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Final report

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1 Acknowledgments

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The project has successfully achieved its objectives and we wish to acknowledge the valuable contribution from all the team members and collaborators, including:

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- From NARI: Dr Norah Omot (Team Leader), Dr Sim Sar, Dr Birte Komolong, Anton Mais, Amanda Wandau, Moses Robby, Eleo Dowa, Miriam Simin, Isidora Ramita, and Joel Waramboi.

- From South Wahgi Organic Farmers Association: Agnes Merep.

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2 Executive summary

The aim of the project was to improve the economic returns and income of sweetpotato farmers and other supply chain players, through adoption of improved sweetpotato postharvest and marketing practices. Sweetpotato is the major staple food crop in Papua New Guinea, and surpluses have historically been sold at local markets. However, increasingly sweetpotato is grown specifically for the markets in urban centres, such as Lae and Port Moresby, where demand for good quality sweetpotato is increasing due to economic growth and urbanisation. However, marketing opportunities have been constrained by the transport system and marketing infrastructure, as well as limited postharvest management, value chain coordination, and market orientation on the part of farmers and value chain players. The main research questions to be answered by the project were:

- What are the most effective ways of reducing postharvest losses and the costs of marketing?
- What are the major constraints to the adoption of postharvest technologies, and to group marketing and collective action?
- What are the most appropriate strategies to overcome those constraints?
- What are the potential impacts of planned interventions on smallholder farmers?

Our work in years 1 and 2 focused on socio-economic research (consumer survey, farm survey, business buyer survey, and gross margin analysis) and postharvest research (quality and waste assessment). These were followed in years 3 and 4 by training and capacity building (in marketing, postharvest management and gross margin analysis) and dissemination and communication of research results to stakeholders.

Key results

- Consumer preferences for sweetpotato varieties and quality attributes were found to be very specific. However, the majority of farmers taking part in the farm survey were not aware of those preferences, and were not market-oriented.

- Demand for sweetpotato has been declining in Port Moresby due to socio-demographic changes, and competition from rice. Misreading of consumer preferences and demand conditions can result in oversupply, and hence low prices and product wastage, leading to low or negative returns for farmers.

- Waste assessments in Port Moresby show minor skin diseases and product losses of sweetpotato. Major losses occurred when there were delays in transport, and could be avoided if transport is scheduled correctly and the crop is not allowed to become wet and hot during the long journey to market. Therefore, there is no need for expensive packaging or a cool chain, as suggested by previous research.

- One possible reason that low product losses were identified was the emerging wholesaling sector, which seemed capable of coordinating the supply chain logistics more effectively, as well as imposing some quality requirements on their suppliers.

- Quality assessments in Port Moresby show that rejection rates of poor quality sweetpotato roots were high (up to 80% by weight). The main issues were with small roots, an uneven surface (ridging and misshapen) and harvest stick damage. Market survey in Port Moresby show price premiums existed for good quality, medium size sweetpotato. These results suggest that sorting and grading in the Highlands is essential for improving quality outturn and economic returns. In addition, curing of sweetpotato is a superfluous activity for PNG farmers because the crop can be produced year around in the Highlands.

- Training and educating farmers and extension officers on gross margin analysis (GMA) show that GMA was useful as a management tool both on-farm (what to produce) and off-farm (where to sell), as well as for identifying areas for cost cutting, value adding and productivity improvement. Successful application of GMA can be achieved by using a farmer field/business school approach whereby farmers learn as a group and at their own pace. This approach is especially appropriate for women who are often illiterate and time-poor, and it is more cost effective than training workshops.

- Transport and storage facilities remain the binding constraints on improving the sweetpotato value chain in PNG.

Scientific and community impacts

- Product losses in Port Moresby were found to be much less (2-5%) than previously claimed (30-50%). This is a significant finding because costly changes to current postharvest practices (such as curing, small packaging, cool chain, etc.), as suggested by previous research based on heavy losses, can be avoided. The varieties and physical characteristics preferred by consumers identified in this research can be used as a guide for variety selection and future breeding programs.

- Postharvest research and training activities have increased awareness and understanding of consumer demand and the quality and marketability of sweetpotato. Farmers in Minj and a wholesaler in Port Moresby who practiced sorting and grading testified that they received positive feedback from their customers, and were able to sell more or sell out faster than otherwise. Participating supermarkets in Port Moresby also showed significant improvements in product displays and store design in their fresh produce sections.

- An improved understanding of the relationship between prices, costs and returns through GMA has encouraged farmers to sell to local traders. As a result, a wholesaling sector has begun to emerge. This development, when continues, will have a significant impact on improving quality outturn, reducing marketing costs, and increasing economic returns and income for farmers.

Conclusions and recommendations

- Declining per capita consumption due to socio-demographic changes and competition from rice as a staple food has emerged as a real threat to the long term development of the sweetpotato sector. More investment is required in transport and storage infrastructure, as well as in value chain research, to improve the overall competiveness of the sweetpotato sector.

- Engaging with and educating traders and marketers on consumer demand and postharvest management may be a more effective strategy for improving product quality and chain efficiency than working primarily with farmers. Capacity and strategies to engage with the private sector need to be developed and strengthened.

- Educating farmers on market demand and costs and returns can facilitate changes in marketing and postharvest practices, leading to improved sales and marketing efficiency. This can best be done using the farmer field/business school approach whereby farmers learn as a group, and at their own pace.

- Participatory action research and capacity development are useful tools for achieving systemic change and sustained development of the sweetpotato value chain, but to achieve widespread adoption they must have the support of a functioning local extension system. Extension services may be improved if it is a built-in component of an agricultural research for development project, and necessary resources are allocated accordingly.

3 Background

This project is a progression of the ACIAR project (ASEM/2006/035 Improving marketing efficiency, postharvest management and value addition of sweetpotato in Papua New Guinea). That earlier project confirmed high postharvest losses and marketing costs, as a result of inadequate storage and transport infrastructure and a lack of value chain coordination. The main conclusion was that to improve economic returns, smallholder sweetpotato farmers must be better organised, work collaboratively, and change their current postharvest and marketing practices. The ACIAR-commissioned review of the project, while acknowledging the significant progress made in understanding the functioning of sweetpotato value chains, identified several areas that required further consideration. On the demand side, there was a need to better understand buyers' preferences for sweetpotato in different market segments. On the supply side, there was a need to speed up the development and uptake of postharvest technologies and to improve supply chain coordination through group action.

In response, an integrated approach was proposed to account for the influences of social, cultural, economic and political forces on current marketing and postharvest practices and on fostering adoption of improved practices and desired institutional and behavioural changes. This integrated approach aimed at incorporating people elements into seemingly technical issues of curing, sorting/grading and packaging, as well as improving the research-development-extension nexus. It was also a part of a more strategic approach to sweetpotato research and industry development in PNG, with an increased emphasis on market demand, value chains, and the long-term competitive position of the sweetpotato sector. It was consistent with the proposed integrated program for sweetpotato research work in PNG, looking at the linkages between the production system, the marketing system, and the enabling environment.

4 Objectives

The overall aim of the project was to improve the economic returns and incomes of smallholder farmers and supply chain operators through the adoption of improved sweetpotato marketing systems. Specific objectives and associated activities are:

Objective 1. To identify the social, cultural, and political factors impacting on the sweetpotato supply chain in PNG

- Activity 1.1: Identify and select supply chains for case studies
- Activity 1.2: Identify critical control points for reducing product losses and marketing costs
- Activity 1.3: Conduct farmer surveys to understand the social and economic context underpinning decision-making and resource allocation within the household and along the supply chain
- Activity 1.4: Conduct market surveys to understand the demand and quality requirements for sweetpotato in key market segments
- Activity 1.5: Educate farmers on consumer preference and buyers' requirements and on postharvest losses
- Activity 1.6: Identify and evaluate market opportunities

Objective 2. To improve quality outturn and reduce transit losses through the development of locally appropriate postharvest management practices

- Activity 2.1: Develop quality standards for key market segments
- Activity 2.2: Pilot test consignments (with grading and without grading) to define "marketability" and to assess buyer's willingness to pay for quality and economic returns to farmers
- Activity 2.3: Develop locally appropriate curing solutions
- Activity 2.4: Identify locally appropriate packaging solutions
- Activity 2.5: Conduct packaging/coolchain trials based on full container loads (with and without curing) and assess quality outturn and economic returns
- Activity 2.6: Mid-term review

Objective 3. To improve uptake of postharvest technology

- Activity 3.1: To understand the social and political contexts underpinning behavioural changes
- Activity 3.2: To identify appropriate social networks, especially opinion leaders, and communication channels for extending recommended postharvest technologies to supply chain players
- Activity 3.3: Provide necessary training to extension officers and value chain players in postharvest management
- Activity 3.4: Involve local communities in the wider dissemination of locally appropriate postharvest technologies
- Activity 3.5: Link farmers to selected market segments through locally appropriate market institutions, and with improved postharvest management and graded products, and assess economic returns

Objective 4. To assess the social impacts of proposed interventions on smallholder farmers and their communities

- Activity 4.1: To identify impact pathways and constraints and to develop impact evaluation plans to bring about desired changes
- Activity 4.2: Measure changes in income and poverty levels
- Activity 4.3: Measure changes in women's empowerment

Objective 5. The Australian component: to improve sweetpotato supply chains and uptake of technology in Australia

- Activity 5.1: Map sweetpotato supply chains in NSW and Queensland
- Activity 5.2: Select supply chains for case studies
- Activity 5.3: Conduct a feasibility study to identify opportunities and constraints to expanding sweetpotato production in NSW

5 Methodology

In-depth case studies of selected value chains were used to gain insights into the effects of institutional structure and social dynamics on the functioning and performance of the chains, including uptake of new technology, group learning, and collective action. In the PNG Highlands, most sweetpotato is marketed individually by farmers, with women focusing on local markets and men on distant coastal markets. The concentration of female farmers in the local market often causes oversupply and hence low prices, simply because sweetpotato is grown by most local residents. Participating in local marketing, often with small returns, also generates additional workload for female farmers on top of their responsibility for food production and household chores. Collaborative marketing and more orderly marketing could potentially increase returns, save time, reduce workloads, and improve the wellbeing of female farmers. Long distance marketing is potentially more profitable, especially to Port Moresby which appears to be undersupplied. However, postharvest management and marketing strategies must be improved to cut costs and improve quality outturn to ensure better returns. The case studies, which focused on the social and cultural contexts, would help us understand why activities are carried out the way they are, and to determine whether and how the activities and behaviours could be changed.

Contrasting cases considered included: (1) long distance value chains from Mt Hagen to Port Moresby normally operated by men, versus local marketing predominately carried out by women along the roadside and at open markets close to home; (2) within the long distance and local value chains, comparisons were made between value chains operated by farmers individually, versus value chains operated by wholesalers/traders; and (3) comparisons between value chains that were vertically coordinated (i.e., partnerships established with suppliers, service providers, and customers in target markets, and a regular supply of product), versus chains that were fragmented and disjointed (i.e., farmers going to the market without a marketing plan). Four supply chains in two study sites, Minj in the Jikawa Province, and Kelua in the WHP, were selected to trace the long distance sweetpotato value chain from those villages to Port Moresby and local marketing at the open markets and to buyers/wholesalers in Mt Hagen.

In years 1 and 2, our work focused on socio-economic and postharvest research, including:

- a farm survey in the PNG Highlands to understand smallholder farmers' attitudes, perceptions, and knowledge of postharvest and quality issues, relating to long distance marketing of sweetpotato from the PNG Highlands to Port Moresby;
- a consumer survey and informant interviews of business buyers in Port Moresby, to better understand buying preferences and quality requirements for sweetpotato, as well as to identify marketing opportunities in different market segments;
- marketability and quality trials to understand farmers' quality perceptions, and their influences on postharvest management practices (grading and packaging);
- quality and product loss assessments in Port Moresby open markets, to determine whether and how quality out-turn could be improved and product losses reduced; and
- an assessment of consumer willingness to pay for good quality sweetpotato.

In years 3 and 4, our project activities focused on capacity building, and dissemination of research results to stakeholders in collaboration with farmer groups and development partners. Key activities included:

- informal and formal training and education of farmers on consumer preference and market requirements for sweetpotato, as well as postharvest management, marketing, financial literacy, and gross margin analysis;
- publication of technical reports, conference papers and journal articles;
- information sheets presenting key results and implications for value chain players;

- regular consultations with program managers, project leaders and extension officers at FPDA and provincial and district offices on working together to build capacity of extension personnel and smallholder farmers;
- an extension forum to identify ways to improve research-development-extension linkages, and to introduce and promote the farmer field/business school approach to extension; and
- farmer business school trials on gross margin analysis with selected farmers' groups.

Research methods employed in this project are summarised in Table 1.

Table 1. Activities and research methods

Activities	*Methods*
Socio-economic research	Farm household survey Consumer survey Buyer survey Supplier network analysis Gross margin analysis
Postharvest research	Define marketability/grades Assess quality and product losses
Capacity building and training workshops	Training workshop on postharvest Training workshop on business skills Farmer business school trials on gross margin analysis Literature review of extension methods and approaches
Linking farmers to markets	Sales trials with Boroko Foodworld Postharvest training for supermarket fresh produce supervisors and handlers

6 Achievements against activities and outputs/milestones

Objective 1: To identify the social, cultural, and political factors impacting on the functioning of the sweetpotato supply chain in PNG

No.	Activity	Outputs/ Milestones	Completion date	Comments
1.1	Select supply chains for case studies	4 supply chains in 2 sites selected and chain leaders identified and consulted	Sept 2012	Completed/report written. In September 2012, 4 selected supply chains were consulted in their villages. They were informed of project objectives and their role in the project.
1.2	Identify critical control points	CCP identified and documented	3 December 2012	Completed/report written. The CCPs were identified and used as input into Objective 1.5.
1.3	Conduct farmer survey	Socio-cultural constraints to improving quality and supply chain coordination identified and documented	Dec 2012	Competed. Farm survey conducted with 186 farmers in Jiwaka in Dec 2012. Selected results were presented at various training workshops, as well as at the ACIAR socio-economic workshop in Lae in June 2013, which was later published in the workshop proceedings. A draft report was completed in February 2014. Three conference papers have been presented at various conferences.

1.4	Conduct market survey	Market requirements and market segments identified and documented	May 2013	Completed.
				The market survey in POM included a survey of 356 households/consumers conducted in April 2013 and informant interviews of 25 institutional buyers and food services in May 2013.
				Survey results have been presented to FPDA staff (September 2013) and postharvest training workshops in Mt Hagen (August 2013), Goroka (March 2014), Mt Hagen (April 2015) and Goroka (May 2016).
				Two conference papers have been produced and were presented at IHC 14-18 August, 2014 in Brisbane, two at the International Conference on Agribusiness Economics and Management Conference in Davao, the Philippines, 22-24 Oct 2015, and one at the 2014 International Society for Southeast Asian Agricultural Sciences (ISSAAS) International Congress and Meeting, November 8-10, 2014, Tokyo, Japan.
				Results from the institutional buyers' survey showed that quality awareness was low and there were no quality checks along the supply chain. There is a need to provide postharvest training to raise awareness along the supply chain and to improve communication between supply chain players. Similar issues were raised at the FPDA Value Chain Forum in POM in March 2014.
				We also learned that volumes purchased by the formal market were small: supermarkets and catering services bought 3 bags/week and kai bars and international hotels, 1 bag/week. This means open markets are still the main outlets for sweetpotato. We have adjusting our quality standard work to reflect this.
1.5	Educate farmers and supply chain players on consumer preference and quality losses	Improved marketing information and understanding of key marketing issues; training workshops held	June 2016	Completed.
				Formal postharvest training/marketing workshops were held (March 2013, August 2013, March 2014, October 2014, and April 2015) to educate farmers on consumer preference and quality issues. Informal training was held in each village on every visit to the villages (Gusamp Kudjip, Kelua, Minj, Kukpa, Kindeng).
				There is increasing awareness of quality and marketability, especially amongst farmers in the Highlands and within supermarkets in POM.
				Farmers who practiced grading received positive feedback from consumers, and were able to sell their sweetpotato faster than otherwise.
				Information sheets outlining consumer preferences were produced and distributed to farmers in Gusamp village and to FPDA partners.

| 1.6 | Identify and evaluate market opportunities | Target markets identified | June 2016 (in conjunction with Objective 3.5) | Completed.

The POM buyer survey showed that volumes purchased by the formal market were small: supermarkets and catering services bought 3 bags/week.

These markets are difficult to access because they all seem to have their own "regular suppliers" who are wantoks of the shop.

However, volumes at the supermarkets may increase 2 to 3-fold if quality can be improved.

Several attempts were made to work with sweetpotato wholesalers in POM to grade and supply quality sweetpotato to Boroko Foodworld (BFW). However, no action from the wholesalers was forthcoming despite their interest and verbal agreement.

The research team resorted to grading and delivering three bags of good quality sweetpotato to BFW in April 2014. Market responses were positive. However, FPDA were unable to provide resources to allow us to determine appropriate grades and packaging for supermarkets. We also lost our key supermarket collaborator in BFW through death. This objective would be a valuable area for future research. |

PC = partner country, A = Australia

Objective 2: To improve quality outturn and reduce transit losses through the development of locally appropriate postharvest management practices

No.	Activity	Outputs/ Milestones	Completion date	Comments
2.1	Define marketability and develop quality standards	Minimum requirements and quality grades defined for different market segments; and key stakeholders consulted	April 2014	Completed. Several quality and marketability exercises were undertaken with FPDA and farmer groups (Mt Hagen, POM, and Goroka), and at villages in Jiwaka and WHP. At this point, marketable roots are those without rots or physical damage (e.g., cuts, rat bites, broken) and are of reasonable size (>100 mm). Three grades (L, M, S) are available. Supermarkets prefer medium size (150-250 mm long), while consumers usually prefer medium size, and catering services and larger group functions prefer larger sizes. The technical report 'Quality and Waste' consolidates the results reported in individual travel reports.
2.2	To assess buyers willingness to pay for quality	Willingness to pay quantified and documented	April 2014	Completed. Several 'willingness to pay' trials were undertaken along with the quality and marketability exercise discussed in 2.1. The trials involved farmer groups and traders who had little knowledge of formal markets. Consumer survey and formal trials in POM open markets showed quite conclusively that there was a demand for better quality sweetpotato. However, the willingness to pay results were very variable. This is due to weak market signals as sweetpotato is sold mostly by bags or in heaps. Results from the consumer survey are detailed in a conference paper prepared by Villano et al. The technical report 'Quality and waste' consolidates the results reported in individual travel reports.

2.3	Develop and trial locally appropriate curing solutions	Curing trials undertaken and optimum solutions identified and documented	April 2014	Completed.
				A literature review on sweetpotato curing has been distributed to team members.
				Small trials were undertaken in September 2013 to determine whether curing has occurred during transit and storage. The results were negative. Several quality/waste assessments in POM led us to conclude that curing is not necessary in the PNG context as in most cases: waste is low when sweetpotato arrives in POM, and sweetpotato is sold within 2 weeks and not stored over long periods.
				The technical report 'Curing Sweetpotato in Papua New Guinea – what, why, how, and is it necessary?' was prepared.
2.4	Identify locally appropriate packaging solutions	Packaging trials undertaken and optimum solutions identified and documented	April 2014	Completed.
				Similar to Activity 2.3 on curing solutions, quality/waste assessment also led us to conclude that current poly bags are appropriate for PNG conditions (where product is generally sold within 2 weeks of harvest) as long as cuts are avoided during harvesting, roots with rots and cuts are removed before packing, and bags are kept dry during transport and storage.
				As sweetpotato is harvested, transported, and paid for on a per bag basis now (and will be into the near future), any costs associated with changes in packaging may not be offset by improvements in quality or price.
				The technical report 'Quality and waste' consolidates the observations reported in individual travel reports.
2.5	Pilot test container load packaging/ coolchain trials	Pilot test done and product losses and economic returns assessed and quantified	April 2014	Terminated.
				Discussions have been held with major shipping companies in Lae (March and September 2013). They are not yet prepared to lease refrigerated containers to the Highlands. However, transport in chiller containers from the Highlands to Lae (loose or full container load) is available from transport companies. This issue was raised at the POM Value Chain Forum in March 2014, but results are unclear. There is need to consult with stakeholders and monitor development in the market.
				Sweetpotato is unlikely to be packaged for protection until transport is calculated by weight or volume rather than the current entrenched per bag method. Crop value is also probably too low compared with other higher value vegetables such as carrots, beans, capsicum, and cabbage that are more likely to benefit from a cool chain.

2.6	Mid-term review	Stakeholder workshop held	March 2014	Completed. Based on comments from the reviewers, further work has focused on extension and dissemination of research outputs to next users, i.e. extension officers at FPDA, NARI, Provincial DALs, and district offices, as well as VEWs and our lead farmer collaborators.

Objective 3: To improve uptake of postharvest technology

No.	Activity	Outputs/ milestones	Completion date	Comments
3.1	Understand socio-cultural and political contexts of behavioural changes	Key socio-cultural and political constraints to behavioural change identified and documented	Dec 2013	Completed. A literature review on PNG culture was completed and the implications incorporated into our work where appropriate. Opportunism and rent-seeking, and resulting distrust, appeared to be the major social-cultural constraint to establishing any meaningful long-term working relationships within the project and along the value chain.
3.2	Identify communication channels for extension	Social networks identified and documented	July 2014	Completed. Social mapping, led by Dr Lilly Sar, was conducted to in Kelua village in July 2014 to understand suppliers' networks of Joe Kold. This was based on the same analytical framework was used in the villages of Sibi and Gabensis in Morobe, for the ACIAR sweetpotato processing project. After initial comments, a second draft of this report was received in April 2015.
3.3	Provide training on postharvest technologies	Benefits from new technologies understood; training workshops held	May 2015	Completed. Six formal postharvest training workshops were held (March 2013, August 2013, March 2014, October 2014 (2 groups) and May 2015) to educate farmers and traders on quality issues. There is increasing awareness of quality and marketability, especially in Minj. Farmers who practiced grading claimed that they received positive feedback from customers, and were able to sell their sweetpotato faster than before. Postharvest quality training was delivered to supermarket managers specialising in fresh vegetables in Port Moresby in April and October 2015, in order to improve product presentation and sales. This was to become a regular activity of FPDA after project completion. Three information sheets on postharvest to improve quality were produced and distributed to farmers in Gusamp village and to FPDA partners.

3.4	Involve local communities in the dissemination of technology	Sweetpotato Fairs held, with the support of local governments; events held	June 2016	Completed.
				Three information sheets on consumer preference, marketing strategies and marketing options (through a gross margin analysis) were distributed to workshop participants of the extension forum held in Mt Hagen in April 2015.
				At the extension forum, extension models and GMA were discussed with extension staff from FPDA, NARI, Provincial DALs, and district offices, as well as VEWs and our lead farmer collaborators. Subsequently, the farmer field/business school approach to learning about GMA was trialled with Agnes's group in Gusamp village. Two groups have completed the exercise, and useful data on cost of production and yield of sweetpotato were collected.
				There is significant interest from other groups in the training. We are hoping that FPDA will adopt the approach for their VEW program and continue the good work.
				In collaboration with the Jiwaka provincial government, a sweetpotato fair was held in the provincial HQ in October 2014 to celebrate World Food Day and to promote our project and research outputs.
3.5	Link farmers to selected market segments	New supply chains developed and initial shipments to target markets occurred	June 2016	Completed.
				Attempts were made to link Joe Kold, Rocky Aino, John Kewa and Thomas Soles to Boroko Foodworld (BFW), but without success. Basically, farmers' quality perceptions are so different from market demand, it will take time and a lot of convincing, as well as large enough price premiums to change perceptions and traditional practices.
				Although there is demand for quality sweetpotato, farmers are likely to continue supplying the informal market and continue to employ the same marketing and postharvest practices until the formal market for fresh produce has become mainstream.
				We liaised with BFW manager over several trips to run some trials in store using quality sweetpotato. The loss of our key supermarket collaborator in BFW through death was a major blow as these relationships are difficult to build on quickly.

