.9	3.6	0.12	0.05	0.2	25	38	1.6	17.2					22	19	59

	pH	EC	SOC	N	C/N	Ca	Mg	K	Na	Al	CEC	Base Sat	Ca/Mg	Olsen P	Mn	Fe	Zn	Cu	Sand	Silt	Clay
	water	mS/cm	%	%			Cmol(+)/kg					%	ratio			mg/kg			%	%	%
ACIAR PNG SP10 - Tapini/Jolo R (Forest to new Garden) - Brown Tenosol																					
0 - 25	4.9	0.04	3.03	0.35	9	9.3	0.7	0.16	0.03	0.05	21	48	12.8	16.4	11	4	1	1	42	31	27
25 - 50	5.1	0.03	0.78	0.18	4	9.8	0.3	0.10	0.03	0.03	19	53	31.6	2.8	3	1	1	1	47	23	30
50 - 75	6.9	0.13	0.08	0.09	1	15.7	0.2	0.08	0.09	0	16	98	65.5	4.2	2	1	1	1	49	24	27
75 - 120	7.4	0.08	0.06	0.07	1	17.8	0.2	0.08	0.02	0	19	97	74.0	3.8					58	18	24
120+		0.06	0.05	0.06	1	17.1	0.3	0.22	0.02	0	19	91	58.8	8.8					64	14	22
ACIAR PNG SP11 - Tapini Ridgeline (grassland to new graden) - Colluvial Brown Vertosol																					
0 - 5	5.3	0.14	15.05	0.98	15	27.1	16.1	0.53	0.12	0.05	53	82	1.7	15.1	5	11	1	1	80	13	7
5 - 20	5.2	0.09	5.59	0.45	12	21.1	17.4	0.28	0.12	0.03	44	88	1.2	2.4	4	9	1	1	74	11	15
20 - 35	5.7	0.04	1.97	0.13	15	30.1	16.9	0.12	0.23	0	43	110	1.8	1.6	26	4	1	1	54	17	29
35 - 75	5.8	0.03	0.8	0.08	10	24.3	18.8	0.11	0.25	0	44	98	1.3	2.3					55	11	34
75 - 105	5.9	0.03	0.63	0.09	7	30.9	20.7	0.14	0.24	0	53	97	1.5	1.8					55	8	37
105 - 200	5.9	0.03	0.96	0.09	11	26.8	16.7	0.10	0.20	0	43	102	1.6	2.0					52	7	41
ACIAR PNG SP12 - Tapini High School - Airstrip - Alluvial Redoxic Hydrosol																					
0 - 20	5.6	0.05	2.89	0.22	13	9.3	0.5	0.11	0.06	0	25	40	17.8	4.0	9	5	1	1	31	43	26
20 - 33	5.8	0.05	1.54	0.17	9	9.8	0.5	0.09	0.09	0	17	60	21.2	2.7	6	3	1	1	31	43	26
33 - 50	6.2	0.13	0.47	0.09	5	8.1	0.4	0.08	0.12	0	21	42	21.3	1.5	1	2	1	1	21	45	34
50 - 70	5.5	0.02	0.2	0.06	3	10.9	1.2	0.09	0.14	0.06	26	48	8.9	1.4					36	17	47
75 - 110	4.9	0.02	0.16	0.04	4	10.1	2.9	0.14	0.60	0.06	26	53	3.5	1.6					32	21	47
110 - 150	6.5	0.06	0.11	0.03	4	12.4	3.6	0.11	0.53	0	28	59	3.5	2.3					22	29	49

GIS Based Land Capability Assessments of Prime Agricultural Lands (PAL) in Central Province of PNG

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The GIS component of the ACIAR Vegetable Project aimed to provide a method for identifying prospective land capable of sustained arable use (Prime Agricultural Lands - PAL) in Central Province of PNG.

Introduction

Accurate and reliable digital spatial and geochemical data on soil profiles is quite limited and patchy in Papua New Guinea with half-a-dozen or so CSIRO soil and land surveys completed in the 1980's (Bleeker and Healy 1980 and Bleaker 1983, see Figure 1). The soil and landform maps from this work form part of the national digital dataset now available via the Papua New Guinea Resource Information System or PNGRIS. Initial work with the PNGRIS database examined the interrelationships of Resource Mapping Units (RMU's), soil fertility, slope, aspect and inundation. This data was presented as a series of "Highest Agricultural Land Suitability" maps and tables for the areas of interest (Sogeri, Tapini, Laloki and Rigo) to NARI and the other project partners in 2011 as printed and digital outputs. Ground-truthing during field trips to our research trial sites indicated that the Land Suitability interpretations generated via this method were not being expressed as in either suitable soils or landscape positions on the ground.

