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1 Acknowledgments

We would like to express our appreciation to all local farmers, traders, processors, extension staff and other local collaborators in the villages of Cat Trinh, Cat Hiep (Binh Dinh province), An Chan (Phu Yên province) and Phuoc Dinh (Ninh Thuan province).

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2 Executive summary

This project was directed to assist the South Central Coastal (SCC) region of Vietnam where low-income levels are related to natural constraints of infertile sandy soils and an extended dry season. Relative remoteness and limited market development has resulted in restricted access to regional markets and international trade. The aim of this multi-disciplinary project was to identify and facilitate adoption of promising resource management practices for sustainable and profitable crop and livestock production systems best suited to local conditions that enable improved market engagement.

To achieve an understanding of the major value chains of products suited to the region, an assessment was made of the existing factors in the region and of nearby markets. After interaction with specialists, local extension and research staff, the products chosen were peanuts, cashews, cassava, beef, mango and sesame. These all have great potential and were chosen based on a strong understanding of demand and potential production. Of particular interest is the strong value chain of the peanut which has a high return and potential for greater integration through a crop rotation and intercropping role in the region. Limitations and threats to this come from poor agronomy, nutrient constraints, groundwater depletion, post harvest handling and seed storage. Intervention in the form of increased small and large scale drying facilities for the product and the seed is recommended and has been successfully tried on a small scale through this project, greatly improving the product value. Similarly the fertiliser and soil amendment inputs required to improve peanut nutrition have been widely investigated here following research to diagnose a number of nutrient deficiencies and treatments to alleviate these constraints.

Mango from the region has a particular market advantage due to a harvesting period that does not coincide with that from the Mekong Region. High value varieties with good quality and yield from the region are well situated for access to markets in both Hanoi and Ho Chi Minh City. However, a wide range of limitations on quality products for distant markets currently exist including poorly organised post-harvest handling and marketing, and poorly investigated varieties. Balanced nutrient supply including micronutrients gave promising results for improved production and profitability.

The SCC region of Vietnam is an area of low agricultural (crop and livestock) productivity compared to other regions of Vietnam mainly due to the presence of infertile sandy soils with limited water resources. Surveys of on-farm organic resource use and nutrient balance, assessment of soils with SCAMP and on-farm experiments in the SCC region confirmed that: i) a diverse range of sands occurred in the study area with variations in clay content, texture trend with depth, pH and parent materials; (ii) deficiencies in K, S, Cu, B, Zn and Mo and limited water availability during the dry season restricts crop productivity; iii) fertility and water availability of these regions can be improved by using new techniques (mini pan irrigation scheduling, biochar, manures and balanced nutrient supply) and iv) although limited in supply, natural resources (animal manure and crop residues and feed-stocks for biochar manufacture) are locally available and have been shown to increase crop productivity if used appropriately. Biochar amendments in particular improved crop productivity for up to four years after application. These research findings are now being incorporated in experiments to save input costs (irrigation, labour), increase yield and profit, while also building resilience in sandy soils to avoid negative implications and achieve profitable and sustainable crop production systems.

Poor water quality (high levels of NO_3 and PO_4) was identified in groundwater under deep sands and may be attributed to adverse impacts of agricultural land use, animal housing or poor sanitation in An Chan commune, Phu Yen province. Variation in levels of NO_3 and PO_4 were observed with season as a result of rainfall and management practices. Work is now in progress to identify sources of NO_3 and PO_4 in ground water that will help devise strategies to overcome the adverse impacts of land uses on water quality. Promising options involve using amendment materials (local clay, biochar, manures, bentonite, plastic lining etc) that have the capacity to hold nutrients and their minimise leaching in sands and further build resilience for a more robust sustainable system in this region. Minipan water scheduling has demonstrated increased water use efficiency in peanuts, however, improved calibration is necessary for other crops such as mango and cashew. Installation of plastic lining in sandy soils at depths improved nutrient and water use efficiency in vegetables (pumpkin) largely by halving the amount of irrigation water required. A Master's project is underway to test the ability of different amendment materials in increasing nutrient and water use efficiency and minimise contaminant leaching to groundwater. The outcomes from this research should be relevant to nutrient and water management on sands in other provinces in SCC Vietnam.

In parallel, research in Western Australia on sands, similar to sands of SCC Vietnam, aimed to enhance nutrient and water use efficiency for grain cropping. A study of soil organic carbon (SOC) under annual *vs* perennial pastures in the high rainfall zone of the south coast region of WA revealed no significant differences in levels after > 10 years of perennial pastures. Modelling suggests that SOC accumulated slowly in the sands and would take 35 years or more before measurable changes can be expected. Soil amendment materials (clay and biochar) were evaluated to develop resilience in such soils. Clay was most effective in increasing pasture yields when mixed (by spading) to 15 cm depth. Crop yield responses to both biochar (10 t/ha) and clay (200-300 t/ha of a sub-soil material containing 31-40 % clay) were reported on sands near Esperance, Western Australia. While biochar supplied a significant level of readily soluble P for plant uptake, the P was found to be prone to leaching on grey sand. Sub-soil material containing kaolin and Fe oxyhydroxides when applied to soils at 50 t of clay/ha, strongly reduced P leaching on sands. Current experiments are examining the benefit of adding clay and biochar separately and together on nutrient availability and nutrient retention in sands in both field and glasshouse experiments.

Interventions introduced into beef cattle production enterprises have shown a rapid uptake of improved forage cultivars and production methods. This is now providing opportunities to improve overall animal nutrition and management. For case study farmers, this has resulted in improved productivity and reductions in demand for scarce labour. The impact of feed supplementation was clearly demonstrated to improve profitability of beef production and work on manures and the nutrition of forages is on-going. The SCC region has the greatest livestock numbers/landholder and the linkage of cassava production for processing to by-product consumption for livestock has clear advantages. Potential exists for the expansion of cassava especially in the more arid province of Ninh Thuan where interventions identified include: appropriate varieties, improved agronomy, product preparation for livestock consumption and; development of industrial processing capacity.

The outputs of this project already point to a wide range of interventions for improving production of a number of commodities with market potential, and to research needs for the short to medium term. However, a program to pilot an expansion and on-farm evaluation on these interventions with Vietnamese agencies is needed. Such work would benefit from on-going partnership with Australian researchers investigating equally pressing issues of sustainable and productive use of sandy soils in Australia.

A significant knowledge gap hindering the realisation of the potential gains from the present research investment in SCC Vietnam is the inadequate understanding of the availability of water resources in the region for agriculture. Observations of present inefficient irrigation techniques suggest a significant potential for more efficient use of available water. However, there is a need to both develop the water resource for agricultural productivity and to manage the fragile reserves sustainably. This needs to be coupled to better diagnosis of nutrient requirements for crops on sands and improved nutrient use efficiency. An assessment of the water resource potential for increased profitability of agriculture and the threats to its future use is a high priority and Australian research and management capacity is poised to contribute to both.

3 Background

At a stakeholder workshop in March 2008, ACIAR and the Vietnam Ministry of Agriculture and Rural Development (MARD) agreed that an integrated research and development project on Sustainable and Profitable Crop and Livestock Systems should be developed for the South-central coastal region of Vietnam. It was agreed that the focus should be on farming systems on sandy soils which are extensive in the region and where farmer incomes are typically low.

The geographical focus of this project is on two central (Binh Dinh and Phu Yen) and one southern (Ninh Thuan) provinces of South-central Vietnam, with an emphasis on coastal and sloping areas under 400 m above sea level. Three provinces selected for the study represent a rainfall gradient (1800 mm in Phu Cat district to 700 mm in Ninh Phuoc district): a range of sandy soils; varied water resource availability (sites with access to supplementary water from shallow groundwater, or from farm dams filled from groundwater or run-off water, or fully rainfed systems).

This multidisciplinary project was designed to integrate and broaden the scope of ACIAR project SMCN/2003/035: '*Improving the utilisation of water and soil resources for tree crop production in coastal areas of Vietnam and New South Wales*'. The project was originally planned and proposals drafted for three distinct smaller projects and were then integrated into a combined farming systems approach to form this multidisciplinary project.

3.1 Value chain analysis

Improved market engagement of small and medium landholders is important for long term livelihood improvement and poverty reduction. In regions that are geographically isolated, such as the South Central Coast of Vietnam, currently there is poor access to profitable markets and limited opportunity to utilise market information.

Farmers in this region currently graze or house-feed goats, sheep and cattle, opportunistically grow annual crops and harvest cashews. Social research has shown that farmers in Ninh Thuan are vulnerable to drought and, even in normal years, often do not have sufficient water to grow enough rice for family needs and that they rely on the sale of livestock to generate income to buy enough food to subsist (Oxfam, 2005).

The Vietnamese government is interested in understanding the capacity of smallholders to improve sustainability and profitability based upon changing market demands. With this need to understand the capacity of smallholders to more effectively engage with the market and improve relationships for long term benefits, ACIAR's Vietnam strategy emphasises both technical and agribusiness research to enhance smallholder incomes from selected areas of high value agriculture.

The emphasis of this agribusiness approach (the focus of this component) in conjunction with technical research (the focus of components 2 and 3) will mean that there is a focus on a selection of commodities with regional advantage, through both market demand and through regional production capacity, in terms of environment, labour and/or natural resources. For farmers to receive benefits from this approach, the market and supply chain analysis needs to identify critical points for commodities, enhance stakeholder relationships and focus technical intervention to deliver improved market returns.

Implementation of enhancements in supply chain performance, assessment of the impacts along the chain including relationship building and assessment of incentives at the farmer level for improved quality, including better postharvest handling, are critical for sustainable improvements in smallholder livelihoods.

In a similar manner, Australian horticultural producers are struggling to remain globally competitive. This is particularly evident in the Western Australian vegetable industry which is the leading vegetable exporting state in Australia. The VegVision 2020 strategic plan for the Australian vegetable industry (Australian Vegetable Industry Development Group 2006) outlines the strategic imperative of developing ‘internationally competitive Australian vegetable supply chains’. The general focus areas contributing to this include establishing efficient supply chain relationships, promoting best practise business models and minimising costs within supply chains. In parallel with the Vietnam component, Australian horticultural value chains will be analysed principally to underpin the development of strategies aimed at positioning Australian produce more competitively in both domestic and export markets. This will be done with recommendations for more appropriate intervention strategies. Australian vegetable producers have struggled to remain competitive in international markets over the past 6 years. Australian fresh vegetable exports have declined from $352 M in 2001/02 to $178 M in 2007/08 (ABS data).

In 2001/02 Australia exported $15 M worth of broccoli but by 2007/08 this had fallen to $4.6 M. While Australian labour rates mean that remaining competitive with countries with comparatively lower labour cost is difficult, Western Australian export carrot producers have led the way adopting labour efficient production systems that produce consistent, high quality product and an outstanding food safety record. There is potential to raise the efficiency of production for a range of vegetable commodities through increased adoption of mechanisation and technology for a range of exported vegetable products such as broccoli, lettuce, celery, melons, sweet corn and hydroponic tomatoes. Competitiveness can also be improved by differentiating products in the more sophisticated markets where consumers are conscious of food safety and environmental sustainability issues.

Although chain analysis is not new, the use of market and supply chain analysis to both guide technical intervention and improve the impact of that intervention is relatively new. As an example of this approach, Hofman and Ledger (2006) outlined a supply chain approach for guiding research related to the introduction of a new mango cultivar to Indonesia.

3.2 Sustainable cropping systems

Coastal sandy soils occupy 500,000 ha in Vietnam (Ha et al. 2007). Significant areas of coastal sandy soils occur in the North-central and South-central regions of Vietnam and it collectively supports 14% of Vietnam’s population (10 million people) representing only 5% of Vietnam’s total agricultural land.

High value crops are under-represented in the region and the productivity of the area is relatively low. At present only 13% of the mango production of Vietnam emanates from the South-central region, and yields of mango are only 42% of those in the Cuu Long Delta region. Similarly, 17% of the cashews of Vietnam are produced in the South-central coastal region, but yields average 0.6 t/ha, about half those in the South-east region.

Novel soil management and crop management technologies are needed to boost yield potential on sandy soils after diagnosing key constraints. These technologies will address the need to increase water and nutrient use efficiency, slow soil-degradation processes, and develop integrated water and nutrient management packages including those related to fertiliser types (inorganic and organic), the use of crop residues, manure, bio-char, clay, fertiliser timing and placement. Conservation technologies are required to minimise the cost of production and optimise production without compromising the environment to move to more sustainable systems.

Rainfed agriculture on sandy soils is a widespread production system in south-west Australia where key limitations to crop and pasture production include low water and nutrient retention. Robust and dynamic cropping systems have developed for sandy soils as a result of improved soil management practices. However there is need to further improve the efficiency with which water and nutrients are used, especially to manage greater climate variability and increased fertiliser costs.

3.3 Livestock integration

The growing demand for beef in Vietnam, driven by increased disposable incomes and tourism, is providing an opportunity for smallholder crop-livestock farmers in some Vietnamese provinces to change the balance of their farming systems with a greater emphasis on beef cattle and thus improve their income. Cattle numbers for the three provinces (to 2006) are shown in Figure 3.1. It is evident that cattle numbers are increasing, and that the Central Coast provinces of Binh Dinh and Phu Yen, which have long been important for cattle production have shown rapid increase in production since 2001. Cattle production faces more difficult challenges in Ninh Thuan where production is more extensive and rainfall is lower.

The trend of cattle numbers in Binh Dinh and Phu Yen (Figure 3.1) are typical for the South Central Coast Region. Growth is led primarily through domestic demand from cities (an estimated 95% of beef is consumed domestically). Although this presents an attractive opportunity for smallholder farmers, there are a number of obstacles that need to be addressed in order for the opportunity to be realized, especially in relation to feed quantity and quality.

Cattle production systems in these provinces can be broadly divided into two types – extensive and intensive production. Extensive production is based on local (yellow) cattle, and typically involves a combination of feeding with poor quality crop stovers (predominantly rice) and labour intensive grazing or collection of feed from communal areas. More intensive systems, based on Zebu and Zebu crossbred cattle, mainly Brahman, Red Sindhi and Brahman and Red Sindhi cross cattle, are predominantly stall-fed, and involve additional investment in forages and purchased supplements.

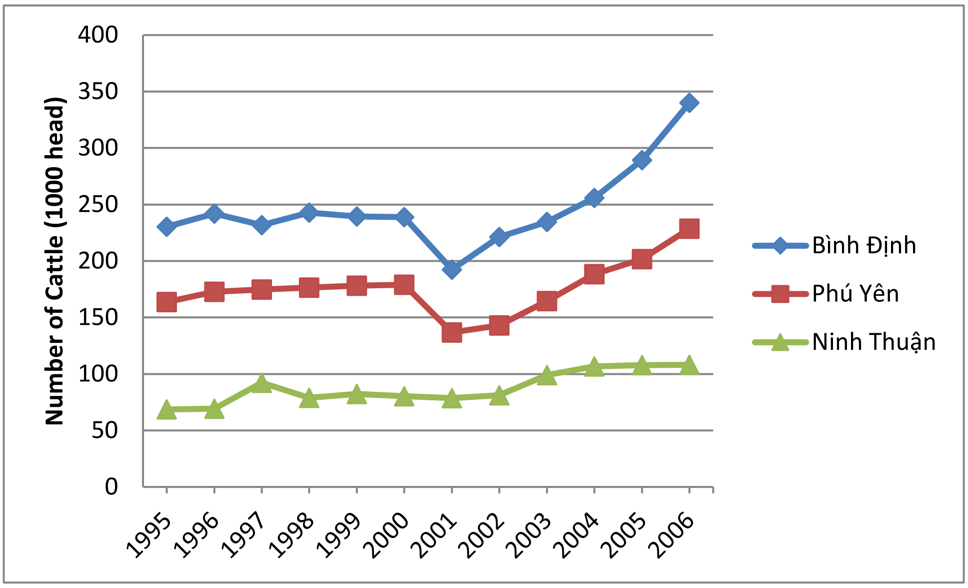

Figure 3.1 Cattle numbers for selected Coastal Provinces from 1995 to 2006. (Source: General Statistics Office, Vietnam)

The constraints to be addressed by this project component are addressed at three levels: the animal, the farm and the agency. Poor nutrition of animals limits growth and makes inefficient use of feed, with the problem most evident during the long dry season. Making the best use of feeds that are or could be available is poorly understood by farmers, extension agents and also researchers. At the farm level the combination of crop, forage and beef production options is virtually infinite, with significant interactions between each element of the system, making decisions about change quite complex. The project component is addressing these constraints by combining a farming systems approach with a strong emphasis on farmer and institutional participation and capacity building.

4 Objectives

The overall aim of this multi-disciplinary programme is to identify and facilitate adoption of promising resource management practices for sustainable and profitable crop and livestock production systems best suited to local conditions that enable improved market engagement. In Vietnam, the project will integrate with SMCN/2003/035 “Improving the utilisation of water and soil resources for tree crop production in coastal areas”, and the other project components, “Value chain analysis for sustainable and profitable farming systems on the South Central Coast” led by DAFWA, “Sustainable cropping systems for sandy soils of south central coastal Vietnam” led by Murdoch University, and “Better integration of beef cattle production with crop production systems in South Central Coastal Vietnam” led by the University of Tasmania to achieve the objectives.

4.1 Value chain analysis

The questions to be raised in this study by this component (1):

- What is the structure of the value chain of peanut, mango, cashew, sesame, beef-cattle and cassava? How are they operating? What is the profit it generates for farmers? How is it positioned in the economic environment?
- What are the types of markets and desired products specifications?
- What are the relationships within the chain and who has the power?
- How is information shared within the chain?
- What are the weakness, strength, constraints and opportunities within each chain?
- How can improvements be implemented that will benefit farmers?

The project aim is a combined research program targeted at crop and livestock systems in conjunction with an emphasis on an understanding of the market to underpin a sustainable impact on smallholder well-being.

This study aims to fulfil these objectives as following:

- Analyse markets and supply chains to identify limitations and critical control points for selected commodities to focus technical interventions to deliver market impact.
- Implement support activities to enhance supply chain performance and implement appropriate technical intervention.
- Identify supply chain based strategies for stakeholder engagement to scale out adoption past the farmer and extension groups who were directly involved in the research.

4.2 Sustainable cropping systems

The specific aim of this component (2) is the development of sustainable crop production systems for sandy soils that target market opportunities.

The objectives are to:

- Characterize selected mini-catchments in Vietnam in three study districts (Phu Cat district, Binh Dinh province; Tuy Hoa District, Phu Yen province, and; Ninh Phuoc district, Ninh Thuan province) in terms of sandy soil properties and their distribution, water resources, current crop production systems and practices, and farming systems to determine the key on-farm resource constraints to productivity.

- Understand resource (carbon, water and nutrients) management in the farming systems for identification of promising farming practices best suited to local conditions.
- To evaluate soil and crop management technologies and practices (manures, fertilisers, tillage, soil amendment and intercropping) for more sustainable and profitable farming systems to enhance the livelihoods in South-Central Vietnam and in south-west Australia.

4.3 Livestock integration

The aim of the Livestock Integration Project component (3) is to improve the productivity and profitability of beef cattle production integrated with cropping systems, thereby improving smallholder farmer livelihoods.

The specific objectives are:

- In conjunction with the other two project components, establish benchmark information on the farming systems of households with cattle in Binh Dinh, Phu Yen, and Ninh Thuan Provinces.
- Develop strategies for improving cattle production, through improved management and better utilization of on- and off-farm resources.
- Evaluate the biophysical and socioeconomic impacts of cattle management interventions on smallholder farms through on-farm participatory research.
- Address specific knowledge gaps in cattle nutrition.
- Enhance utilization of manure resources in farming systems (in conjunction with component 2).