Objective 4: To assess the social impacts of proposed interventions on smallholder farmers and their communities

No.	Activity	Outputs/ milestones	Completion date	Comments
4.1	Identify impact pathways and constraints	Baseline data collected (Output of Activity 1.3) logic model and impact evaluations plans developed.	March 2013	Completed. A farm household survey to collect baseline data was conducted in December 2012. A participatory impact pathways analysis workshop was conducted in March 2013 in Mt Hagen.
4.2	Measure changes in income and poverty levels	Indicators for poverty reduction developed; endline data collected and impact analysed.	June 2016	Incomplete. A self-assessment poverty indicator, based on a multi-dimensional measure of poverty was generated. Changes in income levels were not assessed due to absence of endline data. There was some difficulty in obtaining accurate information with regards to income, particularly for produce used for home consumption. Nevertheless, information regarding different sources of "cash" income were obtained.
4.3	Measure changes in women's empowerment	Indicators for empowerment developed; endline data collected and analysed	June 2016	Incomplete. An empowerment indicator was developed from the farm survey conducted in Dec 2012 and determinants of gender roles and empowerment at the household level were obtained. A manuscript entitled "Gender Participation and Women Empowerment in Sweet Potato Farming in Papua New Guinea" by Villano, Chakma and Chang has been submitted for publication.

Objective 5: To improve sweetpotato supply chains and uptake of technology in Australia

No.	Activity	Outputs/ milestones	Completion date	Comments
5.1	Map sweetpotato supply chains in NSW and QLD	Supply chains in NSW and QLD surveyed and documented	Dec 2013 (revised to Dec 2014)	Completed. Stakeholder consultation with NSW sweetpotato farmers was conducted in August 2013, followed by a farm survey in November 2014. Sweetpotato wholesalers in Sydney and Melbourne Markets were interviewed in Dec 2013 and Jan 2014, respectively. Results from the farm and market surveys were presented to the Cudgen group in August 2014. A Queensland survey was not completed as it was beyond the mandate of NSW DPI.
5.2	Select supply chains for case studies	Opportunities and constraints identified and documented	Terminated	Incomplete. Discussions with NSW suppliers and sellers and our analysis suggested the markets were well matured and the supply chain was short and efficient, whether via wholesalers or not. The majority of supply chain players were happy with the current marketing arrangements with their buyers and returns on investment, and productivity of the predominant variety 'Beauregard' (80% of the market share). We saw no need for further case studies in NSW or QLD.
5.3	Conduct feasibility study	Opportunities and constraints identified and policy recommendations provided; report written	June 2015	Completed. Production trials by NSW DPI (Roberto Marques) were completed in April 2015, and the report was delivered.

7 Key results and discussion

Key results and discussion are provided for the following activities:

- Farm household survey;
- Consumer survey;
- Matching demand and supply;
- Define marketability/grades;
- Assess quality and product losses;
- Training on postharvest management and marketing;
- Training and capacity building on business skills using gross margin analysis; and
- Assessment of the agronomic potential for sweetpotato production in the NSW Riverina.

7.1 Farm household survey

The survey was conducted in selected districts and villages of Jiwaka province[1] (Figure 1).
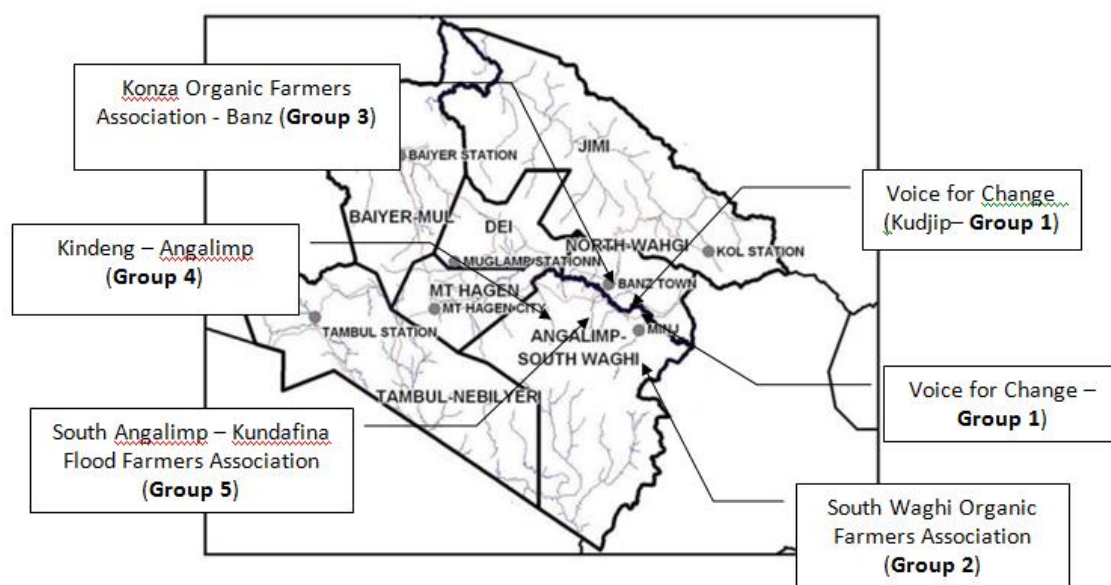
Figure 1. Location of survey groups and respondents within Jiwaka province

Overall, 186 respondents from 5 groups/locations were interviewed (Table 2). The sample was divided into farmers taking part in the project and those who were not, allowing impact assessment to be conducted at the end of the project to determine whether the project had achieved its goals in changing postharvest and marketing practices, by comparing participating and non-participating farmers.

Table 2. Respondent groups—farm household survey

	Group number				
	1	*2*	*3*	*4*	*5*
Name of group	Voice for Change	South Wahgi Organic Farmers Association	Konza Organic Farmers Association	Village extension worker (VEW) group	Kundafina Flood Farmers Association
Location	Kukpa and Kudjip	Minj	Banz	Kindeng	Wahgi Flat
Number of respondents	77	49	24	17	19

The semi-structured survey questionnaire covered the following topics:

- socio-demographics of the farm households—age, gender, education and role in sweetpotato production and marketing of household members;

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[1]*The areas comprising the current Jiwaka province were part of Western Highlands province until May 2012, when it was officially recognised.*

- production activities and decision-making—landholdings and tenure, garden size, share of sweetpotato production compared with other crops, and varieties of sweetpotato grown and their characteristics;

- postharvest activities—practices regarding curing, packaging and storage of sweetpotato;

- product utilisation and marketing—share of sweetpotato grown/used for home consumption, animal feed and markets, market outlets, and pros and cons of different selling methods;

- finance—income sources, assets, expenditures and access to credit;

- access to basic services;

- access to training and extension—group membership, training received and training needs; and

- self-assessment of wellbeing—degree and source of happiness, and areas of dissatisfaction and for future improvement.

7.1.1 Socio-demographics

Of the total of 186 respondents, those in Groups 1 and 2 (77 and 49 respondents, respectively) formed the target groups, while Groups 3, 4 and 5 (24, 17 and 19 respondents, respectively) formed the 'control' groups. The number of respondents differs between groups because of the varying degrees of importance of sweetpotato marketing to their income activities, and due to the difficulty in reaching farmers in more remote areas. Overall, 64% of the respondents are female, with Groups 1, 2 and 4 having over 70% female respondents (Table 3). This was intentional, as the project was interested in empowering women in our target groups (Groups 1 and 2), with Group 4 serving as a control group.

Overall, 37% of respondents were illiterate, with between-group differences varying from 18% in Group 4 to 47% in Group 2 (Table 3). Some 20% of all respondents attended high school and 2% attended college/university. Group 4 was most educated while Group 2 was least educated. The level of education is important for the selection of trainers/facilitators at the village level and the design of extension and training methods and materials. Our previous experience has shown that farmers with Grade 9 and above are easier to work with because there is no language barrier between farmers and the research team, and hence communication can be direct and two-way. For farmers who are less educated, there is a need for translation, which tends to result in loss of information and, at times, misinformation and distortion. Therefore, the effectiveness of training and extension programs depends crucially on selection and capacity building of the appropriate people to act as trainers/facilitators on the ground.

Table 3. Demographic characteristics of respondents and households

Item	Group number					Total
	1	*2*	*3*	*4*	*5*	
Number of respondents	**77**	**49**	**24**	**17**	**19**	**186**
Gender (%)						
Male	25	24	71	29	74	36
Female	75	76	29	71	26	64
Education (%)						
Nil	36	47	38	18	26	37
Grade 1–4	10	8	21	18	21	13
Grade 5–8	35	24	17	24	32	28
Grade 9–12	18	18	25	35	16	20
College/university	0	2	0	6	5	2
Engagement in production/marketing (%)						
Male engaged in production	58	47	51	61	51	55
Male engaged in marketing	20	36	34	36	28	28
Female engaged in production	70	66	71	66	60	68
Female engaged in marketing	63	61	67	61	55	62

Overall, 55% and 28% of the male household members were engaged in sweetpotato production and marketing, respectively (Table 3). By contrast, 68% and 62% of the female household members are engaged in sweetpotato production and marketing, respectively. These figures are consistent across groups. They highlight the importance and role of women in the sweetpotato supply chain in the PNG highlands, as well as the need to focus research and training activities for postharvest and marketing on women.

7.1.2 Landholding and land-use patterns

In all, half the respondents owned their cultivated land, while 39% were cultivating customary land (Table 4). However, there were differences across the groups. While 67% and 76% of respondents in Groups 2 and 5, respectively, claimed to own the land they cultivate, this was only the case for 34% of respondents in Group 1. The overall high level of private land ownership, if true, is an important development, as customary land tenure was said to have hampered commercial activities and economic development in PNG.

As it was difficult to obtain an accurate measure of farm size, we recorded the size of gardens based on farmer estimates. Farms were relatively small: 54% of respondents had land area under 1 hectare (ha), 23% had land area of 1–2 ha, and 24% had over 2 ha (Table 4). About two-thirds of respondents were growing crops other than sweetpotato (data not shown), such as corn, banana, peanut and vegetables, for both home consumption and cash income. The main cash crop was coffee.

Sweetpotato production was the most important crop for the respondents, grown both for home consumption and marketing. Overall, 46% of total area cultivated was planted to

sweetpotato. The highest proportions were in Groups 1 and 2, with nearly 50% of the land planted to sweetpotato (Table 4). The average number of sweetpotato gardens was 2.6 per farmer (Table 4).

Table 4. Landholding and land-use (% of respondents)

Item	Group number					
	1	2	3	4	5	Average
Size of landholding (%)						
Up to 0.1 ha	14	2	0	12	0	8
>0.1–0.5 ha	30	12	17	18	16	21
>0.5–1.0 ha	26	22	17	29	32	25
>1.0–2.0 ha	13	31	38	6	42	23
>2.0 ha	17	33	29	35	11	24
Total[a]	100	100	100	100	100	100
Land tenure status (%)						
Owned	34	67	43	59	76	50
Customary land	61	27	39	6	6	39
Relatives	3	4	13	0	0	2
Rented/other	2	2	4	35	18	9
Total[a]	100	100	100	100	100	100
% of area under sweetpotato	**50**	**52**	**40**	**31**	**35**	**46**
Average no. of SP gardens per household	**2.5**	**2.8**	**2.4**	**3.1**	**2.1**	**2.6**

[a] Total may not equal the sum of the column due to rounding.

7.1.3 Varietal choice and preferences

In the majority of villages, approximately 30% of respondents grew four varieties of sweetpotato, with a range of one to six varieties per household (Table 5). About 36 varieties were named distinctly by farmers, with the most preferred being Wahgi Besta (preferred by 74% of farmers), Sugar (14%) and Rachael (8%) (Table 5). The most preferred variety for Groups 1, 2 and 3 was Wahgi Besta, whereas Sugar was most preferred by Group 4, and for Group 5, Wahgi Besta and Sugar were equally preferred.

A farmer's decision to grow these varieties was influenced by several factors, including the growing duration, purpose and their perceptions of the quality of each variety. The growing duration of these varieties ranged from 3 to 6 months. Among the most commonly grown varieties, 18% of the respondents were growing Wahgi Besta specifically for the market, while 13% indicated that they grew the Sugar variety for home consumption. These results show that most farmers did not grow sweetpotato specifically for the market. Instead, farmers tended to sell what they have grown. This is an indication of a production/supply orientation, as opposed to a customer/market orientation whereby varietal selection is based on market demand.

Table 5. Varietal use in sweetpotato production by respondents

Item	Group number					Average
	1	2	3	4	5	
Number of varieties grown	1–6	1–6	2–5	2–6	2–6	1–6
Most preferred varieties (% farmers preferring)						
Wahgi Besta	83	98	63	12	42	74
Rachael	7		17	24	5	8
Sugar	4		17	59	42	14
Other	7	2	4	6	11	5

Perceived varietal attributes

Respondent perceptions of desirable and undesirable traits of the varieties they grew are included in Table 6. Good eating quality, yield performance, market price, early maturing, and resistance to pests and diseases were some of the most common reasons for selecting those varieties. Some morphological attributes were also mentioned, including colour of the skin and the flesh. 39% and 32% of respondents indicated that these varieties were easy to handle and travel well to long-distance markets, respectively.

Table 6. Perceptions on attributes of sweetpotato varieties (% of respondents)

Attribute	Sweetpotato variety				All varieties (average %)
	Wahgi Besta	Rachael	Sugar	Other	
Good eating quality	99	100	100	78	99
Yield performance	91	86	76	56	88
Price on the market	85	79	68	67	83
Colour of the skin	83	57	72	67	80
Colour of the flesh	80	50	72	78	77
Early maturing	55	57	20	11	48
Easy to harvest and store	50	14	8	0	39
Resistant to pests and diseases	39	21	36	11	35
Travel well	37	21	16	11	32
Other	17	7	20	11	16

7.1.4 Postharvest practices

Curing

Curing extends the storage life of sweetpotato, and is a physiological process that requires defined conditions (28–30 °C and 85–95% relative humidity for 5–7 days) in order to inhibit disease and repair damaged skin.
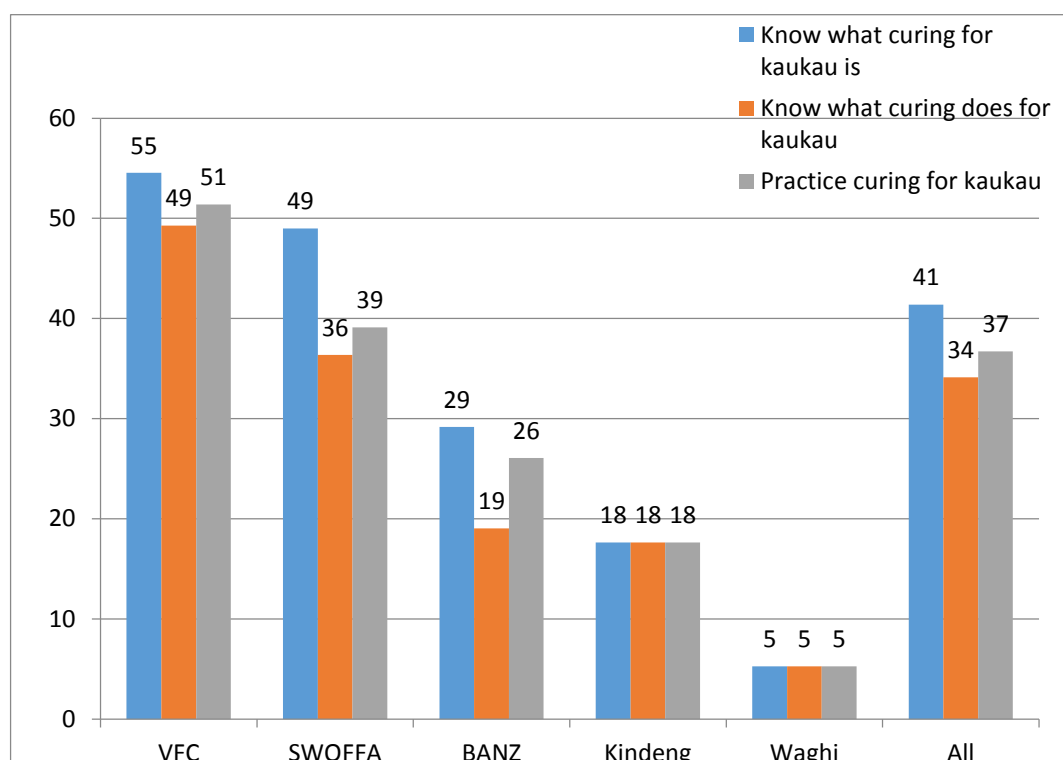
Figure 2. Knowledge and practice of curing (% of respondents)

Respondents were asked about their knowledge, perceptions and practices of sweetpotato harvesting and postharvest activities. Of the total respondents interviewed, 41% indicated they knew what sweetpotato curing was, 34% knew what curing does for sweetpotato and 37% said that they practiced curing (Figure 2).

In discussing actual practices with the farmers, it seemed that what they thought of as 'curing' did not actually resulting in curing the sweetpotato produce. Their practices included:

- leaving sweetpotato to mature in the field longer (84% of respondents; Figure 3), which produces stronger and sweeter roots with thicker skin, but only appears to be carried out as a consequence of delayed harvest and lower dry matter, possibly after vine deterioration;
- letting the sweetpotato dry on the ground after harvest for 4–5 hours (18% of respondents); and
- removing the tops (vines) about 7 days before harvest (18% of respondents), potentially resulting in some in-ground curing producing a tougher skin, but whether curing has occurred has not been determined objectively. This practice is used by Australian sweetpotato farmers.

However, from periodic observations of highlands sweetpotato in Port Moresby, there was no indication that curing has occurred. A simple stain test is available, and could be developed and utilised to determine the presence of curing (e.g. van Oirschot et al. 2006).
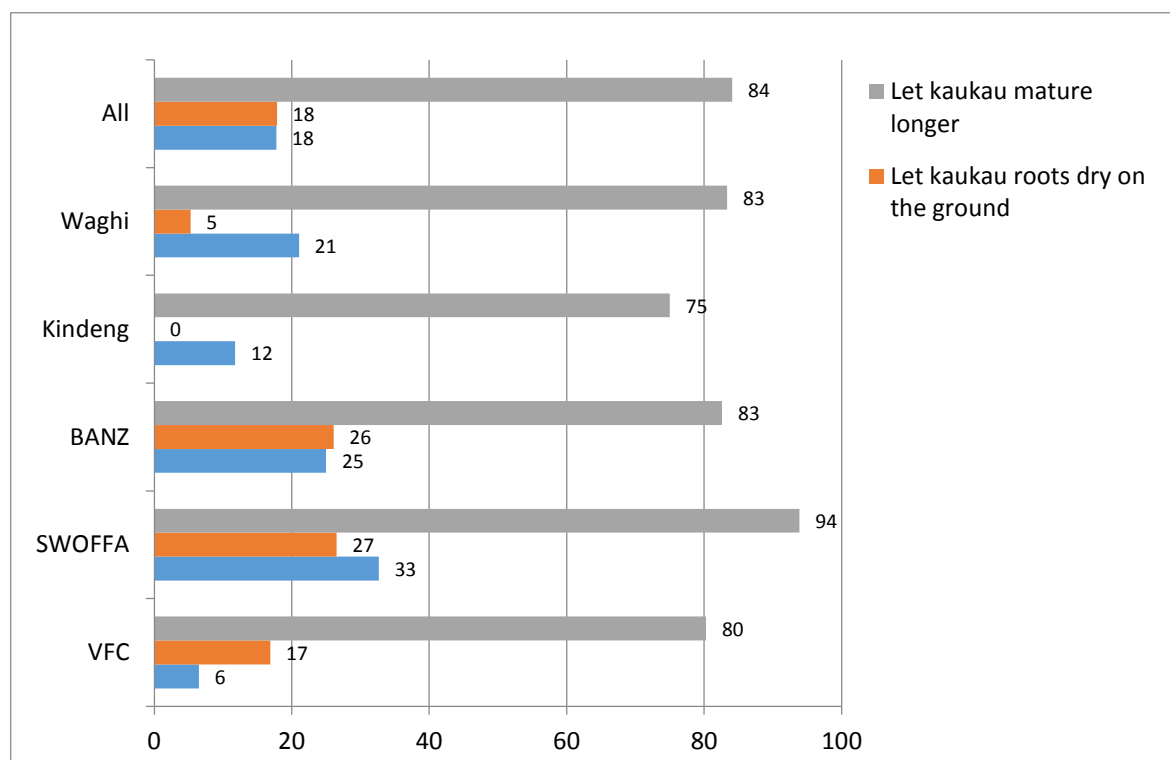
Figure 3. Practices of farmers undertook in 'curing' sweetpotato (% of respondents)

Despite the lack of curing, we observed very low disease incidence sweetpotato in Port Moresby, despite prolonged storage in hot, damp conditions during transit. However, this could be further reduced by taking more care at or prior to harvest (where digging-stick/shovel damage may introduce disease), and by removing diseased roots before packing.

Packaging

The majority of farmers used polyethylene bags to pack their produce and have expressed satisfaction with their current packing materials because they were cheap, readily available and convenient. However, overpacked polyethylene bags are known to result in rots, skin damage and breakage of roots because they reduce evaporation of free water, and can become too heavy to handle. A small percentage (around 20%) of farmers expressed discontent with the use of polyethylene bags and indicated their willingness to change, especially if other packaging materials are as strong as polyethylene bags, allow good airflow to reduce free water accumulation, and are of reasonable size and easy to carry (Table 7).

Table 7. Conditions under which farmers would be willing to change their packaging materials (% of respondents)

Condition	Group number					All
	1	*2*	*3*	*4*	*5*	
If selling to long-distance markets	12	2	16	19	15	9
If there is more produce (increase in production)	27	6	0	0	0	13
Availability of other packaging materials [a]	7	32	52	19	15	20
If there is access to own transport	1	9	0	19	10	6
If made aware of new packaging materials	9	6	28	38	40	18

[a] Packaging materials that are strong enough, permits airflow to reduce free water accumulation, are a reasonable size, and are easy to carry.

Quality and quality attributes

Respondents demonstrated an appreciation of the importance of selling good-quality sweetpotato. Approximately 62% of respondents (Table 8) indicated grading and sorting sweetpotato before packing and/or at the market. In most cases, sweetpotato was sorted according to colour, size and shape. Most farmers relied on their own experience and knowledge to sort or grade sweetpotato. While grading and sorting were said to be the most common practices undertaken to ensure meeting quality requirements of consumers, around 33% of respondents nominated proper postharvest handling (washing and packing) and 24% indicated choosing the appropriate variety to be important in this respect. While 78% of respondents believed that the quality of sweetpotato was important for both consumers and farmers (producers), 16% indicated that quality was only important to consumers.