Further field examination and a review of the PNGRIS datasets and manual revealed that the soils dataset, and hence interpretive map layers, within PNGRIS is a highly extrapolated and modelled GIS dataset generated from a number of sparse and often spatially inaccurate and/or sporadic on-ground observations and datasets, i.e. less than 50 chemically analysed soil profiles in the whole of Central Province (Figure 1 and 1a).

As part of this project key areas have been ground surveyed and 20 new soil profile observations recorded and 12 full analysed profiles completed (shown on Figure 1). The approximate locations of the original set of soil descriptions from the 1980's work of Bleeker and Healy (1980) were digitised to help analyse and simplify the modelled PNGRIS soils dataset to provide a more practical representation of fertile soils within the study area.

The coastal lowlands and adjacent elevated areas are known to have highly variable topography, including coastal plains, steep escarpments and dissected uplands/plateaux. Soils are also variable, with substantial areas of the coastal lowlands susceptible to inundation and steeper slopes overlain by shallower soils being susceptible to mass movement and slope wash erosion processes (Bleeker 1983, Hanson *et al* 2001). For expansion of agriculture in Central Province, more detailed understanding of the location of suitable soils and their topographic limitations is needed. Historically, this would have been achieved through interpretations from detailed soil surveys, reliable climatic layers, and landforms mapped using stereoscopic aerial photography. However, modern tools of Geographical Information Systems (GIS) with existing geological maps and radar imaging provide for rapid assessment of broad scale land capability interpretations for particular purposes. This assessment can be followed by 'ground truthing' and coupled with existing knowledge from, for example, field trials of crops and field data on soils, to assist in final assessment and decision making regarding agricultural development.

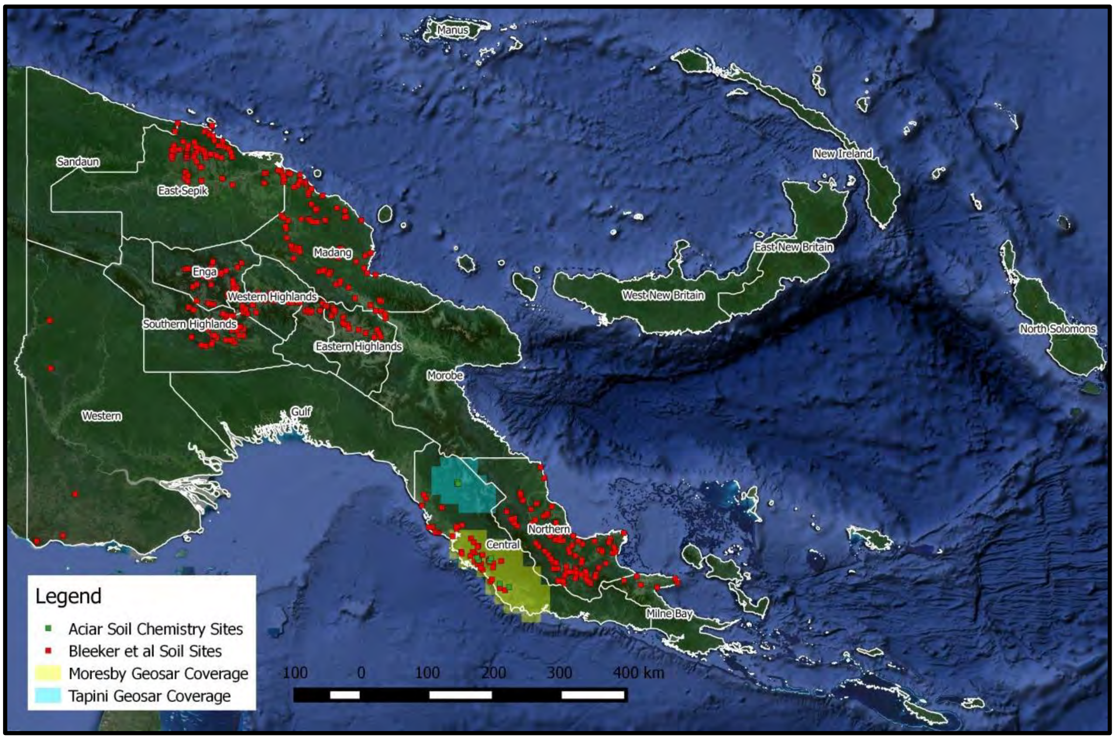

Figure 1. Soil profiles with chemical analytical data and areas with GEOSAR Radar data coverage within Papua New Guinea. Note 'Bleeker et al' means data form the CSIRO soil and land surveys while 'Aciar' represents the 12 new soil chemically analysed profiles added to our research trial areas (ACIAR funded).