5 Methodology

5.1 Value chain analysis

Analysis of key agricultural value chains from the south central coast is required to identify appropriate interventions that will improve competitiveness and identify limitations and critical control points for selected commodities to focus technical interventions to deliver market impact.

Key value chains were mapped and analysed (mango, cashew, peanut, cassava and beef cattle) from the South Central Coast. In areas with coarse sandy soils common farming systems include perennial fruit and nut production with annual intercropping and small-scale animal husbandry. Understanding value chains for key products was the initial step in identifying the impediments and opportunities for improving farmer well-being.
The strategy for this component was to focus on value chains for 'key' products which are important in the sandy soil areas of the south central coast. Mangoes, cashews, beef cattle and peanuts were considered initially because they are already produced and there was potential for improving productivity of these within an integrated farming system. Sesame was later added to the list of value chain analyses following requests from the Departments of Agriculture and Rural Development (DARDs) of Phu Yen and Binh Dinh.

The methodology of the value chain analyses was based on the Making Value Chains Work Better for the Poor - A Toolbook for Practitioners of Value Chain Analysis: (http://www.markets4poor.org/Making%20Value%20Chains%20Work%20Better%20for%20the%20Poor)
This participatory value chain approach (Mayoux 2003 and Bammann 2007) was used to assess value chains for mango, cashew, cassava, peanut and beef cattle using the following general approach:

a. Collection and review of relevant secondary data from the following sources: industry associations, aid organizations, research institutes, scientific literature, commodity journals, government statistics, market information services e.g. IPSARD, the internet, export associations, wholesale and retail markets.
b. Initially a whole project base-line farm survey was conducted. However because of the requirement for more detailed data, smaller more focused surveys were conducted for component 1. A commune level survey was conducted for each of the focus communes. A detailed farm economic survey (c.15 farms/province) representing range and farming systems. Further surveying of farmers along with other chain actors was completed as part of the value chain.
c. In mapping the value chains, the 'first pass' was using a 'rapid supply chain' approach (Collins and Dunne 2008). This included:
    - Preliminary market assessment,
    - Downloading collaborator understanding of specific market chains,
    - Identifying governments and NGO members with understanding of market and supply Chain linkages,
    - Finalising key collaborator responsibilities,
    - Assessment of current industry and market situations by identified experts,
    - Identification of actors along the chain and the types of governance relationships,
    - Developing a basic understanding of government policy and regulations influencing supply chain function,
    - Developing the preliminary value chain map.

The preliminary value chain map then became the basis for a 'continuous refinement' approach:

- Further refinement of the value chain mapping and analysis where key stakeholders were interviewed and available data analysed to identify impediments that limit profitable smallholder participation in the supply chain.
- Feedback workshops with regional DARD staff on value chain analysis were held to review findings and document feedback. This was another step in the continuous refinement cycle. The identified limitations were intended to help define technical interventions delivered through the research, development of components 2 and 3 of the project although because the components were running concurrently, the guidance from component 1 to other components was in reality limited. Ideally the market analysis component would be conducted before the commencement of the production research and development.

Various institutes coordinated analysing value chains as follows:

- SOFRI (Southern Fruit Research Institute)– mango
- SIAEP (– cashew)
- IAS – cassava and beef cattle
- Nong Lam University – grain legume, peanut
- ASISOV – sesame (commenced mid 2010)
- Project consultant Nguyen Van Bang, garlic commenced May 2012

Some details of the steps involved in the Peanut Value Chain Analysis follows as a typical example of the approach employed for the products studied. (More detailed methods are outlined in the various product value chain reports).

- The initial phase involved a thorough desk study to gather background data on peanut crop in Vietnam and the world market (2009).
- Upon compilation of this information, in 2010 a Rapid Value Chain Analysis approach and Rapid Market Assessment approach was applied. Fieldtrips to the targeted sites in Binh Dinh, Phu Yen and Ninh Thuan were carried out in companion with the staff from ASISOV and DARDs in order to collect information about the value chain. Additional fieldtrips to Hanoi, Dong Nai province and Ho Chi Minh City were taken thereafter to interview relevant traders and research institutes. During the fieldtrips, in-depth interviews and focus group discussion were implemented with 54 grain legumes farmers; and with 37 collectors, assemblers and wholesalers in and out of the research sites. As a result, a complete value chain and peanut marketing channels were depicted. Main constraints to the peanut value chains were also identified.
- In 2011, a survey of 36 selected farmers at Cat Trinh and Cat Hiep communes in Binh Dinh province was conducted with structured questionnaires to collect farm level economic data from smallholders. Nineteen of the 36 surveyed farmers had been participants in the more general original project base-line survey.. Quantitative analytical methods such as statistical analysis and econometric method were used for data analysis. Another fieldtrip to Binh Dinh was conducted during the harvest of the fall-winter peanut crop to assess the economic status of this crop and the operation of two mechanical dryers that had just been introduced to farmers by the local authority.

A spreadsheet based Farm Economic Model (FEM) was developed as a tool for comparing farm enterprises and for analyzing farming system performance, including labour utilization and cash flow.

In December 2011, two workshops with relevant stakeholders were organized by ACIAR partners in Binh Dinh and Ninh Thuan to present the research results and get their feedback for the improvement of research conclusions.

5.2 Sustainable cropping systems

To achieve the diverse objectives of Component 2, the following methods were used and described in brief:

- A survey of 180 farming households (60/commune in An Chan, Cat Trinh, and Phuoc Dinh) was conducted to assess cropping systems, inputs, outputs and management practices such as use of crop residues for various purposes such as fuel for cooking, animal fodder, crop mulching, bedding or litter with manure. Rice straw, cassava and peanut residues have widespread use, being returned to soil, used as animal feed, or as litter and household fuel.
- The Soil Constraints and Management Package (SCAMP) was used to determine basic soil properties such as texture and structure to identify soil constraints (acidity, low CEC, low organic carbon, high P fixation, hard-setting characteristics, and dispersion) to productivity on a site/soil specific basis (Moody and Phan Thi Cong, 2008). In total, 69 profiles have now been described.
- Partial nutrient balances were calculated at field plot and farm levels in farming systems to quantify inputs (fertilizer, manures, crop residues added) and outputs (harvested products removed) of macronutrients (NPK) over one year duration at 10 farms each in An Chan, Cat Trinh, and Phuoc Dinh communes and the outcomes of nutrient balance were calculated by using the formula:
  Σ Element inflows – Σ Element outflows = Change in total element stored within/potentially lost from the system. Losses from leaching, denitrification, erosion were not considered due to lack of relevant data.
- The mini-pan technique applied in the earlier ACIAR project (SMCN/2003/035) was further evaluated to assess moisture demand of crops for scheduling of irrigation for peanut, cashew and mango. In the cashew and mango trials, increased rates of N and K fertiliser and supply of the micronutrients B, Cu, Zn and Mo (by foliar application) was tested in combination with irrigation treatments (farmer's practice versus mini-pan guided irrigation) to examine the effects on fruit yield and quality also in the case of mango (Type 1, Type 2 and Type 3 based on its colour, vigour and taste).
- In all, five nutrient omission trials were conducted in the field to examine the need for particular nutrient elements, including micronutrients to overcome deficiencies for peanut. One trial was conducted in Cat Hanh in 2010 and two trials in 2011 in Cat Hanh and Cat Trinh, respectively and two trials were conducted in Ninh Thuan (Phuoc Dinh and An Hai communes) in 2012. In Omission experiments, a complete supply of nutrients (N, P, K, S, B, Cu, Mo, Zn) was supplied to one treatment (referred to as All) and all remaining treatment had one or two of those elements omitted. The aim was to determine yield potential with all elements added, and then to assess the magnitude of yield depression, if any, when an individual element was not supplied. Fertiliser rates chosen for the All treatment were based on Bell et al. (1990) from studies on peanut in sands of North-east Thailand plus local recommendations. Leaf samples of peanut crops (youngest fully expanded leaves) were taken and analysed to verify the deficiencies diagnosed by yield decline.
- The double pot technique was also used to carry out omission experiments on additional representative soils from all three provinces. A schematic of the double-pot design is shown in Figure 5.1. This method, like the method of Janssen (1974, 1990), involves growing the test plant in a small amount of soil in a container suspended above a nutrient solution; the plant roots can access nutrients from the soil and from the nutrient solution. By selective omission of nutrients from the nutrient solution, the relative nutrient supply capacity of the soil can be easily assessed. Our method differs from the original method of Janssen (1974) in the design of the apparatus and the nutrient solution used. Instead of the plant roots

being able to grow through a gauze layer to the nutrient solution under the soil, the nutrient solution is supplied to the soil via a wick system.
The containers used were produced for use in the take-away food industry. Dimensions of the upper container were 115 mm width x 40 mm height with a 6 mm hole pressed out in the centre of the base to accommodate the absorbent wick. The lower container is 115 mm width x 100 mm height. The cylindrical wicks are uncut cigarette filters measuring 7 mm x 125 mm. The wick must touch the bottom of the lower container and be approximately 5 mm below the surface of the soil when in the upper container. The dimensions of the containers and wick need not be the same as used here. Cotton wicks used in fuel-fed lights can be used.

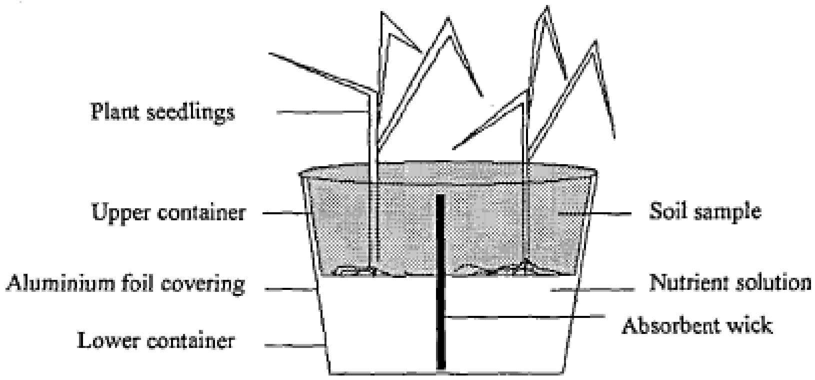

Figure 5.1 Schematic diagram of modified double pot.

- Integrated Nutrient Management (INM) experiments were conducted in Binh Dinh province in 2012 to fully explore utilization of available organic and inorganic sources of nutrients in combination for peanut, cashew and mango production. The in-house organic resources (manure, crop residues, biochar etc) are re-used to save cost of inputs for crops.
- Fodder species were evaluated in the field at Binh Dinh and Ninh Thuan. The Ninh Thuan experiment was abandoned due to a land dispute before any data could be gathered.
- Composting of manure with crop residues was tested with the farmer's practice (heap) compared with alternative storage and composting techniques to maximise nutrient retention. A double pot technique, as described above, was used to rapidly assess nutrient supplying capacity of manures when added to sands. The double pot experiment was conducted in 2011 to assess the nutrient supplying capacity of manures prepared by the heap storage method (farmer's practice) versus covered storage. A field experiment was conducted to evaluate the quality of manures produced in terms of peanut yield and nutrient uptake. Based on the promising findings of 2010 with covered storage and composting of manures, we used this method to test the effect of adding different materials to the cattle manure on compost quality:

    1. Cattle manure collected from outside cattle shed to make compost (control)
    2. Control + biochar (1:1)
    3. Control + Rice straw (1:1)
    4. Cattle manure from inside cattle shed (recovered every 5 days)

  The manure collected from the farms was mixed thoroughly to homogenize it. One ton of manure was amended with 10 kg of lime and 10 kg of superphosphate before storage. Pits of 1×1 m and 0.7 m deep were dug and filled with manure on a base constructed of compact earth. The constructed pits were covered with plastic sheets. The pits were turned three times during storage (30 days, 60 days and 90 days of storage, respectively), by removing all the material from the pits prior to weighing. The pits were re-filled by placing the former surface material at the bottom and vice versa to simulate mixing of the material in the pit.

- Conservation tillage practices were introduced through the use of a Versatile Multi-crop Planter (VMP) that was imported from Bangladesh. The planter was set up and tested initially under the supervision of Dr Enamul Haque from Bangladesh. The planter is capable of seeding soybean, cowpea, rice, and with aperture adjustment, will be able to sow peanuts. The planter is mounted on a 2-wheel tractor. It was evaluated for sowing soybean and peanut.
- Samples of water were collected periodically over 2 years from streams, wells, bores and hand pumps to monitor water quality in An Chan commune that may have been influenced by farming or other human activities. Water was analysed for nitrate-N and ammonium-N, phosphate, pH, EC.
- Vegetables (pumpkin/cucumber/onion) were grown by using different soil amendment materials (local clay, manure, bentonite, plastic lining, biochar etc) in An Chan to look at the potential of increasing water and nutrient use efficiency of sandy soils and also prevent them from becoming pollutants for groundwater via leaching.
- An established field trials at Dalyup, near Esperance, WA was maintained for 3 years. In Year 2, clay treatments (0, 50, 100, 200, 300 t of sub-soil /ha applied in 1999) were left without disturbance or mixed by spading to 15 or 30 cm depth. Pasture growth over 2 years was monitored to assess the biomass response to clay and spading.
- A new experiment was established on a fine sand at the Esperance Downs Research Station by assessing crop response to 0 or 15 kg P/ha/ year on plots with nil, biochar drilled at 10 t/ha or compost at 10 t/ha. The crop sequence over three years was wheat, sorghum, lupin, sorghum and canola. Sorghum was sown in summer without any inputs to make use of stored profile water and rainfall. Crop yield was determined for all crops, VA mycorrhizal infection of sorghum roots was assessed in 2011 and a final soil sampling will be taken in the summer of 2013.
- A carbon survey was conducted within farmers paddocks surrounding Esperance, Western Australia. The soils at each sites are part of the Esperance sandplain and are classified as Sodosols and Tenosols (Overheu et al 1993, Isbell 2002). The soils are fine sands overlying light to medium kaolinitic clays. Bleached A2 horizons and iron stone gravels are often present. The A1 horizon (zone of carbon accumulation) extends 10 – 20 cm below the surface and comprises 95% sand. The depth to clay can vary from less than 20 cm to more than 2 m.
  The survey consisted of 95 sites that were chosen based on vegetation, soil type and rainfall. The sites were made up of four treatments consisting of long term (>10 yrs) annual and perennial pastures on deep (>80 cm sand over clay) and shallow (< 30 cm sand over clay) sands. Each combination had no fewer than 19 and no more than 29 sites. At each site average annual rainfall ranged from 500 to 600 mm. The annual pastures included capeweed (*Artotheca calendula*), annual ryegrass (*Lolium rigidum*), brome grass (*Bromus spp.*), silver grass (*Vulpia spp*), sub-clover (*Trifolium spp*), Erodium spp. and serradella (*Ornithopus spp*). The perennial pastures were all dominated by Kikuyu (*Pennesitum clandestinium*) but included annual companion species of ryegrass, brome grass, silver grass, sub-clover and serradella.
- Glasshouse and laboratory experiments at Murdoch University were undertaken by PhD student, Fariba Mokhtari and Endeavour Fellow, Prof R. Singaravel of Annamalai University, Tamil Nadu, India. They examined the sorption capacity of chicken manure and wheat straw biochars for sorption of nitrate-N, ammonium-N, phosphate, sulfate, molybdate, K, Zn and B. Biochars were then incubated with clay (nil, bentonite or kaolin at 50 t of clay/ha) in Fleming sands to assess effects of nutrients released on extractable mineral N, K, sulfate and fractions of

phosphate, Zn and B. Biochar, clay treatments (nil, bentonite, kaolinite) and fertilizer rates (low, adequate) were applied in columns of sand and subjected to leaching every 5 days for 5 events. No leachate was obtained from the bentonite columns due to clogging of pores. The concentration of K, phosphate and sulfate in leachate and in extracted soil solutions was determined. A follow up experiment with columns used the same treatments except bentonite was replaced by sub-soil clay and wheat plants were grown in columns for 35 days. Columns were leached at sowing and just before harvest to collect soil solution and leachate for analysis. A long term incubation experiment was established with chicken manure biochar, sub-soil clay, fertilier and crop residue treatments to test the hypothesis that the value of clay and biochar in increasing soil organic carbon on sands depends on inputs of organic matter and nutrients.

5.3 Livestock integration

The project component methodology is based on a combination of targeted research, farming systems research and participatory approaches (Figure 5.2). The first activity, in conjunction with the other project components, was to gather information and data to understand and characterize the current farming system. This information, in conjunction with information arising from discussion at farmer workshops, was used to identify the key constraints to cattle production and to define and plan relevant component research (on- and off-farm) to address specific knowledge gaps. Strategies were then identified to address the constraints based on consultation with farmers, modelling and input from component research activities. These strategies were then trialled on selected farms and their biophysical, economic and social impacts measured over the course of the project. These trials all serve as an extension platform for other farmers and extension agency staff via field days and farm walks. Communication and capacity building activities were conducted throughout the course of the project.

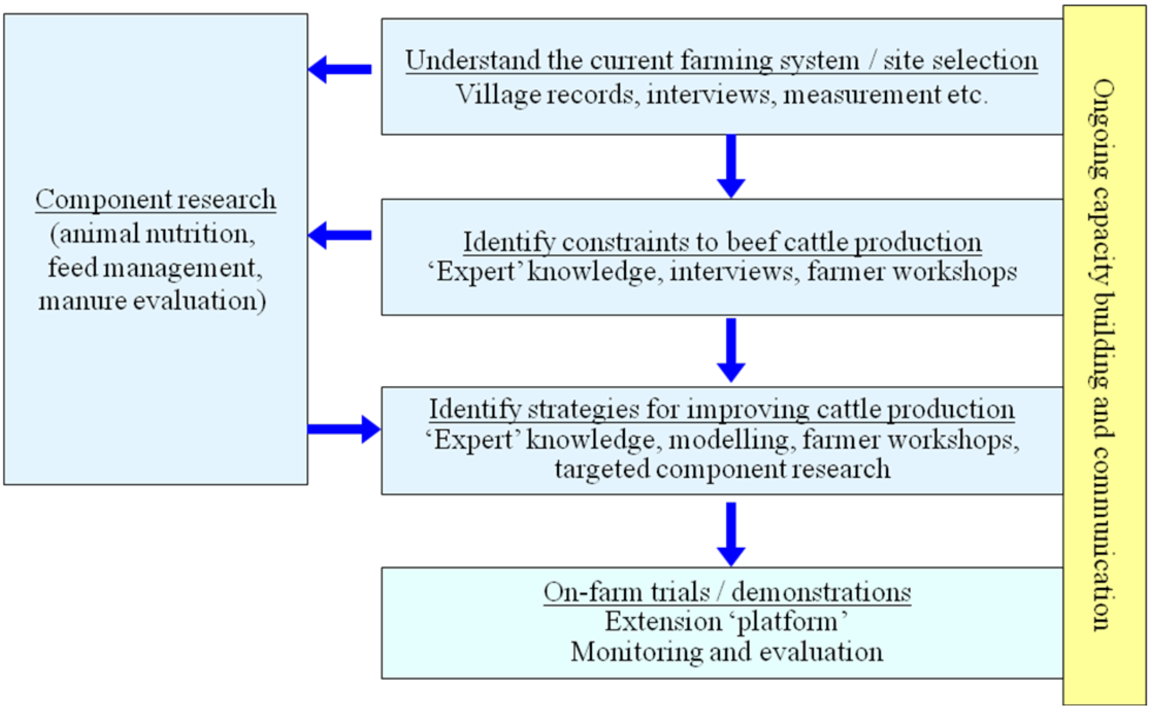

Figure 5.2 Outline of proposed project component methodology.