Table 8. Perceptions on quality of sweetpotato (% of respondents)

Item	Group number					Average of all Groups
	1	2	3	4	5	
Basis for sorting						
Colour	73	83	48	47	47	67
Size	99	100	100	100	100	100
Shape	85	92	83	77	89	86
Other	3	2	17	29	37	11
Source of information about grading						
Own experience	97	95	100	94	89	96
FPDA[a] workers	3	13	0	0	5	5
Traders and buyers	2	6	0	0	5	3
Other	2	2	4	12	11	4
Perceptions as for whom quality of sweetpotato is important						
Consumer only	41	6	0	0	0	16
Consumer and producer	48	94	96	82	100	78
Actions taken to ensure good quality sweetpotato						
Choosing the variety	21	33	25	12	21	24
Grading and sorting	52	57	83	71	79	62
Handling[b]	38	43	21	24	16	33
Presentation[c]	7	2	0	6	5	4
Harvesting on time	3	4	4	0	0	3

[a] FPDA = Fresh Produce Development Agency
[b] Proper postharvest handling (washing and packing)
[c] Presentation when selling (big heaps, clean)

The results from Table 8 are most surprising because, while most respondents claimed to have sorted and graded sweetpotato to ensure good quality, this was not what we observed at the market. The discrepancy could be a result of a lack of commonly accepted quality standards. Therefore, the standards used by the farmers could be different or much lower than what were considered to be acceptable by the research team. The development of locally appropriate quality standards, through the marketability and grading trials to define quality (as discussed below), was a key objective of this project.

Product losses

Product losses are an ongoing problem in sweetpotato marketing. The most common causes of product loss for respondents selling at long-distance markets included skin damage, broken roots, water loss and rots (Table 9). By comparison, the most common causes of product losses at local markets included skin damage, broken roots, oversupply, rots, wrong skin/flesh colour, as well as produce being too small or of mixed sizes (Table 9). These results indicate that the local market was more discriminating mainly because of an ample supply of freshly harvested sweetpoato at the local market, consumers therefore have much more choices than their city counterparts and can more easily reject or accept what is on offer.

Table 9. Perceptions of causes of product loss (% of respondents)

Cause	Farmers who sell at:	
	long-distance markets	local markets
Wrong cultivar	19	12
Too big	19	18
Too small	19	35
Mixed sizes	22	32
Rots	33	45
Insect/rat damage	22	30
Wrong skin/flesh colour	15	45
Broken roots	41	51
Skin damage	44	59
Water loss	33	18
Sprouting	11	20
Oversupply	19	49

7.1.5 Marketing practices

Overall, approximately 61% of the total sweetpotato produced by a farm household was sold. The majority of respondents reported that the remaining sweetpotato was used for home consumption, animal feed, or exchanged and given to friends and relatives.

On average, 32% of farmers surveyed were planting sweetpotato with the intention of taking the crop to the market. More than 50% of farmers in Group 2 (mostly members of the South Waghi Organic Farmers Association) were engaged in planting-for-marketing (Figure 4). Farmers in other groups also sold sweetpotato, but mainly for meeting immediate cash needs of their household.
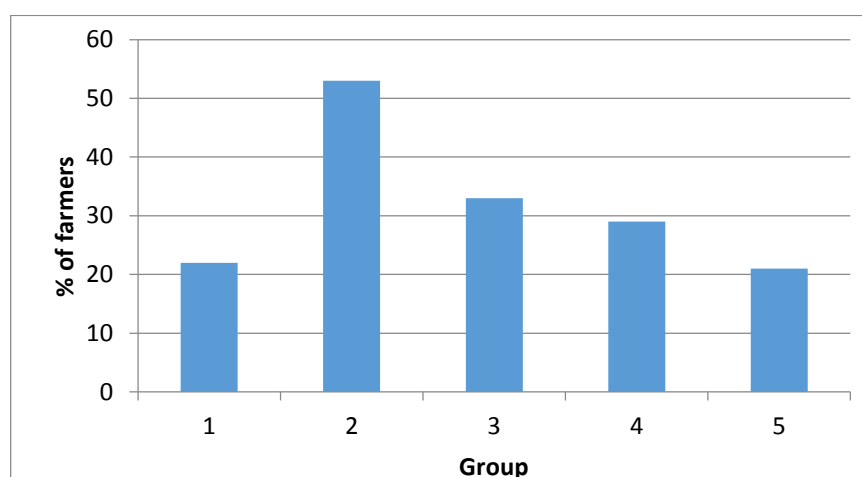
Figure 4. Percentage of farmers planting sweetpotato specifically for sale

Market options

In general terms, farmers have four options for selling sweetpotato, including direct marketing to final consumers, selling to intermediaries, selling at local markets, and selling at distant markets. It is likely that some farmers use several different combinations of these basic options. 15% of respondents have sold at long distance markets and 89% have sold

at local markets (Table 10). 89% have sold at the open markets and 20% have sold through traders and other buyers such as catering services, supermarkets, restaurants, hotels.

Comparing across the sample, the highest proportion of farmers engaged in long distance marketing were those from Group 2 (29%) and Group 5 (32%), while from Group 1 only 1% undertook long distance marketing. Similarly for selling sweetpotato to traders. The proportions of farmers selling at the local markets or at the open markets was similar between groups, indicating that open markets in the local areas offer a quick option for farmers to sell their produce due to their accessibility, and because of the small volume of produce for sale.

Table 10. Marketing options for sweetpotato

	Group (% of respondents)					
Item	*1*	*2*	*3*	*4*	*5*	*All*
No. of respondents	77	49	24	17	19	186
Selling at long distant markets						
Yes	1	29	13	18	32	15
No	99	71	88	82	63	85
Selling at local markets*						
Yes	92	90	92	82	74	89
No	1	10	8	18	21	8
Selling at open market						
Yes	92	88	88	82	84	89
No	8	12	13	18	16	11
Selling at traders/other buyers*						
Yes	8	43	17	12	26	20
No	90	55	83	82	68	77

*Three percent of the interviewees did not answer either of these two questions.

Long distance marketing

In total, 27 surveyed farmers were engaged in long distance marketing. Two farmers were selling to Port Moresby, eight to Lae and 17 to other destinations, such as Madang, Wewak and other islands. When taking their produce to long distance markets, 85% sold at the open markets, and the rest to traders and other buyers (Table 11). The majority of sweetpotato was sold by bags or in heaps, with only 4% being sold in kilogram. Farmers were asked about the benefits of selling at long distance markets. Higher prices were the main motivation (55%), followed by an oversupply at the local market (18%), higher demand (15%) and fast sale (13%). The most common difficulty encountered in selling to the long distance markets was the high cost of transportation (43%), followed by lack of funds and resources (17%), insufficient volume (13%) and product losses (10%). 40% of the respondents selling to the long distance markets said that they have experienced product losses. The risk associated with product loss, quality loss, accident, stealing and difficulty in transporting was another setback when selling to long distance markets (8%). Farmers also incurred additional costs to meet logistical requirements. On average, three members of the family travelled to the markets. These would either stay with relatives/friends and church members, or in paid accommodation.

Table 11. Features of selling at long distance markets

Item	No. of responses	% of responses
Place where selling		
Port Moresby	2	7
Lae	8	30
Others*	17	63
Outlet at long distance markets		
Open Market	23	89
Traders/other buyers	3	11
Reasons for selling at long distance markets		
Price is higher/good income	22	55
Oversupply in local market	7	18
Demand is high	6	15
Fast sales	5	13
Problems associated with selling at long distance markets		
Cost of transportation	26	43
Lack of finance/funds	10	17
Lack of labour	5	8
Lack of produce	8	13
Risk - accident, stealing	5	8
Product loss	6	10
Methods of selling at long distance markets		
By bag	7	27
By heaps	7	27
By kilogram	1	4
Bag and heaps	10	38
Heaps and kilogram	1	4
Whether quality loss experienced		
Yes	11	41
No	16	59

Local marketing

Nearly all farmers (95%) used the open market as their main sales outlet, with 1% selling to traders. 4% have used both outlets. When farmers sold to the local market, 89% of farmers sold within their village, 13% sold at the district market, 5% sold at the provincial market in Hagen (Table 12).[2]

Proximity and accessibility were the main reasons for selling at the local markets (56%). Farmers (58%) also believed that having regular customers (friends and wantoks) made it easier to sell their produce. Some women indicated that they felt safe selling at the local markets. On the other hand, more than 50% of farmers indicated that too much competition, oversupply, and hence insufficient numbers of buyers were the main concerns associated with selling at village and district markets. This in turn implies a lower income from selling at these markets, an issue reported by almost 19% of farmers. Lack of law and order at

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[2] *The numbers add up to more than 100% because one farmer can sell at more than one outlets, as is often the case.*

local markets, associated with disturbances due to tribal fights and drunkenness, as well as roaming pigs, were additional concerns.

Table 12. Features of selling at local markets

Item	Group (% of responses)					
	1	2	3	4	5	All
Place where selling						
Village	100	84	77	93	57	89
District market	3	23	18		36	13
Hagen market	6	3		14	7	5
Others	4	5	14		7	6
Outlet						
Open market	100	87	89	100	100	95
Traders/Buyers		3				1
Both		10	11			4
Reasons for selling at local market						
Low cost and accessibility	54	66	59	36	57	56
Easy to sell/quick money	49	50	59	93	86	58
Good price	1	2	9	14	7	4
Regular customers [a]	10	11	9	7		9
Small volume	4	2	5			3
Safety of women	7	11				6
Less quality loss		5				1
Problems associated in selling at local market						
Low income [b]	16	11	23	36	36	19
Oversupply/too much competition	47	36	9	43	57	39
Market fee	21	5		7		11
Disturbances [c]	27	25	14	7	14	22
Transport	4	7	23	7	7	8
Lack of buyers/takes time to sell	18	11	9	29	21	16

[a] Friends and wantoks living nearby are regular customers.

[b] Low price, too much bargaining

[c] Due to tribal fight, stealing, pigs, drunkards and death in village

Direct marketing -- selling at the open market

We asked farmers to indicate their reasons for selling at the open market (as opposed to selling to traders), as well as associated problems. The results are summarised in Table 13. Most farmers indicated that accessibility (that is, ease of sale and ability to receive an income quickly) was the main reason for selling at the open market. In the local market, they also indicated that high demand and low marketing costs were also desirable factors. While 18% of farmers believed that the price they received on the open market was good, 68% indicated that low prices, associated with oversupply, excessive competition and bargaining, and availability of the same variety at the same time, was the main problem

associated with selling on the open market. Market fees and disturbances were also reported as problems, by 19% and 21% of respondents, respectively.

Table 13. Reasons and problems of selling at the open markets

Item	Groups (% of responses)					
	1	2	3	4	5	All
Advantages						
Demand is high	51	54	14	36	31	44
Easy to sell/quick Money	59	51	67	93	94	64
Good Price/Income	10	23	38	7	25	18
Low cost/save money	24	28	48	21	19	27
Easily check price	3	12	14	14	0	7
Safe/less risk	9	12	10	14	19	11
Disadvantages						
Low price*	78	56	48	71	81	68
Disturbances	27	19	5	14	31	21
Weather	11	2	5		19	8
Gate fee	25	19	24		6	19
Inconvenient**	1	26	24	29	13	13

* Oversupply, competition, and same variety in the market

** Produce that was not sold at once incur loss, and was hard to carry back home

Indirect marketing -- selling to traders

Farmers were asked to provide further details of their transactions with traders or other buyers. At the time of the survey, 38 farmers were engaged in selling to traders and buyers. As shown in Table 14, farmers believed that some of the benefits of selling to traders and buyers included: having certainty that they had a particular buyer (66%); receiving cash payment (37%); lower transportation costs associated with produce being picked-up by the buyer (18%); and the option to buy and sell produce at the same time (24%). However, some of the drawbacks in dealing with traders included the uncertainty of looking for a buyer (24%), and farmers not having the power to dictate price (26%). 14% of respondents in Group 2, which included the largest proportion of farmers selling to traders, indicated the problem of not meeting the quality requirements set forth by buyers, and 10% of respondents indicated that traders could not be trusted.

For farmers who were selling to traders, they indicated a long-term business relationship. The average length of period of transaction with the main traders was 4 years. Certainty and prompt payment (47%), relatively good price (32%), certainty of price (29%) and prompt payment (26%) were the main reasons for choosing a buyer (Table 14).

Table 14. Transaction details with sweetpotato traders and buyers

Item	Groups (% of responses)					
	1	*2*	*3*	*4*	*5*	*All*
No. of selling to traders/buyer	6	21	4	2	5	38
Average no. of years selling to buyer	2.0	4.9	5.0	2.3	3.0	4.0
Benefits of selling to trader/buyer						
Save transport cost/pick-up	33	19		50		18
Cash money	33	48	50			37
Certainty of buyer/sell fast	33	67	100	100	60	66
Buy/sell at the same time	33	29		50	20	24
Good price					40	5
Problems with selling to trader/buyer						
Uncertainty of buyer	33	29		50	40	24
Too much bargaining	17	38	50	50	40	26
Did not meet quality requirement	17	14				8
Not enough to sell	33	5				5
Buyers cannot be trusted		10				5
Reason for the main trader/buyer						
Certainty of payment	17	52	50	100	40	47
Good price	33	29		50	60	32
Certainty of prices	17	33	25		40	29
Prompt payment	50	10	50		60	26
Family relationship		5		50		5

Table 15 shows that 92% of farmers were satisfied with transactions with their trader. 48% of farmers said there was alternative buyers whom they could sell to. In fact, over the last five years, 66% of farmers indicated that they had changed traders more than two times. Buyers went out of business was the main reason behind the switch to other buyers (49%), as well as inadequate prices (20%).

Transactions with traders come with conditions, which may be detrimental or favourable to farmers. Some 59% of farmers indicated that their produce was picked up by their trader, and they were paid cash (93%). While 80% of farmers were able to bargain on price, they also have to meet quality requirements imposed by buyers. About 88% of respondents said that buyers had specific requirements, and 95% of farmers said they were able to meet those specifications. If produce did not meet quality requirements, the most common fall-back position was then to sell at the open market (53%), followed by finding another buyer (28%).

Table 15. Relationships between sweetpotato farmers and traders/buyers

Item	% of responses
Satisfaction with buyer	
Always	31
Often	61
Seldom	8
Opportunity to sell to other buyers	
Yes	48
Number of times buyer was changed in the last five years	
1 to 2 times	34
More than 2	66
Main reason for changing buyers	
Inadequate price	20
Uncertain payment	9
Buyer went out of business	49
Others	23
How sweetpotato was delivered	
Picked up	59
Delivered	10
Rental car/PMV/Trucking	31
Mode of payment	
Cash	93
Ability to bargain	80
Traders have quality requirement (% Yes)	88
Ability to meet quality requirements	95
Options if quality requirements are not met	
Find another buyer	28
Sell in open market	53
Others	13

Market information

Most farmers (48%) obtained price information from other farmers, while 47% indicated no other source of price information but themselves (Table 16).

Table 16. Source of information on the price of sweetpotato (% of responses)

Source	Groups					
	1	2	3	4	5	All
Extension workers		7				2
Village buyers	3	5				3
Wholesalers			5			1
Other Farmers	25	59	50	100	75	48
Nowhere	72	30	45		25	47

In this survey, we also wanted to know whether price information is readily available, how prices are arrived at and whether farmers have a say on the prices received. Nearly half of the respondents disagreed that price information on sweetpotato was easily accessible (second row, Table 17). Farmers considered price to be an important factor, regardless of whether a contract was in place, or whether they knew to which buyer their harvest was destined. While some farmers believed the prices received by farmers were low, same percentage of farmers disagreed. Although more than half of the farmers interviewed did

not know whether the prices received by middlemen were sufficient (in relation to the services provided), but believed that middlemen could not be trusted. Nearly 60% of farmers interviewed disagreed with the statement that produce be sold to a single buyer only. These results confirm that price information is important to farmers in sweetpotato marketing so they can make informed decisions on what to produce and where to sell.

Table 17. Perceptions on key market variables

	Strongly disagree	*Disagree*	*Agree*	*Strongly agree*
Price information is easy to get	7.1	38.3	42.6	9.8
Farmer have no power to decide the price	24.6	51.9	19.1	4.4
Price would be less important if farmers have a production contract	13.7	38.3	26.8	5.5
Price is less important if they know all of the harvest is going to buyer	15.3	41.5	20.2	7.7
The price received by farmers is low.	3.3	33.5	30.2	6.0
The price is sufficient for middleman.	3.4	24.6	13.4	2.8
It is better to sell our produce to a single buyer.	7.9	50.6	12.9	5.6
Middlemen cannot be trusted.	7.9	6.2	32.2	23.2

7.1.6 Household income

Household income is defined as the value of all goods and services accruing to a farm household from farming, off-farm and non-farm activities, as well as other sources of income such as pensions and/or remittances from relatives. Farmers were asked to name their major sources of income. As shown in Table 18, more than 75% of farmers named crop farming to be the main source of income, supplemented by incomes from livestock and poultry. A small proportion of farmers indicated other sources of income (eg off-farm employment and trade store) to support their household.

Table 18. Major sources of income

Sources	Group (% of responses)					
	1	*2*	*3*	*4*	*5*	*All*
Crop Farming	87	65	67	88	79	78
Livestock	6	27	21	12	16	15
Others*	6	8	13	0	5	7
Total	100	100	100	100	100	100
* Employment, trade store, remittances, and pensions.						

Breakdowns of household income

As there was difficulty in valuing produce used for home consumption, we present the cash income accruing to each household. Table 19 presents a more detailed picture of income from different sources. The average household cash income at the time of the survey (2012) was K5,190[3] per household, ranging from K3,520 for Group 1 to K8,915 for Group 5. The highest cash income per household was in Groups 4 and 5, which showed a more

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[3] *A PNG Kina is equivalent to AUS$0.45.*

diversified farm operation and income source, and with the sale of coffee being a significant income source. Income from livestock and poultry was also considerable for Groups 1 and 2, which had lower overall incomes.

Table 19. Average income and income sources, in Kina/household

Item	Group					
	1	*2*	*3*	*4*	*5*	*All*
Sweetpotato	403	2158	1769	1053	2155	1280
Coffee	556	552	778	1929	2821	936
Fruits and Vegetables	336	850	672	1224	1641	719
Livestock - pig/poultry	1018	1427	890	982	1993	1206
Trade store	716	313	292	647	53	482
Others*	491	662	880	546	252	567
Total	3520	5960	5281	6381	8915	5190

* Include employment, remittances, and pensions.

Distribution of average income for a household is presented in Figure 5. In general, 25% of cash income came from sweetpotato production, closely followed by sale of livestock and poultry (23%). Coffee and fruits and vegetables contributed 18% and 14%, respectively, to the total household income. The remaining 9% came from operating a trade store and 11% from off-farm employment, remittances, and pensions.
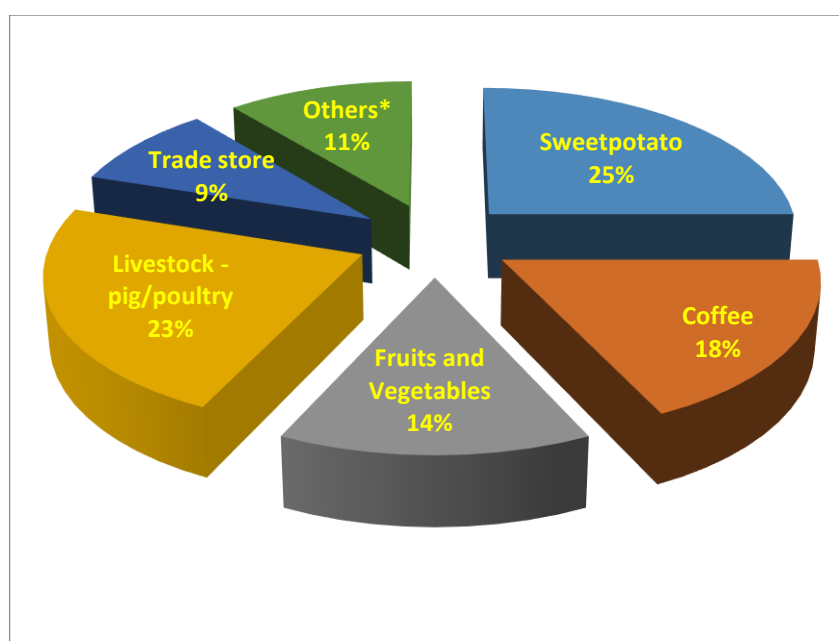

Figure 5. Distribution of household income by sources

Constraints to increasing household income

Most households reported some constraints to increasing household income. Of the total sample, 54% of farmers interviewed indicated lack of finance and resources that could be used to invest in income generating activities (Table 20), followed by lack of labour (41%), attributed to lack of family support. Low level of production (11% of farmers interviewed) and lack of knowledge on agricultural production (12.9%) were also limiting factors to increasing income. 15.3% of respondents suggested that lack of market and highs cost of

production and marketing associated with current marketing practices were limiting factors in increasing total household income.

Table 20. Constraints to increasing household income (% of responses)

| Constraints | Groups | | | | | |
	1	2	3	4	5	All
Output is low	15.9	11.6	4.5	0.0	10.5	11.0
Lack of market		11.6	27.3	31.3	47.4	15.3
Environmental constraints		7.0				1.8
Lack of funds/finance/resources	58.7	51.2	40.9	56.3	57.9	54.0
Lack of skills/knowledge	7.9	18.6	13.6	12.5	15.8	12.9
High cost of production/marketing	3.2	16.3	4.5			6.1
Lack of labour*	39.7	37.2	40.9	50.0	47.4	41.1
Lack of employment/off-farm income	3.2		4.5			1.8

*lack of family support, husband not helping

Opportunities for increasing incomes from sweetpotato farming

Most farmers believed that they could increase their income from sweetpotato farming, mainly by an increase in production, either by increasing the area planted to sweetpotato (90% of respondents) or by increasing yields (59%) (Table 21). More than 20% of farmers indicated that yields could be achieved by using fertiliser (19%) and by implementing proper disease management (22%). In addition, it was suggested that an increase in income could be achieved by reducing the cost of production (22% of respondents), and through higher prices received for their produce (23% of respondents).

Table 21. Perceptions on how to increase income from sweetpotato

| Item | Groups (%. of responses) | | | | | |
	1	2	3	4	5	All
No. of respondents	76	47	23	16	19	181
Expand area planted	92	96	87	75	84	90
Increase yield	43	85	70	38	63	59
Use fertiliser	4	49	17	13	16	19
Pest and Disease management	4	55	30		16	22
Reduce costs of production	22	36	4		16	22
Increase price	18	36	26	6.3	21	23
Others	1	4	9		11	4

Constraints to commercialising sweetpotato production

Farmers were asked to indicate major constraints to increase sweetpotato production. The results are presented in Table 22. The majority of farmers (82%) indicated lack of capital to be the major constraint to increasing income from sweetpotato – the same response we got in relation to how to increase household income (Table 20). This is particularly pronounced for all groups apart from Group 5. Lack of labour, both for production and marketing, is another significant limiting factor across all groups (80%). 53% of farmers believed that there was insufficient land available to increase sweetpotato farming. The land issue appeared to be most severe for Group 5 (71%) and less severe for Group 3. With regards to marketing aspects of sweetpotato production, lack of market (65%), high transportation costs (70%), and lack of business skills (47%) were also important issues.