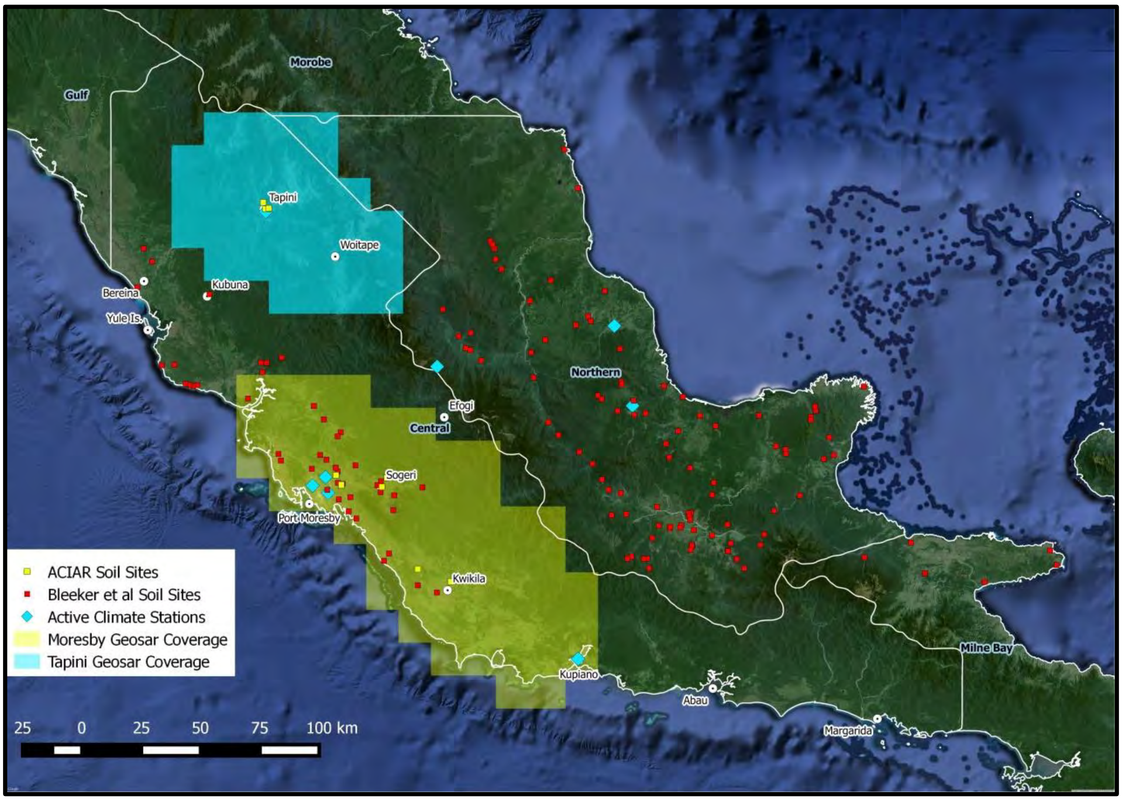

Figure 1a. Soil analysis sites, active climate stations and GEOSAR Radar data coverage within Papua New Guinea. Note "Bleeker et al" refers to the profiles analysed by CSIRO and reported in Bleeker and Healy 1980).

Methods of GIS Based Land Capability Assessment of Prime Agricultural Land (PAL)

Papua New Guinea Resource Information System (PNGRIS) datasets were initially analysed and considered to be an over extrapolation of the natural resource data sets available, particularly as they relate to soils and soil properties. The main inputs for the modelled PNGRIS soil dataset are geology, climatic data, limited soil chemistry and a 90 metre DEM.

It was decided given the large primary study area to focus on two broad scale areas that were considered most suitable for arable agricultural uses (Prime Agricultural Lands). These trial areas where centred about the Port Moresby and Tapini regions. The areas surrounding these two sites where roughly constrained by suitable Resource Mapping Units (RMU's) within PNGRIS. These RMU's are broad areas of homogenous geology, climate and topography compiled at a scale of 1:500,000 (Bellamy and McAlpine 1995).

For the first stage assessment of Prime Agricultural Land in Central Province PNGRIS soil datasets for prospective fertile RMU's was intersected with the PNGRIS Slope and Inundation datasets to provide a large merged dataset. The land seen as suitable for arable agriculture (Land Capability Classes 1 – 3 in system of Grose 1999) was constrained via the following limitations.

STONINESS - Not to Moderately stony or rocky
DEPTH - 50 cm to greater than 1 m
DRAINAGE - Imperfectly to Well Drained
TEXTURE - Medium to very fine
ANION FIXATION - Low
CATION EXCHANGE CAPACITY - Moderate to High
AVAILABLE PHOSPHORUS - Moderate to High
EXCHANGABLE POTASSIUM - Moderate to High
BASE SATURATION - Moderate to High
% TOTAL NITROGEN - Moderate to High
SLOPE - Less than 10 degrees

These attributes provided the first indication of where potential arable areas occurred. Unfortunately the soil chemistry, DEM, climate and geomorphic data used in PNGRIS were incomplete, poorly spatially located or of insufficient spatial resolution. Field validation of the datasets indicated other approaches may be more representative on actual suitable soils for agricultural expansion.