A whole farm modelling tool referred to as the Integrated Analysis Tool (IAT) developed for use with smallholder farmers in eastern Indonesia (ACIAR project AS2/2004/005) was adapted for use in this project component to examine the potential production and socio-economic impacts of possible livestock improvement strategies prior to on-farm trialling. The IAT is a smallholder household simulation model that integrates three separate models: a farming system model (APSIM, Keating et al 2003), a model for cattle growth, and a smallholder enterprise economic model.

Methods used in addressing each of the five component objectives are summarised as follows:

Objective 1: Establish benchmark information on the farming systems of households with cattle in Binh Dinh, Phu Yen, and Ninh Thuan Provinces.

Surveys were conducted for a selected commune in each Province, taking into account existing survey data and working in conjunction with the Sustainable Cropping Systems and Value Chain components of this project. The selected communes were the primary targets of subsequent research, development and extension activities.

In-depth biophysical data relating to the existing feed resource and cattle performance/husbandry were collected from 10 households in each commune. This included direct measurement of forage quantity and quality, live weight gain and condition, and the collection of information related to breed and animal husbandry practices.

Objective 2: Develop strategies for improving cattle production, through improved management and better utilization of on- and off-farm resources.

Information on the nutritive characteristics of on- and off-farm feeds was compiled into a database to be used to develop year-round feeding options and for the parameterisation of simulation models.

The Cornell Net Carbohydrate and Protein System (CNCPS) was used to evaluate diets and help design improved feeding strategies. This involved using the data from Activity 2.1 and additional forage quality analyses where necessary.

Published data relating to the growth of the local breeds, data collected during the benchmarking phase of the project, and outputs from feeding simulations were used to parameterise the cattle model within the IAT.

Climate data, soil characteristics, and local management details (from benchmarking) were used within the APSIM model to generate a database of forage and food crop performance and to modify the IAT model to suit local resource conditions.

Objective 3: Evaluate the biophysical and socioeconomic impacts of cattle management interventions on smallholder farms through on-farm participatory research.

Workshops were held in each target village to present, review and clarify the benchmarking results and to agree on constraints to, and opportunities for improving cattle production.

The IAT model was used to explore the impacts of various cattle improvement options on key farm resources (i.e. land area usage, labour, finances, feed supply) and to develop improved feed plans. The results were discussed with the farmers in follow-up workshops and a shortlist of best-bet strategies for on-farm testing was developed.

The best-bet options arising out of Activity 3.2 were then trialled on case study farms, commencing at the beginning of year 2. Final best-bet selection was based on suitability for the farm in question and farmer preferences. The range of best-bet options included a range of feeding, resource allocation, cattle management, breeding, crop management, and manure management strategies. On-farm trials were designed in consultation with the specialist team, the Provincial on-ground team, extension operatives and commune leaders, and continue to serve as platforms for capacity building, extension and communication. Farmers were encouraged to adapt the best bet options to their own needs and resource constraints. Forage options were selected based on past forage projects (e.g. AS2/97/18, LPS/2002/078), literature review, use of the *Tropical Forages* *interactive selection tool* (an output from AS2/2001/029), and expert knowledge within ACIAR and the project team..

A training course focused on farming systems and participatory theory, practice and tools was developed and delivered to better enable participants to carry out future research projects of a similar nature.

The socio-economic and biophysical impacts of the on-farm trials were monitored using similar approaches to those outlined for benchmarking. Farmers' perceptions and experiences relating to the various interventions and the innovations that they generated were evaluated via individual and group interviews/discussions.

Field days were conducted using the case study farmers and best-bet trials as an extension and communication ‘platform’. Signage was installed at field sites, and information sheets describing the key results, outcomes and approaches were developed and delivered to farmers through collaboration with extension agency staff.

Objective 4: Address specific knowledge gaps in cattle nutrition.

A literature review was conducted to summarize the relevant work on cattle nutrition research that has been done in Vietnam. Dr Peter Doyle visited the target region to identify the key cattle nutrition knowledge gaps and to help design research activities to address these. An experiment was conducted at IAS which examined the growth and nutrient digestibility responses of ~200kg Brahman-cross cattle to supplementation with concentrates. A following experiment focussed on the fattening stage of more mature cattle.

Two experiments were conducted to compare the growth response of young (200 ± 1.5 kg live-weight) and mature (451 ± 5.8 kg live-weight) steers with respect to levels and type of supplement. Experiment 1 involved barley grain versus cottonseed meal supplements. Experiment 2 involved ryegrass haylage versus a concentrate-based diet. It was hypothesized that young steers would grow faster than mature steers because of the composition of the grain and that diet and supplement type would have most effect on live-weight gain of mature fattening steers because of their requirement for glucogenic precursors for fat deposition.

Objective 5: Enhance utilization of manure resources in farming systems.

Manure quality was assessed for a range of cattle diets in a study conducted by component 2, with input from component 3.

A field experiment has been established to assess the effect of nitrogen fertilization from composted cattle manure and urea on *Brachiaria* cv. Mulato II yield.

Strategies for management of stockpiled manure were examined in a study conducted by component 2, with input from component 3.

Previous efforts to describe the effects of manuring have focused on manure incorporated into the soil soon after application. A field experiment has been established to assess the effect of incorporated and surface applied manure on the growth of *Panicum maximum* cv. TD58.

6 Achievements against activities and outputs/milestones

1.0 Value chain analysis (Component 1)

Objective 1: Analyse key agricultural value chains from South Central Coast to identify appropriate interventions that will improve competitiveness

No.	Activity	Outputs/ Milestones	Completion date	Comments
1.1.1	Map and analyse key value chains (mango, cashew, peanut, cassava and beef cattle) from South Central Coast	Interviews conducted, data collected and collated, reports prepared	See comment	Preliminary survey field work completed in July 2009. The surveys were extended for detailed interviews of farm management and with traders, collectors and processing factories. Value chain analysis reports completed for mango, cashew, peanut, cassava and beef cattle.
	Project staff value chain analysis training	Project workshop, workshop report	2010	Value chain workshop conducted 11-13 August 2010. Workshop proceedings produced in Vietnamese.
1.1.2	Assess selected international and domestic markets for potential linkages to the identified supply chains.	Reports of market status, outlook and opportunities for key products (mangoes, cashews, legumes, cattle).	2011	Desktop analysis of international mango markets completed. Later focus was on the domestic market for most products from the south central coast for the foreseeable future.
1.1.3	Identify additional product (e.g. high value vegetable) with potential to improve farm profitability and sustainability within South Central Coast integrated system	Report of production and market options for non-key products	2011	Sesame value chain analysis was commissioned in July 2010. Lead responsibility with ASISOV (Dr Phuong). Sesame value chain report for sesame completed. Value chain analysis of garlic in Ninh Thuan completed in August 2012 by Mr Nguyen Van Bang Ninh Thuan DARD also identified goats, sheep, table grapes and onions as enterprises with potentially good returns. Some work on onions commenced in late 2012 (not yet reported). Value chain analysis for goats, sheep and table grapes in Ninh Thuan is being conducted as part of the Tam Nong - Agriculture, Rural and Farmers, World Bank loan project
1.1.4	Develop a comparative analysis between 2 key value chains from South Central Coast and market identified value chain 'leader' in Vietnam (SIEAP)	Survey report	2011	Cattle value chain studies conducted in Dong nai and Ba Ria -Vung tau for chain comparison. Mekong Delta mango supply chain field studies conducted in June 2010. Not reported due to loss of SOFRI laptop late in the project. A financial comparison of beef production in Dong Nai province is included in the appendices.

1.1.5	Test market local varieties or differentiated products into efficient supply chains and gauge wholesaler and consumer response	Report on market response to varieties and products		Opportunities for test marketing have not arisen. There is a need to introduce and test market new and differentiated varieties of mangoes however such material was not yet available
1.1.6	Conduct economic analysis of integrated farming systems to provide insight to farmer decision making	Reports on economic analysis of farming systems	2011	Farm economic survey report completed. Working version of spreadsheet based Farm Economic Model completed.
1.1.7	Identify key constraints of SCC value chain limiting competitiveness in key markets for beef-cattle & cassava (IAS) and other key products.	Identification of key constraints –report on key constraints	2011	Key constraints have been identified and reported within the product value chain reports for mango, cashew, peanut, cassava, beef, sesame, garlic and onion.
1.1.8	Identify and agree on appropriate technical intervention (all Project)	Agreed approach for technical interventions documented	2011	Chain improvement strategies reported in appendices.

Objective 1.2: Implement support activities to enhance supply chain performance and implement appropriate technical intervention

No.	Activity	Outputs/ Milestones	Completion date	Comments
1.2.1	Improve smallholder understanding of whole supply chain, including product flow, information flow and services to support supply chain	Evaluation report of knowledge development of smallholders involved in supply chain	2012	Seminars and value chain reports presented to regional DARD staff, along with value chain training to enable improved information flow to farmers. Thus direct feedback to farmer level has been limited and has operated with regional DARD staff as intermediaries. Summary value chain brochures for farmers were prepared for mango, beef, cassava, cashew and peanut.
1.2.2	Develop provincial agribusiness forums as a public-private interface	Active forum in selected province to test mechanism to input into government policy development	2012	Recommendations for public-private agribusiness partnerships have been made as suggested interventions based on assessment of constraints with the product value chains. No specific agribusiness forums have been run as part of this project but informal groups have met as discussion groups during value chain investigations

1.2.3	'Walk the chain' for each value chain, right into target market to improve relationships within the chain	Tour and evaluation reports of the main commodity market chains by representatives of producers who visit key chain links	Cancelled	Tour was cancelled due to flooding and was unable to be re-scheduled.
1.2.4	Facilitate capacity building in regional delivery of suitable GAP systems to growers and other supply chains members	Training and accreditation material development. Train the trainer courses run.	Jan 2013	Market need or advantage in GAP accreditation identified. Food safety systems for domestic market compliance likely to be more useful than GAP system targeting export markets in the medium-term. Mango GAP training for SSC conducted by SOFRI staff in January 2013. (Held at Cat Trinh, attended by 24 mango growers from Cat Trinh and Cat Hanh Communes plus 4 regional extension staff
1.2.5	Identify farmer level supply chain incentives to improved product and supply chain performance	Report of the identified incentives including an assessment of producer understanding	Dec 2012	Incentives for product improvement are included where appropriate within the interventions recommended each value chains report.

Objective 1.3: In close collaboration with other project components, identify supply chain-based strategies for stakeholder engagement to scale out adoption past the farmer and extension groups who were directly involved in the research

No.	Activity	Outputs/ Milestones	Completion date	Comments
1.3.1	Identify and develop appropriate extension and communication strategies for scale out	Methods to scale out used and tested within the project with recommendations for appropriate scale out documented	Jun 2012	Strategies should focus on overcoming bottlenecks in chains and how farmers and other chain actors can adopt recommended crop and livestock improvements. Extension brochures with farmers as target were developed for peanut, cashew, cassava, mango and beef. A range of approaches have been developed and used across the breadth of the project. 'Best Bet fodder production to support cattle production within Component 3 is a good example.
1.3.2	Test scale out mechanism with project participants and non-project participants and compare delivery mechanisms	Evaluation report of approaches and development of final methods	Dec 2012	Project reviewers recommended testing with project and non-project areas to identify the impacts. This activity has not been implemented within the scope of this project and could be the basis of a follow-up programme delivered by possible local DARDs.

1.3.3	Develop materials and mechanism to be used by agencies involved in extension and scale out	Appropriate tools for agencies developed and documented to support market driven approach	Oct 2012	A farm economic analysis tool (Farm Economic Model) has been developed and a draft version is available. Training for DARD and agencies has been carried out in August 2012 (22 staff from Binh Dinh, Phu Yen and Ninh Thuan) and in December 2012 (24 staff from Binh Dinh, Phu Yen and Ninh Thuan) to develop capacity to use the tool. By the second training the FEM had been simplified and translated into Vietnamese with 2 key staff being identified as contacts in each of the provinces.
1.3.4	Train extension agencies in techniques and approaches	Capability developed to deliver market driven approach to sustainable and profitable agricultural systems. Training material developed	Dec 2012	Value chain training delivered to regional DARD staff (total 46 participants) in 3 provinces November 2012. Agencies have capability to continue to use market driven approach

2.0 Sustainable farming systems (Component 2)

Objective 2.1: To characterize the three study districts in terms of sandy soil properties and their distribution, water resources, current crop production systems and practices, farming systems to determine the key on-farm resource constraints to productivity

No.	Activity	Outputs/ Milestones	Completion date	Comments
2.1.1	Reconnaissance land resource assessment of the study districts. Baseline farm survey to assemble and analyse benchmark data on local farming systems	180 households were selected from the three study sites and interviewed. The survey data were analysed and a technical report was prepared and distributed	Report completed in Aug 2010	This baseline farm survey provided the project with critical information for (a) better understanding of local farming systems, (b) identifying 'gaps' that could be used to plan R&D activities, (c) providing benchmark information on the current crop production and practices for the proposed future project impact evaluation.

2.1.2	Diagnosis of soil constraints			Three approaches have been used to identify soil constraints for both annual and tree crop production.
	(a) Soil investigation to identify soil constraints using SCAMP in Ninh Thuan, Phu Yen and Binh Dinh	The total of 69 soil profiles were assessed using SCAMP in Phu Yen (23), Ninh Thuan (23) and Binh Dinh (23), The soil samples were analysed for physical and chemical characteristics.	Report re-scheduled to Dec 2012	Additional sites have been described in 2011/12. Soil analysis for all sites has been completed (**Appendix 2.1.2a-XL**), soil-landscape maps have been generated for Ninh Thuan, Phu Yen and Binh Dinh (**Appendix 2.1.2a-maps**). Maps indicating SCAMP sites described have been generated and reports detailing the results for SCAMP in each commune (Ninh Thuan, Phu Yen and Binh Dinh) are attached (**Appendix 2.1.2a reports**).
	(b) Omission experiment	The omission field experiment was conducted in Binh Dinh to diagnose nutrient limitations for peanut growth and production on deep sands. A total of 3 experiments were completed by May 2010. One omission trial was planted in Ninh Thuan in 2011 also but was not harvested. Two peanut trials were selected on red sand in Ninh Thuan in Sept. 2011 but failed. Two peanut trials were conducted in 2012 in Ninh Thuan.		In these experiments a full range of nutrients that could limit peanut growth and production, were assessed (All-N, All-P, All-K, All-S, All-Cu, All-Zn, All-B and All-Mo). In all three Binh Dinh omission trials, lack of K, or S, or Cu or B supply decreased the pod yield by 20-30%. In addition at one experiment lack of P supply decreased shoot yield but not pod yield and lack of Mo supply generally reduced shoot yield but not pod yield The omission trial at Ninh Thuan was abandoned due to a land dispute at the site in 2010. The Sept. 2011 trials were abandoned due to lack of rainfall. Two omission trials conducted in Ninh Thuan (Phuoc Dinh and An Hai commune) in 2012 showed that lack of P, K, S, Zn can limit peanut yield by 12 to 25%. In addition, the variation in reduction of yield is dependent on type of sands and residual nutrient status from previous crops. (Appendix 2.1.2 b (NT and BD)).
	(c) Leaf sampling and analysis in cashew and mango	Leaf samples were collected in Jan/Feb 2010 from the three cashew field experiments and one mango experiment established in Binh Dinh.		The cashew work was being carried out in collaboration with the previous project SMCN 2003 035. The work is designed to develop diagnostic leaf sampling in cashew and mango that can be used for correcting nutrient deficiencies and making better fertiliser decisions. Progress has been hampered by the need to achieve satisfactory quality control on determinations of S, Cu, Zn and B at IAS. The accuracy of analysis for these elements is now satisfactory except for over-reporting for S determinations (Appendix-cashew and mango report 2.1.2c).

	(d) Soil sampling for baseline nutrient status	Sampling soils at depth with auger was carried out in Binh Dinh	Aug 2011	Building capacity of ASISOV staff to sample and prepare soils for analyses from selected trial sites. This exercise improved efficiency and saved costs as ASISOV is based in Binh Dinh where most of the experiments are carried out. This exercise was earlier carried out by IAS based in HCM which was too far from experimental sites.
	(e) Lime requirement for acid soils	Soil samples were collected in Dec 2011 from two INM peanut trials that are acidic	Feb 2012	A lime incubation trial was conducted at ASISOV glasshouse to work out how much lime will be required to raise the pH to normal to eliminate impacts of acidity on yield (Appendix 2.1.2.e)
	(f) Water holding capacity /Field capacity measurement.	Soil samples were collected from two INM peanut trials	Dec 2011	This activity was carried out to build technical and lab capacity at ASISOV (Appendix 2.1.2.e)
2.1.3	Establish standards and protocols for data recording, storage and communication.		Dec 2009	The initial meeting and demonstration were held at ASISOV to discuss and show data recording and management using Excel and Genstat. Subsequently a coding system was developed for unique identification and labelling of each field experiment.
2.1.4	Training in soil analysis and analytical equipment	Training completed and new procedures implemented in ASISOV lab	Sep 2012	After completion of the new laboratory building at ASISOV, two ASISOV staff travelled to Murdoch University in Australia for laboratory training under assistance from Crawford funding (Appendix 2.1.4).
2.1.5	Diagnosis of constraints	Meeting held to evaluate evidence for and prioritise constraints	2009-2012	Key constraints identified for Activity 2.1.6 Appendix 2.1.2a
2.1.6	Select and evaluate soil amendments.	Trials set up in year 2-3 to determine which amendments are cost-effective. Report of study completed	2011-2012 Dec 2012	Relative effectiveness of amendments evaluated for Activity 2.1.8 and 2.3.1. Appendix 2.1.6 (pumpkin trial)
2.1.7	Evaluate zero tillage planting on sandy soils to conserve soil organic matter and minimise erosion risks.	VMP planter imported from Bangladesh assembled and tested.	Dec 2011 Mar 2012	VMP Planter was assembled and trialled for seeding rice, cowpea, soyabean. Peanut seed size was bigger than anticipated and will require a new seed meter and seed dropping tube with larger aperture. The planter was tested on farmers' fields in March/June 2012 for planting soybean and peanut (Appendix 2.1.7-soyabean report).

2.1.8	Overcoming constraints in crop agronomy sowing time windows and crop legume species for cashew/legume intercropping systems in low rainfall region (Ninh Thuan)	The sowing time experiment was conducted in 2009 and 2010. Both experiments were completed. Report of study completed	2010 2011	The experiment was conducted from August to December 2009 and was repeated in 2010. It could not be repeated in 2011 due to drought. Peanut yields were low. Cowpea yields were promising especially for September planting. Cowpea could become an alternative crop to peanut in Ninh Thuan. (Appendix 2.1.8-time of planting)
2.1.9	Two rhizobium experiments were conducted in Binh Dinh to:			
	(a) evaluate if use of a commercial strain of inoculant NC92 with or without Mo could improve peanut production but reduce N input	The field experiment was conducted from Jan to May 2010 and completed. A repeated experiment was conducted in Jan to April 2011	May 2010	Yield results and leaf analysis suggested that the yield potential of these trials was limited by lack of S, Cu and B in the basal nutrient supply. The trials were repeated in Jan 2011 with full basal nutrients. The 2011 results suggest that neither Rhizobium nor Mo nor their combination was as effective for peanut growth and yield as 30 kg N/ha. Nodule formation in both experiments was slow to occur even with Mo and inoculation (Appendix 2.1.2b-omission/rhizobium).
	(b) evaluate if adding bio-char on sandy soils could improve peanut root growth and thus nodulation, and improve the effectiveness of rhizobium	The field experiment was conducted from Jan to May 2010 and completed. A repeated experiment was conducted in Jan to April 2011	Jan 2010	Biochar increased peanut yields (>20%) in this experiment (Appendix 2.1.2b-omission/rhizobium).
	(c) Review implications of market study for cropping systems	Revise experimental plans based on implications of Value Chain study	Nov 2010	Project priorities were re-assessed and decisions made to direct research towards cashew, mango and peanut due to market opportunities. Promising market opportunities for cassava and sesame were not pursued to due to lack of resources.