Table 22. Main constraints to become a commercial sweetpotato famer (% of responses)

Constraints	Groups					
	1	2	3	4	5	All
No. of respondents	77	49	23	16	17	182
Lack of capital	88	84	83	75	59	82
Lack of labour	88	78	74	63	77	80
High transportation cost	61	78	70	75	82	70
Lack of market	70	57	52	75	71	65
Lack of land	57	47	39	56	71	53
Lack of business skills	40.	63	44	44	35	47
Others	1	8	4	0	12	4

The results presented in Table 22 above indicate a need for intervention to minimise some of these constraints, both from institutional and extension perspectives. While some of these factors are difficult to address (such as lack of land), some can be addressed through appropriate training and extension support.

Training needs

The majority of respondents depended on their own experience and knowledge with regards to cultivation, new varieties, pest control, growing other crops and sweetpotato marketing. Extension workers and farmer organisations also play an important role in the dissemination of information and skills training on various farming operations. About 52% of farmers indicated they needed to know more about sweetpotato production in general, and 28% needed information specific to marketing and postharvest activities. In all, 47% of farmers had attended farmer training relating to various skills, including farming in general, marketing and postharvest skills, and financial literacy. About 34% of farmers wished to have more training and improve their skills on accessing long-distance markets and selling produce using this option.

7.1.7 Gender roles

The PNG Highlands is traditionally a patriarchal society. Although time is changing, there is still significant division in gender roles both within and outside the home. The roles of husbands and wives in various activities and decision-making processes are summarised in Table 23. Overall, an average gender role score of 3.6 was obtained, with Groups 1, 2 and 4 attaining 4.0, 3.7 and 3.5, respectively (Table 23). By contrast, Groups 3 and 5 scored 2.8 and 2.9, respectively. This means for the former groups, household decisions were made by women, while for the latter groups, most decisions were made jointly by husband and wife. In addition to variations among groups, our survey results showed that women appeared to play a greater role in decisions within the home, especially in regards to varietal selection and marketing of sweetpotato, with overall gender role scores of 4.0 and 3.8, respectively (Table 23). A number closes to 4.0 means that the decision was made mainly by the wife. By comparison, numbers close to 2.0, such as borrowing/credit and training and extension for Group 3, mean that those decisions were made mainly by the husband.

Table 23. Gender roles on various activities within the household [a]

Decision-making on:	Group number					
	1	2	3	4	5	All
Farming activities	3.9	3.8	2.8	3.7	2.7	3.6
Varietal selection	4.4	4.0	3.3	4.2	3.4	4.0
Marketing	4.2	3.9	3.5	3.5	3.2	3.8
Income	3.8	3.8	2.8	2.9	2.8	3.5
Savings	3.9	3.6	2.9	3.2	2.9	3.5
Expenditure	3.7	3.7	3.1	3.5	3.2	3.5
Borrowing/credit	4.1	3.6	1.9	3.3	2.7	3.5
Training and extension	4.3	3.7	2.1	3.5	2.4	3.6
Future farming activities	3.4	3.6	2.8	3.2	2.9	3.3
Average	*4.0*	*3.7*	*2.8*	*3.5*	*2.9*	*3.6*

[a] Where a value of 1 indicates husband only is making the decision; 2 = mainly husband; 3 = both husband and wife; 4 = mainly wife; 5 = wife only

At this point, it is too early to draw a conclusion on whether a higher average score is necessarily better (or worse), since an ideal situation would be for all the household decisions to be shared equally by husband and wife.

7.1.8 Self-assessment of well-being

The 'subjective well-being" approach is one of a range of poverty assessment tools available to researchers. One of the dimensions used in this approach involves deriving a level of happiness and satisfaction with overall life status. A subjective assessment of level of happiness was therefore included in the survey, and results are reported in Table 24.

Overall, 82% of respondents indicated that they were happy with their current status in life. As expected, good family support (66%), good health (66%) and respect in the community (53%) were the overwhelming sources of happiness for farmers. While material possession and sufficient income were also reported, they were not as important. However, when we asked how their quality of life could be improved, increasing incomes (55%) and material possession (37%) were important means, followed by improving family support (20%), better education for their children (12%) and better social and community services.

Table 24. Source of happiness

Description	Group					
	1	2	3	4	5	All
Happy						
Yes	81	74	96	100	74	82
No	20	27	4		26	18
Source of happiness						
Material possession	11	39	35		7	20
Good family support	57	81	61	65	79	66
Good health	63	56	74	71	86	66
Law and order	16	31	35	47	36	28
Respect with community	42	61	48	65	79	53
Sufficient income	39	50	22	29	36	38
Others	8	8	22	18	21	13
How quality of life could be improved						
Improve material possession	40	39	17	24	53	37
Improve family support	25	16	17	24	11	20
Improve sweetpotato income	22	27	42	59	53	37
Better education for children	16	18				12
Better social/ community services	14	16	4	6	5	12
Increase income from employment	71	53	17	24	58	55

Finally, farmers were asked to rate their status in life on a scale of 1 to 10, with 10 being very happy and contented with their status in life. Overall, farmers rated themselves an average score of 6 on a scale of 1 to 10 (Figure 6). The variation in this self-assessment was quite evident across groups, with farmers in Group 4 rated themselves between 5 to 7 while other groups ranged between 2 and 10. This mean the community where Group 4 resides may be more egalitarian than other groups.
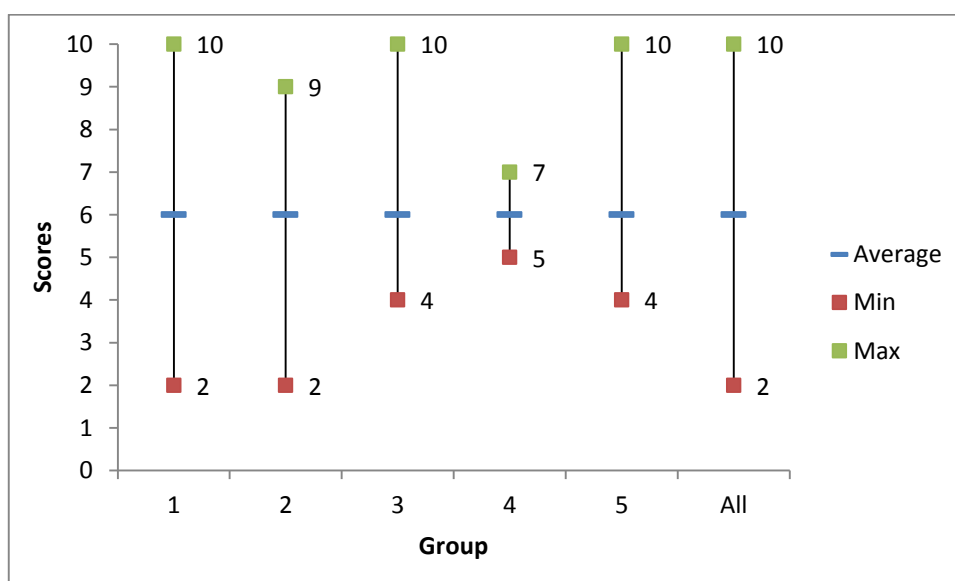

Figure 6. Self-assessment of well-being

These results suggest that despite their meager income and poor living conditions, most respondents were reasonably happy and content with their life. In addition, respondents have made the distinction between internal and external factors that impact on their well-being. While income and material possession can help meet their basic needs and improve their living condition, and hence their quality of life, happiness comes from within, such as good health, family support and respect.

7.1.9 Summary

- There were significant variations between the five groups in terms of education, land tenure, variety preferences, and gender roles in household decision-making, as well as on all aspect of sweetpotato postharvest and marketing. These results indicate broad social and cultural diversity in Jiwaka province alone. It means that these social and cultural factors need to be better understand and for any intervention to be effective in improving productivity and livelihood, it needs to take into consideration this diversity.

- Women were major contributors of labour as well as major decision-makers in various sweetpotato production and marketing activities. They need to be included in training and extension activities aimed at improving productivity and livelihood.

- Major sources of information and advice regarding sweetpotato marketing came from other farmers and farmers' own experience. This means there is need to examine how a formal extension system can use existing social networks to leverage its resources, and facilitate farmer-to-farmer extension.

- While some farmers were knowledgeable of how to improve the quality of sweetpotato for the market, a lot more needs to be done to educate and spread the knowledge to the majority of farmers.

7.2 Consumer survey

A consumer survey was completed in April 2013 in Port Moresby (POM), the capital of PNG. The survey was conducted in nine locations across POM, to account for ethnic and socioeconomic diversity amongst the population. Local team members from the Fresh Produce Development Agency (FPDA) identified the survey sites, and respondents from each site were self-selected volunteers. A pre-tested semi-structured questionnaire was used by 10 enumerators to complete a total of 356 respondent interviews. The interview schedule was divided into four components:

- Component A—consumption patterns and preferences for sweetpotato and other staple food crops.

- Component B—varietal preferences and preferred product attributes.

- Component C—purchasing decisions and issues related to sweetpotato marketing, including the availability, quality, product information and pricing schemes of sweetpotato.

- Component D—socio-demographics of the respondents.

Key results from the consumer survey are summarised and discussed in the sections below.

7.2.1 Socio-demographics of the respondents

PNG is diverse, both culturally and demographically, with more than 800 languages. POM, being the capita and the largest city of PNG, reflects this diversity as migrants across PNG come to POM in search of employment and improved basic services. The nine locations included in the consumer survey covered a wide area across POM. Therefore, they are somewhat representative the cultural and demographic diversity of the PNG population. The nine locations were: Gabutu, Erima, Gordon Ridge/5 mile, Morata 2, Segani/Ranugari/4 mile, Bomana and other (Boroko/Taurama/Central) (Table 25).

Table 25. Respondent groups in consumer survey

Location	No. of respondents	% of respondents
Gabutu	25	7
Erima	55	15
Gordon Ridge /5 Mile	44	12
Morata 2	58	16
Segani/Ranugari/4 mile	84	24
Bomana	43	12
Others (Boroko/Taurama/Central)	47	13
Total number of respondents	*356*	*100*

As can be seen in Table 26, 77% of respondents were women, a reflection of the more traditional role of PNG women as homemakers and food shoppers. Some 80% of respondents were aged between 21 and 50. With regards to the level of education of household head, 16% had no formal education, 40% had completed schooling up to grades 9-12, and 11% had a college degree. Some 53% of respondents had lived in POM for more than 10 years, 35% had regular employment, and 93% earned more than K100/week (the minimum wage for in PNG). Among the respondents, 21% were from Chimbu, 18% from Southern Highlands, 9% from Eastern Highlands, 9% from Jiwaka, 7% from Enga, 6% from Western Highlands and 2% from Hela. Therefore, Highlanders made up 72% of the sample. They are major sweetpotato consumers in POM, as observed by Gibson (2001).

Table 26. Demographic information of respondents

Item	% of respondents	Item	% of respondents
Gender of respondent		**Home province of HH head**	
Male	23	Central	6
Female	77	Simbu (Chimbu)	21
Age of respondent		Eastern Highlands	9
Less than or = 20	10	East New Britain	2
21-30	29	East Sepik	5
31-40	33	Enga	7
41-50	18	Gulf	3
More than 50	10	Madang	1
Education of HH head		Manus	0.3
Nil	16	Milne Bay	1
Grade 1 to 4	8	Morobe	5
Grade 5 to 8	20	New Ireland	1
Grade 9 to 12	40	Oro	3
College and above	11	Southern Highlands	18
Years living in POM		Western Highlands	6
Less than a year	3	West New Britain	1
1 to 5 years	27	NCD	0
6 to 10 years	16	Hela	2
11 to 20 year	22	Jiwaka	9
21 to 30 years	20	**Average income per week (in Kina)**	
More than 30 years	11	0 to 100	7
Main income source		101 to 200	10
Regular employment	35	201 to 300	13
Casual employment	19	301 to 400	22
Self-employed	24	> 400	48
Others	1		

7.2.2 Most preferred food staples

Rice was found to be the most preferred staple food, followed by sweetpotato and cooking bananas. Some 55% of the respondents chose rice as their most preferred staple food, while 40% chose sweetpotato and 3% chose cooking bananas (second column, Table 27). In order of preference, 46% of respondents chose sweetpotato, 22% rice and 20% cooking bananas as their second most preferred staple food (third column, Table 27). For their third most preferred staple food, 42% of respondents chose cooking bananas, 25% chose potato and 23% chose either rice or sweetpotato (fourth column, Table 27).

Table 27. Most preferred food staples

Item	Order of preference (in % of respondents)		
	1st	2nd	3rd
Sweetpotato	40	46	12
Potato	1	8	25
Tao	0	2	3
Yam	0	0.3	1
Cooking banana	3	20	42
Cassava	0	1	3
Rice	55	22	11
Sago	0	1	1
Others	0.3	1	2

The main reason for choosing rice as a preferred staple food was availability (30% of total responses), followed by others (28%), price (20%), taste/preference (17%), and nutritional value (6%). The main reason for choosing sweetpotato as a preferred staple food was taste/preference (40% of responses), followed by availability (20%), nutritional value (19%), and price (13%) (Table 28). These results suggest that respondents who preferred rice valued its availability, while respondents who preferred sweetpotato valued its good taste. The results suggest that to compete with rice, sweetpotato suppliers will need to improve its availability, as well as price competitiveness.

Table 28. Consumer preferences for sweetpotato and rice (in % of responses)

	Taste and Preference	Price	Nutritional Value	Availability	Others
Sweetpotato	40	13	19	20	8
Rice	17	20	6	30	28

7.2.3 Sweetpotato consumption patterns

A total of 40% of respondents consumed sweetpotato at least once a day, with 5% of respondents consumed sweetpotato three times every day, 16% consumed sweetpotato twice a day and 29% consumed sweetpotato once a day (last column of Table 29). The remaining 60% of respondents consumed sweetpotato at least once a week. When sweetpotato was consumed less frequently than three times a day it was more likely to be consumed at dinner, presumably because it takes more time to prepare, compared with rice or cooking bananas.

Table 29. Sweetpotato consumption patterns

Item	No. of households	% of households
Every day (3 times a day)	19	5
Twice a day	54	16
Breakfast	34	
Lunch	20	
Dinner	53	
Once a day	102	29
Dinner	102	
Once/week	50	14
Twice/week	31	9
Thrice/week	65	19
Four/week	28	8
Five/week	4	1

7.2.4 Changes in sweetpotato consumption patterns

When respondents were asked about changes in their sweetpotato consumption compared to a year ago, 23% indicated that they were eating more, 29% were eating less, and 48% were eating about the same amount of sweetpotato (Table 30). The main reasons for eating more included changes in preference associated with sweetpotato (for example, due to taste or its perceived health benefits), an increase in family size, and greater availability of sweetpotato in the market. The main reasons for eating less included reduced affordability, changes in preferences, particularly amongst children who preferred rice and potato, availability, product quality, and a reduction in household size. The proportion of respondents eating less sweetpotato compared to a year ago (29%), combined with the socio-demographic factors behind this decline, is a potential threat to the sweetpotato sector because those changes are likely to continue and to have negative impacts on sweetpotato consumption.

Table 30. Changes in sweetpotato consumption patterns

Item	% of respondents
Eating more	23
Eating less	29
Eating about the same	48
Reasons for eating more	% of responses
Change in preferences (taste/health)	25
Increase in household size	24
Availability - more supply in the market	10
Affordability - more competition/prices	29
Others (Convenience/accessibility/usual practice)	12
Reasons for eating less	% of responses
Affordability – expensive	33
Change in preferences (kids)	14
Availability	19
Low quality of sweetpotato in the market	21
Others (less people to be fed)	13

7.2.5 Quality indicators/cues

When respondents were asked what they considered to be the factor/s demonstrating good quality sweetpotato, 35% of total responses received indicated "good appearance – no pest/insect damage", 20% indicated "sweet taste", 15% indicated "uniform shape and size", and 14% indicated "fresh and clean" (Table 31, left hand side panel). In contrast, sweetpotato was most likely to be considered of poor quality when it had "pest/insect damage" (36%), and was "of poor taste" (22%) or "of poor shape" (15%), and skin damage (13%) (Table 31, right hand side panel). Dried and withered roots and small roots were also considered as of poor quality.

Table 31. Product characteristics consumers consider as good or poor sweetpotato quality

Good quality sweetpotato		Poor quality sweetpotato	
Item	**% of responses**	**Item**	**% of responses**
Physical appearance [1]	35	Pest/insect damage	36
Taste (sweet)	20	Poor taste	22
Uniform shape and size	15	Poor shape[3]	15
Fresh and clean	14	Skin damage[2]	13
Strong tuber	6	Dried and withered roots	7
Maturity	3	Small size	4
Nutritional/dietary value	3	Others (coastal varieties)	3
Others	3		

[1] no pest/insect damage;
[2] has spots/discoloration/bruises/ skinning/cracked/wrinkled;
[3] crooked, disfigured or not straight /rough skin/odd and irregular shape.

7.2.6 Quality perceptions

Over 90% of respondents considered the quality of sweetpotato they have bought to be either good (70%) or very good (21%). Some 41% of respondents thought quality had improved over time, while 29% of respondents thought quality had deteriorated over time and 24% thought it was about the same (Table 32). Respondents attributed changes in quality to issues associated with postharvest handling and transport/logistics. One interesting result was that 28% of respondents thought quality had improved because of increased competition (more sellers) in the market. In addition, 77% of respondents recognised there was inconsistency in quality across the calendar year.

Table 32. Quality perceptions of sweetpotato in the market

Item	No. of responses	% of responses
Quality perceptions		
Very good	74	21
Good	249	70
Poor	32	9
Very poor	1	0
Change in quality over time		
Better	144	41
Worse	102	29
Same	84	24
No idea	21	6
Reasons for getting better		
Availability - more good quality sweetpotato in the market	26	19
Improved handling and transport (less rotting)	34	24
More sellers/competition (increase awareness of quality)	39	28
More varieties available on the market	38	27
Improved marketing facilities	3	2
Reasons for getting worse		
Dry-looking sweetpotato in open market	4	4
Delays in logistics	26	25
Improper handling	32	31
No improvement in transport or handling	40	39
Quality is variable		
Yes	254	77
No	31	9
Do not know	47	14

When respondents were asked about how they thought quality could be improved, "transport", "handling", "grading/sorting", "packaging", and "storage" improvements were all mentioned (Table 33).

Table 33. Suggestions on how quality could be improved

Item	% respondents
Improve transport system/improve supply chain/shipment schedule)	20
Extension advice (to ensure good quality/good variety/timing of supply)	14
Proper storing/cooling system	11
Proper handling during transporting and carrying/selling/washing	10
Grading/sorting	9
Information campaign to sellers regarding shading/shelving/heap presentation/pricing	6
Proper packaging (good bags/aerated)	6
Don't know/no idea/no comment	22

7.2.7 Preferred physical characteristics of sweetpotato

Specific physical characteristics that consumers looked for when shopping for sweetpotato included: Highlands grown, medium-size, elongated shape, yellow/cream-coloured fresh, firm, dry and smooth textured, red skin, unwashed, fully matured, and non-sprouted (Table 34). These attributes chould therefore be considered when seeking genetic improvement in sweetpotato varieties.

Table 34. Preferred physical characteristics of sweetpotato (in % of responses)

Flesh colour		Skin Colour		Taste	
Yellow	49	Red	34	Sweet	26
White	37	Brownish white	26	Powdery/Dry	25
Orange	13	Purple	21	Smooth	18
Purple	1	White	16	Firm	24
		Other	3	Soft	3
				Grainy	2
				Watery/Moist	2
Cleanliness		**Maturity**		**Freshness**	
Unwashed	76	Fully matured	68	Non-sprouted	88
Washed	24	Young	32	Sprouted	12
Size		**Shape**		**Source**	
Medium	77	Elongated	76	Highlands	99
Large	21	Round	24	Lowlands	1
Small	2				

7.2.8 Varietal preferences

Wanmun and *Wahgi Besta* were the most preferred sweetpotato varieties amongst respondents, being preferred by 40% and 39% of respondents respectively (Table 35). The main reasons for choosing *Wanmun* and *Wahgi Besta* were: "good taste" (sweet; creamy; good flavour/aroma); and "good quality" (skin colour; long shelf life; strong/firm flesh; does not sprout quickly; good appearance). A previous demand study conducted in Lae (Omot et al., 2010) found *Karot* to be the most preferred variety, followed by *Wahgi Besta.*

Over the course of this project, we observed different varieties being produced by different regions. Consumers and farmers alike tended to prefer varieties grown in their villages, suggesting a clear link between varietal choice and origin. For example, *Gimane* is grown in the Eastern Highlands, while *Wahgi Besta* comes mainly from Jiwaka, and *Korowest* and *Rachael* are mostly grown in the Western Highlands. These were the "commercial" varieties commonly found on the market.

Table 35. Varietal preferences

Variety	% of respondents	Reasons for preferring these varieties* (in no. of responses)							
		1	2	3	4	5	6	7	8
Wanmun	40	117	48	47	23	73	11	39	4
Wahgi Besta	39	110	41	36	14	77	12	57	15
Karot	8	25	8	5	4	11	4	7	0
Trimun	3	11	4	4	3	6	2	4	0
Rachael	3	9	5	5	1	7	3	5	1
Korowest	2	8	3	4	1	2	2	4	1
Gimane	1	3	1	1	1	0	0	2	0
Marasondai	1	3	1	1	1	2	0	1	1
Others	3	8	5	5	4	7	3	4	0

Notes:

1 Taste (sweet; creamy; taste/flavour/aroma);

2 Size and shape of roots (good shape/ shape/elongated/straight);

3 Flesh characteristics (soft/moist/starchy/powdery/firm/not too watery);

4 Availability;

5 Good quality (colour of skin/long shelf life/strong/firm flesh/does not sprout quickly/good appearance);

6 Easy to prepare (easy to peel/fast cooking/easy to cook);

7 Nutritional value (filling/hunger buster/strength/energy/last long);

8 Others – familiarity/habit (used to eat this variety).

7.2.9 Market information and purchasing decisions

Respondents showed a strong preference for a particular type of sweetpotato, with 89% indicating that their buying decision was made before they went to the market, meaning that they went to the market with a particular variety in mind (Table 36). In terms of availability, 62% of the respondents said it was easy to find what they wanted. If the variety they wanted was not available in the market, 60% said they would buy other varieties while 38% said they would buy alternative food staples. When in doubt about their purchase decision, 36% of respondents asked the vendors for product information, mainly about variety (53% of these respondents), origin of production (37%), price (19%), colour of the flesh (17%), and harvest date (15%) (Table 36). Some 86% of these respondents were satisfied with the information provided by vendors.