Consequently, P-band GeoSAR radar elevation data, X-band GeoSAR Magnitude Radar Imagery, Regional Scale Geological Data and field observations of soils coupled with data from crop trial plots were used as primary data sources for the study.

X-band and P-band radar data is collected concurrently from each side of a survey aircraft at an elevation between 10,000 and 12,500 metres. The X-band wavelength penetrates clouds and reflects from tree canopy to deliver surface model data in forested areas and accurate terrain elevation in open areas. The P-band wavelength penetrates both clouds and tree canopy to deliver terrain elevation and surface feature extraction in forested areas. These characteristics make GeoSAR ideal for mapping large areas of mixed land cover particularly in Tropical areas such as Papua New Guinea (Williams and Jenkins 2009). The regional scale geological data provides the only credible bedrock information available for the selected study areas.

Tiled P-band radar surface points which penetrate all but the densest vegetation provide a high resolution model of the terrain. The points were provided by the Australian Defence

Imagery and Geospatial Organisation as ASCII point data with spacing of 2.5 metres, and were gridded to a mosaic of 5 m Digital Elevation Model (DEM) surfaces using the ArcGIS "3D Analyst" extension. This data provides a more accurate and higher resolution representation of the local topography than the publically available 90 metre Shuttle Radar Topography Mission (SRTM) data for the study area. The release of the reprocessed SRTM data in March 2015 enabled the comparison of the GEOSAR 5 metre, SRTM 30 metre and PNGRIS 90 metre datasets and provides a mechanism to produce similar outputs across the entire country.

From the detailed elevation model data a four class Topographic Position Index was generated using Land Facet Tools Extension for ArcGIS (Jenness *et. al* 2011). This extension divided the topography into Ridges, Upper Slopes, Lower Slopes and Valleys. Using this classification 'Lower Slopes' of less than and equal to 10° were selected as potential suitable sites for intensified arable agriculture as they are considered 'very gently to moderately sloping'. Land less than 10° or 18% can be classified as falling within Land Capability Classes 1 – 3 i.e., 'arable cropping lands' or Prime Agricultural Land (PAL) in the Tasmanian Land Capability classification systems (Grose, 1999) and similar systems used in the USA and NZ (Ministry of Works, 1979). Slopes above 10° gradient are more susceptible to mass movement (landslides) and rill and sheet erosion due to the intense high precipitation events experienced during the wet season. The valleys and associated low angle plains below and between these 'Lower Slopes' while providing good potential for arable agriculture where not included in our this initial analysis due to high prevalence of flooding, inundation and waterlogging as indicated by PNGRIS.

This broad topographic classification was further constrained by the lithology or soil parent material underling the previously identified lower slopes. The area's deemed most suitable for intensified agricultural production were identified as those areas underlain by high nutrient containing parent rocks like intermediate or mafic lithologies (basalts, gabbros and related rock types) or derived alluvium and colluvium which provide for deeper and base rich soil parent materials (see Table 2). Thus their derivative soils such as Ferrosols (iron rich structured clayey soils), Dermosols (structured soils) and Vertosols (reactive clay soils) (Australia Soil Classification) or Andosols, Inceptosols, Vertosols, Mollisol and Oxisols (USDA Soil Taxonomy) generally provide the potential for the more productive and sustainable agricultural lands. Limited numbers of soil profiles were described and soil types noted in road cuttings and gardens in the district to verify our interpretations.

Results

This broad first-pass classification using the GEOSAR radar data identified 48,394 ha of land for potential agricultural expansion within the Port Moresby study area in Central Province (Table 1). A further 13,664 ha of land is subject to various levels of inundation and waterlogging. The land was underlain by a wide range of parent material/bedrock, though most were of volcanic origin dominated by gabbro (see Table 2 and Figure 2).

The recently acquired publically available SRTM (Shuttle Radar Topographic Mission) 30 m DEM was processed using the same methodology as the GEOSAR radar data and the results were very similar with the largest discrepancies observed in Aroma Rural and Kairuku Rural areas (Table 1) due to the inclusion of areas not covered by the GEOSAR data.

The majority of this land is centred on the town of Kwikila some two hours by road south east from Port Moresby. Of the 48,314 ha identified some 13,664 ha is listed within PNGRIS as being prone to waterlogging and inundation of varying duration and severity (Table 3). Of the 13,664 ha susceptible to inundation 4,146 ha (Inundation types 1, 2, 4 and 6) would probably be excluded from agricultural use.