Objective 2.2: To Understand resource (carbon, water and nutrients) management in the farming systems for identification of promising farming practices best suited to local conditions

No.	Activity	Outputs/ milestones	Completion date	Comments
2.2.1	(a) Understand the cycling of organic matter. Farm survey (linked with the baseline survey) to better understand use of crop residues and manure in the local farming systems	180 households were interviewed. The survey data were analysed and report was completed in August 2010	Dec 2009 Report was completed Aug 2010	The survey has greatly improved our understanding of the role of organic materials (crop residues and manure) in local farming systems, particularly the use of organic materials (OM) for crop production and differences in the use of OM among the households (Appendix 2.2.1a-Farm survey on organics.
	(b) Sampling study to characterize local organic materials (crop residues and manure) to assess their potential in supplying nutrients to crops.	91 samples (crop residues and manure) were collected and their nutrient content (C%, N%, P% and K%) were analysed. The report was completed in August 2010	Dec 2009 Report was completed Aug 2010	The sampling and characterisation of crop residues and farmyard manure has provided useful information on nutrient supply power of different organic materials, and this information will help the project develop integrated nutrient management practices. Subsequent experiments were designed to determine whether improved storage methods for manure can increase nutrient concentrations and fertiliser value for crops. (Appendix 2.2.1b-Characteristic and agricultural use of organic materials in sandy area of South Central Coast, Vietnam.

2.2.2	(a) Nutrient budgeting studies at a field level	In each study commune, 10 representative households were selected to conduct farm-level and field-level nutrient budgeting for major cropping systems.	2010-2011	The Cat Trinh study was conducted in 2010 and results reported in May 2011. The An Chan and Phuoc Dinh studies were conducted from May 2010 to May 2011 and results reported in July 2011, At field level N and P were generally in positive balance whereas K balance was commonly negative (Appendix 2.2.2-Partial nutrient balance at farm and field levels).
	(b) Method of composting manure with rice straw	Composting manure with rice straw residues in constructed pits and heaps	Oct-Dec 2010	The method of composting was trialled in 1 household with 3 replications in Cat Trinh to compare quality of manure in pits and heaps. Composting in pits showed slightly better quality of compost (Appendix 2.2.2-composts).
	(c) Method of composting manure in pits and heaps	Composting manure with different crop residues in constructed pits	Jun-Dec, 2011	Composting manure in pits was trialled in 5 households in each commune of 3 provinces. Pit storage of manure could be more suitable for storing manure for long periods with the aim of retaining organic matter and nutrients for return to cropping fields (Appendix 2.2.2- composts)
	(d) Method of composting manure with different materials	Composting manure with manure only, or with added rice straw, biochar and different crop residues in constructed pits compared to manure storage in house	Jul – Sep, 2012	The study was conducted in Cat Trinh. K content tends to increase in cattle manure collected from inside raising house as compared with composting the manure sourced from outside the shed. The results suggest that storage method has significant effects on K content. Final report will be submitted in 2013.
	(e) Double pot experiment	Double pot experiment with different types of composts	Jan – Apr, 2011	A double pot experiment carried out in the glasshouse at HUAF proved to be a good tool to evaluate the nutrient supplying capacity of soils and manures. (Appendix 2.2.2-various composts-double pot).
	(f) Double pot experiment	Double pot experiment with different types of soils	Jun – Sep 2012	The double pot technique described and evaluated here has proven to be a valuable diagnostic tool to evaluate the nutrient supplying capacity of soils. Its simplicity and cheapness makes it ideal for large scale screening of soils. Limiting nutrients in sandy soil in the experiment is in the following order: potassium> sulfur > boron> phosphorous> copper> zinc and molybdenum. Final report will be reported in 2013. (Appendix 2.2.2-various composts-double pot).
	(g) N mineralization	Experiments were conducted in laboratory of HUAF with different types of composting manure	Feb – Apr 2011	The experimental approach focused on addition of organic matter to see the fate of mineral-N, considered as a prime source of available N to plants. Based on significant differences of chemical properties among four types of manure, mineralizable-N was usually higher in soils by adding manure than in control (Appendix 2.2.2-various composts-N mineralization).

	(h) N mineralization	Experiments were conducted in laboratory of HUAF with different rates of composting manure	Feb – Apr 2012	Based on significant differences of manure amount, mineralizable-N was usually higher in soils by adding higher rates of manure than control (Appendix 2.2.2-various composts-N mineralization).
2.2.2	(i) Method of compost application in fields	Application of manure in rows and broadcasting	Jan – May 2011	Application of compost in rows increased peanut yield in comparison to broadcasting. (Appendix 2.2.2-various composts).
	(j) Performance of different type of composts on peanut production	A field experiment was conducted to evaluate the effect of composts prepared by adding different types of crop residues	Jan – May 2012	Types of organic amendments from different households applied for peanut had significant positive effects on actual pod yield and the economic efficiency (Appendix 2.2.2-various composts).
	(k) Establishment of forage nurseries to evaluate prospective forage grass, legume and tree species for livestock production.	Forage nurseries established in Binh Dinh.	Oct - Dec 2010	This work was conducted in collaboration with the Component 3. 12 forage species were included in the nurseries. They comprise 4 perennial grasses, 4 perennial legumes, 3 annual legumes and 1 tree legume.
		Forage nurseries established in Ninh Thuan	Aug 2011	The Ninh Thuan nursery was planted in May-June with early wet season rainfall, but the site was destroyed after one harvest due to a local land dispute.

Objective 2.3: To evaluate soil management technologies and practices for more sustainable and profitable farming systems to enhance the livelihoods

No.	Activity	Outputs/ milestones	Completion date	Comments
2.3.1	Integrated Nutrient and water management: in peanuts and mango	Two peanut trials and one mango trial	Peanut trials harvested in Apr 2012; Mango harvested in Jun 2012	Bio-char, compost and inorganic fertilizers were used to supply nutrients. The treatments were designed to see the impact of individual materials on yield. Farmer's irrigation with N, K and micronutrients increased yield of mango and also had high Type 1 quality fruits. Appendix 2.3.1-cashew and mango Appendix 2.3.1-peanut
2.3.2	Data at the mini-catchment scale will be modelled by the UTas group under the Livestock component project and will use the data collected by both projects	Model Field days completed		Extension materials developed by component 3 for delivery by DARDs and ASISOV.

2.3.3	Improved understanding of nutrient retention and organic carbon management in sandy soils in south-west Australia	Soil C survey	Dec 2009	More than 100 soil samples were collected from the high rainfall sandplain of the south coast region using the National Carbon Accounting methods. Samples were collected from deep and shallow sands which had been sown to annual or perennial pastures. Analysis of samples was done by UWA and CSIRO. Roth-C modelling of soil organic C was also completed. Both indicated slow accumulation of soil organic C on sands under perennial pasture
		Establish Bio-char and compost Experiment.	May 2010	Experiment established at Esperance Downs Research Station to evaluate the effects of bio-char (straw, manure), compost and P fertiliser on soil nutrient availability and retention. Experiment concentrates of soil biological processes that affect phosphorus uptake and fertiliser use efficiency. Wheat was harvested in 2010, a summer sorghum crop in April 2011, lupin were planted in May-June 2011, a second summer sorghum, crop was harvested in April 2012 and followed by a canola crop.
		Establish clay spading trial	May 2010	Spading treatments (0, 15, 30 cm depth) were superimposed on a long term clay rates trial (0-300 t/ha). Productivity of a serradella pasture was assessed together with changes in soil properties. This trial continued in 2012.Appendix.2.3.3-Hall's report
2.3.4	Using precision agriculture to increase water and nutrient use efficiency on sands in south-west Australia			Appendix.2.3.3-Hall's report

3.0 Livestock (Component 3)

Objective 3.1: To establish benchmark information on the farming systems of households with cattle in Binh Dinh, Phu Yen, and Ninh Thuan Provinces.

No.	Activity	Outputs/ milestones	Completion date	Comments
3.1.1	Design and implement surveys to document biophysical and socio-economic aspects of cattle production systems in Binh Dinh, Phu Yen, and Ninh Thuan Provinces.	Report on baseline survey completed	See comment	The field work component was completed in Jul 2009. Report completed (Sep 2010).

3.1.2	Collect baseline feed and cattle performance data for the target provinces.	Report on baseline data collection completed	Jul 2010	10 representative farmers from each commune were selected for benchmarking. Benchmarking protocols were developed and project members trained. Weather stations were set up in 3 communes.
3.1.3	Collect baseline information on farming system and cattle production system for the target provinces.	Farmer workshops completed	Dec 2009	Farmer group discussions were conducted in December 2009 in each of the three study communes. Monthly data on household income, cattle marketing, and labour usage for cattle husbandry were collected.

Objective 3.2: To develop strategies for improving cattle production, through improved management and better utilization of on- and off-farm resources.

No.	Activity	Outputs/ milestones	Completion date	Comments
3.2.1	Develop a database of nutritive characteristics of available feeds.	Database completed	31 Dec 2009	Information on the nutritive characteristics of on- and off-farm feeds was gathered from previous studies. This was organised in the specific format for CNCPS analyses.
3.2.2	Use and provide training in modelling tools for predicting cattle requirements and performance based on combinations of locally available feeds.	Workshop held Feeds characterized CNCPS calibrated	Apr 2010	A workshop on cattle nutrition modelling was held in April 2009. Work done in small group workshops showed that CNCPS can adequately predict performance of VN cattle. The paper 'Evaluation of a nutrition model in predicting performance of Vietnamese cattle' was published in AAJAS.
3.2.3	Modify the IAT Bali cattle model to represent the prevailing local breeds in the study Provinces	Livestock component of IAT modified	Jul 2010	See appended scenario modelling workshops report.
3.2.4	Generate an IAT database of crop and forage performance under local conditions based on output from the APSIM farming system model	Database of IAT crop performance finished	Jul 2010	See appended scenario modelling workshops report.
3.2.5	Modify the IAT economic model to accommodate local resource flows	Economic component of IAT modified	Jul 2010	See appended scenario modelling workshops report.

Objective 3.3: To evaluate the biophysical and socioeconomic impacts of cattle management interventions on smallholder farms through on-farm participatory research.

No.	Activity	Outputs/ milestones	Completion date	Comments
3.3.1	Conduct farmer workshops to discuss and identify the constraints to cattle production and identify opportunities for addressing these constraints.	Constraints and opportunities identified,	Mar 2010	Farmer workshops conducted. See appended baseline survey report. 'Systems of cattle production in South Central Coastal Vietnam', submitted to Livestock Research for Rural Development.
3.3.2	Use decision support tools to quantify and discuss the potential biophysical and socioeconomic impacts of these opportunities and agree on sets of 'best-bet' options for improving cattle production.	Workshop evaluated and reported	Mar 2010	Best-bet opportunities assessed. Paper presented at the Farming Systems Design conference in 2011, 'Improving cattle profitability in mixed crop-livestock systems in south central coastal Vietnam using an integrated modelling approach'.
3.3.3	Establish on-farm trials/demonstrations to evaluate and promote the best-bet options.	Best-bet options chosen and reported	Jul 2010	Best bet options chosen for each farm. See best-bet research report. See attached report 'On-farm forage production in South Central Coastal Vietnam'.
3.3.4	Deliver a farming systems workshop for the specialist and Provincial teams	Workshop held Workshop evaluated and reported.	Dec 2009	The training workshop on farming systems was presented by Dr Shaun Lisson, Dr Cam McDonald and Dr Le Dinh Phung
3.3.5	Monitor and communicate the biophysical and socio-economic impacts of best-bet interventions.	Best-bet trials monitored according to accepted protocols. Results of best-bet trials reported	Mar 2013	Best-bet trials are being monitored via regular visits and interviews. See best-bet research report.

Objective 3.4: To address specific knowledge gaps in cattle nutrition.

No.	Activity	Outputs/ milestones	Completion date	Comments
3.4.1	Identify gaps in cattle nutrition and develop experimental plan	Peter Doyle report. Experimentation plan finalized.	Mar 2010	Report on cattle nutrition priorities completed. Experimentation protocol completed for feeding experiment 1.
3.4.2	Conduct experiments to address knowledge gaps in cattle nutrition.	Research report 1 completed Research report 2 completed	Dec 2011 Dec 2012	Feeding experiments 1 and 2 completed. See appended reports.
3.4.3	Conduct Masters research in cattle nutrition at UQ	Research report completed	Mar 2011	Research project successfully completed. MSc thesis available.

Objective 3.5: Better utilization of manure resources in farming systems.

No.	Activity	Outputs/ milestones	Completion date	Comments
3.5.1	Evaluate manure quality and quantity produced on smallholder farms	Component 2 report completed Component 3 report completed	July 2010	This activity has been addressed by component 2. In addition, manure is being analysed as part of the value chain analysis.
3.5.2	Better understand the potential of manure and biosolids for soil structural and fertility improvement in crop and forage production.	Research report completed	Dec 2012	A field experiment is still in progress assessing the effect of manure application on *Brachiaria* x cv. Mulato 2. An interim report is appended: "Nitrogen management for Mulato 2"
3.5.3	Develop improved strategies for management of stockpiled manure	Research report completed	Dec 2012	This activity has been addressed by component 2.Two field studies on manure storage methods and manure quality evaluation were conducted and a double-pot technique tested as a bio-assay of manure nutrient supply.
3.5.4	Develop improved outcomes with surface-applied manure Report on suggestions for modification of the APSIM model	Report on suggestions for modification of the APSIM model	Dec 2012	A paper was presented at the Australian Agronomy Conference in 2010, 'Improved modelling of manure mineralisation through new methods for characterising the carbohydrate pools'. A field experiment is currently being completed assessing the effect of the method of manure application on *Panicum maximum* cv. TD58 (appended)

7 Key results and discussion

7.1 Value chain analysis

7.1.1 Grain legumes- Peanuts

A diverse range of grain legumes are grown throughout the three provinces, Binh Dinh, Phu Yen and Ninh Thuan; spreading from mountainous regions and highlands, down to sandy coastal plains (Table 7.1).

These grain legumes can be divided into two groups. One group including soybeans, mungbeans and peanuts, are widely grown and intensively farmed usually with irrigation. The second group (eg small red beans đậu săn, đậu ván) is grown specifically by ethnic minority peoples in mountainous regions in an extensive farming system without irrigation and, with self-supplied seeds in mountainous regions.

Among the diverse grain legumes grown in the SCC, peanut is the most significant crop in terms of poverty alleviation and sustainable farming system especially in areas dominate by sandy soils:

Table 7.1 Common legume crops by cultivation methods

Province	Cultivation method	
	Intensive farming	Extensive farming
Binh Dinh	Peanut, soybean, mungbean, black bean	
Phu Yen	Peanut, soybean, mungbean, black bean	Small redbean, đậu ván
Ninh Thuan	Peanut, mungbean, black bean, đậu bi	Small redbean, đậu ván, đậu săn, đậu cúc, đậu cua.

Source: Component 1 survey, 2010.

Peanuts

Peanuts are important in rotation with other annual species or intercropped with perennials on sandy coastal soils of the South Central Coast. Models of intercropping peanuts with crops such as cassava, sesame and corn have been widely adopted. The adoption of peanuts in order to break the mono-cultivation system on thousands hectares of sandy coastal zone in Phu Cat District, Binh Dinh province has resulted in smallholder income growth. (Viet Linh, 2010).

Growing peanuts not only helps increase income for farmers but also contributes to the improvement of soil fertility, prevention of land degradation and desertification which is occurring largely in Quang Ngai and Binh Dinh provinces.

Peanuts generate income 2.5 to 5 times as much as other crops such as rice and cassava. Price stability has a part in boosting more economic returns of peanut production than other crops. Peanuts are considered to have a major role in raising farmer incomes on sandy soils of the South Central Coast region.

Regions of peanut cultivation

Binh Dinh province is the most productive area for peanuts in the South Central Coast and there is an informal peanut trading centre at Dap Da town.

In the three South Central provinces where surveys were conducted (Binh Dinh, Phu Yen and Ninh Thuan), the growing area and peanut output are not high compared with those of three North Central provinces, Thanh Hoa, Nghe An and Ha Tinh. Peanut productivity of Phu Yen and Ninh Thuan is relatively low compared with other provinces within the region. However in Binh Dinh, peanut productivity is higher and with an increasing trend. The yield in 2009 was the highest in the region at 2.6 t/ha (GSO 2010).

Binh Dinh has emerged as a primary provider of peanuts in the region (with peanut production ranked eighth in the country) and as the leading producer in the South Central Coast, Moreover, Dap Da Center, An Nhon district, has formed a group of merchants, known by many merchants nationwide such as Mrs. Son Duong, Huong Thai. In this town, there are four assemblers owning threshing and sorting machines, and some have even bought dryers for drying seed peanuts purchased from Daklak in the rainy season (November). A group of about 40 local collectors buy peanuts from local farmers to sell to these assemblers. Contrary to assemblers in Phu Yen or Ninh Thuan who mostly purchase peanuts within the province, assemblers in Binh Dinh buy and sell peanuts all year round, and have warehouses. In addition to the time of purchasing peanuts in the province, they also buy peanuts from other provinces in the north (Hanoi, Nghe An), central (Binh Thuan, Phu Yen), Western Highlands (Gia Lai, Daklak) and the south (Tay Ninh, Ho Chi Minh City, Dong Nai) in harvesting times, and then sell to areas with peanut shortages. They have sold peanuts in Binh Dinh and to Nghe An, Daklak, Gia Lai, Dong Nai, Hanoi, Ho Chi Minh and export to China.

There are some reasons why Dap Da Town emerged as a peanut-trading centre nationwide:

a) Historical factors: Since Dap Da was formerly the region of growing peanuts, a group of assemblers specialized in trading peanuts which few other dared to trade due to its perishable characteristic. Quy Nhon Port was once a major export site for peanuts.
b) Dap Da Town and its neighbourhood concentrate numerous peanut processing facilities; apart from dryers and threshing machines, there are many oil pressing, peanut candy making, peanut roasting facilities and other home craft businesses using by-products from peanuts such as peanut husk as fuel for rice paper, noodle factories. Thus, the local assemblers can buy assorted peanuts at relatively high price, then grade and market them to different channels.

Peanut quality is judged by local traders based upon the shelling percentage (kernel relative to pod weight), moisture, seed colour and plump grain shape (well rounded and glossy). Good quality peanuts have a shelling percentage of 75% while poor quality is 60-65%. Of the kernels, 5% of low quality seed include granules, broken, and small black nuts. These low quality grains in Dap Da, after sorting, are all sold.

The peanut value chain in the SCC is an inter-province chain with trading within SCC and between SCC and other regions (seed inputs from the Highland and outputs to the North and to the South).

In the three studied provinces, the main peanut crop is in winter-spring (from December to March). In some irrigated areas, peanuts can be grown in consecutive crops but winter-spring gives the best yield. Every year, the majority of farmers in Binh Dinh and Phu Yen have to buy seeds chiefly brought in from Dalak, Gia Lai, Dong Nai by private traders.

The seed quality assurance is, therefore, entrusted to traders. But a few traders purchase seeds directly from farmers, thus the control of seed quality is impossible to achieve. As a result, Department of Agriculture in Binh Dinh has actively conducted a program of bulking seed from autumn-winter crops on sandy soils in Phu Cat district.