Table 36. Market information and purchasing decisions

Decision is made before going to market	*% of respondents*
Yes	89
No	11
Ease in finding the desired sweetpotato in the market	*% of respondents*
Very easy	27
Easy	62
Difficult	8
Very difficult	3
What to do if sweetpotato desired is not available	*% of respondents*
Do not buy sweetpotato at all	9
Buy other varieties	60
Go to different market	6
Buy other food staple	25
Talk to vendors for information	*% of respondents*
Yes	36
No	64
Questions asked of vendors	*% of responses*
Name and availability of preferred variety	53
Place of origin/production	37
Price	19
Colour of flesh	17
Shelf life /harvest date	15
Able to get the information required	*% of respondents*
Yes	86
No	14

7.2.10 Information needs and sources of information

When respondents were asked about their information needs and how best information could be provided, 22% indicated that they would like to have more information on shelf life/harvest date (22%), flesh colour (15%), place of origin (13%), actual volume in the heap (9%), and variety (4%) (Table 37). According to the respondents, such information could be made available by providing a sample to show the colour of the flesh (50%) or through appropriate labelling (15%). However, 22% of respondents were unable to comment on how suitable information could be provided. This is an indication that consumers had not thought about this information issue, either because the issue was not considered important, or because they were less demanding or quality conscious than consumers in other countries. However, we have observed that more and more vendors are displaying slices of sweetpotato to show the colour of the flesh.

Table 37. Information need and sources of information

Item	% of responses
Information needed to make purchase easier	
Shelf life/harvest date	22
Flesh colour	15
Place of origin/production	13
Quantity (no. of roots/heaps)	9
Indicate name of variety	4
Unable to comment	20
How information should be provided	
Provide sample for flesh colour	50
Unable to comment	22
Proper labelling	15
Market authority/media	7
Market information/board in the market	4
Price tagging	2

7.2.11 Views on current selling methods

When respondents were asked to comment on the way sweetpotato was marketed, 92% said they had no problem with current practices. However, a small percentage (8%) did not like current practices because they caused damage to sweetpotato and selling mixed size in heaps did not provide a clear price signal. Some 76% of respondents wanted sweetpotato graded for quality and size, but 80% did not want sweetpotato to be sold by weight (for example, price per kg; Table 38).

Table 38. Views on the way sweetpotato is marketed

Item	% of respondents
Like the current way of selling sweetpotato	
Yes	92
No	8
Reasons for NO	% of responses
Easily damaged and rotten	17
Should be packed	8
Mixed sizes	38
Price not commensurate with volume or quality	13
Sweetpotato sold by weight and price/kg	
Yes	20
No	80
Sweetpotato graded by quality and size	
Yes	76
No	24

The consumer survey strongly suggested that consumers had a clear preference for certain sweetpotato varieties and for particular physical characteristics. These information needs can be met simply by providing cut samples showing the colour of the flesh, by vendors communicating such information directly to consumers, and/or by labelling the product.

We also concluded that although Highlanders who migrated to POM a decade or two before still preferred sweetpotato over rice, the younger generations (who are engaged in formal and casual employment, as well as living in households of reduced family size) tend to prefer rice because of its relative availability and convenience. These changes in socio-demographical trends are likely to have a negative impact on future sweetpotato consumption. To compete with rice and other staple foods, such as potato, noodles and bread, sweetpotato value chain players will therefore need to work together to improve the availability, quality and price competitiveness of their products.

7.3 Matching demand and supply

In this section, we focus on comparing consumers' and farmers' varietal choice and associated product attributes.

The results from the consumer survey are summarised below.

- **Most preferred food staples.** In Port Moresby, rice is the preferred staple food, followed by sweetpotato and cooking bananas. The main reason for choosing rice is its availability, while for sweetpotato the main reason is taste/preference.

  With regard to changes in sweetpotato consumption, 23% of respondents indicated that they are eating more, 29% are eating less, and 48% are eating about the same, compared to a year ago. The main reasons for eating more were changes in taste/preference for health reasons and an increase in family size, while the main reasons for eating less were affordability (higher prices) and children who prefer rice and potato.

- **Variety preferences**. In Port Moresby, *Wanmun* and *Wahgi Besta* appeared to be the most preferred sweetpotato varieties. The main reasons for preferring *Wanmun* and *Wahgi Besta* were similar, including "good taste" (sweet; creamy; good taste/flavour/aroma) and "good quality" (colour of skin; long shelf life; strong; firm flesh; does not sprout quickly; good appearance). In the Lae market, *Kerot* was found to be by far the most preferred variety, followed closely by *Wahgi Besta, Trimun, Korowest, Wanmun* and *Gimane* were found to be equally preferred (Omot et al., 2010).

  We observed that different varieties are grown in different regions and consumers and farmers alike tend to prefer the varieties that are grown in their villages. Therefore, the varietal choice we found in our surveys depends importantly on where the respondents came from.

- **Quality attributes.** Indicators for good quality sweetpotato were "good appearance – no pest/insect damage", "sweet taste", "uniform shape and size", and "fresh and clean". Sweetpotato was considered of poor quality when it had "pest/insect damage", "poor taste" and "poor shape".

  In general, the majority of respondents considered the quality of sweetpotato in the market to be good and acceptable. Some 40% of respondents considered that quality has improved while 29% considered quality had deteriorated over time. Overall, 70% of respondents indicated that quality was variable throughout the year. When respondents were asked how they thought quality could be improved, "transport", "handling", "grading/sorting", "packaging", and "storage" improvements were all mentioned.

- **Preferred physical characteristics**. Specific physical characteristics of sweetpotato that consumers appeared to look for when shopping are: Highlands grown, medium-size, elongated shape, yellow/cream-coloured fresh, firm, dry and smooth textured, red skin, unwashed, fully matured, and non-sprouted.

- **Buying decisions**. Respondents have strong preferences when buying sweetpotato. Overall, 89% said that their selection was made before they went to the market. In terms of availability, 62% of the respondents said it was easy to find what they wanted. But if

what they wanted was not available in the market, 60% said they would buy other varieties, while 38% said they would buy other food staples.

- **Product information**. Respondents often seek information from sweetpotato vendors on variety, place of origin of production, price, flesh colour and harvest date.

The results from the farm survey are summarised below.

- **Varietal choice.** In our survey, 36 varieties were named distinctly by farmers. However, we were unable to verify whether they were indeed different varieties genetically. In most cases, farmers grew between one and six sweetpotato varieties. While there was no difference in the number of varieties grown within a group, there was a significant difference in the average number of varieties grown between groups.

    The most preferred varieties in Jiwaka province were *Wahgi Besta* (preferred by 74% of respondents), *Sugar* (14%) and *Rachael* (8%). There were regional differences between groups, with the most preferred variety for Groups 1, 2 and 3 being *Wahgi Besta*, *Sugar* for Group 4, and *Wahgi Besta* and *Sugar* being equally preferred by Group 5.

- **Perceived varietal attributes**. Good eating quality, yield performance, market price, early maturing, and resistance to pests and diseases, as well as colours of the skin and the flesh, were some of the most common reasons for growing the varieties. Some respondents also mentioned "easy to handle" and "travelled well" to long-distance markets as selection criteria. Most varieties were grown both for home consumption and for sale. Only 18% and 5% of the farmers, respectively, said that they grew *Wahgi Besta* and *Sugar* specifically for sale in the market.

These results show that most farmers do not grow sweetpotato specifically for the market, but rather sell what they are growing. This is an indication of a production/supply orientation, as opposed to a customer/market orientation. It may be coincidental that Jiwaka is growing *Wanmun* and *Wahgi Besta*, the varieties preferred by consumers in Port Moresby. Omot et al. (2010) also looked at farmer perceptions of consumer preference for sweetpotato variety, physical characteristics, eating quality, and how farmers responded to these factors. They found that sweetpotato suppliers from the Highlands were not fully aware of consumer preferences. However, because they thought they *were* aware of consumer preferences, they could not and did not respond adequately to consumer demand. One possible reason for this may be that the majority of farmers did not go to the market regularly enough (most likely once or twice a year) to fully understand consumer preferences. Rather, when they did go to the market, they simply brought whatever varieties they had grown.

7.3.1 Conclusions

Based on the results from the farm and consumer surveys and previous research, it is clear that farmer and consumer preferences for sweetpotato are much more variable within and among populations, regions, and over time. This makes it difficult for farmers and marketers to select the varieties that best meet current consumer demand and market requirements. However, the physical characteristics preferred by consumers, as identified in our survey research, can be used as a guide for variety selection and also for future breeding programs. In general terms, farmers are not customer- or market-oriented, as they grow varieties that are common in their areas mainly because these are suitable for the agro-climatic conditions for production, rather than in response to consumer demand. In rare cases where varieties are grown specifically for the market, they are chosen because they travel well to long distance markets, especially Port Moresby. This is despite these varieties taking 7-8 months to mature (for example, *Korowest*), as opposed to 4 months (for example, *Gimane* and *Wahgi Besta*). Misconceptions of consumer preferences can result in oversupply, and hence low prices and product wastage. Education farmers on consumer preferences, as well as providing consumers with product information (through, for example, product standards, labelling or advertising), will help improve marketing efficiency.

7.4 Marketability and grading trials to define quality

Determining what is marketable, where, and what quality standards are required, is considered essential for farmers to contemplate new markets for their produce. One of the key requirements of a locally appropriate quality system is that the language is suitable for the people who will use it. The method used to arrive at this information, using group activity sessions, is detailed in Box 1.

Box 1. Instructions for exercises on marketability and quality standards—formal markets

1. Form a group of 3–4 people maximum
2. Get a 'normal' bag of sweetpotato[a]
3. As a group, fill in the header portion of the attached SUPPLY CHAIN SHEET and DIMENSIONS SHEET. Collect an individual MY PREFERENCES SHEET and fill in the header[b]
4. Open the sweetpotato bag and spread out the roots on a canvas
5. Separate the sweetpotato into two heaps, one for marketable and one for unmarketable
6. Describe the unmarketable heap (e.g. rots, odd shapes, too large, too small, rat damage, breaks, splits, surface roots, cuts, weevil damage). Record descriptors on the SUPPLY CHAIN SHEET. These sweetpotato are unmarketable, unsaleable and unsuitable for human consumption
7. Count and weigh all unmarketable roots together and record number and weight on the SUPPLY CHAIN SHEET
8. Put unmarketable sweetpotato back into the bag
9. For the marketable sweetpotato, separate into 3 heaps of choice decided by the group
10. For each marketable heap (called grade 1, 2, 3 on the SUPPLY CHAIN SHEET), count the roots and weigh the roots together. Record weights and numbers for each marketable heap on the SUPPLY CHAIN SHEET
11. Describe each marketable heap (i.e. the reasons sweetpotato were put into each group). Record the reasons used in the descriptors column on the SUPPLY CHAIN SHEET
12. Each member should then separately record their preference for each grade by ranking each heap as 1 (like best), 2 (like second), to 3 (like least) on the MY PREFERENCES SHEET
13. Take 10 roots at random from each marketable heap and measure and record individual lengths, maximum widths and weights. Please keep these as separate heaps. Record the values on the DIMENSIONS SHEET
14. Make a traditional heap of mixed sizes and of similar size to the heaps of step 13 (similar volume or weight) using sweetpotato from each graded heap in step 10
15. Each individual member of the group should indicate the price they would be willing to pay for each of the 4 heaps. Record these prices on the MY PREFERENCES SHEET
16. If 'Korowest' is the standard variety, each individual should indicate which varieties of sweetpotato you would pay below or above that for 'Korowest'? Record on the MY PREFERENCES SHEET
17. The assessment is now complete.

Marketability trials were integrated into the training workshops to determine farmer perceptions of quality. This information was used to devise some form of product specification that was locally and culturally appropriate, and which minimised complexity. The philosophy was to determine farmer perceptions, followed by consumer perceptions, and then to establish a quality specification that met the expectations of both groups. The

training workshops were designed to provide a focus for the research, such that the activities could also be completed by farmers within their own business if they were considered worthwhile.

As an example, we undertook a marketability trial with participants at the Goroka postharvest workshop, run in March 2014 (Figure 7). The variety used in the training was *Gimane* rather than a purple-skinned varieties used in the other training workshops. The participants included farmers and traders who shipped sweetpotato and other vegetables to Port Moresby, up to several times per year. They were shown a series or Powerpoint slides exposing them to the elements of postharvest technology, with a special focus on factors influencing product quality at the market. These slides were presented in the March 2013 travel report. A similar Mt Hagen workshop included a major section on postharvest diseases and their impacts on quality. Participants were then taken outside, and asked to determine which sweetpotatos provided by a local village were 'unmarketable', with the remainder being sorted into 3 grades. We did not prescribe any of the grading criteria, as we wanted the farmers to begin to think about what quality means to them, and how to put this meaning into their own words. The resulting responses are presented in Table 39.

As expected, grading was based largely on size. However, one group chose the largest sweetpotato as belonging to grade 2, for reasons not made clear. For quantitative analysis, the data for grades 1 and 2 were swapped so that logical comparisons on the basis of size could be made. The attributes of of 'smooth skin', 'uniformity', and 'easy to peel', were also discussed in the training session prior to lunch. The group exercise took approximately 90 minutes. This allowed time for the leaders of each group to explain to the other groups, how they had sorted their sweetpotato into grades.

Table 39. Grades and descriptors by vegetable traders at the Goroka postharvest training course (summary of grading criteria for each workshop group).

Grade	Description
Unmarketable	odd shapes, small, scratches, breaks, sprouts, weevil damage
	small, broken, cuts, etc
	broken, curved, weevil damage, small, growth cracks
	rat damage, cuts, weevil damage, splits, breaks, odd shape, small
Grade 1	all quality sizes and large
	large, look good, no scratches, disease, pests etc
	large, smooth, heavy
	same size, medium, attractive, quality, high price
Grade 2	medium size, uniform in size and length
	medium size, look good, uniform size
	medium size, look good, smooth
	large, customer's choice, second price
Grade 3	small size
	small size
	small size, good looking, easy to peel
	small size, low price, more sweetpotato in a (market) heap

These descriptions indicated there were no specific cultural differences in how the grades are defined – the comments could be applicable in any world setting. It was interesting to note that farmers also factored in possible market responses into their sorting decisions (e.g. 'low price', 'high price', 'second price', 'customer's choice'). It should be realised that these comments came after a training course, but based on the comments in Table 39, farmers and marketers appeared to be well aware of what is a 'good' looking sweetpotato.

It was also interesting that small size, breaks, and weevil damage were cited as reasons for declaring sweetpotato unmarketable (Table 39). This is notable because, on average, 40% by number and 32% by weight were deemed to be unmarketable, and this is from two bags just delivered from the village that morning. A similar outcome occurred on several occasions. As described in the September 2012 travel report, in one workshop farmers judged that 50% of a bag was unmarketable (incidentally, FPDA officers graded the same bag and similarly scored 46% by number as unmarketable), while in another workshop described in the August 2013 travel report, farmers judged 65% of a sample to be unmarketable. So, farmers appear to be packing sweetpotato for markets when they are aware that a large proportion of what is in the bag will not be marketable. In all likelihood, this decision is based not on the consumer, but on a desire to fill sweetpotato bags at packing time.

Figure 7. Traders grading sweetpotato in groups during the postharvest workshop in Goroka

Another interesting point, as shown in Table 40, is that based on the selections made by the groups, there is no substantial evidence, at least amongst this very small sample, that farmers are packing lower quality sweetpotato into the bottoms of these bags. Rather, the marketable sweetpotato seemed more or less equally distributed in both the top and bottom halves of the bags in this test. However, we believe that many years ago, this was a regular practice farmers used to fill the bags with lower quality product.

Table 40. Sweetpotato numbers and weights (in %), total numbers and weights (kg), and position in bag 1 or bag 2 (top half (T1 and T2) or bottom half (B1 and B2) for grades selected by four groups during postharvest training at Goroka. Unmark. = unmarketable.

Group	No. (%)	Unmark.	Grade 1	Grade 2	Grade 3	Total	Position
Joshua		41	18	22	19	122	T1
G2		33	14	25	27	90	B1
Thomas		37	19	7	37	86	T2
Sakias		48	10	15	27	137	B2
	Average	*40*	*15*	*17*	*27*	*----*	
	Weight (kg, %)						
Joshua		26	34	24	16	54	T1
G2		21	30	31	18	39	B1
Thomas		32	25	19	24	42	T2
Sakias		47	19	19	20	50	B2
	Average	*32*	*27*	*23*	*20*	*---*	

The physical dimensions (length, maximum width, weight of 10 roots combined) from each grade are presented in Table 41. These measurements of a random sample of 10 roots selected in each grade were taken to determine whether the participants were using common understandings of grades, and whether these could be quantified by some simple estimates of dimensions. The data were analysed as a factorial, with Group and Grade the main factors.

For the factor Group, there was no effect on length, meaning that all groups selected roots of similar length (data not shown). However, for the maximum width, one group (Joshua) selected more narrow roots (P<0.05) than the other groups. Group had no effect on weight.

For the factor Grade, lengths of grade 1 and 2 were similar (means of 26-28 cm), but length of grade 3 roots was shorter to a statistically significant extent (Table 41). Different grades were more discernible when maximum width was measured, although the differences were on average only 1 to 3 mm. Finally, weights were higher (P<0.05) for grade 1 than for grades 2 and 3 sweetpotato. The weight comparison held even though data for one group (Thomas) were not included in the analysis as these data were an outlier that affected normal distribution of weights that could not be normalised by transformation. Including this point would have increased the size of the differences, but it is questionable whether trader farmers would favour such large roots as a general rule.

Table 41. Mean length (cm), maximum width (cm) plus standard errors of individual roots from 10 randomly selected roots from each grade, plus the average weight of the 10 roots combined (g/root) from 3 grades selected by four groups during postharvest training at Goroka. Statistical significance of comparisons is explained at the base of the table.

Group	Grade 1 Mean	S.E	Grade 2 Mean	S.E	Grade 3 Mean	S.E
	Length					
Joshua	27	1.0	25	0.6	27	1.5
G2	29	1.0	24	1.1	22	1.0
Thomas	27	1.2	29	0.9	23	0.8
Sakias	26	0.7	27	1.2	29	1.0
Average	28A		26A		23B	
	Width					
Joshua	7	0.4	4	0.2	5	0.2
G2	8.5	0.2	7	0.2	6	0.3
Thomas	7	0.4	9	0.4	5	0.3
Sakias	8	0.4	7	0.3	5	0.2
Average	8A		7B		5C	
	Weight					
Joshua	900		500		700	
G2	850		500		300	
Thomas	1317 [z]		600		500	
Sakias	780		500		300	
Average	*864A*		*525B*		*450B*	

For length, critical value for comparison Tukey HSD (5%) = 1.9
For maximum width, critical value for comparison Tukey HSD (5%) = 0.6
For weight, critical value for comparison Tukey HSD (5%) = 285. As weight is an average of the selected roots combined, there are no error terms.
[z] not included in ANOVA as this is an outlier.

Overall, this example is representative of our experiences at the postharvest training workshops. Farmers and traders judged the higher grades (grades 1 and 2) to be made up of the larger roots for the variety sample being examined. Training can be given, but it is of little use if the learned principles are not put into practice. Chang et al. (2014) showed there was a clear gap in understanding of quality between Highland producers and Port Moresby consumers. In very conservative farming communities, change is treated with suspicion. However, through the hard work of our collaborators, particularly Agnes Merep, some evidence of application was seen in the local Gusamp village roadside market (August-September 2013 travel report) where sellers were constructing heaps using more uniform sized roots, and where they were not hiding poor quality (e.g. rotten, rat-bitten, or cracked) roots at the bottom of the heaps. Feedback indicated the prices were higher and the produce sold faster as a result.

It appears that farmers understand the need to prevent the roots getting too big as in most instances, the 15-25 cm long roots were most commonly placed in the higher grades, while higher priced (K10, K5) market heaps generally contained roots of this size. The Goroka

variety *Gimane* can get very large if harvested late, but these seem more frequent in local Goroka markets rather than in Port Moresby markets. It appears that the city and local market sellers want to make heaps that contain similar numbers of sweetpotato, so that buyers do not feel they are being misled, which they may do if roots were sold on a weight basis (e.g. heaps consisting of three 2 kg roots versus ten 600 g roots).

7.4.1 Conclusions

It is apparent that it is not always useful to assume what market the respondents are referring to, for example a local roadside market, a local central market, a long distance open market, or a supermarket. In addition, farmers may not have a specific market in mind during sorting. To some extent this was our fault because we were engaged in generic training with a diverse audience, and we use frequent references to local and city open markets. The target market needs to be specified in training exercises, especially where farmer groups are involved. To this point, no farmers had asked us to clarify what market they should grade for. It is also possible that many of the farmers and labourers involved in packing do not really understand what consumers (or even market sellers) require of the produce. Instead, they are just concerned with filling bags and getting paid. The Goroka group discussed above was more homogeneous than others, in that most members were involved in trading vegetables to Port Moresby, in whole or in part, whereas other groups had been mainly made up of farmers.

Another lesson is that our training can enlighten some farmers on product quality, but they require consumer feedback to reinforce this training. In most instances, farmers were sending produce to markets and accepting losses as inevitable, and at times this was due to being duped by sellers. Without constant reinforcement of the importance of product quality, farmers will keep doing what they are doing and the price of a bag of sweetpotato will remain uniformly low, only to skyrocket during times of drought or low supply. This is why associated business skills are vey much needed by Highland farmers.

A further point of interest is that in fact, everything appears to be marketable in Port Moresby – sellers simply discount the price. This is another reason why the concept of 'unmarketable' produce is difficult to grasp by farmers, because they can pack everything they dig into a bag and will be able to sell it. Only when the final market seller has to dispose of the remainder of their produce at a discounted price does the 'unmarketable' component become obvious. We have seen bags in the Port Moresby wholesale yards that are riddled with knife cuts, symptomatic of low quality sweetpotato failing repeated inspections by potential market sellers. This 'unmarketable' produce costs the same as good quality sweetpotato to ship to market, so discounted price eventually applied to sell the produce invariably leads to losses. We therefore consider that it may be helpful to come up with another term for 'unmarketable' produce sold at discounted rates, but although marketers may be able to understand the term, we feel it would simply complicate farmer understanding further.

7.5 Assessment of quality and product losses in POM markets

Although consumers in Lae have expressed their views on sweetpotato quality (Omot 2010), there are no product specifications or quality standards for sweetpotato in PNG (Chang and Griffith 2011). In our paper submitted to the 7th International Conference on Agribusiness Economics and Management, Philippines (Irving et al. 2015), we noted that if smallholder Highland farmers desire to increase their income by sending their crop to the larger coastal cities, it is important for them to know what quality the consumers in those markets require. Farmers can then prepare their produce for the appropriate market (local or coastal city). Omot's (2010) study suggested that Highland farmer producers had some idea of consumer preferences, but that they did not seem to make a concerted effort to respond to these preferences. Our study aimed to help some farmers gain an understanding of preferences amongst Port Moresby consumers.

At harvest, during the journey to market, and at the market, there are ample opportunities for product loss. In most instances, all sweetpotatoes harvested (including those damaged or diseased) are packed into large bags that are thrown around, causing damage including breakage of roots and skinning. In the Highlands and in Lae, bags of sweetpotatoes may be outside for days (there being no designated cool room storage) and then transported to Port Moresby where again they may be unattended for a period in the storage areas used by buyers. The environmental conditions inside bags that have been left in the rain and sun are conducive to diseases and rotting organisms that thrive in warm moist conditions.