Table 1. Potential suitable arable agricultural land around Port Moresby, Central District Papua New Guinea as constrained by GEOSAR, SRTM and PNGRIS data.

GEOSAR 10m	AROMA RURAL	HIRI RURAL	KAIRUKU RURAL	KOIARI RURAL	RIGO CENTRAL RURAL	RIGO COASTAL RURAL	RIGO INLAND RURAL	TOTAL
No flooding or inundation	1209	5123	3048	10380	16448	265	11920	**48394**
Long term inundation	7	31	28	2	2661		84	2812
Near permanent inundation							6	6
Periodic brief flooding	63	571	758	782	2822	27	783	5805
Permanent inundation		2		665				667
Seasonal inundation	24	152	101	6	3220		209	3713
Tidal flooding		342	255				64	661
TOTAL	1303	6222	4190	11835	25151	293	13065	62058

SRTM 30m	AROMA RURAL	HIRI RURAL	KAIRUKU RURAL	KOIARI RURAL	RIGO CENTRAL RURAL	RIGO COASTAL RURAL	RIGO INLAND RURAL	TOTAL
No flooding or inundation	2922	5083	6734	11248	16411	278	12380	**55055**
Long term inundation	7	32	31	2	2532		85	2688
Near permanent inundation							6	6
Periodic brief flooding	106	550	838	849	2702	29	842	5915
Permanent inundation		2	45	947				993
Seasonal inundation	27	155	165	6	2958		226	3538
Tidal flooding		332	252				59	643
TOTAL	3062	6154	8064	13052	24602	307	13599	68839

PNGRIS 90m	AROMA RURAL	HIRI RURAL	KAIRUKU RURAL	KOIARI RURAL	RIGO CENTRAL RURAL	RIGO COASTAL RURAL	RIGO INLAND RURAL	TOTAL
No flooding or inundation	13580	5885	3758	18851	3561	3086	9133	**57853**
Long term inundation	1	2485	1143	26	990	7	246	4898
Near permanent inundation			455					455
Periodic brief flooding	2081	3896	1928	882	1581	2618	899	13885
Permanent inundation		2	1					3
Seasonal inundation	3	2043	418	89	1430	12	454	4448
Tidal flooding	2	6	4			9		21
TOTAL	15666	14316	7707	19848	7561	5732	10732	81562

Table 2. Geological bedrock and associated areas of land assessed as suitable for agricultural development using GEOSAR data about Port Moresby, Central district, Papua New Guinea

Geological Bedrock	Area (Ha)
Andesitic and basaltic vitric, crystal, lithic tuff, minor agglomerate; partly calcareous; strongly jointed	41
Basalt and andesite pyroclastics, lava, volcanic sandstone	3378
Basalt and andesite pyroclastics, minor lava: remnants of cappings	2360
Basalt and andesitic agglomerate, minor tuff; tuffaceous sandstone and volcanic conglomerate at base	624
Basalt and minor andesite agglomerate and tuff, partly reworked	8586
Basalt and minor andesite agglomerate, tuff, lava, lava breccia, partly reworked	4008
Basalt and pillow lava with gabbro and dolerite intrusives (dykes), minor calcilutite	684
Basaltic and andesitic agglomerate and lava: shoshonitic affinities; volcanic plugs	218
Basaltic and minor andesitic agglomerate, tuff, lava, lava breccia, with intercalated volcanically derived conglomerate and sandstone	63
Diorite and porphyritic microdiorite, monzonite and granodiorite stocks. Oveia Diorite equivalent	25
Gabbro, diorite and other acid differentiates to the west; fine-grained gabbro, dolerite and basalt to the east	25626
Gravel, sand, silt, mud, clay: alluvium and beach deposits	1973
Lavas and pyroclastic rocks of the Mount Cameron Range volcanic cone	379
Massive green mafic schist derived from basalt, dolerite, gabbro, & volcanic sediment; minor calcareous & felsic schist or phyllite.	64
Porphyritic, vesicular basalt and andesite lava; shoshonitic affinities	91
Volcanic conglomerate, tuffaceous sandstone, minor siltstone; moderately consolidated	273
TOTAL	**48 394**

Figure 2. Potential suitable Arable Agricultural Land as constrained by geology and SRTM 30 m DEM (areas in Blue) in Central Province PNG. (Note – this layer excludes alluvial landforms prone to flooding constraints – see Figure 4 show alluvial area inclusion).