Peanut value chain

The peanut value chain in SCC is traditionally a long chain with many local collectors, assemblers, wholesalers and retailers of which local assemblers play the most important role:

Local Collectors: purchase products directly from farmers (at home or at the open market), then have them shelled, sorted at local processing facilities and sell them to local assemblers in the province. Local collectors have a small capital base (about 20-50 million VND), buying about 1-2 tons of peanut/day. Some do peanut business only at harvesting times in a locality then take on other jobs at other times. Others purchase different agro products nearly all year round including buying seed peanuts from Gia Lai, Daklak for sale locally.

Local assemblers: purchase peanuts from local collectors. The role of assemblers is very versatile. They may have peanut threshing workshops, sort peanuts and buy kernels and shells as well. They sell good quality peanuts to city wholesalers in other provinces.

City wholesalers: In the north, peanuts are gathered at the main wholesale markets at the town of Troi; Thuong Tin district and Vinh City (Thanh Hoa). In the south, peanuts and other grain legumes are gathered mainly at Sặt market located in Bien Hoa City (Dong Nai province). The wholesalers have a great capital base, extensive business relationships and warehouse systems. From there, they distribute to other wholesalers or retailers in and out of the province, or sell to import-export companies and processing firms. Some of them have also assumed the role of exporting and importing the peanuts.

Apart from wholesalers there are a number of companies that specialize in purchasing peanuts from provinces across the country to supply to import-export companies and processing firms.

Farmers and collectors have a spot market type of relationship (e.g. no long-term commitments and immediate payment on delivery). But the relationships between collectors and assemblers are more stringent, with payment immediately or usually after 5-7 days; collectors can borrow money from assemblers, yet with a loan interest of 3% per month for maximum loan amount of 70 million VND. The loan amount varies depending on how close the relationship is. The relationship between local assemblers and external wholesalers is risky. Wholesalers worry about quality, especially the high-moisture content of peanuts because if not carefully controlled, the peanuts will be contaminated with aflatoxin which is responsible for food poisoning symptoms, liver damage and death. Conversely, assemblers receive money only a few days after delivery without any documents of sale. They communicate mainly by phone calls. The assemblers and wholesalers usually know each other through the introduction of truck drivers, which means that they hardly ever see each other.

Peanut market facilities

Poor market facilities and poor post-harvest technologies result in peanut quality risks. The open air market system has existed for a long time, it is still active in Phu Yen and is a common agricultural goods trading system in Binh Dinh.

The open market system in Binh Dinh plays an important role in trading agricultural products produced in the province. The system includes a lot of fair markets that alternately operate. Two sessions at the same market are 5 days apart. Markets selling peanuts including Cay Bong, An Thai (An Nhon district), Gom, Phu Cat (Phu Cat), Binh Duong, Cay Da (Phu My).

Open markets usually start very early in the morning (around 2-3 am) at a large area near an official market which will be in operation in the morning. At the market, farmers bring agricultural products for sale and assemblers come to buy. Depending on agricultural season, there will be key products, for example, in peanut season, the market will be selling peanuts mainly, plus coconut, sweet potatoes, etc.

The trading facilities are poor and in darkness with no street lights, collectors carry scales, flashlights, notebooks, pens and calculators. At least 2 sellers usually come together, bringing in peanuts by numerous kinds of vehicles (bicycles, motorbikes, xe thồ). The vehicles and trucks hired by collectors park in disorderly fashion make traveling in the market very difficult, while all buyers and sellers have to walk back and forth through the market several times to get market prices.

Some sellers admit that their peanuts are not dry enough. They mix them with dried ones before selling. Under such market conditions, they easily sell inferior, mixed peanuts.

Water supply issues

The rapid expansion of intensive peanut-based cropping systems has put pressure on the local ground water.

At the research site in Binh Dinh, water is primarily extracted from groundwater wells. The total number of wells has increased rapidly in the period 1995-2005. The number of new wells sharply increased in 2000 due to the expansion of peanut cultivation. Since then the number of wells have continued to rise and is particularly higher in 2010 due to the development of peanut-based farming systems thanks to the transfer of agricultural technology from extension services.

Our estimates of water volumes used by peanut crops ranged from 210m^3/0.1ha/crop (fall-winter crop) up to 837 m^3/0.1ha/crop (winter-spring crop), which is much higher than other cash crops.

Farmer's awareness of water scarcity increases the opportunity for the adoption of water-saving technologies such as manure application, sprinklers and bio-char.

About 80% of peanut farmers commented that the water levels have dropped. 63% of farmers in Cat Hiep commune assessed the water reduction was from serious to a very serious level because groundwater is the only source for irrigation at this commune while the area of upland crops, particularly that of peanut crops also grew rapidly.

The evidence of the drop in groundwater level during the dry season, according to the farmers, is the decline in the water table in the wells (50% of total responses), longer watering time (25%) and water shortage in the following season (22%). The cause of the depletion of water, according to farmers, was mostly caused by drought due to climate change (48% of total responses), and also due to the increased exploitation (15%) or both (33%)

Although water for irrigation is almost free of charge, due to the awareness of the decline in ground water resource, about 35% of farmers have applied measures to save water in irrigation that consisted of manure application (14%), bio char application (12%) and using sprinklers (9%).

Bio-char made from rice husk, in particular, was researched by ASISOV, as part of this ACIAR project, at Phu Cat district, Binh Dinh in 2010 – 2011. This experiment showed a good result in increased peanut yield by 15-30%. This productivity gain may have been through increased water holding capacity, nutrients in the bio-char and reduced rate of nutrient leaching when applying bio-char. Having given this information to farmers, there were 45 of total 60 interviewed farmers (75% of total) who agreed that they would use bio-char, of which 35 households (58%) will be able to self-produce bio-char and 10 households (17%) agreed to buy, if bio char is commercially available in the market. Therefore, there is a good chance that farmers will adopt bio-char.

In order to assess the determinants for farmer adoption of water saving technology, a binary logit regression model was used. This model can correctly predict 70% of the result whether a person can choose to apply one of the measures to save water. The regression results showed that a person with higher education level, more years in growing peanuts and especially more awareness of the severity of water resources decline would more easily adopt water-saving measures. In addition, the farming area is also a factor affecting the adoption: at a weaker level, the larger the land holding, the higher the likelihood of adoption.

Peanut post harvest processing

Mechanical dryers have just been introduced to Binh Dinh province to facilitate the development of the autumn-winter peanut crop for seed provision.

According to the Decision No. 43/2009/QD-UBND dated 10/20/2009 of People Committee of Binh Dinh Province, the People Committee encourages organizations and individuals to invest in developing peanut seed production in the autumn-winter crop for seed supply for the winter-spring crop. Provincial budget subsidized 60% of seed price in 2010 and will reduce to 10% in 2015 for farmers participating in this program. The planned peanut seed production area is 100 ha for autumn-winter crop in Phu Cat District. The project is undertaken by the Centre of Agricultural Extension.

The main constraint to this project is the difficulty in drying as this is a wet season crop. There were 75% of farmers reported post harvest damage due to peanut germination. In 2011, the DARD has provided to farmers two small dryers with a capacity of 1.5 tons / batch / 48 hours designed by the Energy and Farm Machinery Centre (The University of Agriculture and Forestry at Thu Duc). The cost of buying the machine is 65 million VND/ unit. The two dryers were transferred to two municipal farmers representing 20 poor households in Cat Hiep commune to operate.

The application of the dryer opened up prospects for increasing local peanut seed production. This machine can also be applied to the drying of other important agro products such as cassava.

Key Opportunities for peanuts

- World market and domestic market prices for peanut have been favorable.
- Peanut crops are suitable for the natural environment in coastal areas.
- Supporting policy for peanut growing on the coastal areas is being implemented by some local authorities such as in Binh Dinh province.
- There are international projects to support research and development in local areas.
- Growing peanut crops as an adaptive measure to climate change is supported.
- Mechanical peanut dryers have been introduced to Binh Dinh province.

Key Constraints in peanut chain

- Lack of quality control and poorly developed relationships in the value chain.
- Rapid development of peanut cropping has been causing groundwater depletion in the dry season.
- Poor wholesale market facilities result in poor peanut moisture control.
- City wholesalers concerned about high moisture causing loss during storage. As a result, they are considering larger imports of Chinese peanuts.
- Local assemblers: lack of finances, market information.
- Local collectors also have insufficient finance.

Recommended peanut chain improvements

- Development of water saving technologies such as sprinkler irrigation systems and use of bio-char.
- Mechanization in peanut harvesting operations.
- Continuing support for farmer adoption of peanut dryers
- Better control of peanut moisture via improvement of wholesale market facilities (eg. lights for night markets), training traders on peanut quality controls.
- Credit to local traders for their improvement of postharvest practices.

What resources are needed to implement these chain improvements?

- Public-private partnership in improving wholesale market facilities.
- Better co-operation between research institutes and DARDs to train and transfer technology to peanut farmers.
- International and Vietnamese experts can deliver relevant trainings.

Action plan for changes that are feasible to implement

In 2013, the following activities should implemented;

- Establish a peanut association in Binh Dinh to include wholesalers, collectors, farmers , researchers and agricultural extension staff.
- Train peanut wholesale traders in quality control, IT for business management.
- Train farmers in sprinkler irrigation, using bio-char and grain drying techniques.
    - Training local government officers in IT for management.

Summary (peanuts)

Peanuts are a profitable and environmentally sustainable crop for the coastal sandy soils. Strengthening the value chain with the establishment of an association and appropriate training for farmers, traders and local DARD officers are the key to peanut value chain improvement.

7.1.2 Cashew

Cashew nuts have been identified as one of Viet Nam's eight key products for export during the period 2006-2020. In 2009, the total national area of cashew nut plantation was 389,100 ha. Cashew production divides into 4 regions: South Central Coast, Central Highland, Southeast, and Mekong River Delta. Southeast is the area growing most cashew trees with 60.6% and South Central Coast consists of 18.9% of the total area. Cashew plantation in Central Highland is 22.5% and the lowest percentage is 1.8% in the Mekong River Delta.

Cashew trees were considered as forest trees or shading trees. Seedlings were used as planting materials, and originally less care was practiced. As a result, the cashew trees gave very poor yield and poor nut quality. Since August 1989, cashew trees were recognised by the Government as an industrial crop and it was shifted to Ministry of Agriculture′s supervision. In 1990, The Vietnam Cashew Association (VINACAS) was set up to promote cashew production; and up until recently then there has been a fast growing trend in cashew trees areas in the country. The area under cultivation increased to 420,000 ha in 2010 from 90,000 ha of cashew trees in 1995 and harvesting area rose from 90,000 ha to 320,000 ha. The area of cashew production has recently declined because of poor yields and consequently poor returns relative to other crops.

To ensure a supply of raw materials to process for export, cashew firms plan to import from Ivory Coast, Cambodia, Nigeria, Indonesia, Guinea and Ghana.

Viet Nam imported 250,000 t of nut in shell and exported 167,000 t of cashew nuts worth US$914.34 million in 2008, a growth of 166% in volume and an increase of 142% in value, according to figures from the VINACAS

In the three provinces surveyed, only Binh Dinh province has a significant area and production of cashews.

Cashew nut economic analysis

Table 7.2 Cashew nut input cost analysis

Cost Items	BINH ĐINH (n=14)		PHU YEN (n=9)		NINH THUAN (n=8)	
	Average value (VND)	*%*	*Average value (VND)*	*%*	*Average value (VND)*	*%*
Seed or seedling	1,001,800	8%	41,667	3%	0	0%
Ploughing	0	0%	0	0%	0	0%
Inorganic fertilizer	5,850,000	49%	702,222	58%	250,000	35%
Manure	0	0%	46,667	4%	0	0%
Pesticide	2,767,857	23%	376,667	31%	250,000	35%
Irrigation	0	0%	0	0%	-	0%
Labour	2,378,571	20%	43,333	4%	210,000	30%
Transport	57	0.0%	0	0%	50	0.0%
Total Costs	**11,998,286**	**100%**	**1,210,556**	100%	**710,050**	**100%**

Table 7.3 Cashew nut profit analysis

Average value	BINH ĐINH (n=14)	PHU YEN (n=9)	NINH THUAN (n=8)
Input cost	11,998,286	1,210,556	710,050
Revenue	41,160,000	6,356,000	3,500,000
Production volume (kg)	2,400	454	350
Unit price	17,150	14,000	10,000
Profit (VND / surveyed farmer)	29,161,714	5,145,444	2,789,950
Profit (VND / ha)	12,257,971	6,770,321	1,115,980
Profit (VND / kg)	12,150	11,333	7,971

The results indicated that farmers in Binh Dinh earned a profit of nearly 11 million VND per year for one hectare of cashew. Farmers in Phu Yen had a lower profit, about 2.55 million VND, and farmers in Ninh Thuan earned only about 1.38 million VND per year (

Table 7.2,

- Table 7.3).
- In Binh Dinh province, the cashew price in 2010 was high and it will motivate the farmers to invest more in the next season in order to harvest higher yields. In Ninh Thuan and Phu Yen, cashews are not such a profitable crop so farmers are changing to new crops.

Average value of costs and profit of purchasing stations and processors

Table 7.4 Costs of purchasing stations

Cost Items (%cost/total costs)	**BINH ĐINH province (n=7)**	**PHU YEN province (n=7)**	**NINH THUAN province (n=5)**
	Average value (%)	Average value (%)	Average value (%)
Material	98.33	99.49	99.43
Labour	1.42	0.25	0.31
Preservation	0.01	0.00	0.00
Drying	0.00	0.00	0.00
Transportation	0.17	0.16	0.21
Packaging	0.03	0.03	0.03
Information	0.04	0.07	0.02

Table 7.5 Profit of purchasing stations

Average value (VND)	**Binh Dinh province (n=7)**	**Phu Yen province (n=7)**	**Ninh Thuan province (n=5)**
Input cost (VND/tonne)	9,500,411	15,077,340	14,885,000
Revenue (VND/tonne)	10,234,136	16,000,000	15,000,000
Profit (per tonne)	1,167,606	922,660	115,000
Average purchasing station profit (VND)	**454,385,714**	15,394,575	3,737,500

- Analyzing costs and revenue shows that purchasing stations in Binh Dinh province earn more profit than Phu Yen and Ninh Thuan province because Binh Dinh has a larger scale cashew nut production area (Table 7.4, Table 7.5).
- In Binh Dinh province, because purchasing stations are large scale, they earn an average 454,385,714 VND per year for cashew nut business which is about 30 times that of Phu Yen purchasing stations and about 120 times that of Ninh Thuan purchasing stations. So we can see that cashew nut purchasing stations in Binh Dinh province are more effective and more profitable than those in Phu Yen and Ninh Thuan provinces.

Table 7.6 The distribution of cost, revenue and profit in value chain of cashew in Phu Yen province (2010 – 2011)

Item (VND/tonne)	**Farmer**	**Purchasing station**	**Processor**
Total cost	1,210,556	15,077,340	17,328,360
Revenue	6,356,000	16,000,000	21,312,552
Profit	5,880	922,660	3,984,192
Profit as % of total profit of farmer, purchasing station and processor	69.8%	24.5%	5.7%

Table 7.7 Average cost of 1t of raw cashew in processor in Phu Yen province.

Cost Items (cost/total costs as a %)	Average value (VND)	Average value (%)
Input cost -cashew nut material	58,250,000,000	84.04
Labour	8,612,500,000	12.43
Electricity and water	2,400,000	0.00
Packaging	423,280,423	0.61
Oil	158,400,000	0.23
Packaging and transport	952,380,952	1.37
Broker	914,478,400	1.32

Table 7.8 Average profit of 1 t raw cashew nut in processor in Phu Yen province

Item	Average value
Total costs (VND/t)	17,328,360
Revenue (VND/t)	21,312,552
Profit (VND/t)	3,984,192
Average profit of 1 processor which has a processing capacity about 4000 t of raw material (VND/year)	**15,936,768,162**

The results show that:

- The contribution of profit of each member of the value chain of cashews over the total profit of all members in value chain were 69.8% for farmers, 24.5% for processors and 5.7% for purchasing stations (Table 7.6).
- Although famers received the highest proportion of the profit from 1 t of cashew nut, this profit covers the investments of one year. Moreover, the cashew area of each household is small; therefore total production of each orchard is not high. As a result of this, the size of the profit per household is low (Table 7.7, Table 7.8).
- In contrast, although the percentage of profit of purchasing stations was much lower than that of farmers, the period of cashew trading was very short (from 3 days to 1 month) and the quantity of cashew nut which was bought in this season was very large therefore total profit which purchasing stations received was extremely valuable. This is the same with processors who also earn a large profit from processing and trading.

SWOT analysis of the cashew value chain

Strength	**Weakness**
1. Not complex growing technique 2. Technology Supported by Government, DARDs, Centers, Research Institute, University. 3. Local active collector's system 4. Developed cashew nut processing industry	1. Productivity is low due to an extensive cultivation approach and adverse weather conditions 2. To improve productivity farmers need to move to intensive cultivation, implement improved cultivation practices, and plant good varieties 3. Farmers currently have very limited understanding of technology and how to use it to improve productivity. They also appear to lack entrepreneurship. 4. Crops are grown on infertile soils and barren hillsides for reforestation purposes 5. Plants grown from seed and orchards are often over 20 years old 6. High density of trees 7. Introduction of new grafted varieties is slow
Opportunity	**Threat**
1. Domestic cashew nut supply is inadequate to fulfill the requirements of processors. 2. Cashew nut processing industry is a potential major source of jobs for the population in the South Central Coastal area of Viet Nam. 3. High demand for the export of cashew nuts	1. Main market is export, mainly raw cashew kernel so the value of process is low. Processors depend on the world market; consequently cashew nut processing is not stable. 2. Issues with cashew nut quality 3. Lack of raw material: Domestic cashew nut supply is inadequate to fulfill the requirements of processors so that processors depend on the imported cashew nut. 4. Shortage of labour 5. Many members in supply chain 6. Some farmers do not focus on the quality of cashew nut 7. Economic return is lower than other crops so the area is reduced

Recommended cashew chain improvements

Suitable production areas and varieties

It is necessary to have a sector plan for cashew areas with intensive cultivation and afforestation. The intensive areas should be focussed on fertile soil. Potential productivity is about 1.5 – 2 tonnes per hectare, so searching internationally for well adapted, high yielding varieties to replace the old and stunted varieties is essential. Farmers need to apply fertilisers and pesticides at the right time in the right dosage and to take good care of their cashew trees. More research to seek new cashew varieties that have good quality, high yield, pest resistance and adaptation to the region's changing weather.

Quality

The quality of cashew nut is ensured by providing appropriate humidity for preserving and processing. After harvesting the nut should be in a humility of 17 – 19%, necessary to eliminate disease and foreign matter. Nuts are dried on the ground or in drying systems until the humility reaches 11%. Before being packed in gunnysacks the dried nut should be cooled to ambient temperature. This will maintain good quality and avoid infection with fungi. In times of heavy rain or no drying yards, cashew nuts can be spread in a thin layer and ventilated or force fanned.

Mechanisation

The priority for mechanisation is in the skilled phases of cashew processing to reduce labour requirements and costs, and take advantage of by products of cashew processing, thereby increasing the value for the cashew value chain. Installing steaming and drying machines made by SIAEP with capacities of 1 ton per hour improved the quality of cashew kernels and shortened processing time.

Market strategy

It is a necessary strategy to expand the market and to increase the competitiveness of Vietnamese cashew products.
- Firstly, the cashew processors and the cashew export companies need to improve the quality of products and to comply with international standards for establishing a trademark for Cashew Vietnam.
- Secondly, it is necessary to develop the price system for potential markets, to develop and care for loyal customers and to protect the domestic market.
- Finally, it is necessary to strengthen the management of transport and to shorten the time for supplying cashew nuts to increase turnover.