Postharvest diseases have the potential to impact greatly upon the quality, food safety, and marketability of sweetpotato. A survey on postharvest diseases was conducted in 1989 (Morris & Forbes-Smith) and the most common postharvest pathogens identified were *Fusarium sp* and *Rhizopus arrhizus*. However, others included *Ceratocystis fimbriata* (Black Rot) and *Monilchaetes infusans* (Scurf). During their survey, the authors did not find examples of *Trichoderma* and *Aspergillus* species, contrary to an earlier survey by Shaw (1984). Surveys undertaken by Lazar-Baker *et al.* (2009) identified similar organisms, but also identified *Lasiodiplodia theobromae* (Java Black Rot). They identified the main postharvest diseases as *Fusarium* dry rot, *Penicillium* rot, soft rot (*Pectobacterium* spp. and others), *Rhizopus* rot, and Java Black Rot.

The conclusion from the survey by Lazar-Baker *et al.* (2009) was that although disease was frequently observed, the severity (or impact of the diseases) was low. This finding led us to complete some random sampling to get an indication of how important disease was to product loss. The significance of this research was that with the low disease impact found, it was not necessary to impose any additional packaging and handling restrictions on the sweetpotato supply chain. Consequently, the entire postharvest technology component of the project was redirected into defining quality for the markets.

In horticulture, quality (Shewfelt 1999) generally refers to the size (individual or pack), shape, and appearance (product quality attributes). However, it may also include nutritional value, composition, flavour, and texture (consumer quality attributes). In this report we consolidate our findings from various trips undertaken to PNG during this project, previously presented in several individual trip reports. Our emphasis was on determining what PNG farmers and consumers understand by *quality*, since we are of the opinion that although PNG consumers probably have similar understandings of quality as western consumers, we should not necessarily expect this to be the case.

This research comprised several components: postharvest training for farmers to determine their perceptions of quality, exploring market seller perceptions of quality for Port Moresby consumers, trial sales of graded quality sweetpotato, training of supermarket managers for increased sales, and assessments of product loss. In some instances, we refer to publications, our travel reports (by month and year of travel), or to conference submissions, some of which are yet to be published.

7.5.1 Market seller perceptions of quality for the Port Moresby consumers

Omot (2010) undertook a study of consumer perceptions of sweetpotato quality in Lae. The study concluded that Lae consumer purchase decisions for sweetpotato were based on individual preferences including mainly smooth skin, sweet flavour, long shape, and medium size. Lae consumers were also found to have sought out preferred varieties. Our project market survey of Port Moresby (Chang et al. 2014) showed that POM consumers have different preferences to those in Lae (e.g. varieties *Wahgi Besta* and *Wunmun* v *Kerot*, *Wahgi Besta*, *Korowest*, and *Gimane*) probably because many ex-Highlanders reside in Port Moresby and they favour the varieties grown in their family villages.

In the Port Moresby consumer survey (Chang et al. 2014.) quality perceptions were obtained through questionnaires. Qualitative assessments of quality referred to medium-large size, elongated, red skin (e.g. *Wanmun*) or brownish white skin (e.g. *Wahgi Besta*). Additional research was conducted to support the survey data with some quantitative assessments of quality, especially size (length, width, mass), allowing us to recommend dimensions to Highland farmers so they could prepare size grades for specific markets. Here we cover perceptions of sweetpotato size, consumer demand in terms of price paid for quality sweetpotato, and a short trial to determine supermarket customer perceptions of quality.

To provide a direct indication of what the market wanted in terms of size, we purchased heaps at random, amongst those heaps selling for K2, K5, and K10, from up to five sellers in 3-5 open markets in Port Moresby. Purchases were made in August 2013, April 2014, and October 2014. These heaps (Figure 8) are the same as those purchased by consumers in the market. We bagged and labelled the heaps, brought them back to the FPDA office, and measured several attributes including the length, widest diameter, and narrowest diameter of individual roots, and the combined weight of all produce in the heap. Data from each of those studies are reported in the associated travel reports, but here, we have summarized the data from Irving et al. (2015) in Table 42. These data span the 3 dates, several markets, and several sellers within each market.

Figure 8. The Waigani market in March 2013 with K2, K5, and K10 heaps

The mean lengths were 165-187 mm for grades 1 and 2 (Table 42). In the October 2014 trip report, we outlined our choice of grading recommendations. The dimensions of sweetpotato in the heaps were variable (none of the sellers used a model sweetpotato for

length, nor did they use measuring tapes, and nor did they use weighing scales). Consequently, looking at the dimension data as a whole we came to a decision that specific lengths for grades (as in western systems) were not a locally appropriate intervention. Instead, we suggested implementing a single marketable grade for the farmers, leaving the heap construction to market sellers, whose decisions are already made very effectively in response to market demand, product size, and quality. Thus we focussed on appearance factors for quality.

The recommended grade standard was as follows: length 150-250 mm, minimum diameter >40 mm, no rots, no cuts, not rat bites, no splits, no weevil holes, no breaks >10 mm, elongated shape, smooth skin. These were the recommendations we made to our famer groups during subsequent training sessions, and in the Information Notes we distributed in the Highlands.

Table 42. Sweetpotato dimensions

Dimension*	Heap price		
	K2	K5	K10
D_{min} (mm)	42.5	53	65
D_{max} (mm)	46.3	59.0	69.7
Length (mm)	135.3	164.7	186.7
Wt. per root (g)	131.3	282.7	464.7

*Narrow diameter at centre, D_{min}; widest diameter at centre, D_{max}, length and weight; averaged from heaps sold at 3-5 open markets in Port Moresby on 3 sample dates (August 2013, April 2014, October 2014). Each cell is the mean of 2 to 4 observations.

Based on the grade standard outlined above, we assessed the marketability of sweetpotato purchased from the wholesale market, the place where most of the open market sellers purchase their sweetpotato. This was described in the March 2014 (twice) and October 2014 (once) reports, for a total of 3 marketability trials. Bags were purchased from the wholesale market and hand-graded the sweetpotato by the project team (Figure 9). Descriptors used included: 'graded – all roots that fitted the standard; and 'mixed' – the remaining roots including those that were broken, small, misshapen, rotted (only a few rots seen), as well as those bitten by rats, with weevils, featuring harvest cuts, etc.

Figure 9. All hands in for sweetpotato grading in Port Moresby

The results for marketability in the three trials are shown in Tables 43 and 44. The percentage by weight judged as 'graded' averaged out at 26%, 16%, and 15% across the three trials. Based on a modest sample, this suggests, consistent with what we observed during the project, that only about 20% by weight of sweetpotato arriving in Port Moresby satisfy our criteria for good quality marketable sweetpotato. The main issues were with small roots and uneven surfaces (ridging and misshapen), but harvest stick damage was also prevalent. In these samples, we recorded only 1-2 roots with rots.

Table 43. Results from selling graded sweetpotato from bags purchased from the Gordons wholesale market, Port Moresby in March and April 2014.

Date	Bag	Graded (kg)	Price (K/kg)	Mixed (kg)	Price (K/kg)	Total (kg)	Graded (% total, kg)
24/03/14	1	25.5	1.84[WS2]	49.6	1.42[WS2]	75.1	34
	2	17.5	1.71[MS1]	58	1.00[WS1]	75.5	23
	3	17.5	1.92[WS1]	62	1.00[WS1]	79.5	22
	4	18	1.84[WS2]	55	1.42[WS2]	73.5	24
	5	19	1.92[WS1]	59	1.02[MS1]	78.0	24
	6	19	2.10[MS2]	53	0.85[MS1]	72	26
	x̄±sd		1.84±0.08		1.12±0.24		25.5
01/04/14	1	10	2.88[MS1]	67	1.09[MS2]	77	13
	2	10	2.00[WS1]	64.5	1.35[MS1]	74.5	13
	3	12.5	2.88[MS1]	71	1.09[MS2]	83.5	15
	4	14.5	2.49[MS2]	56	1.43[WS2]	70.5	20
	5	13.6	2.49[MS2]	67	1.04[WS1]	80.6	17
	6	16	1.06[WS2]	65	1.35[MS1]	81	20
	x̄±sd		2.30±0.69		1.22±0.17		16

Sweetpotato were hand graded into two groups – 'graded' and 'mixed' and sold by local sellers (S1 and S2) in Waigani (W) or Malaro (M) markets in March and April 2014. Means and standard deviations (x̄±sd) are presented where relevant.

Table 44. Price per kg from selling graded sweetpotato in Table 4A sellers (S1 and S2) in Waigani (W) or Malaoro (M) markets, October 2014.

Market	Bag No.	Graded weight (kg)	Graded total sales (K)	Graded price (K/kg)	Mixed weight (kg)	Mixed total sales (K)	Mixed price (K/kg)	Graded (% total)
WS1	1,3,4	35.4	60	1.69	190.5	210	1.10	15.7
WS2	2,5,6	32.5	80	2.46	174	375	2.15	18.1
MS1	7,10	19.8	50.60	2.56				
MS1	7,8				119.9	242	2.02	14.2
MS2	9,10	18.8	50.40	2.68				
MS2	8,9				123.8	221	1.78	13.3
Mean				*2.34*			*1.76*	*15.3*

7.5.2 Trial sales of graded quality sweetpotato

In order to test consumer demand for graded produce, the sweetpotato (graded and mixed) were distributed to two sellers in each market (Waigani and Malaro) who were selling their own sweetpotato at the same time (Figure 10). They were provided the sweetpotato for free, on the understanding that they kept the money from sales of graded and mixed produce separate. Project team member Gus Maino negotiated with the sellers (all women), and carried out follow-up calls to collect the sales data (Tables 43 and 44). In order to avoid attracting attention, we did not stay at the market or take photos during the sales periods.

Figure 10. Sweetpotato sellers in Waigani market

The results (Tables 43 and 44) indicate that sellers earned more money from selling graded sweetpotato than mixed (ungraded) sweetpotato. For the March-April trials, T tests confirmed a greater level of income (T=5.68, P=0.000). T tests also indicated that sellers at Malaro earned more for graded sweetpotato than those at Waigani (T=2.80, P=0.02) but that there was no significant difference between markets for mixed grade sweetpotato

earnings (P=0.49). Finally, T tests indicated that date had no significant influence (P>0.05) on seller earnings for the two grades.

The finding that date in the March-April trials had no influence was of interest, as we thought the overall appearance of sweetpotato from the second date was inferior to produce available on the first date. Both batches came in on the same ship, so the second batch was older than that from the first date.

Some observations were made on the time taken to sell each grade. In general, we were told that sales took place over 3 days. The sellers also had their own sweetpotato to sell, although one was selling Irish potatoes in Waigani. This seller (WS2 in Table 44) was near the entrance, so that customers could walk past them *en route* to the lighter vegetables and perhaps buy the heavier sweetpotato on the way out, therefore not having to carry a heavy load around the market. This seller sold her sweetpotato on the delivery day on the first date, and in 2 days on the second date. Seller WS1 indicated she had sold her graded sweetpotato in 2 days and the mixed sweetpotato in 3 days.

WS1 sold her sweetpotato (both grades) on Friday 31 October 2014, and if the wholesale price was K90 per bag, she sold at the wholesale price. WS2 sold graded sweetpotato on Monday 3 November, and mixed grades on Wednesday 5 November. Her sales indicated she earned K180 above the wholesale price.

This is only an early stage study of consumer choice surrounding purchase of sweetpotato in the open markets. However, it shows that, at least in the Malaro and Waigani markets, consumers are prepared to pay more for quality sweetpotato. This was valuable information for our farmers in Western Highlands, Jiwaka, and Eastern Highlands as it should encourage them to take on board our training where we indicated that a proportion of their shipments to Post Moresby could be of higher quality, and that they should have an expectation of getting a higher return for that portion. At the time of writing, there was no indication that quality was understood or applied in the Port Moresby market by Highland farmers. However, such an understanding must be obtained if Highland farmers are to sell sweetpotato to city markets in the longer term, when rice, pasta, and bread will offer greater competition.

We followed this open market research with an initiation into the supermarket segment. We spoke to the produce manager at Boroko Foodworld, a higher quality supermarket in Port Moresby, about delivery of graded sweetpotato for a better price. The manager was very keen for us to deliver on this, and previously we had taken a 1.5 kg sample of first grade (our judgement) medium-sized sweetpotato to the manager in a perforated plastic bag. He was quite enthusiastic, although the 4 pieces were thought to be more suitable for a small family meal, and his preference was for larger sweetpotato, or for more pieces per bag. The sweetpotato were not washed, the air-conditioning caused the bag to fog, and the fine dust attached to the moisture droplets and made the bag opaque. This suggests that sweetpotato needs to be washed prior to placing in the bags. The fogging was caused by a change in temperature from outside the shop (32 °C) to inside (25 °C). It is a principle of postharvest management of vegetables that to stop such fogging, produce must be brought down in temperature before it is bagged. These are possibilities for the future. During the April-May travel, we saw supermarket sweetpotato in small red onion bags holding about 1-2 kg. This appears to be a great innovation, but ideally the bag should hold 3-5 kg of sweetpotato and the roots shoot be of a uniform size, to justify the expense of using these bags. Onion bags are good for sweetpotato as they enable airflow, while the product is clearly seen.

Because we had access to our collaborator's sweetpotato shipment straight from the ship during the March-April 2014 trip, we were able to grade 8 bags to provide 156 kg of unwashed, unpackaged sweetpotato that was taken to Boroko Foodworld. The price obtained from the supermarket was K1.80/kg, comparable to that obtained for graded sweetpotato in the open market. The supermarket sold the sweetpotato for K2.99/kg. A major issue was that the shelves were not continually restocked while the product was sold.

This small exercise suggests that sweetpotato can be graded on-farm, with training, and

consequently sold for a higher price in the supermarkets. This would give entrepreneurial farmers or traders a distinct advantage over others who sell directly to the wholesale markets and take whatever prices they can get. Our advice has only ever been to consider the higher value Port Moresby markets for a portion of the shipment sent, as this will ensure that a price differential between average sweetpotato and graded sweetpotato is maintained. Supply and demand, together with incurred costs, are key influences on returns to farmers, but we chose to offer good advice to those involved in the project, to give them a start if they chose to try something new and consumer-orientated.

7.5.3 Assessments of product loss (waste)

In March 2013, Andrew Watson (NSW DPI) accompanied provided plant pathology advice at a workshop conducted in Mt Hagen. The workshop provided industry representatives with advice on postharvest diseases, covering topics such as sources of infection, factors that increase disease expression, and methods to minimise the impact of these diseases. We also examined sweetpotato when unpacked from randomly selected bags (70 kg each) bought at the local Port Moresby wholesale market (Gordon's market).

At the FPDA office in POM, the contents of the large bags of sweetpotato were spread on the floor (Figure 11). Sweetpotato were separated into good quality (supermarket), small, broken and rotten (unmarketable), and other (misshapen, cracked, dimpled, cut, rotten). A small number of broken roots were separated out as in Table 45.

Figure 11. Donald, Gus, and Poela sorting sweetpotato into groups to determine marketable from non-marketable (waste) in Port Moresby.

Table 45. Approximate distribution of sweetpotato from a single bag, Port Moresby, 18 March 2013

'Grade'	Weight (kg)	Number	Average weight (g)
Supermarket	36.45	129	282
Small	14.65	116	126
Other	20.97	77	272
Unmarketable	5.35	27	198
Total	77.42	349	220
Unmarketable %	7%	8%	

Only minimal disease was found, and most of the bag contents were considered by the collaborator to be marketable (only 7% by weight unmarketable). This bag had many roots with new shoots, indicating that they had been stored somewhere for about two weeks since harvest. Disease levels were low (Figure 12). We discussed the relative merits of the groupings, but decided that all 'supermarket', 'small' and 'other' were marketable. For this assessment, we determined 'unmarketable' sweetpotato to include those rotten and small pieces that had been broken off the ends of larger sweetpotato roots.

Figure 12. Note the sprouts on the roots (left), an indication that they had been stored for about two weeks since harvest; and right, those that were considered unmarketable, including one severely rotted root, and others broken but still no disease.

On 28 March another bag of sweetpotato was purchased from Gordon's market to assess the quality of marketable sweetpotato. The bag was examined for any diseased and other unmarketable roots. The sweetpotato were generally of good quality, but many had begun shooting, and many had splits and growth cracks (Figure 13). This is not seen as a problem in PNG, but rather, is indicative of a mature root. Numbers of diseased roots were again low, however three had clear signs of rot. One was identified as having *Penicillium* (Figure 14), another as *Aspergillus* (Figure 15) while the colour suggested *A. flavus*, and the third was identified as having *Fusarium* dry rot (Figure 16).

Figure 13. Sweetpotato from Gordon's market (left). Some split roots (right) possibly from machete damage at weeding, or growth cracks. Sliced root showing damage due to weevils.

The presence of *A. flavus* is of concern because the aflatoxins produced are harmful to human health. However, in previous surveys by Lazar-Baker *et al.* (2009), *Aspergillus flavus* was not observed, while Clark and Moyer (1988) considered both *Penicillium* and *Aspergillus* diseases to be minor diseases of sweetpotato. The sweetpotatoes with disease would not have been consumed by humans, and most likely would have been used for pig feed.

Figure 14. The *Penicillium* infected sweetpotato (left) showing typical green coloured fruiting bodies and the damage internally to the sweetpotato (right).

Figure 15. The *Aspergillus* infected sweetpotato (left) showing typical yellow fruiting bodies (inset), and internal damage (right).

The diagnosis of these diseases was not backed up by microscopic or other plant pathological methods, but was considered to be correct from the experience of the observer.

Postharvest diseases were not as serious as expected on this trip, but the potential for them to occur was clearly evident. A problem that became more obvious after closer inspection of the roots was the presence of harvest injuries to the roots that were hidden by the soil particles. This made identification of damaged roots difficult, and so we may have missed many of them. Such damage would become apparent after washing the roots at the market, or prior to preparation for a meal. What was observed was of reasonable quality considering the potential for deterioration, especially after long-term storage in the open.

Figure 16. *Fusarium* dry rot symptoms seen on one sweetpotato when sliced.

The apparent absence of disease on skinned areas led us to reassess the need for curing. In particular, it emphasises the need for a curing test, so that it would be possible to determine whether any curing-type protection develops during handling and transport, or whether harvest injuries, rather than skinning injuries, are responsible for most of the rots observed (Objective 2.3).

For the routine assessment, unmarketable sweetpotato in Port Moresby open markets were henceforth defined as those with rots (any rot visible), and small pieces broken from larger roots (i.e. 2-3 cm diameter and up to 10 cm in length).

In August-September 2013 we assessed whole bags from three Lae markets and five Port Moresby markets using these criteria. From the full bags purchased in Lae, we deemed 6.5% by weight (12% by number) to be unmarketable, mainly due to rots and a number of small broken off pieces. In Port Moresby, 8.6% by weight (13% by number) were not marketable. These indicate quite reasonable levels of waste, considering the transport distances required for sweetpotato crops. Of interest, and reflecting the over-supply, we purchased a bag in Lae for K 80 and a bag in Port Moresby for K 80. Thus there would be losses equal to the cost of freight, airline tickets, accommodation, food, and incidentals for those shipments.

Bags of sweetpotato used for grading to supply open markets were also used to monitor waste as part of a routine inspection carried out during each trip. The sweetpotato were sent from Mt Hagen to Port Moresby as part of a regular shipment. On 24 March 2014, six bags purchased from Joe Kold at Gordon's wholesale market (Table 43) were inspected for waste. Our experience was that there was no 'waste' in Port Moresby because everything was sold, as indicated above in Table 43 (mixed grade data). In addition, we had loosely used the words 'unmarketable' and 'waste' to mean the same thing. However, much of what we called 'waste' in the initial stages of the project was packed at the farm (small roots, cuts (stabs from the harvest sticks), poor shaped roots, rat-eaten, some rots), while some extra 'waste' occurred as a result of transit (breaks from dropping the heavy bags during multiple loading and unloading operations). It would have been advisable to refer to the small portion of each bag with small roots, rate-eaten, rots etc. as 'waste' from the beginning, to

distinguish it from the lower quality sweetpotato (mis-shapen, too large, sprouted etc.) that we later called mixed grade. On 24 March 2014 there were only 6 roots from 6 bags that we noticed with rots. Instead, the main quality problems were small size, poor shape (round, bent, ribbed), and harvest cuts.

On 1 April 2014, a further six bags were inspected (Table 43). These bags also came from the same wholesale market, but had been stored in the open since 24 March. Upon inspection for grading, only a single root was found with rot. Some roots in a bag were moist, but there were no obvious rots present.

Our FPDA collaborator, John Kewa, received a ship load of his own sweetpotato from Mt Hagen. This was harvested on Thursday 27 March 2014, trucked to Lae overnight and handed over to Bismark (shipping company) on Friday 28 March. The ship docked at Port Moresby at 8 am on Wednesday 2 April, and the crop was released from the shipping container on Thursday 3 April at noon. This was probably the most direct and quickest route for the sweetpotato from the Highlands to Port Moresby.

Eight bags from the shipment were taken for grading. From those eight bags, Gus found no rotted roots. Of the total (586.2 kg), 156 kg (27%) were classed as graded and sent to Boroko Foodworld, 413.7 kg were classed as mixed, and 16.5 kg were considered waste (small pieces and soil).

On 22 October 2014, 10 bags purchased from Gordon's wholesale market were inspected for waste. These bags were likely at the wholesalers in the open for at least a week. On this occasion, there were only 3 roots from 10 bags found with rots. The main quality issues were small size, poor shape (ribbed), and presence of harvest cuts, with these roots being sold at lower prices. Farmers may be better off composting waste or feeding it to pigs, thereby saving labour and transport costs to distant markets.

7.5.4 Conclusions

Our observations from assessment of waste and loss suggest there were no major losses in the sweetpotato chain. The observations also suggest that where there are problems with rots, the sweetpotato may have been affected at the farm, have been rained on after harvest and/or during storage in Port Moresby, and/or delayed by the shipping company in Lae. Initially we thought skinning damage would lead to higher disease incidence, because skinning is a severe surface injury. However, our many observations of sweetpotato at the Port Moresby wholesale market did not confirm this hypothesis. In addition, our observations suggested that curing appeared superfluous, since its goal is to reduce skinning injury at harvest. Nonetheless, even after arrival in Port Moresby, skin diseases appear to be minor. Moreover, there appeared to be no need to store sweetpotato for months in PNG, because the crop can be produced year-round in the Highlands.

The mass losses reported earlier were mainly due to inferior product being packed on farm, transport disruptions, and the crop getting wet at harvest or during storage. Another possible reason for low losses may have been that the emerging wholesaling sector in recent years had been able to coordinate the supply chain better, and impose some sort of quality requirements on their suppliers. This is good news for current low tech (but high cost) sweetpotato transport to market, because if transport is scheduled correctly, and the crop is not allowed to get wet during the journey to market, sweetpotato will reach the market in reasonable condition without the need for expensive packaging. This part of the project was initiated to devise packaging solutions to avoid major losses of sweetpotato *en route* to market, but our careful analysis of the supply chain has enabled us to pinpoint the hazards through our HACCP exercise. In our opinion, large losses only occur if these hazardous events occur. Under those conditions, heavy losses would be expected anywhere in the tropical world. There is no need for curing or for expensive packaging. Keeping the crop dry requires facilities that cover the crop during transport and storage – issues the industry needs to address.