Figure 3. Potential suitable Prime Agricultural Land (arable) as constrained by PNGRIS and SRTM 90 m DEM (areas in Yellow) in Central Province PNG

Table 3. Areas of land subject to inundation about Central District

Inundation Type	Area (Ha)
1. Long term inundation	2,812
2. Near permanent inundation	6
3. Periodic brief flooding	5,805
4. Permanent Inundation	667
5. Seasonal inundation	3713
6. Tidal flooding	661
TOTAL	**13,664**

While this method provides a guide on where potential arable agricultural land occurs, the various models could be dramatically improved with more detailed geological, landform and inundation inputs, e.g., based on catchment flood flow data/modelling, and a comprehensive on ground soil mapping program. There are many areas of alluvium and colluvium that are currently modelled as being subject to inundation that appear to be highly prospective for and expansion of agricultural use.

We also provide a further extrapolated Prime Arable Land layer in Figure 4 which includes these alluvial soils on active floodplains to show areas where small-holder gardening could and can be undertaken, with suitable alluvial soils, but this may be subject to seasonal flooding and consequent crop losses (Figure 4). This was in part based on our observation that much current gardening occurred on such landforms despite potential inundation hazards. By incorporating these alluvial soils into the analysis within Central Province an additional 31636 hectares of potential PAL is identified within the 7 sub-provinces documented in Table 1.

Figure 4. EXPANDED - Potential suitable Arable Agricultural Land (PAL) as constrained by geology and SRTM 30 m DEM (areas in Blue) in Central Province PNG. Note in this layer we have included many alluvial landforms formerly excluded due to flooding hazards. However these soils are often of a fertile nature, due to mixed mineralogy and annual siltation, and they have been included in this layer to show the maximum extent of Prime Agricultural Lands (Classes 1 – 3), despite this flood risk to production.

GIS Training of NARI and other agricultural officers

We believed it important to extend some of the GIS based land resource mapping learnings and resources to local agricultural officers in PNG. This is because this work is often iterative in nature and uses changing or upgraded data layers as their availability and resolution changes (improves). So during February 2015 a week-long GIS training workshop was delivered to 17 PNG participants from the projects partner organisations at the NARI research station in Lae (mainly NARI and FPDA but also Palm Oil and Coffee Institute officers). The training course provided a comprehensive introduction to the open source QGIS system and provided hands on practical instruction on common data collection and mapping tasks.

Participants were provided with a copy of the QGIS software along with a number of other useful open-source software packages plus the full set of the PNGRIS GIS coverage's for their respective provinces. The training course was customised such that all the course datasets were from Papua New Guinea, either Port Moresby or the area immediately surrounding the Research Station at Lae. This enabled a much quicker uptake of the technology with the datasets providing context for the complex tasks being undertaken (Figure 5).

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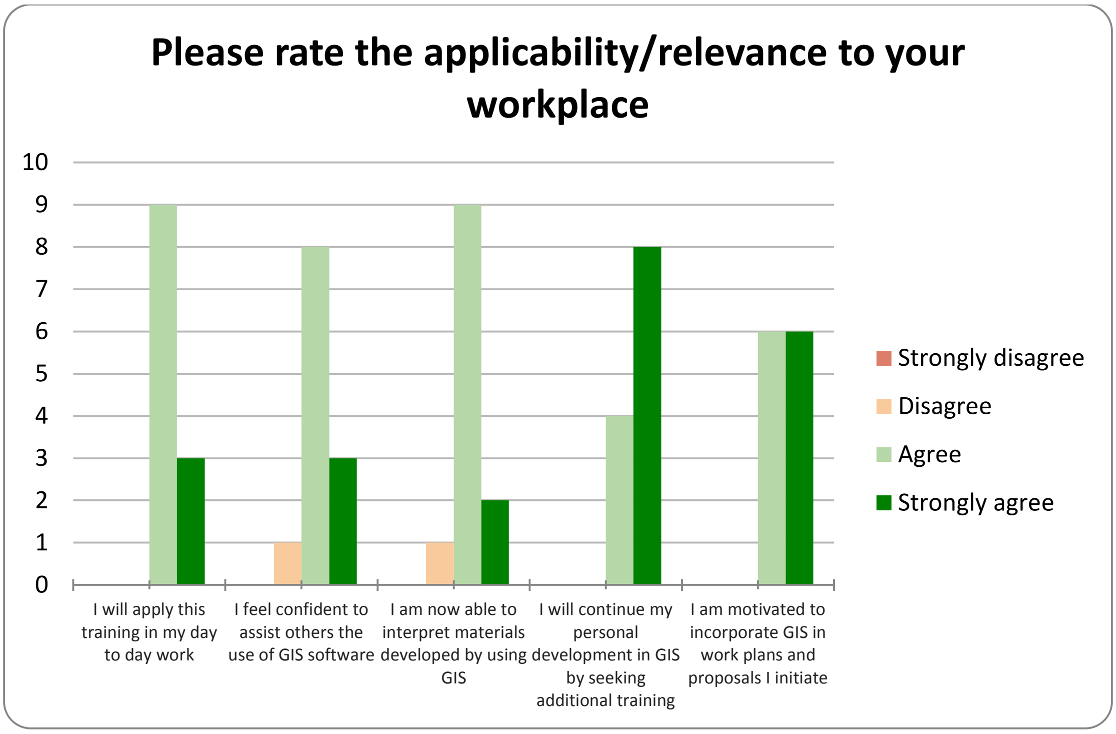
Figure 5. Participants hard at work at the QGIS Training Course, Lae February 2015