7.1.3 Mango

Mango is grown widely throughout Viet Nam. However, major production is concentrated in the Mekong River Delta region. In 2008, according to the National Institute of Agricultural Planning and Projection, the total area and production of mango in agricultural zones of Viet Nam was 85,500 ha and 518,000 t, respectively. The Mekong River Delta is the major producer of mango and ranks first both in area and production. It contributes nearly 49 and 58% of total mango area and production of the whole nation, respectively. In contrast the South Central Coast has only 10% of the area and 9% of Viet Nam's mango production.

Regional mango production

All of the districts in Binh Dinh, Phu Yen and Ninh Thuan provinces grow mango trees (Table 7.9). Ninh Phuoc district is the leading producer of mango in Ninh Thuan province, while Phu Cat district is in seventh position in Binh Dinh province. In the last few years, mango cooperatives have been established in Binh Dinh and Ninh Thuan provinces. This is an important factor in the development of the mango production in the South Central Coast region.

Table 7.9 Mango varieties, cost and yield in each province

Items	Binh Dinh	Phu Yen	Ninh Thuan
Cat Hoa Loc			
Used Fertilizer (%)	100	100	100
Used plant protection (%)	100	100	100
Yield (kg/ha)	4,650	4,200	5,400
Thai Mango			
Used Fertilizer (%)	100	-	100
Used plant protection (%)	100	-	100
Yield (kg/ha)	4,800	-	5,500
Local varieties (Cat moc, Da Trang, Queo…)			
Used Fertilizer (%)	25	0	0
Used plant protection (%)	28	0	20
Yield (kg/ha)	2,400	1,800	2,200

Regional economic analysis of mango production

Binh Dinh

Table 7.10 Profit or mango varieties in Binh Dinh

Items	Cat Hoa Loc	Thai Mango	**Local varieties** (Cat moc)
Output (kg/ha)	4650	4800	2400
Avg. Price (VND/kg)	11500	13500	6000
Total Revenue (million VND/ha)	53.48	64.80	14.40
Total cost (million VND/ha)	23.90	28.70	4.65
Profit (million VND/ha)	**29.58**	**36.10**	**9.75**

- Thai mango has the highest profit (36.10 millions/ha) due to higher yield and prices than other varieties (Table 7.10).
- Profit of Cat Hoa Loc mango was 29.58 million VND/ha.
- Due to lack of investment, low productivity and price, the profit of local varieties of mango was only 9.75 million VND/ha.

Phu Yen

Table 7.11 Profit or mango varieties in Phu Yen

Items	Cat Hoa Loc	**Local varieties** (Da Trang, Queo…)
Output (kg/ha)	4200	1800
Avg. Price (VND/kg)	11500	5000
Total Revenue (million VND/ha)	48.30	9.00
Total cost (million VND/ha)	21.40	3.40
Profit (million VND/ha)	**26.90**	**5.60**

- The profit of Cat Hoa Loc mango was highest (26.90 millions VND/ha) due to higher prices compared with other varieties (Table 7.11).
- Due to lack of investment, low productivity and low price, the profit of local varieties of mango was only 5.60 million VND/ha.

Ninh Thuan

Table 7.12 Profit or mango varieties in Ninh Thuan

Items	Cat Hoa Loc	Thai Mango	Local varieties (Cat moc)
Output (kg/ha)	5400	5500	2200
Avg. Price (VND/kg)	11500	13500	5000
Total Revenue (million VND/ha)	62.10	74.25	11.00
Toatl cost (million VND/ha)	26.45	32.20	3.95
Profit (million VND/ha)	**35.65**	**42.05**	**7.05**

- With high investment, Thai mango in Ninh Thuan gave the highest profit (42.05 million VND/ha) Table 7.12.
- Profit of Cat Hoa Loc mango was 35.65 millions VND/ha.
- Due to lack investment, low productivity and low price, the profit of local varieties of mango was only 7.05 million VND/ha.

Opportunities for development of mango production in the South Central Coast region.

The weather conditions in provinces of South Central Coast region are favourable for mango production development. Especially, Khanh Hoa and Binh Dinh provinces which are suitable for mango production due low humidity in the monsoon. The harvest season for mango in South Central Coast region is off-season (later) than the Mekong River Delta region. Therefore there is big opportunity to sell out of season to other areas of Vietnam. The growers may receive higher prices during this later season supply to markets. Demand for mango is increasing in local markets.

The good quality mango varieties growing in the provinces of South Central Coast region are Cat Hoa Loc, Kieu-Sa-Voi, R2E2. There is substantial potentially suitable production capacity for mangoes in the South Central Coast.

Economic analysis of mango value chain

Table 7.13 Value adding of the actors in value chain of mango in Binh Dinh

Unit: 000 VND/t

Particulars	Farmer	Collector	Wholesaler	Retailer
Input cost	**5,120**	**11,000**	**13,500**	**16,000**
Labour cost		20	20	20
Transportation cost		450	700	350
Packaging costs		30	50	400
Loading cost		100	100	60
Rent cost			40	30
Tax			50	25
Power, fuel…			10	10
Marketing cost		15	20	10
Depreciation		35	10	10
Total		**11,650**	**14,500**	**16,915**

Economic analysis of the value chain was based on 1t of mango sold locally. Value adding of the actors in value chain was expressed as follows:

Table 7.14 Cost profit and margin in the mango value chain.

Particulars	Farmer	Collector	Wholesaler	Retailer	Total
Total cost	5,120	11,650	14,500	16,915	
Value added		650	1000	915	7685
% Value added	67%	8%	13%	12%	100%
Price	11,000	13,500	16,000	21,000	
Profit	5,880	1,850	1,500	4,085	13,315
% Profit	44%	14%	11%	31%	100%
Margin	11,000	2,500	2,500	5,000	21,000
% Price	52%	12%	12%	24%	100%
Cost/Price as a %	47%	86%	91%	81%	
Profit/Price as a %	53%	14%	9%	19%	100%

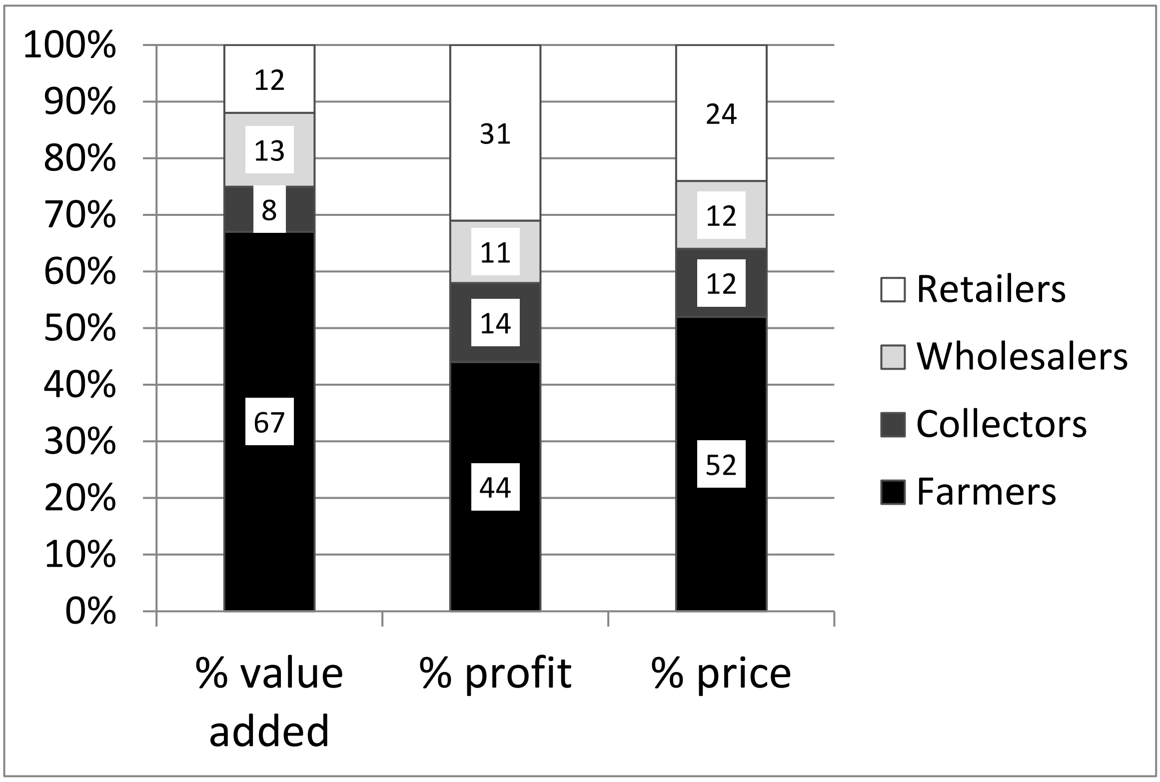

Figure 7.1 Distribution of cost, profit and margin in the mango value chain.

The results showed that the contribution of actors in value chain of mango was farmers (67 per cent of total value added), wholesalers (13%), retailers (12%) and collectors (8%) (Table 7.13, Table 7.14, Figure 7.1)

Distribution of cost, profit and margin in the mango value chain

Farmers received the highest profit (44% of total profit) and accounted for the largest proportion of total value added. Therefore, distribution of profit to farmers in the mango value chain is reasonable.

Retailers received about 31% of total profit, followed by collectors (14%) and wholesalers (11%). However, the actual total profits of wholesalers are difficult to estimate due to the unknown quantity of sales of wholesalers which are several times higher than the other actors in the mango chain.

Strategies to improve the mango value chain:

Actors	Main difficulties	Solution	Who	How
I. Farm input				
1. Seeding	- Lack of good seeds / seedling. - Poor management of seeding.	- Transfer mango breeding techniques to farmers. - Research to strengthen the mango varieties. - Strengthen the seeds and seedling production.	Institute, DARD's, Seed centres	- Training in mango breeding techniques. - Manage seeds. - Find funds for research.
2. Capital	- Lack of capital	- Support the policies for development of the mango value chain	DARD's, Banks, Farmers' Union	Soft interest loans
3. Extension	Lack of fruit extension staff.	Enhance the knowledge of extension staff	Institute	- Train and transfer new technologies to staff.
4. Information	Actors do not seek market information	Improve the knowledge of market information	Institute, companies, farmers	Training in use of market information
II. Farmers				
1. Cultivation	- Scattered and small scale;irrigation problems - Low investment, productivity and profit.	Improve the farm scale and investment	Govern-ment, Institute, DARD's, Banks, Companies	- Planning areas of mango production and building project on development of fruit.
2.Cultivation techniques	- Most farmers practice traditional mango production. - Farmers are not experienced in growing fruit trees. - Low productivity - The quality is not stable.	- Improve the cultivation techniques - Change the farmers' thinking and methods. - Demonstration models of mango production, and compliance with GAP standards.	Institute, DARD's, Companies , Farmers	- Training and workshops on GAP standards. - Demonstrations of mango production and compliance with GAP standards.
III. Market				
1. Trademark	No trademark			

2. Marketing	Poor knowledge of customers and consumers	- Update knowledge in marketing and developing a trademark. - Promote the product.	Farmers, companies	- Register the trademark. - Promote of product in fairs and exhibitions - Mango production compliance with GAP standards.
3. Domestic market	- The quantity and quality are not stable. - Little market information and forecasts.			
4. Export	Mango is still not exported due to not meeting the requirements for quantity, quality, and standards.			

Summary for Mango

- The weather conditions in SCC are favorable for mango production.
- Mango growers in SCC can exploit an off-season market compared to Mekong River Delta
- High demand in the domestic market and potential export.
- Mango can be supplied to the local and neighbouring markets.
- Mango production in the research area is large scale with lack of investment in inputs and low productivity.
- The number of fruit traders are low.
- Linkages between mango growers to collectors, wholesalers and retailers is still limited.
- Growers of mangos benefited most in the chain gaining the majority of profits from the chain which is reasonable.
- Training and transfer of cultural farm practice and plant protection is required for farmers of mango in the research sites.
- Encouragement, assistance and support is required for the development of mango production (e.g. good seedlings, soft loans)
- The establishment of a mango cooperative is required to create large-scale production areas
- Provision of market information is required to maximise competition and participation.

7.1.4 Cassava and Beef Cattle

Situation of cassava and beef-cattle production, 2000-2011

In general, three target provinces of Binh Dinh, Phu Yen and Ninh Thuan have agricultural production systems based on crops and animal husbandry such as: food & foodstuff crops (rice, legumes and corn), industrial plants (sugar cane, cassava, tobacco, peanut and sesame), perennial crops (cashew, fruit trees) and livestock (beef-cattle, goat and sheep). The population density is high, while the agricultural land area is limited so that small holders play an important role in agricultural production and socio-economic aspects. In recent years, cassava cropping and beef-cattle husbandry have both played very important roles as sources of family income in the South Central Coast region.

Trends in cassava production

The production of cassava has increased since 2000 following establishment of cassava-starch processing factories in Binh Dinh and Phu Yen. In the past, traditional cassava processing was at a small-scale using family labour and simple equipment, so that the product was mainly supplied to small local markets. Since the establishment of processing factories, a large amount of cassava tuber and root is processed into tapioca starch or chip then exported to countries such as China, Singapore, Thailand and a small proportion is used as a raw material for domestic industries.

The market price of cassava (chip, fresh tuber) which is the major factor that affects cassava production has fluctuated between 2000 and 2010 with an increasing price trend from 2006-2011 driven by exports to China[1]. As a result, the cultivated area of cassava also increased from 2006. However, from the middle of 2009 to 2010, the price of cassava fell because of a slowdown in exports of cassava starch. Consequently, in 2011, the cultivated area fell. In 2010, cassava plantings reduced by 57,800 ha (occupied 10.4%) compared to 2008[2]. In the Northern Central and South Central Coastal (SCC), area was reduced by 13,300 ha, equivalent to 7.9%. In Binh Dinh, Phu Yen and Ninh Thuan, the total cassava area was reduced by between 600 and 1,300 ha. In Phu Yen, the area increased by 1,000 ha in 2010 compared to 2009 when a new processing factory commenced operation.

In SCC region, production fell about 4.7% (129,000 t of cassava tubers) in 2010 compared to 2008.

However, the cassava crop still plays a very important role in contributing to the income of small farmer households and in farming systems in SCC region.

Trends in beef-cattle production

Generally there was a downward trend in the production of beef-cattle from 2007 to 2010 in SCC region, particularly in Binh Dinh, Phu Yen and Ninh Thuan. From 2009 to 2010, in SCC region, the number of cattle fell from 2,489,000 to 2,391,000 (equivalent 3.9%). The main reasons for this fall were technical impacts (disease) and the falling price of beef.

However, the herd of beef-cattle recovered by the middle of 2011 in all SCC provinces because of increasing demand for beef meat in the cities (such as Ho Chi Minh, Ha Noi, Da Nang, Vung Tau) where demand exceeds supply. Annual beef imports range from 200,000 to 300,000 t. In 2010-2011, the beef price fluctuated from 180,000 to 250,000 VND/kg, being 2 to 3 times higher than price of pork. As a consequence, farmer returns from cattle have been favourable. Furthermore, the beef-cattle husbandry is an important part of farmer income and cash flow as well as being an effective use of by-products from crops (cassava leaf, peel and root, peanut stems, paddy straw, green forage etc.).

Dynamic of socio-economic factors and production in villages

Cat Trinh village

Cassava production :

In the SCC, cassava is intercropped and rotated with other cash crops such as peanut, sesame in sandy soil areas. Cassava area varies from 350,000 ha to 500,000 ha; it increased by 20,000 ha and reaches to total of 430,000 ha in 2011. The main variety is

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[1] In 2010, price of cassava chip at farm-gate is from 4.500 to 4,700 VND per kg; Price of cassava fresh root is from 1,500 to 1,700 VND per kg. In 2009, average price of cassava is 500 – 1,000 VND per kg higher than that of 2010 (average price of fresh tuber is 2,200 VND/kg; chip price is 5,500 VDN/kg). Buying price in factory based on starch percentage (Appendix).

[2] Statistical Publishing House (2011).

KM94, but the quality of this variety is considered to have degraded since its release last decade. When combined with insufficient input of fertilizers and poor production practices, the yield of KM94 has been relatively low and unstable especially under difficult weather conditions (average yield in 2011 was 20 t of roots, lower than that of 2010 due to drought, lack of irrigation water and disease attack). The starch content has also been low affecting quality grade and selling price of roots (in 2011, at harvest time, average price varied from 1,500 to 1,700 VND/kg (in 2010: 2,200-2,400 VND/kg), lowest price was 800-1,500 VND/kg, reduced by 200-700 VND/kg. Total revenue was reduced by between 4 and 14 million VND/ha in comparison to 2010. The cost of production has increased in recent years, mainly due to higher labour wages.

The price reduction of cassava fresh roots in 2011 was the main reason for farmers shifting from selling fresh root to processing root into chip. The price of dried chip varies from 4,500 to 4,600 VND/kg. Price reduction of chips was less than that of fresh roots.

In recent years, the distribution channels for cassava root and chip have developed rapidly in 3 provinces, particularly in Binh Dinh where small enterprises and middlemen controlled it. Farmers sell cassava roots to middlemen before it is transported to processing factories or cassava chip was consumed in factories located in southern provinces (Bien Hoa - Dong Nai and Ho Chi Minh City). Therefore, the intermediate costs are high.

As mentioned above, establishment of the cassava starch factory in Binh Dinh has consumed a large amount of fresh cassava root, strengthened the value chain of cassava in this region, and helped farmers to improve their income. However, in 2011, there were some constraints in the chain as follows: (i) A large amount of cassava root at harvest time could not be processed because the factory capacity was exceeded and export demand fell. (ii) Price fell; (iii) Doubtful measurements of starch proportion; (iv) High discount rates for extraneous matter, from 5-11%.

In conclusion, the farmers and local authorities suggest that the cassava value chain needs improvement by increasing the processing capacity of starch factories and building the drying factories for production of dried chips.

Beef-cattle production:

According to the 2011 survey, the cattle numbers in Cat Trinh have increased slightly in comparison to 2010. The price of live cattle increased by between 5,000 to 10,000 VND/kg in 2011 (up from 40,000-45,000 VND/kg in 2010).

Some households now apply fattening techniques and get higher incomes than in the past. They buy 6 month old calves, modify nutrients in daily feed and sell 12 to 13 month-age cattle and get 1 to 1.5 million VND profit.

Table 7.15 Change of production factors for the beef cattle value chain in Cat Trinh, 2009-2011

Factors & agents	Trend	Cause	Impact
Number of head & scale of herd	Slight upward	- high price for live cattle - convenient markets - national program on cattle (credit, training, policy)	- improved income and balanced cash-flow in households - enhanced efficiency of farming system based on beef-cattle husbandry

Market	High demand for beef	- import of large amounts of meat (demand exceeds supply of beef in domestic market) - high demand for beef in big cities such as: Da Nang, HCMC, Bien Hoa, Vung Tau	- more opportunities for farmers - high price of meat ➔ increasing income & benefit for farmers - encouraging farmers to enlarge herds and quality of beef meat (crossbred species of beef-cattle)
Techniques	- Feed more crossbred species of beef-cattle - more fattening cattle	- high demand for meat - high quality requirement for meat - high economic efficiency of cattle production	- need to improve quality of herd - supply more meat - improve farmers' benefit and contribution of cattle to family income

The main markets for beef-cattle from Cat Trinh village are central (Da Nang city), north (Ha Noi), south (Dong Nai) and neighboring provinces.

The main feeds for cattle are rice straw, natural and cultivated grass, peanut straw, leaves and by-products of cassava processing.