7.6 Training on postharvest management and marketing

Research results from the assessment of quality in Port Moresby show that rejection rates were as high as 80%. While packing good quality sweetpotato was the responsibility of farmers, quality standards and requirements could potentially be established and enforced by marketers, including traders, wholesalers, supermarkets and other buyers. This meant there was a need for postharvest training for both farmers and marketers. In this section, we summarise a series of training workshops that were conducted to educate farmers and marketers on quality issues, and to introduce improved marketing and postharvest practices.

Altogether, six formal postharvest training workshops were held, including: March 2013 (Hagen), August 2013 (Banz) and October 2014 (Kukpa and Kelua villages) for farmers in Jiwaka and Western Highlands provinces; March 2014 for traders in Eastern Highlands province (Goroka); and in April and October 2015 for mangers and fresh produce handlers of supermarkets in Port Moresby. The topics and activities covered in those workshops included:

- What the market wants—quality;

- Postharvest biology—understanding the vegetable;

- Handling and packaging—protecting the vegetable;

- Postharvest diseases—reducing waste;

- Marketing—improving product presentation and sales; and

- Presentation of a video on sweetpotato postharvest handling that was produced by a previous ACIAR project (ASEM/2006/035, 'Improving marketing efficiency, postharvest management and value addition of sweetpotato in Papua New Guinea').

The farmer workshops also included training on financial literacy and marketing planning, presentation of farm survey results on quality perceptions and postharvest practices of farmers, and the marketability and quality exercise discussed in Section 7.4.

Feedback from the participants in these training workshops was positive. They found the training and information provided to be new and useful, and were excited about putting what they had learned into practice. Most wanted to come back and learn more. Farmers enjoyed coming to the workshop and spending a few days in town being accommodated in a guesthouse or a training centre. There was an increasing awareness of quality and marketability, especially in Minj. Farmers who practiced grading claimed that they received positive feedback from customers, and were able to sell their sweetpotato faster than before. However, in general terms sorting and grading was still not widely practiced by farmers, including those who had attended previous postharvest training workshops.

There were several factors limiting adoption and scaling out, including:

- Not always having the right people selected as trainers/agents of change, because extension officers and farm leaders tended to invite people with whom they have good prior relations, rather than those people who had the greatest capacity and interest to learn;

- High staff and farmer turnover, meaning that there was no momentum in taking what was learned in the workshop further, or passing the information on to others.

- Limited follow up by local extension staff due to lack of resources, as well as motivation, for farm visits.

- Inertia meant that one meeting or two was simply not enough to initiate change in the mindset and behaviour of farmers, especially when the level of education and literacy was low and there was little previous exposure to new ideas.

- Although marketers had the potential to enforce sorting and grading, this was not carried out as there was no quality standard to guide them.

- There appeared to be little drive for change, as most farmers appeared to be happy with their lives. Our farm survey showed that farmers ranked their level of happiness 6 out of 10.

- Due to relative profitability, farmers appeared to be more interested in working on cash crops other than sweetpotato.

- The deeply entrenched production orientation of the majority of farmers. Although all farmers wanted to improve their access to the market, in the end, they appeared to be more (if not only) interested in production, rather than improving postharvest and quality to meet market requirements.

- Famers also appeared to be reluctant to acknowledge the fact that they played a key role in improving the overall quality of sweetpoato along the value chain. They tended to blame adequacy in the transport and storage system for quality deterioration, despite the fact that they intentionally packed poor quality sweetpoato into the bag.

7.6.1 Training of supermarket managers for increased sales

In April-May 2015, the project conducted a postharvest short course for managers and supervisors of vegetable displays in Port Moresby supermarkets. The objective was to improve presentation of quality product, and to link FPDA more closely to the fresh produce retail sector, where quality improvements could lead to improved sales of vegetables in general, and of sweetpotato in particular. There was a good reason for including training for supermarkets, in addition to farmers and traders in the village. During this project, several observations of poor sweetpotato presentation at supermarkets were made. Although presentation was recognised as a problem by some managers, there was no evidence from visits to the supermarkets that much attention was given to this issue. Supermarket management were clearly interested in quality, so there appeared to be plenty of opportunity for FPDA involvement with quality in the market places as well as on the farm.

Fifteen participants attended this short course. Of these, most were supervisors and workers (including Micki from Boroko Foodworld), and three were farmers, including Joe Kold, our collaborator. Joe was not trading at the time due to having a number of shipments not making much money as a result of oversupply. This experience confirms the difficulty in supplying the informal open market, and reinforces the importance of encouraging farmers to consider higher quality produce in the longer term.

Although our focus was on sweetpotato, we used examples of other vegetables to make the course more applicable to the majority of attendees. They saw examples from Australian markets and from their own stores.

We started with the video showing sweetpotato coming from Mt Hagen to Port Moresby, and then participants were able to discuss their impressions. Farmers and marketers were able to share their perspectives during the workshop and these were reflected in the comments made during 'Yu tok'. Comments related to poor quality sweetpotato being received at the supermarket, sweetpotato being considered a low value crop that supermarkets didn't make much profit from, managers being loath to remove rotted or poor quality product as they wished to sell everything, and that in some city supermarkets, consumers were becoming more discerning. It was also clear that not much money was made from sweetpotato overall, and that perhaps much of the blame for this could be associated with lack of a quality standard and lack of regular supply – issues that we raised throughout the project.

In October 2015, the project supported a postharvest short course for managers and supervisors of vegetable displays in RH Supermarket in Port Moresby. The course was run by FPDA team members, Ms Masiala Mek and John Kewa (Figure 17). The aim was to

arrange training for four supermarket managers as well as staff dealing with fresh vegetables and fruit, to educate them on correct postharvest temperature management, quality, and presentation. Unfortunately, we lost a most valued co-operator and manager at SVS Boroko Foodworld, who passed away around July 2015. Micki was a motivated manager who was very sympathetic to our endeavours, and his loss meant we were dealing with a new manager with whom we had no history. This was a recurring theme throughout the project – often, we worked to develop relationships only to find they were terminated for various reasons beyond our control.

Figure 17. Masiala Mek and John Kewa conducting postharvest training in Port Moresby.

Masiala Mek prepared a short presentation on postharvest handling of vegetables, presenting to 18 RH Supermarket managers and staff on Thursday 21 October. This segment included a 15-minute presentation, time for questions, and a walk through the supermarket shelves so that we could point out where the displays were very good, and where they were poor. The problem with poor presentation, is that to a consumer, the perceived value of the product is close to the value of the worst on display. In other words, why would a sound sweetpotato or eggplant (aubergine) be worth the same as a rotten one, when both are presented together in the same display box? In the case of poor displays, consumers are expected to do the sorting themselves, rather than the sellers. It is therefore most likely that consumers would walk away, therefore resulting in lost sales.

The presentation included brief discussion of physiology, including the roles of temperature and ethylene in product deterioration. Staff seemed very interested in learning more about grading, storing and handling of their fruit and vegetables. The verbal feedback from the manager (in the position for six weeks) was very good, and the general presentation of the produce was also very good. This supermarket sent a representative to our training course on an earlier visit, and staff members had continued to manage the section diligently. The manager was keen to get Masiala back to advise on the layout of the fruit and vegetable displays, to reduce the influence of ethylene. Temperature management was also of prime concern, as temperature-sensitive vegetables, such as ginger, eggplant, zucchini, and green pepper are often stored at 5 ºC with other vegetables.

Short training sessions appeared likely to be required on a regular basis as staff turnover was usually high. Masiala appeared able to undertake this type of role, and her images were appreciated by staff when they were informed these came from their supermarkets, not from the internet. John discussed with Masiala the possibility of setting up a budget for ongoing training sessions, and establishing two contacts per company for regular contact, to avoid the problems that occur when the manager leaves.

In second part of 2015, drought in the Highlands had had a severe impact on vegetable production. Most of the rivers in PNG were low or dry, and electricity generation was hampered by lack of water in hydro dams. The farmers themselves suffered from food shortage, and were relying on stored reserves. In such times, it was difficult to promote strict requirements for fresh food handling and storage.

Nonetheless, it seemed the short courses helped participants, as determined on the basis of feedback received from our PNG collaborators, as well as improvements in store layout and product presentation in a couple of participating supermarkets. It is hoped that the collaboration between FPDA and supermarkets on improving postharvest management and product presentation will continue, as this is an avenue for improving value chain coordination as well as improving the working relationship between FPDA and industry that will ultimately benefit PNG farmers.

7.7 Training and capacity building in business skills using gross margin analysis

From the consumer survey and sales trials at the open-air and supermarkets in Port Moresby, there was clearly a demand for quality sweetpotato, and willingness to pay more. However, meeting growing demand for higher quality sweetpotato requires a change in mindset, as well as new skills, to move from subsistence farming to commercialised farming. This has been challenging for the smallholder farmers, value chain players and policymakers, because the majority of smallholder farmers do not have the resources and necessary technical and business management skills to meet the market requirements for quality and consistency of supply. Most of these issues may be addressed by equipping smallholder farmers with the necessary skills through education and training. This section summarises the research, development and extension activities undertaken to build the capacity of smallholder sweetpotato farmers, as well as the lessons learned and policy implications for further improvement and scaling out.

Altogether, more than half a dozen training workshops were held on enhancing business skills. Initially, the three-day training workshops covered several topics, including financial literacy (household budgeting, cash management and savings and loans), marketing principles, and gross margin analysis (GMA). However, as time went by we came to the realisation that the GMA covers most of the key concepts that we would like the participants to learn and understand, including:

- Cost of production;
- Cost of marketing;
- Breakeven price;
- Gross margin;
- Garden size;
- Output;
- Yield (tonnes/ha) estimation; and
- Relative profitability/returns to labour.

In addition, we also discovered that a complex skill like GMA can only be obtained by practicing, and it would it be best learned in a group setting and at a farmer's own pace. This realisation prompted us to conduct a farmer business school trial with Agnes' group at the Gusamp village. In Agnes' case, a group of 15 people first met to discuss when and how often they wanted to meet, and what to do based on their availability and interest. At the meeting, the group decided to meet once every other week for two hours. They would learn a topic from the above list one at a time, after a brief introduction of GMA by Agnes in the first meeting. For each topic, Agnes would provide an example first, followed by small group exercises on the crop or vegetable of each group's choosing. The results from the group exercises were then presented to the class for comments. After the class, each participant was asked to carry out an individual exercise for himself/herself at home. The same process was used for each topic. Participants were encouraged to share information, learn from and help each other, and to seek help from others (family members, extension officers, etc). In addition, project team members were asked to monitor progress, and provide assistance as required.

Agnes managed to help two groups of farmers learn GMA with a very small budget. We were able to collect data on cost of production and yield for sweetpotato from farmers' fields, as well as several other cash crops. Results for sweetpotato obtained from various workshops are presented in Table 46.

Table 46. Cost of production and yield estimates for sweetpotato in the Highlands

Cost of production (K/bag)	Yield (tonne/ha)
Hagen: 17, 26, 8 (Average= 17); Goroka: 20, 23, 22, 31, 14, 15, 27, 8, 18, 9, 10 (Average=18) Gusamp: 11, 30, 10, 10 (Average= 15)	Gusamp 1: 7, 10, 15, 7, 14, 29 (Average=14) Gusamp 2: 13, 15, 11, 28, 18, 7 (Average = 15) Central Hagen: 10 Dobel: 10 Kindeng: 20
Average = K17/bag	*Average = 15 tonne/ha*

It can be seen from Table 46 above that, despite variations within the group and between groups, average cost of production was K17/bag (without the packing and bag costs) and average yield was 15 tonnes/ha. If packing and bag costs were taken into account, a reasonable estimate for the cost of production of sweetpotato per bag in the Highlands would be K20/bag. What accounted for the variations within the group and between groups is beyond the scope of this project, but it does warrant further investigation to ensure on-farm productivity is as high as it can be given the PNG context.

7.7.1 Conclusions

The farmer business school trials on gross margin analysis enabled farmer participants to think beyond prices, and instead to focus on costs and profits. In addition, this approach is a value chain analysis in action at the farm level, since it considers all the activities that are conducted on-farm and off-farm, as well as costs associated with these activities, from which weaknesses and competitive advantages can be identified. Therefore, it is a useful farm and marketing management tool. It is recommended that the basic concepts and procedures behind gross margin analysis be included in future farmer training, to build capacity in management skills. The exercises also produced useful data as shown in Table 46. However, it is still necessary for research and extension personnel to revise these data and produce "representative" or "best-practice" figures, be it on the cost of production, yield or gross margin. The resulting data can be used as benchmarks for comparing performance across farmers and regions.

7.8 Assessment of the agronomic potential for sweetpotato production in the NSW Riverina

While commercial crops of sweetpotato (*Ipomea betatis*) are produced in Cudgen in northern NSW, around 70% of the Australian crop is grown in Queensland (Australian Sweetpotato Growers Inc., 2015). Historically, sweetpotato production has been trialled in NSW inland regions. Research has demonstrated sweetpotato's adaptability, with good experimental crops having been produced on sandy soils in the Dubbo region, (Anon, 1969) and at Gosford on the NSW Central Coast (Meakins, 1981).

Historically, sweetpotato has also been grown in the NSW Riverina. There was a small industry with a limited number of growers based around Coleambally in the Murrumbidgee Irrigation Area in the early 1980's. This resulted in the white fleshed sweetpotato variety "Coleambally" being released, but a combination of high input costs and white fleshed types not receiving consumer support most likely led to its demise (Boulton, 2015).

The NSW Riverina produces a wide range of vegetable crops. The availability of regulated water and proximity to the major wholesale markets in Sydney and Melbourne are the key advantages to production in this area.

The aim of this study was to empirically determine the feasibility of sweetpotato production in this region, and to provide an approximate economic comparison to regions in which sweetpotato production is well established.

7.8.1 Crop management and Harvest

A block on Yanco Agricultural Institute (34° 36'S; 146° 24'E) was disced, irrigated, and then deep ripped in preparation for establishment of nursery and production beds.

The soil type of the block was a red brown Sandmount sand, with a high iron content and a light free draining texture. The irrigation supply involved fixed overhead sprinklers.

Some 500kg of sweetpotato seed tubers (cv Beauregard) were obtained from Aus Sweetpotato Seed (Eric Coleman), and sown into three nursery beds on 16 October 2014. Despite attempts to diversify sweetpotato varieties in Australia (Queensland Department of Primary Industries, 2000), *Beauregard* remains dominant across all existing growing regions. Therefore, the influence of variety was not considered in this study.

Three fertiliser application techniques were trialled (Table 47), to determine their effect upon emergence and seedling vigour of nursery tubers:

1. Fertiliser added on to the tubers before covering with soil;
2. Fertiliser added on to soil after tubers covered with soil; and
3. No fertiliser added.

No significant difference in emergence or seedling vigour was noted.

Table 47. Pre- planting fertiliser rates.

	N%	*P%*	*K%*	*S%*	*Ca%*	*Rate (kg/ha)*
Rustica™	12	5	14	8.3	4.5	250
Utilzer™	7.5	17.5	0	8.2	6.4	180
Muriate of Potash	0	0	50	0	0	150
Urea	46	0	0	0	0	50
Plus						
Magnesium sulphate						25kg
Zinc sulphate heptahydrate						1.44kg

Crop requirements as determined from the literature and agronomic advice indicated a plant usage of 100 units of N, 40 units of P and 180 units of K. The base fertiliser at planting thus involved applying 66% of N, 110% of P and 61% of K.

Base fertiliser was applied to all production blocks prior to transplanting, using a spreader. Beds of 180cm width where then formed over this base fertiliser to receive the transplants. The remaining Nitrogen and Potassium was applied as top dressing.

Following emergence, shoots were allowed to grow to approximately 35cm in length, before being cut and all leaves being stripped except for the shooting tip, before the plants being transplanted to one of four production blocks. Blocks consisted of 5-6 beds (1.8m). The first transplants occurred 62 days after sowing (16/17th December 2014) in blocks 1, 2 and 3. A further transplant occurred 30 days after sowing (15th January 2015). Transplants were sown with 90cm spacing, at least double the commercial standard, used to guarantee yield, and allow growth to be unlimited by water and fertiliser requirements.

No pre-emergent herbicide was applied. Grass and broadleaf weeds were manually removed when transplants were placed into beds, and subsequently beds were sprayed using Verdict™ (haloxyfop-R methyl) when required, for selective control of grasses. Subsequent emerging broadleaf weeds were controlled manually. No significant pest or disease damage was recorded. Hares caused some chewing damage to tubers and cuttings after the planting of nursery beds and production blocks, and a scare gun was deployed. Hawkmoth caterpillars (*Agrius convolvuli*) were observed at transplant and pupa were unearthed at harvest, but these caused no noticeable damage and no specific control was required.

Transplants were irrigated as soon as possible after planting into production beds. Subsequent irrigation was applied as necessary, usually involving a four-hour watering, applied twice weekly.

All production blocks were top-dressed with 200kg/ha Potassium nitrate at flowering/tuber initiation. For Blocks 1-3, this occurred on the 18 February 2015.

Harvest commenced on the 30 March 2015. Beds were mulched and ripped, and final harvest was completed by hand.

7.8.2 Yield and quality assessment

Samples were randomly harvested from three different areas (replicates) across the experimental block. Samples were packed in cardboard cartons labelled with each replicate, and transported by car to the NSW DPI postharvest facilities at Ourimbah (approximately 650 km) on the day following harvest. The next morning, tubers were washed and allowed to dry. Samples with open cuts, cracks, holes, severe damage or which were badly disfigured were counted, weighed, and discarded as rejects. The remaining tubers were re-packed and stored at 20°C for 7 days. Upon removal from storage, all tubers were counted, weighed, and separated into size based on product specifications of the Australian industry (Australian Sweetpotato Growers Inc., 2015):

- small = 4-6 cm diameter;

- medium (preferred by consumers) = 6-10 cm diameter and 15-25 cm long; and

- large=higher than 10 cm diameter.

Tubers were then individually assessed for external quality (e.g. firmness and physical or pest damage, skin marks or blemishes, and diseases). Tubers that were too misshaped, or too small (e.g. less than 4 cm diameter) were also considered rejects. Several tubers were randomly cut/sliced, and assessed for internal quality. A few tubers were randomly selected for eating quality (e.g. flavour after cooking). Samples were peeled, sliced and cooked in boiling water till they were tender (about 15 minutes). An additional commercial sample of the same cultivar was obtained from a local supermarket and cooked in the same conditions

for comparison. Samples were then cooled and tasted by a small panel of five adults who enjoyed and were regular consumers of sweetpotatoes.

A sub-sample was then taken and held at 20°C for a further 8 days. This final assessment was undertaken 16 days after harvest.

7.8.3 Comparative gross margin analysis

A gross margin is the difference between the gross income and the variable (or operating) costs. The calculation does not consider fixed or overhead costs.

Market reports were purchased from the Sydney Markets at Flemington to allow an interpolated estimate of the potential income from the trial crop grown at Yanco. The AusVeg VegTool decision support tool (Kelly, 2012) was then used to define the crop's gross margin.

This was then compared to published gross margins for sweetpotato crops grown in Southern Queensland and the Atherton Tablelands (Queensland Department of Primary Industries, 2000). In making this comparison, a number of adjustments and assumptions were made:

- The published market rate for the Atherton Tablelands crop was increased to reflect current market rates.
- The majority of costs were assumed to be common for crops grown in the Atherton Tablelands and Yanco. Because we are reliant on one season's data for Yanco, this was assumed to provide a more valid comparison of overall gross margins.
- An exception was irrigation costs, which will be greater at Yanco. In this case published irrigation costs for potato crops in the NSW Riverina (Napier et al., 2013) were used.
- Packaging and transport costs also varied between scenarios. Carton costs for Yanco were greater because of a larger forecast crop. Transport costs at Yanco were lower because it is closer to a wholesale market (Flemington, Sydney; 565km)

7.8.4 Results

Mean temperatures similar to those recorded in established sweetpotato production regions exist in the Riverina. Temperatures suitable for planting occur slightly earlier at Cudgen and Herberton compared to Yanco (September *cf* October). Suitably warm conditions for growth also persist slightly longer in Cudgen and Herberton (Table 48).

Table 48. Mean maximum and minimum temperatures* at the study site (Yanco Agricultural Institute) and two regions where commercial sweetpotato crops are grown (Herberton, Atherton Tablelands and Cudgen). Dark grey shaded boxes represent temperatures suitable for sweetpotato crop production.

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Yanco	Max	33.9	32.4	28.7	24.0	19.0	15.3	14.4	16.5	20.7	24.6	28.8	31.0
	Min	18.8	18.5	15.2	11.6	7.6	5.8	4.9	5.4	7.8	10.3	14.3	16.2
Herberton	Max	28.0	27.3	26.3	24.6	22.9	21.5	21.4	22.7	24.9	27.5	28.6	28.9
	Min	18.2	18.3	17.5	15.6	13.2	10.6	9.7	10.1	12.0	14.3	16.2	17.5
Cudgen	Max	29.5	29.0	28.1	26.1	23.5	21.3	21.0	22.4	25.1	26.4	27.7	29.1
	Min	19.8	19.6	18.3	15.6	12.5	9.8	8.6	8.8	11.5	14.1	16.7	18.5

* Source Australian Bureau of Meteorology

7.8.5 Quality assessment

The overall quality (visual appearance both external and internal) was very good. Tubers were well-coloured, and remained firm and crispy throughout the assessment period. About 78% of tubers were of commercially acceptable size/quality (composite grade), with 70% of those having the preferred (medium) size (Table 49).

Apart from skinning (likely caused in part by the fact that samples were washed after transport), there were few skin marks, bruises or blemishes. There were no signs of pest damage, diseases (e.g. rots), or internal discolouration. Sensory quality (flavour after cooking) was very good, with tubers having a pleasant flavour and no 'off' smells or tastes. There was no noticeable difference in flavour after cooking when compared to commercial produce from local supermarkets. The shelf-life of the tubers was good and they appeared firm and still in very good condition after 15 days at 20°C.

Table 49. Summary of the quality parameters of a sweetpotato crop grown at the Yanco Agricultural Institute

	No. plants	No. tubers	Total Wt (kg)	Mean weight per plant (kg)	Commercially acceptable (composite) size/quality (kg)				Rejects* (kg)	% of acceptable tubers	% of medium size tubers
					Medium+	Small	Large	Total			
1	16	54	29.3	1.8	15.9	1.5	5.9	23.3	6.0	80	68
2	16	62	41.2	2.6	22.1	1.0	8.7	31.8	8.6	77	69
3	10	33	22.2	2.2	12.6	1.7	3.0	17.3	4.9	78	73
Total	42	149	92.7	2.2	50.6	4.2	17.6	72.4	19.5	78	70

* Rejects: with open cuts, holes or severe damage (11%), too large/misshaped (>10cm diameter; 5%), or too small (<4cm diameter; 3%)

+ Medium size (the commercially preferred one): 6-9 cm diameter and 15-25cm long.

7.8.6 Comparative gross margin analysis

The extrapolated average yield for blocks within this trial was 1776 (32 L) cartons of tubers per hectare. In all, 78% of these tubers were marketable; therefore the total yield of marketable tubers was 1385 cartons.