Figure 6. Participants during field exercises at the QGIS Training Course, Lae February 2015

All workshop participants were instructed in the collection and collation of field data, collecting spatial locations and tracks using GPS handsets and then transferring the attributes into the GIS software. On completion of the course the participants were able to produce a map applicable to their respective jobs as high quality outputs (Figures 5 and 6).

The participants had a variety of past experience in GIS software and there was only one participant who struggled to complete all the allotted tasks during the training due to missing the first day of orientation and set-up. He is now working through the training materials in his own time with the help of his fellow participants using his own data, and is keen for some more training.

Overall the course was very well received with the participants arriving before the daily sessions began and working through their lunch break to maximise their time where the instructors could answer the many questions that arose.



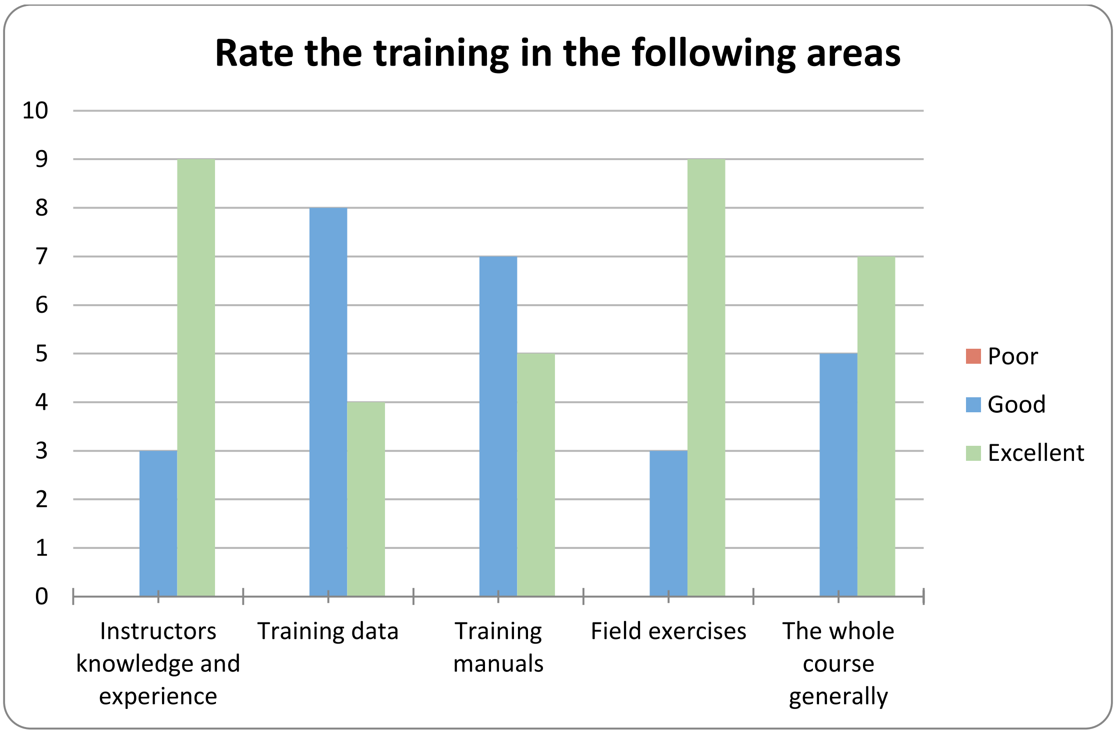


Figure 7. Feedback metrics from the QGIS Training Course. The feedback forms (available in MS-Excel file) were very informative and all participants expressed a desire for more comprehensive QGIS training.

Data Provision and on-going GIS help service

Following on from the training course in Lae the participants set up an online users group where that can post questions or ask for help about all things GIS. This group and the mailing list associated with it has been used participants to further their skills and continue to help each other with their new found enthusiasm for GIS. Through this forum and via email participants regularly make contact with software issues or help with problematic datasets and it is anticipated that this will continue in to the future.

During mid 2015 a series of new high resolution elevation datasets covering all of PNG where made publically available. This data was processed in Tasmania as part of the ACIAR project and made available to all the workshop participants in convenient province sized subsets. For many it is the first time that they have been able to access high resolution elevation data for their respective provinces or study areas. The data is already being used to generate accurate contours, develop drainage models and aid in other Natural Resource Management issues and projects.