The awareness of beef-cattle farmers has changed in recent years. In the past, they feed cattle mainly as a means to save money, for providing traction and getting manure for crops. Now they invest in beef-cattle husbandry, they modify nutrients in feed such as rice bran, dried cassava, mixed components, improve cattle by breeding and pay attention to market (price, demand, forces and consumer behaviour) (Table 7.15)

There is a positive relationship between cassava production and beef-cattle husbandry in the region. In 2011, with the low price of cassava and the high price of beef, many farmers stored and used cassava to modify feed for fattening cattle. As a result, they could improve profits from cattle husbandry and the whole crop-animal system whilst mitigating losses due to the lower price of cassava.

Table 7.16 Change of production factors and cassava value chain in Cat Trinh village, 2009-2011

Factors & agents	Trend	Cause	Impact
Cultivated area of cassava	Slighty downward	- low price of chip & root - low consumption - impacts of 'intercropping peanut & cassava' program	- reduced cassava production - low income & benefit of farmer household
Types of product (chip, fresh root)	- reduced fresh root sales - increased processing into cassava chip	- fall in fresh root price - stable price of chip	- mitigate loss due to price drop - adapt to market demand
Collectors, small enterprises and dealers	- fewer collectors - reduced quantity of fresh partially-dried meal - dealers increase dried chip purchases	- demand for chip exceeds supply - farmers mainly sell as chip - low profit in processing to starch - chip selling price is stable & higher profit	- low demand, less competitiveness in price - low cassava price → reduce planted area - all harvested quantity sold at acceptable prices

Processing factory	- reduced volumes purchased from farmers - low buying price of root - slowdown in starch exports - focus on buying high-starch ratio root (>25%)	- low demand in Chinese starch market ➔ reduced exports - low price of starch in international markets - low economic efficiency due to low starch ratio, harvesting in wet season & immature roots	- negative impacts on farmer profit - farmers reduce area of cassava in next crop cycle - increased focus to improve cassava varieties, change cropping pattern, intensive cultivation for cassava crops

Cassava processing and trading activities:
There is a small cassava-processing unit in the village; the partially dried meal end product is mainly sold in the local market of Phu Cat and the commune market. In 2011, the processing volume of the unit reduced by 10% (in 2010: processing 120-150 t of root) due to falling price of starch and lower profit (net profit from processing 1 tonne of root ranged from 700,000 to 800,000 VND, in 2010).

In 2010, there were many collectors to buy cassava root directly from farmers who would then sell it to small enterprises in the province. Thereafter roots are transported to southern markets. However, because of falling prices in 2011, the number of collectors and middlemen were also fewer than that of 2010. Instead of buying cassava root, they bought dry chip to resell to small enterprises. A prolonged rainy season affected the amount and quality of dried chip cassava. The average quantity of dried chip bought by small enterprises varied from 30 to 40 t in 2011 at price of 4,500-4,900 VND/kg (August to October 2011).

From the above cause and effect analysis (Table 7.16), it is apparent that the establishment of factories for processing cassava roots into chip is very important in SCC region, particularly in Binh Dinh. These factories will be important in adding value within the cassava value chain and diversifying the product lines and markets for cassava products.

An Chan village

Cassava production:

Cassava is a major crop after rice and sugarcane in An Chan. In 2011, cassava production was affected by low price, harvesting of immature roots, that affected quality (starch ratio 27-28%) and slight reduction of root yield (yield 16 to 17 t of root/ha).

At harvest in 2011, average price of root varies from 1,000 to 1,500 VND/kg (selling price in farm-gate); 1,400 – 1,500 VND/kg (buying price in factory); price of dried chip is about 4,500-5,000 VND/kg.

In 2011, the cultivated area of variety KM94 occupied 90% in winter-spring crop (planting September-October) is 1 to 2 months later harvest compared to the cassava crop in Binh Dinh.

Most cassava root is processed in 2 factories that are located in the province (average capacity is 500-600 t of root/day). However, at present the capacity of these factories is much lower than whole province’s production (as planning strategy, cassava area will be 9,500 ha in 2011, down from 15,000 to 16,000 ha in 2010 which mainly shifted from peanut, sesame, maize and deforestation). There is about 60% overall chip production consumed in neighboring provinces (delivery for export to Quy Nhon port).

In order to facilitate the cassava market, the Phu Yen People Committee set up a program that focuses on the following tasks for 2 main crops: cassava and sugarcane; (i)

Monitoring material supplied to regions; (ii) Invest and control the consumption of raw cassava products; (iii) Extend model of cassava – peanut intercrop and introduce new cassava varieties.

Beef-cattle production:

In 2011, the number of beef cattle has trended upward in the region because of good conditions for forage and feeds and because of relative high prices.

Increasing cattle production is facilitated by the provincial program of offering bulls for cross-breeding, artificial insemination, technical training for fattening and credit supply with low interest.

The market of beef-cattle was relatively stable in 2010-2011. There are 2 main market segments as following: (i) low-weight, low quality calves consumed in local markets; (ii) high-quality cattle & calves which are mainly consumed in Da Nang, Nha Trang, Khanh Hoa, Dong Nai and Ho Chi Minh City. The price of beef meat has increased such that farmers get higher returns than previous years. However, the farmers must sell cattle via at least 2 middlemen in hamlet, commune, district level and abattoirs.

An Chan needs to build a slaughter-house with enough capacity and then organize the horizontal (farmer-farmer) and vertical (farmer-middleman-slaughter) coordination in supply chain of beef-cattle.

SWOT analysis of cassava value chain, case study of Cat Trinh.

Strength	Weakness
- efficient use of crop by-products for feeding cattle - use of manure for cassava crop - simple cultivation technique - less use of labor force and greater use of family labour - have processing factory, convenient & high-volume market, diversified product lines (root, chip, sticky and dried starch) - use as feed for animals at small-scale level - farmers have experience in cultivation techniques and storing roots - area of cassava is large enough to meet demand of processing factory	- most of cassava area located in lowland ➔ early harvesting in beginning of rain season ➔ low yield of root (<20 t/ha) and low starch ratio (<20%) ➔ low selling price - traditional processing is small scale ➔ limited product range ➔ dependent on processor - increased costs of buying cassava variety ➔ high cost production - many constraints in processing dried chip (because of harvesting in rainy season)
Opportunity	**Threat**
- have suitable policy in planning for specific cassava areas - value of starch is high (use for industrial sector) - can process into various high-value products such as ethanol (bio-fuel), pharmaceutical, bio-gas, compound fertilizer, etc. - use as feed for animal husbandry (leaves, peel of root, other processing by-products)	- unstable price with downward trend - cost of production (fertilizers, labour hire, transportation cost) is high (increased by 20-30%) ➔ poor profitability - climate change, bad weather conditions, KM84 variety is degraded (low yield, low starch, long growth duration, very susceptible to diseases) - Starch processing factory depends on Chinese market with high risk

SWOT analysis of beef-cattle, case study of An Chan.

Strength	Weakness
- use of family labour - cattle easy to feed, adapted to ecological conditions - farmer has good experience & knowledge of cattle feeding - support from government with veterinary services for insemination, vaccination, treatment disease & credit - quality of bulls for crossbreeding has improved, high proportion of crossbred cattle (>70%) - farmer's awareness changed into trade-driven cattle husbandry - manure is a source of income or used for crops - available source of feeds for cattle husbandry from by-products of crops such as straw, straw of peanuts, green forage, water spinach - have pasture and forage areas - main products (starch) and byproducts of cassava processing are available and can be used for cattle fattening	- area for beef cattle husbandry is limited (lack of forage & pasture, small breeding facilities) - shortage of capital for improving quality of herd - low productivity of planted grass, lack of forage for herd in present and future - new varieties of grass (high yield, drought tolerant) are not yet widely adopted
Opportunity	**Threat**
- high price of beef meat in market, upward trend of price - have a policy to support artificial insemination with Brahman species - apply new technologies such as fermentation of feed, modified nutrient feed, fattening ➔ improve efficiency of cattle husbandry - new grass varieties (high biomass & yield) ➔ availability of feed ➔ more herds and increasing number of head per herd	- increased cost of infrastructure as shifting from traditional feeding (grazing) to feed lots - less use of manure for soil (reducing fertility of land)

SWOT analysis of beef-cattle, case study of Phuoc Dinh.

Strength	Weakness
- use available family labour - relative large area of pasture for cattle grazing - less risk than other farm and non-farm activities - Strong demand and high price of beef meat - farmer's awareness shifted to trade-driven beef-cattle husbandry and profitability of cattle feeding - hired labour wage is still low - relatively large scale of herd - large area of planted grass, supply enough forage for herds through the year - government support program such as training on techniques of fattening, nutrient modification and veterinary services - good quality of meat that fits requirements of city markets	- lack of cutting area of pasture and forage in dry season - high proportion of local species of cattle (>70%) - lack of grass varieties that suit climate change, drought and for supplement of feed in dry season - many diseases in dry season & difficult to control - farmer not accepting method of artificial insemination ➔ proportion of crossbred cattle is low ➔ low weight, small appearance, low yield of meat - no electricity in some communes ➔ high cost of irrigation and reduction of planted grass area
Opportunity	**Threat**

- high demand for beef in neighboring cities. - high market demand - enhance profit by improving quality of cattle – increase scale of herds and shift to large-scale farm	- difficult to control diseases and high rate of miscarriage

Analysis of supply chain of beef-cattle and cassava

Problems of beef-cattle and cassava value chains and solutions are detailed in Table 7.17 and Table 7.18.

Table 7.17 The main problems in beef-cattle supply chain, solutions and involved agent.

Problem	Solution	Involved agent
Techniques/Technology - Beef species - Nutrient supply - Veterinary - Feed supply - Market knowledge	- Program to improve cattle species, artificial insemination - Transferring techniques of micro-elements modification (in dry season), planting grass, use of supplied cassava starch & byproducts - Vaccination and predict diseases - planting new varieties of grass (tolerance of drought & high yield), water-saving irrigation technique - Training on marketing knowledge & skills	- Extension service & private sector - Extension service & communication - Veterinary service & communication - Extension service, communication, institutes & enterprises - Extension service, institutes, universities
Economic factors - Money capital - Supplied materials - Importation of beef meat - Coordination (horizontal & vertical) - Slaughter	- Credit program animal husbandry, particularly for cattle - Adjust the planning of cattle husbandry by market signals & resources (land, labor) - Quota restriction to importation of beef meat, tariff & non-tariff policies - Re-organize cattle husbandry system & value chain by horizontal & vertical coordination, speedup increase in cattle herd - Plan & build slaughterhouse in the region	- Credit organization, Bank, mutual organization, farmer cooperatives - Local government, farmer households, enterprises - Government - Government, enterprise & farmer households - Enterprise & government
Market - Distribution system - Production - Market fragmentation - Exportation (beef meat)	- Transparent policies on price & market, market information & market chain - Large scale of herds and number of head per households - Focus on both of diverse high-quality & high-price cattle husbandry (high rate of meat & quality) to supply for big markets (Da Nang, HCMC, Ha Noi, Bien Hoa) and local markets (small weight calf/beef) - Access to exportation market with advantage of competitive price & good quality (favour meat, natural feeding, less use of industrial feeds)	- Government & private companies - Enterprises & government - Enterprises & government - Government & enterprises

Table 7.18 The main problems in cassava supply chain, solutions and involved agent.

Problem	Solution	Involved agent
Techniques/Technology - Cassava varieties - Fertilizer application - Processing & storing - Marketing knowledge	- Trials and introduce high-yield, short-duration, high-potential starch (in comparison to KM94) cassava varieties - Farmers organize themselves to produce cassava varieties in region (reducing cost of varieties) - Transfer techniques of fertilizer application & manure - Transfer techniques of draft processing & storage at farm-level and combine with animal husbandry - Training on marketing knowledge of accession	- Extension service, private sector, institutes & universities - Extension service & communication - Extension service, institutes & universities - Extension service, institutes, universities - Extension service, institutes, universities
Economic factors - Material-supplied production area - Cassava export - Coordination (horizontal & vertical) - Processing factory & small processing units	- Adjust the planning of cassava by market signal & resources (land, labor) - Access to new market and avoid dependence on Chinese market - Re-organize cassava value chain by vertical coordination - Cooperate farmers into cooperatives, mutual groups ➔contracting with factory - Invest for small processing unit with diversified products (sticky starch, dry powder, chip) - Enhance processing technology for factory to produce high-value products (pharmaceutical, cosmetics chemical, bio-fuel)	- Local government, farmer households, enterprises - Enterprises & government - Enterprises, government & farmer - Government, enterprise & farmer households - Enterprises & government - Enterprises
Market - Distribution system - Production - Market fragmentation	- Transparent policies on price & grading in buying roots - Contract with farmer (factory-farmer) - Market diversification: supply for feed & food factories in domestic; exportation to oversea countries, diversified product lines: fresh & dry starch, chip, ethanol, chemical & pharmaceutical, high-quality & functional food	- Processing factories - Processing factories & farmers - Enterprises & government

Scenario analysis of cassava value chains

According to the survey in 2010-2011:

The yield of fresh roots varied from 18 to 24 t/ha (average yield is 20 t/ha), dried cassava production was from 9 to 12 t/ha,.

- The total production value per hectare (P) of cassava root was 28 million VND with 20 t/ha yield and 1,400 VND/kg selling price. The intermediate cost (IC) per hectare was 9 million VND (mainly fertilizer cost; Added value – VA was 67.3%, of which 33% was labour and the rest was net profit NPr).

This shows that cassava production can generate good economic efficiency for farmers. For every invested VND, the P/IC, VA/IC, NP/IC is 3.1; 2.1 and 1.4, respectively.

- Processing of dried chip is the traditional method in the region and the farmer can store this for a long time, particularly in the wet season, producing a stable selling price (about 3,000 VND/kg in 2010) which generates more revenue compared to selling roots for starch production. For every tonne of root processed into dried chip, farmers can get an additional 100,000 VND in revenue (equivalent 2 million VND/ha with a 20 t/ha root yield).

- In 2011, exports of cassava starch faced difficulties because China reduced imports and price fell by 40% in compared to 2010. The buying price in the Binh Dinh processing factory lower than that of 2010 at about 1,600 VND/kg (if the starch ratio is above 30%) and 1,150 VND/kg (20-20.4% of starch)[3]. Almost all farmers have to sell roots to middlemen with price at 800 – 1,200 VND/kg, being 15-40% lower compared to 2010. Meanwhile, the cost of input materials and wage of labour increased by up to 20%.

From this data, we present 3 scenarios as following:

- ***Scenario 1***: Constant yield of root (20 t/ha), selling price reduced by 45% (770 VND/kg of root), input costs (materials & labour cost) is constant ➔ farmer makes a loss.
- ***Scenario 2***: Constant yield of root & selling price, input costs increased by 85% ➔ farmer make loss if selling root instead of chip.
- ***Scenario 3*** (in 2011): Constant yield, input costs increased by 20%, selling price reduced by 20% (about 980 VND/kg) ➔ farmer get benefit at about 3.7 million VND/ha (equivalent 30% profit level of 2010).
- In scenario 1 & 2, the farmer makes a loss. The other agents in the cassava value chain aren't affected because they give lower buying price at farm-gate. Middlemen get benefit of from 100 to 200 VND/kg.

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[3] *See appendix. Price in factory announced in September 2011 in Binh Dinh Starch Processing Factory.*

Case studies

Small - scale processing unit

* Processing cassava root into fresh/sticky starch

Box 1 - Profile of cassava processing unit in Cat Trinh village, Binh Dinh

1. Business formulation: private processing unit
2. Capital for investment: (i) Equipment: 100 million VND; (ii) Warehouse: family owned
3. Active capital: 5-10 million VND (buying cassava root and fuel)
4. Machine & equipment: engines, washer, mill, water tank...
5. Labour & employee: 3 family labourers (2 men, 1 woman)
6. Input materials: cassava root, starch ratio 25%, supply from 20 farmers
7. Buying price: 2,000 VND/kg (Jun 2011), 1,400 VND/kg (Oct 2011).
8. End products: fresh starch grade 1 & 2
9. Selling price 5,500 – 6,000 VND/kg (Oct 2011)
10. By products: cassava fibre & peel
11. Processing capacity: 1 t of cassava root /day (120 – 150 t/year)
12. Processing parameters: processing 1 t root generates grade 1 starch of 350 kg; grade 2: 300 kg; cassava fresh fibre :120 kg; peel: 100 kg
13. Target market: Bau Cat local market
14. Competitive advantages: high quality starch, meet local consumers' need, relevant price, non-use chemicals & reservation, demand exceeds supply at small scale, stable selling price, and available cassava root in local
15. Environment impacts: small quantity of waste water from processing, no effect on environment.

Source: Interview owner of processing unit (Mr.Dam), DASR, 2011

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Table 7.19 Financial analysis of processing root into sticky/wet starch in Binh Dinh, 2011, Unit: 1,000 VND

Item	Amount	%
I. Total Production	**2,580**	**100.0**
1. Main product (sticky starch)	**2,100**	81.4
Grade 1	1,925	
Grade 2	175	
2. By products	**480**	**18.6**
Dried fibre	480	
II. Costs	**1,988**	**100.0**
1. Fresh root	1,400	70.4
2. Labour	450	22.6
3. other costs	138	6.9
- Fuels	70	
- Electricity	10	
- Packaging	2	
- Communication fee	2	

- Maintenance & repairs	20	
- Depreciation	34	
III. Profit		
Gross profit (included depreciation)	592	
Net profit	558	

Remark: Fresh root grade 1 with 25% of starch

Source: Survey of DASR, 2011. * Processing cassava root into dried powder

Box 2 - Profile of cassava processing unit in Phu Yen

1. Business formulation: private, cooperated with 20-30 cassava processing individual processor (units) in village
2. Capital investment: machines & equipment: 7.5-8 million VND/unit (individual processor).
3. Active capital: 100-300 million VND/unit
4. Labour: 2 persons/unit
6. Input material: fresh cassava root, 28-30% of starch
7. Price of material (cassava root): 1,500 VND/kg (Sep 2011), transportation cost: 500 VND/kg.
8. End product: dried starch
9. Selling price of products: Grade 1 (May, 2011): 16,000 VND/kg. 13,000 VND/kg (Aug, 2011); grade 2: 9,000 VND/kg
10. Processing capacity: 140 t of root/month, processing duration: 8-9 month/year
11. Processing parameters: process 1 t of fresh root generated 280 – 300 kg of starch, 380-400 kg fresh fibre
12. Competitive advantage: high quality of starch, non-use of chemicals, stable price, available cassava root, meet local customers' needs.
13. Impacts on environment: low quantity of waste water from processing, has no effect on environment.

Source: Survey of DASR, interviewed Mr.Thuan in Song Cau, Phu Yen, 2011.

Table 7.20 Financial analysis for cassava root processing into dried powder in Phu Yen, 2011, Unit: 1,000 VND

Item	Amount	%
I. Total Production	**3,640**	**100.0**
Dried starch	3,640	100.0
II. Costs	**2,782**	**100.0**
1. Fresh root	1,500	53.9
2. Transportation	500	18.0
3. Payment for individual processor	780	28.0
4. Communication fee	2	0.1
III. Net Profit	858	

Source: Survey of DASR, 2011

Small slaughter houses in Dong Nai

In 2010, the value chain of beef-cattle has been investigated and analyzed in 3 provinces of the SCC region. However, the agent that contributed importantly to the chain is small-scale slaughterhouses located in Dong Nai and Ba Ria – Vung Tau provinces in Southern Vietnam.

According the Veterinary Bureau of Dong Nai, the beef market in southern Vietnam is very large. Currently in Dong Nai, there are many slaughter houses of varied scale and these supply a large amount of beef meat for the market in Ho Chi Minh City. In Bien Hoa town, there are 6 slaughter houses that can process on average 50 to 100 head/day (Trung Dong slaughter)[4]. They buy from many sources bringing cattle from Tay Ninh, Cambodia, An Giang, Cu Chi and a large amount from SCC region (mainly from Binh Dinh, Phu Yen & Ninh Thuan provinces). Until October of 2011, there were 12,300 of cattle imported from the central region compared to 14,000 head in 2010. This suggests that the number of head will reach 15,000 by the end of 2011 and that the beef-cattle husbandry in the central area is affected largely by the southern beef market.