The sweetpotato average prices for a 32L container at the Sydney Markets over a 3-week period, from 3-17 April 2015 (with very little variation during that period), were:

- Gold One: $20.50 (ranging from $16-25)
- Gold Two: $12.50 (ranging from $10-15)

As a result of this study, we would consider that about 70% of marketable tubers could be classified as Gold One (preferred medium size tubers). The remaining 30% would be classified as Gold Two grade.

The potential income from a crop from Yanco would therefore be:

- 970 Gold One cartons at $20.50 = $19,885/Ha….❶
- 415 Gold Two cartons at $12.50 =$5,188/Ha…❷
- Total potential income (❶+❷) = $25,073/Ha

Assuming a commercial crop from the Atherton Tablelands would receive an identical market rate the revised potential income would be $20,500/Ha

The gross margins for these two crops would then be:

- $7,696/Ha for Yanco and;
- $4,977/Ha for the Atherton Tablelands

7.8.7 Discussion

For a crop to be regionally profitable it must have:

- A gross margin that is comparable to that seen in other regions producing that crop and delivering to similar markets.
- An attractive return in comparison to other crops which are already produced in the region.
- A reliable production cycle which reduces the risk of crop failure.

7.8.8 Regional performance

On a per crop basis – and allowing for assumptions – the gross margins delivered by crops in the Atherton Tablelands and Riverina are comparable. This result is a function of production and supply chain costs and the high quality and yield observed in this study.

Sweetpotatoes produced in the Atherton Tablelands are marketed at a range of locations, but the majority of the crop is sent to the nearest wholesale market at Rocklea; a distance of approximately 1800kms. The major markets for sweetpotatoes produced in the Riverina would be Sydney and Melbourne, requiring transport for 565km and 459km respectively. Shorter transport distances would result in reduced transport costs per unit volume and reduced tuber damage.

7.8.9 Comparison to other crops

The gross margins returned for various cropping enterprises in the NSW Riverina are highly variable (Table 50). Despite the comparatively high labour costs associated with sweetpotato production, returns are relatively attractive in comparison to other cropping alternatives.

Table 50. Gross margins of summer vegetable cropping options for the NSW Riverina (Boulton, 2015)

Riverina summer cropping option	Median gross margin ($)
Potato (processing)	2,110
Tomatoes (processing)	2,286
Sweet corn (fresh)	12,845
Sweet corn (processing)	1,831
Butternut pumpkin	1,701
Watermelon	1,377
Zucchini	2,887

7.8.10 Risk

Sweetpotatoes must be planted under warm (24°C to 30°C), frost-free conditions, as plants are sensitive to cool stress. During the growing season, the plant remains dormant and vegetative growth stops at temperatures lower than 15°C. Cold stresses during growth also lead to malformation of the storage roots, and temperatures lower than 15°C can also cause chilling injuries to developing tubers (Queensland Department of Primary Industries, 2000).

The crop grown for this study produced marketable tubers in 15 weeks. This was slightly longer than required in the Atherton Tablelands (12 weeks), but suitable temperatures exist for a sufficient period to allow production. This shorter season would increase risk. For example, persistence of cool temperatures (< 24°C mean max) in October could significantly narrow the crop production window. Late frost is also more likely.

Tropical production regions have temperatures which allow continuous year-round cropping. However, production of a single sweetpotato crop at Cudgen and the Atherton Tablelands fits within a profitable farm business strategy. This is also likely to be the case in the Riverina.

7.9 Summary of results

7.9.1 Marketing

The consumer survey showed that consumer preferences for sweetpotato varieties and quality attributes were very specific. However, the majority of farmers taking part in the farm survey were not aware of consumer preferences, and were not market-oriented. Farmers tend to grow varieties that are common in their areas, primarily because they suit the agro-climatic conditions for production or long distance travel, rather than because of consumer demand. The consumer survey also indicated that demand for sweetpotato was declining in Port Moresby due to socio-demographic changes and competition from rice. Misreading of consumer preferences and demand conditions can result in oversupply, and hence low prices and product wastage, leading to low or negative returns for farmers. Educating farmers on market demand and costs and returns and facilitating changes in marketing practices will help improve sales and marketing efficiency.

7.9.2 Postharvest

The results from waste assessments conducted in Port Moresby showed that skin diseases were minor, and there were no major losses of sweetpotato as a result of rotting. The mass losses reported earlier (30-50%) were primarily due to inferior product being packed on farm, transport disruptions, and the crop getting wet at harvest or during transport and storage. This finding is encouraging because if transport is scheduled correctly and the crop is not allowed to become wet and hot during the journey to market, sweetpotato can reach the market in reasonable condition without the need for expensive packaging or a cool chain. The results from quality assessments conducted in Port Moresby showed that rejection rates of poor quality sweetpotato roots were high (up to 80% by weight). This suggests that only about 20% of sweetpotato by weight arriving in Port Moresby satisfied our criteria for "good quality sweetpotato" (no rots, no cuts, no rat bites, no breakage, and not too small, too big and/or mis-shaped). The main issues we found were with small roots, an uneven surface (ridging and misshapen) and harvest stick damage. Another finding from the postharvest research in Port Moresby was that price premium exists for good quality, medium size sweetpotato. These results suggest that sorting and grading in the Highlands is essential for improving quality outturn and economic returns. In addition, curing of sweetpotato is a superfluous activity for PNG farmers because the crop can be produced year around in the Highlands.

One possible reason that low product losses were identified was the emerging wholesaling sector, which seemed capable of coordinating the supply chain logistics more effectively, as well as imposing some quality requirements on their suppliers. It also suggests that working more closely with buyers, and providing training to buyers, may be more effective in improving quality than working with, and training for, farmers. However, keeping the crop cool and dry requires facilities to cover the crop during transport and storage, and these are the issues the industry needs to address.

7.9.3 Training and capacity building

The results from training and educating farmers and extension officers on gross margin analysis (GMA) showed that GMA is a useful management tool both on-farm (what to produce) and off-farm (where to sell), as well as identifying areas for cost cutting and productivity improvement. GMA also encompasses other business skills such as book-keeping, budgeting, planning, and weighing up alternatives. Given the low level of education and literacy of most farmers, successful application of GMA can be achieved by using a farmer field/business school approach whereby farmers learn as a group and at their own pace. This approach is consistent with participatory capacity development principles, and was found to be more cost effective than training workshops.

8 Impacts

8.1 Scientific impacts – now and in 5 years

The results of various technical trials have shown that even though packaging, handling and transport of the sweetpotato bags were less than ideal, product losses in Port Moresby were much less (2-5%) than previously claimed (30-50%), providing that sweetpotato could be delivered within 7-10 days and kept out of rain and sun. This is significant since previous research had suggested that substantial changes (curing, small packaging, cool chain, etc.) were needed to improve quality outturn. The new finding not only prevents costly and unnecessary changes to current practices, but is locally appropriate given the current transport system.

8.2 Capacity impacts – now and in 5 years

Six formal postharvest training workshops were held (March 2013, August 2013, March 2014, October 2014 (2 groups) and May and October 2015) to educate farmers and traders on quality issues. Postharvest quality training was delivered to supermarket managers specialising in fresh vegetables in Port Moresby in April and October 2015, in order to improve product presentation and sales. Awareness of quality and marketability has increased. Farmers in Minj who practiced grading claimed that they received positive feedback from customers, and were able to sell their sweetpotato faster than before. There are also improvements in product displays and fresh produce management at the supermarkets.

As a result of taking part in gross margin analysis (GMA) training, more farmers are selling to local traders, rather than travelling long distances to Lae or Port Moresby on their own. A wholesaling sector is emerging. In 2008, we found only a handful of village entrepreneurs who bought sweetpotato bags from other farmers and took them down to Port Moresby. In mid-2015, there were 20-30 sweetpotato wholesalers based in Port Moresby, but with buying agents in the Western Highlands Province (especially around Hagen Central) and the Eastern Highlands Province (around Asaro Valley), who sourced sweetpotato bags from the village and transported them to Port Moresby. We believe that the middleman, or wholesaler, is the key to improving marketing efficiency in the sweetpotato supply chain. When sweetpotato and other fresh produce are consolidated through local buyers or wholesalers, multiple handling is avoided, physical damage to produce is reduced, transaction costs due to diseconomies of scale of marketing in small lots is likewise reduced. The real challenges now are to identify and train local entrepreneurs to be professional marketers, and to build trust between smallholder farmers and buyers/middlemen.

Just recently Agnes, our key collaborator and the trainer and facilitator of the Farmer Business School in Gusamp village, was approached by Tininga, a wholesaling company based in Mt Hagen buying for CPL in Port Moresby, to supply carrots and cabbages in huge volumes. Normally, Agnes would have welcomed such a deal and said yes, because she has been looking for alternative markets for her group since late 2011 after the collapse of the wholesaling operation of Sigma Holdings. Now, with the GMA training, she is more cautious and concerned about costs and returns and standing orders, and not just prices. In this case, Agnes and her group have become more business-oriented than before as a result of their new skills in GMA.

Researchers and extension officers in collaborating organisations are adopting the value chain approach and have become more market-oriented, as well as becoming more aware of their expanded role in linking farmers to market and service providers, in addition to improving farm production.

8.3 Community impacts – now and in 5 years

8.3.1 Economic impacts

The project has contributed to increased household incomes and improved livelihood for smallholder farmers, due to:

- Better postharvest handling practices, enabling farmers to attract customers and sell at a premium; and
- An improved understanding of the relationship between prices, costs and returns that encouraged farmers to sell to local traders. This is an alternative to individual farmers venturing to coastal markets themselves with small numbers of bags, saving time and money, as well as saving female farmers from harassment and attack *en route* to the market.

Female farmers who practice sorting and grading have claimed that they were able to sell fast, at a higher price, and have attracted more customers. Female farmers who attended the Farmer Business School claimed that they were able to negotiate prices with buyers and improve returns to their labour.

8.3.2 Social impacts

- Reduced income risk and vulnerability to food insecurity and family emergencies, due to money being safely tucked away in savings accounts which were established as a part of linking farmers to microfinance activities.

- Improved social status of female farmers in the household and community, because they were contributing more to household income, church activities and social obligations.

- Empowerment of women, because of the knowledge and skills acquired, and their ability to make better-informed decisions, both personal and business-related.

8.3.3 Environmental impacts

NA.

8.4 Communication and dissemination activities

Our project activities and results have been communicated and disseminated through stakeholder and training workshops, information sessions for FPDA and NARI staff, FPDA and NARI newsletters and field days, research reports, conference presentations and extension materials, as well as the sweetpotato fair held in Jiwaka province.

Research outputs from this project include:

- two conference papers presented at the 2014 International Horticulture Congress in Brisbane, August 2014;
- one conference paper presented to the 8th Asian Society of Agricultural Economics Conference, Savar, Bangladesh, 15-17 October 2014
- one conference paper presented at the 2014 International Society for Southeast Asian Agricultural Sciences (ISSAAS) International Congress and Meeting, 8-10 November 2014, NODAI Academia Centre, Tokyo University of Agriculture, Tokyo, Japan.
- one conference paper presented to the International Conference on National Capacity Building Strategy for Sustainable Development and Poverty Reduction, May 2015;
- three information sheets on marketing were distributed to workshop participants in April 2015, and two information sheets on postharvest were distributed to farmers in Gusamp village and FPDA partners. All information sheets have been translated into Pidgin;
- two seminars were given at the Institute for Rural Futures Seminar series;
- five conference papers were presented by the project team (Christie Chang, Donald Irving, Rene Villano, Anton Mais and John Kewa) at the International Conference on

Agribusiness Economics and Management Conference in Davao, the Philippines, 22-24 Oct 2015;

- various technical reports/trip reports;
- key research outputs from the project have been presented at the training workshops;
- stakeholder consultation with provincial and district administrators in Jiwaka and Morobe provinces in December 2014 and May 2015 to promote the research, and to seek collaboration in dissemination of the results;
- a Sweetpotato Fair which was held in the Jiwaka provincial government headquarters on 21 October 2014. Posters for postharvest management, processed sweetpotato products and sweetpotato PT planting materials were displayed, and some were given away;
- survey results were presented to Village Extension Workers (VEWs) and extension officers at the Mt Hagen Workshop, 29 April 2015, by Christie Chang and Donald Irving;
- research results were presented to FPDA and NARI for information and feedback in May 2016; and
- seminars were given to the International Potato Centre in Nairobi and Kisumu and to the National Agricultural Marketing Council in South Africa, June 2016.

9 Conclusions and recommendations

9.1 Conclusions

A review of literature on consumer demand suggests that, as an economy develops and income increases, changes in consumption patterns will occur. First, demand for animal protein and for fruit and vegetables will increase, and consumption of starchy staple foods will gradually decline. Second, demand for higher quality and more convenient products will increase. Third, more shopping will be carried out in supermarkets, as opposed to shopping in traditional open-air or wet markets. These changes have already occurred in the urban areas of PNG, as evident from the consumer survey conducted in Port Moresby. Therefore, per capita consumption of sweetpotato will continue to decline, not only in urban centres but across the country, as the PNG economy develops further. This means that in order to compete with other products and to reduce the pace of such changes, the overall competitiveness of the sweetpotato value chain must improve. This will involve: providing the varieties and quality that consumers prefer; increasing crop yields to reduce the cost of production; and improving postharvest and marketing practices to improve quality outturn and to reduce marketing costs. This means an integrated, value chain approach to improve the overall competitiveness of sweetpotato is needed. Equally important is the balance between investment in research and investment in development and extension, to ensure that research outputs are translated into development outcomes and impacts.

9.2 Recommendations

- Transport and storage facilities remain the binding constraints on improving the sweetpotato value chain in PNG, with declining per capita consumption a real threat. These issues must be taken into account and addressed before embarking on large-scale commercial production. More investment is required in transport and storage infrastructure, as well as in value chain research.

- Engaging with and educating traders and marketers may be more effective in improving product quality and chain efficiency than working primarily with farmers. Capacity building in technical and business skills is required at all levels of the innovation system, and along the value chain.

- Participatory action research is useful for achieving systemic change and sustained development of the sweetpotato value chain, but it must involve and be supported by local extension networks. Extension should be a built-in component of agricultural research for development.

10 References

10.1 References cited in report

Anon. 1969. The Sweet Potato. *The Agricultural Gazette of New South Wales*, Vol.80, pp.284-288.

Australian Sweetpotato Growers Inc. 2015. Australian Sweetpotato Industry key facts. http://www.aspg.com.au/sweetpotato-industry/, accessed 22/5/15.

Boulton, A. 2015. pers comm. NSW Dept. of Primary Industries, Yanco Agricultural Institute.

Chang, H-S, Irving, D.E. and Villano, R. 2013. Identifying socioeconomic constraints to improving sweetpotato quality and postharvest management in Papua New Guinea: preliminary results from a farm survey and marketability trials, pp 48-66. In: G. Hickey (ed.). Socioeconomic agricultural research in Papua New Guinea. Proceedings of a workshop held in Lae, PNG, 5-6 June 2013.ACIAR Proceedings No. 141. Australian Centre for International Agricultural Research: Canberra. 117 pp.

Chang, C., Irving, D., Villano, R., Kewa, J., Anton, C., and Kol, T. 2014. Consumer preference versus farmer preference for sweetpotato product attributes in Papua New Guinea. International Horticultural Congress, Brisbane, August.

Irving, D., Chang, H-S, and Kewa, J.L. 2015. Sizes of sweetpotato required by Papua New Guinea consumers in the main Port Moresby markets. 7th International Conference on Agribusiness Economics and Management, Waterfront Insular Hotel, Davao City, Philippines, 14-16 October 2015. BANWA Supplement 1A (2015) ICAEM-4: 4.

Kelly, G. 2012. Vegetable gross margins using VegTool decision support tool. New South Wales Department of Primary Industries. Primefact 1264 (First edition).

Lazar-Baker, E., Spohr, L., Gangai, S., Bagle, G., Ramita, I., Crampton, K., Misiel, S., Bubun, D., and Komolong, B. 2009. Survey of the postharvest diseases of marketed sweetpotato in Papua New Guinea (Lae and Port Moresby). ASEM/2006/035 Improving marketing efficiency, postharvest management and value addition of sweetpotato in Papua New Guinea Technical Reports, 2009.

Meakins, L. 1981. Gosford vegetable trials give some answers. *The Agricultural Gazette of New South Wales, Vol.* 92, pp.31-34.

Morris, S.C. and Forbes-Smith, M. 1989. Effect of curing on storage and transport of vegetables in Papua New Guinea. In: *Transport of Vegetables in Papua New Guinea*, Edited by Scott, K.J. and Atkinson, G. (editors). Canberra: Australian Centre for International Agricultural Research Technical Reports, 14: 16-21.

Napier, T., Kelly, G. and Watts, S. 2013. Gross Margin Budget – Potato (Processing). http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0004/470029/Potato-processing-gross-margin-budget.pdf, accessed 15/06/15.

Omot, N.M. 2010. Long-distance marketing of sweetpotato from the Highlands of Papua New Guinea: an analysis of consumer preferences and supplier responsiveness [dissertation]. Canberra: University of Canberra.

Queensland Department of Primary Industries. 2000. Sweetpotato information kit. Agrilink series. 108pp.

Shaw, D.E. 1984. Microorganisms in Papua New Guinea. Port Moresby, Department of Primary Industries, Research Bulletin No 33.

Shewfelt, R.L. 1999. What is quality? *Postharvest Biology and Technology*, Vol.15, pp.197-200.

Wolfenden, R., Dennien, S., Coleman, E., McCrystal, R., Henderson, C., Langenbacker, R., O'Donnell, W., Hermann, R., Prichard, M., Zunker, D. and Jess, M. 2014 Evaluating sweetpotato varieties to meet market needs. Final Report HAL Project VG09009.

10.2 List of publications produced by project

Conference papers and journal articles

Chang, H.S., Dowa, E., Malie, R., Anton, C., Anamo, I., Dekene, P. and Bubun, D. 2013. Linking smallholder farmers to microcredit providers in Papua New Guinea: A participatory action research approach. *Australasian Agribusiness Review*, Vol. 21, pp.60-82.

Chang, H.S., Irving, D. and Villano, D. 2013. Identifying socioeconomic constraints to improving postharvest management in PNG: A participatory action research. In Hickey G. (ed.) 2013. Socioeconomic agricultural research in Papua New Guinea. ACIAR Proceedings No. 141. Australian Centre for International Agricultural Research: Canberra.

Chang, H.S., Dowa, E., Malie, R., Anamo, I., Dekene, P., Anton, C. and Bubun, D. 2013. Improving access to credit for smallholder farmers in PNG: Issues and lessons learned. In Hickey G. (ed.) 2013. Socioeconomic agricultural research in Papua New Guinea. ACIAR Proceedings No. 141. Australian Centre for International Agricultural Research: Canberra.

Irving, D.E., and Chang, H.S., Kewa, J., Anton, C. and Kol, T. 2014. Sweetpotato in Papua New Guinea: How farmers' perceptions of quality meet with open market demand in Port Moresby. Paper presented to 2014 International Horticulture Conference, Brisbane, 18-22 August 2014.

Chang, H.S., Irving, D., Villano, R., Kewa, J. Anton, C. and Kol, T. 2014. Consumer versus farmer preference for sweetpotato product attributes in Papua New Guinea. Paper presented to 2014 International Horticulture Conference, Brisbane, 18-22 August 2014.

Villano, R., Chang, H. and Irving, D. 2014. An Evaluation of Market Participation among Smallholder Sweetpotato Farmers in the Highlands of Papua New Guinea. Paper presented at the 2014 International Society for Southeast Asian Agricultural Sciences (ISSAAS) International Congress and Meeting, November 8-10, 2014, NODAI Academia Centre, Tokyo University of Agriculture, Tokyo, Japan.

Chang. H.S. 2014. Future prospects for sweetpotato processing in Papua New Guinea. *Australasian Agribusiness Perspectives*, Paper 99, pp.1-17.

Chang, H.S. 2015. Future prospects for sweetpotato processing in Papua New Guinea. Contributed paper presented to the 2015 AARES Annual Conference, Rotorua, New Zealand, 10-13 February 2015.

Chang, H.S. 2015. Capacity building of smallholder sweetpotato farmers In Papua New Guinea. In the Proceedings of the International Conference on National Capacity Building Strategy for Sustainable Development and Poverty Alleviation, the American University in the Emirates, Dubai International Academic City, Dubai, 26-28 May 2015.

Chang, H.S., Villano, R., Irving, D. and Kewa, J. 2015. Understanding market demand for sweetpotato in PNG. Paper presented to the 2015 International Conference on Agribusiness Economics and Management and Cooperatives, Davao, the Philippines, 14-17 October 2015.

Irving, D., Chang, H.S. and Kewa, J. 2015. Aspects of postharvest quality required by PNG sweetpotato consumers in the main Port Moresby markets. Paper presented to the 2015 International Conference on Agribusiness Economics and Management and Cooperatives, Davao, the Philippines, 14-17 October 2015.

Kewa, J. and Chang, H.S. 2015. The role of village entrepreneurs and wholesalers in the sweetpotato value chain in the Highlands of PNG. Paper presented to the 2015 International Conference on Agribusiness Economics and Management and Cooperatives, Davao, the Philippines, 14-17 October 2015.

Mais A. and Chang, H.S. Promoting sweetpotato in PNG through School Curriculums: A pilot study. Paper presented to the 2015 International Conference on Agribusiness Economics and Management and Cooperatives, Davao, the Philippines, 14-17 October 2015.

Villano, R., Chang, H.S., Irving, D. and Kewa, J. 2015. A socio-economic analysis of the factors affecting consumers' willingness to pay for good quality sweetpotato in PNG. Paper presented to the 2015 International Conference on Agribusiness Economics and Management and Cooperatives, Davao, the Philippines, 14-17 October 2015. Under Review: Australasian Agribusiness Perspectives.

Villano, R., Chakma, D. and Chang, H. 2016. Gender Participation and Women Empowerment in Sweetpotato Farming in Papua New Guinea. Under review: Outlook on Agriculture.

Chang, H.S., Spriggs, J., Anjen, J., Dowa, E., Kewa, J. and Hehona D. 2016. Improving sweetpotato marketing in Papua New Guinea: Results from a value chain analysis. *Australasian Agribusiness Review*, Vol. 24, Paper 21, pp.1-27.

Technical reports

Donald Irving. Curing Sweetpotato (Kaukau) in Papua New Guinea – what, why, how, and is it necessary?

Donald Irving. Assessing quality and determining product losses.

Donald Irving. Identify critical control points for reducing product losses and marketing costs.

Christie Chang. Case studies of four selected supply chain.

Christie Chang. Literature review on social and cultural factors influencing value chain configuration.

Rene Villano. Results from the farm household survey

Lilly Sar, Anton Mais, Moses Robby, Amanda Wanda. Understanding sweetpotato supplier networks through social mapping.

Information sheets

Christie Chang. What the market wants from sweetpotato.

Christie Chang. Marketing practices of sweetpotato farmers in Jiwaka province.

Christie Chang. Marketing costs of selling sweetpotato to different markets.

Donald Irving. How Highland farmers define sweetpotato quality.

Donald Irving. Demand and price for good quality sweetpotato in POM.

Donald Irving. Maintaining sweetpotato quality during transport to market.