The high resolution Radar elevation data acquired from DIGO for the project only covered around 50% of Central Province. This new publically available elevation dataset also enabled a comprehensive model of potential arable agricultural land for the whole of Central Province to be produced. This also means the model could now be expanded to delineate Prime Agricultural Lands across PNG.

This new elevation data along with other data produced during the project and data processed for the range of PNG Agricultural Officers is being distributed via Dropbox. This enables agricultural officers to access new and updated data or get assistance from other GIS trained participants in Port Moresby and Lae headquarter offices to obtain them on their behalf using the higher internet speeds at those locations.

Discussion

The GIS data and radar imagery has been combined to produce informative maps that can be used to prioritise areas for sustainable agricultural development, i.e. Prime Agricultural Land (PAL) of Land Capability Classes (1 – 3) inclusive, i.e., arable lands. They have clearly identified potential areas, and by relaxing or tightening the constraints set when using the radar imagery, the area of potentially useable land might be increased or decreased. For example, if the allowable slope was reduced to say, 7° for a particular agricultural system in which soil cover was limited between crops, or even within that crop (e.g., onions) and thus increasing the erosion risk, the area of suitable land available could be re-mapped and would decrease accordingly. Conversely, if the assessment was being made for land uses involving perennial pastures, forestry and fruit trees the allowable slope limits could be increased, resulting in larger areas of potentially useful land being identified. Hence the need for training of staff in PNG in the process of iterative GIS analysis and reporting. Indeed further training would be warranted and travel to Australia or undertaking of postgraduate studies would be most beneficial.

The present analysis has identified extensive areas of Prime Agricultural Land in the Central Province. When combined with ground based observations along roads and in village gardens augmented with limited examination of augured soil profiles, the approach of using GIS and radar imagery is proving a very useful tool for assessment of broad scale land capability assessment of Classes 1 – 3 inclusive (PAL). Our team has also applied this approach in several other areas in Central Province, with similarly useful output, again with initial validation from ground based observations and soil data. Nevertheless, the approach must be complemented with other detailed and temporal information, such inundation frequency, scale and duration, to gain a more accurate assessment of land capability and guide development and agronomic decisions on crops to be grown and practices used on specific sites.

Figure 8. Potential suitable areas for arable agriculture in and around Rigo, Central District Papua New Guinea (Blue)

Clearly, there are significant areas of suitable land available for agricultural development in Rigo district (Figure 8), and other areas of Central Province and beyond. However, for effective development, appropriate agronomic practices will also need to be developed; these being part of other work being conducted by the broader project. Land tenure issues notwithstanding these data will assist the sustainable agricultural development process in PNG and increase employment and business prospects for local farmer cooperatives. The projects efforts at training a greater number of GIS capable government officers also offers the potential for application, further interpretation and use of these data sets. It is worth noting some efforts to improve the layer registration errors in PNGRIS might also enhance use of this dataset for PNG lands and their sustainable uses in to the future.

A new worldwide elevation dataset became publically available in March 2015, called Shuttle Radar Topographic Mission or SRTM. This 30 metre resolution dataset provides a very useful national dataset for Papua New Guinea. The project team has processed this dataset and produced Digital Elevation Models for each of the Provinces and has been distributed to representative of all the member organisations. This national dataset provides the capacity to apply the same methodology as used with the GEOSAR data to provide a comprehensive regional scale analysis of suitable locations for agricultural intensification. The SRTM dataset and the GEOSAR datasets provide the opportunity to update the numerous other PNGRIS layers that were reliant on the previous 90 metre SRTM dataset.

The GIS training provided a chance for a skills transfer to a group of people who actively embraced the software and could see immediate application of what they learnt to their work. The course also gave the chance to 'upskill' some existing GIS users to a position where they did and can help instruct others. Follow-up training is recommended and has been actively requested by participants.

Conclusions

We recommend using high resolution radar generated topographic coverage's in combination with soil parent material classification based on the mapped bedrock lithology as a base to generate more reliable broad scale maps of Prime Agricultural Lands (Land Capability Classes 1 – 3). This methodology can show national and local government development bodies, aid agencies and the village farmer cooperatives the potential areas available for land use intensification and sustainable national agricultural development. The maps would then be combined with other local data to provide a sound basis for development decisions and to guide agronomic practice and infrastructural development. Where the radar topographic coverage is unavailable the 30 metre global Shuttle Radar Topographic Mission (SRTM) data provides an accurate alternative.

Some care should be taken when using the existing PNGRIS GIS datasets. There are some serious data accuracy and corruption issues that will prove very frustrating for an inexperienced GIS user. Some thought should be given to a review and update of the PNGRIS database as while it has some major issues for the most part it is the only comprehensive resource for farmers and planners alike.

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