However, in recent years, the competitiveness of central & southern beef-cattle market is very high because the high costs of transportation of competing imports. A large amount of cattle is bought from Cambodia and Tay Ninh province instead of from the central provinces. The cattle market in central region is now connected with northern market cities such as Ha Noi and Hai Phong.

The analysis of slaughter agents in Dong Nai and Ba Ria – Vung Tau provinces reveals the tight relationship among agents of the value chain of beef cattle in the central and southern regions, particularly in the 3 provinces of Binh Dinh, Phu Yen & Ninh Thuan. Farmers in SCC depend largely on these markets. The connection of markets will be well arranged if there are slaughter houses and processing factories installed in this chain. Also, the transportation cost for live cattle among central and southern provinces is an important factor because of its upward trend in cost in recent years.

[1] Veterinary Bureau of of Dong Nai issued licences for 42 slaughter houses and animal business enterprises in 2011.

7.1.5 Sesame

Of the product value chains investigated here, sesame was added later as part of the assessment process for products suitable for inclusion in farming systems on sandy soils within the study area.

Sesame (Sesamum indicum L.), is considered the most ancient of oil crops supplying edible oil, seeds for confectionery purposes, paste (tahini), cake and flour. Sesame probably arose in Africa and was domesticated in India as long ago as 2000 BC. It has long been naturalized in many tropical countries.

Sesame is a high value short season crop. Sesame is considered drought tolerant and capable of growing well on stored soil moisture. Researchers at Texas A&M and Auburn University have found that sesame reduces nematode populations, particularly the root knot nematode that attacks peanuts.

Sesame seeds have a high nutritional value. They contain 45 to 55% oil, 19 to 20% protein, 8 to 11% sugar, 5% water and 4 to 6% ash. The major sesame fatty acids are oleic (45.3 to 49.4% of oil) and linoleic (37.7 to 41.2%).

Sesame is mostly consumed as oil. Unlike other oils, sesame oil does not oxidise and develop an unpleasant smell because sesame oil contains sesamol that inhibits the oxidation process.

World production trade

In 2010, 7.8 million hectares of sesame were cultivated producing a world average yield of 0.49 t/ha. Myanmar, India and China were the main sesame producers (Table 7.21). World sesame prices have ranged from $US 800 to 1,500 between 2008 and 2010.

World trade in sesame has been increasing rapidly over the past decade. In 2010, world trade in sesame was worth over $US 1 billion. Japan is the world's largest sesame importer. Inadai is the largest sesame exporter followed by Ethiopia and Myanmar. Sesame oil, particularly from roasted seed, is an important component of Japanese cooking and traditionally the principal use of the seed. China is the second largest importer of sesame, mostly oil-grade sesame. China exports lower priced food grade sesame seeds, particularly to southeast Asia. Other major importers are the United States, Canada, Netherlands, Turkey and France.

Table 7.21 Major sesame producing countries in 2010 (FAO 2012).

Country	Production (million t)	Average yield (t/ha)
Myanmar	0.72	0.46
India	0.62	0.34
China	0.59	1.22
Ethiopia	0.31	0.99
Sudan	0.25	0.19
Uganda	0.17	0.61
Nigeria	0.12	0.38
Burkina Faso	0.09	0.72
Niger	0.09	0.50
Somalia	0.07	0.96
World	3.84	0.49

Sesame production in Vietnam

On March 8, 2004, the Minister of the Ministry of Industry signed a decision approving the planning and development of the Vietnam Oil Plant sector in 2010. This set out the development strategy of oil plants in general and sesame in particular (Table 7.22).

Table 7.22 Proposed expansion of the area and production of oil plants in Vietnam.

Kinds of oil plants	2005		2010	
	Area cultivated (1,000 ha)	Oil processing volume (1,000 t)	Area cultivated (1,000 ha)	Oil processing volume (1.000 t)
1. Soybean	169.10	29.17	205.00 – 400.00	31.40 – 433.20
2. Peanut	302.40	15.90 -17.80	368.60	32.90 – 47.20
3. Sesame	49.90	10.80 -17.73	45.10	22.50 – 35.10
4. Coconut	151.00	39.32	159.10	39.36 – 53.30
5. Rice bran	-	150.00	-	300.00
6. Rice husk	-	1.80	28.00	12.60

(Source: Ministry of Industry, 2006)

In Vietnam, sesame can be grown in most of the ecological regions due to its wide adaptation, ease of production and low investment, short growth duration and fast recovery of capital, making it appropriate to the financial capacity of poor farmers.

The sesame area in Vietnam in 2007 was 45,000 ha with an average yield of 480 kg/ha and production of 22 thousand tonnes. Production only increased six thousand ha in 3 years from 2005-2008. Sesame in the southern provinces accounts for more than 60% of the acreage in the country and is focused in the South Central Coast (9,000 ha), Southeast (7,400 ha) and the Cuu Long (Mekong) River Delta (6,900 ha).

In An Giang province the cultivated area of sesame has increased to 16,000 ha. Higher than average yields of 400-600 kg/ha have been obtained particularly in Chau Phu - An Giang. . If appropriate farming methods are applied, sesame yield can reach 1 tonne/ha.

A propagation model for high-yielding sesame is one of the most important agricultural extension initiatives of the national extension program implemented in the province of An Giang in 2010. With this model, the An Giang Agricultural Extension Centre has developed a project covering 50 ha. After only 2.5 months of cultivation, farmers have achieved returns from 15 to 20 million VND/ha. Based on this result, the rice monoculture area will be decreased to make room for crop rotations consisting of two rice crops – one cash crop, or two cash crops – one rice crop and one other crop, which will bring high economic efficiency.

In Nghe An province the cultivated area of sesame occupies about 7,000 ha, mainly distributed in the coastal sandy soil districts such as Dien Chau (3,050 ha), Nghi Loc (3,600 ha) and Quynh Luu (586 ha).

There are three sesame varieties widely grown. These are Dien Chau (yellow sesame), Huong Son (black sesame) (Tran Van Lai, 1993) and V6 (white sesame) (Vi Nguyen et al., 1996). In particular, Dien Chau (yellow sesame) and Huong Son (black sesame) are local varieties with many good characteristics such as adaptation to climate and soil conditions in Nghe An, low production costs and pest resistance, which are suitable for an extensive type of cultivation, but the productivity of these varieties is low and oil content is not high. V6 sesame varieties are native to Japan with a relatively high yield. However, these have shown some disadvantages such as susceptibility to certain pests and diseases, especially bacterial wilt. Selected plant characteristics are not stable, so purity is not high and the output is variable.

A few enterprises in Ho Chi Minh City purchase the whole sesame production following an agreed price. (The current price for white sesame on the market is around 25 million VND/tonne.) Sesame cultivation requires a very low investment cost. Land rent is around 1.5 million VND/ha/crop season and the cost of seeds, fertilizer, care, harvest in total is 8-10 million VND/ha. After subtracting all expenses the profit per hectare is about 15-17 million VND. Additionally, the growing season for a crop of sesame is only 75 - 80 days. This allows a sesame crop to be grown between two rice crop seasons. Households growing black sesame obtain a larger return because black sesame on the market is quickly consumed and the price can be as high as 35 millionVND/tonne.

Sesame is a 'cash crop' grown in the spring-summer season when it does not affect the production of the two main rice growing seasons. Thus, it is not realistic to compare the economic advantages of sesame with rice as it complements rather than competes with rice. The main aim is to use the land as intensively as possible to increase income. Thanks to this, sesame production is supported by farmers.

Cultivating sesame uses simple methods and the cost of sesame production is low (less than 10 million VND/ha). For these reasons, many poor farmers have enough ability to produce sesame with high net returns. Futhermore, due to being simple to grow, drought tolerant and not requiring pumping of water for irrigation, one household can cultivate a few dozen hectares of sesame without much financial pressure.

Sesame production is already present in each of the 3 focus provinces with better than the national average yield. Production in Ninh Thuan is the lowest of the 3 study provinces because there is less irrigation water available.

Sesame production area and yield in the 3 provinces

Table 7.23 Area and yield of sesame in the 3 focus provinces of the project in 2011

No	**Provinces**	**Area** (ha)	**Yield** (kg/ ha)	**Districts**
1	Binh Đinh	1,687	740	Phu My, Phu Cat, Hoai An, Hoai Nhon, Van Canh, Tay Son
2	Phu Yen	2,000	710	Song Hinh, Son Hoa, Đong Xuan Tuy An
3	Ninh Thuan	432	760	Ninh Hai (250 ha), Bac Ai (140 ha), Ninh Son (120 ha), Ninh Phuoc (70 ha), Thuan Bac (20 ha)
4	SCC	9,000	-	
5	Whole country	45,000	480	

Table 7.24 Cropping seasons and varieties of sesame for three provinces

No	Provinces	Cropping seasons	Varieties	Cropping patterns
1	Binh Đinh	Summer-Autumn 1,500 ha; Winter - Spring: 300 ha	Local black sesame, V6 (white), V36, V10 (black)	Peanut – sesame – dry sowing rice
2	Phu Yen	Spring - Summer (Feb - June)	Local black sesame	Cassava-sesame maize-sesame-maize
3	Ninh Thuan	Winter - spring, Summer- Autumn	VĐ 10 (black sesame) occupying 60-70%, V6 (white sesame), local black sesame	sesame – sesame
4	SCC, whole country	-	New variety: VDM1, VDM2, VDM3, VDM5, VDM6, VDM 12, VDM11, VDM 9, Indian white sesame, DT-04 white, Thailand red sesame, VĐ 10, V6, V36, V10…	

Input →	**Production →**	**Collection, Grading, Transportation →**	**Processing/ Distribution →**	**Consumption**
Direct participant				
Local trader, material supply	Farmers	Collector Local trader Wholesaler/ Retailers		
Support services				
Agriculture and Fisheries Extension Centre, Department of agriculture and rural development (DARD).				
Agricultural service cooperative				
ASISOV; IAS				
Macro level				
MARD				
Provincial/district people's committee and DARDS				
Domestic and international research projects				

Table 7.25 General information on surveyed households.

No	Targets	Binh Đinh	Phu Yen	Ninh Thuan	Average
1	Total of family members	4.0	5.2	4.8	4.7
2	A number of agriculture labourers	2.1	2.6	2.8	2.7
3	Source of main income (%)				
3.1	Crops	*74.4*	*62.0*	*93.0*	*76.5*
3.2	Livestock	*22.9*	*24.5*	*4.0*	*17.1*
3.3	Non – agriculture	*2.7*	*13.5*	*3.0*	*6.4*

Table 7.26 Land ustilisation of surveyed households.

No	Criteria	Binh Đinh	Phu Yen	Ninh Thuan	Average
1	Total of area (ha)	0.73	4.46	2.06	**2.42**
2	Cultivation area (ha)	0.29	4.31	1.09	**1.90**
3	Cultivation area owned (ha)	0.29	4.16	1.07	**1.84**
4	Group of soils	5% sands, 35% loam 60% sandy soil	Light loamy soil, hilly soil, alluvial soil	Hilly soil, alluvial soil sandy soil	
5	Soil ranking	1-4	1-3	1-4	
6	Kinds of main crops	watermelon, sesame, rice, wheat and peanut	rice, sugarcane, sesame, mungbean	sesame, cassava, maize, mungbean	
7	Distance from home (km)	0.70	1.77	1.62	**1.36**
8	Land for housing (m^2)	155.7	355.6	460.0	**323.8**

Sesame production of farmers and its effects

Table 7.27 Area of main crops of surveyed households in three provinces, 2008-2010 (m^2 per household)

	Binh Đinh			Phu Yen			Ninh Thuan			average		
Year	**2008**	**2009**	**2010**	**2008**	**2009**	**2010**	**2008**	**2009**	**2010**	**2008**	**2009**	**2010**
Total crops	10119	9950	9818	46797	51267	48251	56270	57267	73764	37729	39495	43944
Sesame	714	926	896	9280	10158	9571	2958	4510	1708	4317	5198	4058
Rice	2686	2697	2660	9651	10606	9965	5000	5947	6021	5779	6417	6215
Peanut	2408	2380	2359							2,408	2380	2359
Mung-bean				9390	10334	9737	20071	13714	22071	14731	12024	15904
Water-melon	1100	700	620							1100	700	620
Cassava	3211	3247	3283	9,84	10115	9501	17241	20429	26464	9912	11264	13083
Sugar-cane				9192	10054	9477				9192	10054	9477
Tobacco							11000	12667	12500	11000	12667	12500
Maize							0	0	5000	0	0	5000

Reasons given by farmers for changing kinds of crops for the last years: Binh Đinh: depending on the market and policy; Phu Yen: due to economic benefits and the market; Ninh Thuan: due to climate and high cassava price.

Table 7.28 Table 2.2. Sesame cropping months in 3 provinces

Months	12	1	2	3	4	5	6	7	8	9	10	11	12
1. Binh Đinh	X	X	X		X	X	X	X					
2. Phu Yen			X	X	X	X							
3. Ninh Thuan	X	X	X	X		X	X	X	X				

Table 7.29 Sesame cultivation of households in 3 provinces

Provinces	Area (m^2)	Name of varieties	Sources of varieties	Yield Quintals ha	Advantages and disadvantages of varieties
Binh Đinh	988	- 20% of local variety - 80% of V6 variety	- 53% self-sufficiency - 47% purchasing	8.02	Advantages: Good, drought tolerance, short-day, wide adaptation, high yield, easy to do
Phu Yen	5,495	- 33% of sesame with 6 ridges - 37% of sesame with 8 ridges	- 32,5% available; - 47,5% exchange; - 32,5% purchasing	9.83	Advantages: less pests and diseases, good germination; many users; Disadvantages: impurities; low yield
Ninh Thuan	5,408	Local black sesame	Agency	2.34	Advantages: drought tolerance Disadvantages: Low yield, more pests and diseases, depending on the climate

Table 7.30 Perceived major limitations to sesame production in 3 provinces

No	Provinces	Major limitations
1	Binh Đinh	Risk of weather; lack of water, capital and information; low price.
2	Phu Yen	Technique, variety and climate conditions, low yield, market information, purchasing, mass production
3	Ninh Thuan	Variety, climate (depending on rainfed), labour costs, havesting costs, loss, low product quality, low yield, lack of technical knowledge, unreliable selling enterprises, lack of production capital

Table 7.31 Costs and economic benefit of sesame farming housholeds (calculating 1 sao = 500 m²)

Items	Binh Đinh	Phu Yen	Ninh Thuan	Average
A. Gross expenses (I+II+III+IV) 1,000 VND	**664.95**	**586.40**	**200.09**	**483.81**
I. Materials	265.95	174.20	53.79	164.65
II. Labour costs	399.00	345.22	146.30	296.84
III. Transportation (VND/ton)	0	7.16	0	2.39
IV. Interest	0	59.82	0	19.94
B. Gross income (1,000 VND)	**1,019.18**	**1,328.63**	**240.96**	**815.02**
Yield (kg/ha)	802	973	240	672
Selling price (1,000 VND/kg)	25.42	27.31	20.08	24.27
C. Net Profit 1,000 VND	**354.23**	**742.23**	**40.87**	**331.21**
Net revenue (1,000 VND)	753.23	1,087.45	187.17	628.05
Profit ration (Net profit/Gross expenses)	0.53	1.27	0.20	0.68

Table 7.32 Issues that need to be solved for sesame in 3 provinces before farmers were prepared to increase

No	Provinces	Problems that need to be investigated in growing sesame
1	Binh Đinh	Variety, fertiliser and labour
2	Phu Yen	Variety, fertiliser and labour
3	Ninh Thuan	Variety, high materials and labour costs

Table 7.33 Variation in cultivated area, yield and selling price of sesame growers from 2008-2010

No	Criteria	2008	2009	2010	Reasons
I	**Binh Đinh**				
1	Area/household (HH) (m²)	727	941	913	
2	% of sesame farming HHs compared to all surveyed ones	80.3	93.3	91.7	
3	Yield (kg/ha)	720	790	800	
4	Selling price (VND)	19,271	21,813	25,455	
II	**Phu Yen**				
1	Area/ HHs (m²)	4,715	3,018	668	Low price, low economic benefits, changing cropping patterns to improve soil, weather, no new varieties, pests and diseases.

2	% of sesame farming HHs compared to all surveyed HHs	87.5	67.5	25.0	
3	Yield (kg/ha)	1,100	1,142	1,022	Weather, varieties, lack of labour, lack of care
4	Selling price (VND)	27,100	27,259	27,200	Market, collector, selling time
III	**Ninh Thuan**				
1	Area/ HHs (m^2)	3,974	5,436	1,667	low economic benefits, weather, price, lack of labour, changing other crops
2	% of sesame farming HHs	22.5	44.9	34.7	
3	Yield (kg/ha)	222	311	242	
4	Selling price (VND)	16,875	18,579	21,875	

Table 7.34 Main market issues identified for sesame farmers

	Provinces	Problems in sesame farming
1	Binh Đinh	Low price and pricing pressure, no purchasing agency. If there are outputs, reasonable price and good products, the market will develop
2	Phu Yen	Unstable prices, the prices decided by collectors, the market (output), no factories, no agencies, collectors only, poor varieties (rate of impurities),
3	Ninh Thuan	No access to market information, low price, a few collectors, pricing pressure, small-scale producers.

In 2010, most households didn't borrow capital for production of sesame

Table 7.35 Main clients purchasing sesame seed (%)

No	Provinces	Consumer	Collector	Agency	Processing enterprise
1	Binh Đinh		100		
2	Phu Yen		100		
3	Ninh Thuan	6	62	32	

Table 7.36 Suggestions of households to improve income of sesame cultivation

No	Criteria	Binh Đinh	Phu Yen	Ninh Thuan	Ave.	Priority ranking
1	Variety	30.0	82.5	10.2	40.9	1
2	Technical training	30.0	67.5	18.4	38.6	2
3	Storage		7.5		2.5	10
4	Selling price	56.7	35.0		30.6	3
5	Market information		15.0		5.0	7
6	Consumption marketing	8.3	5.0	6.1	6.5	5
7	Capital			2.0	0.7	12
8	Variety support, materials, capital.			16.3	5.4	6
9	Supporting machinery			2.0	0.7	12
10	Material costs			4.1	1.4	11
11	Investment in irrigation system			10.2	3.4	8
12	Purchasing agency	1.7		7.5	3.1	9
13	Processing factory/ enterprise		32.5		10.8	4

Reasons for limitation to sesame cultivation

- Sesame varieties with low yield and quality
- Extensive farming.
- Farmers reluctant to change cropping patterns.
- Fresh cassava prices have been high, so the area of sesame decreases.
- Farming cultivation, post-harvest technology
- Poor market structure. Only a few processing enterprises and purchasing agencies
- Selling price increases do not offset material and labour costs;

Sesame business activities of households

Table 7.37 Problems identified by collectors in purchasing sesame from farmers

Provinces	Selling price
Binh Đinh	Small production scale
Phu Yen	No quality classification; buying at a fixed price; Farmers high pricesl; High moisture and high impurity levels; Small production scale
Ninh Thuan	Limited quantity means small business for collector; Low quality; Small scale households is a problem.

Table 7.38 Purchasing price and sesame production

No	Kinds	Yellow sesame	Black sesame	Other sesame	Average
I	**Bình Định**				
	Sesame seeds (VND/kg)	28,500	33,000		29,310.3
	Purchasing volume (t/year)	13.66	3.00		16.66
II	**Phú Yên**				
	Sesame seeds (VND/kg)	29,375		22,625	26,721.6
	Purchasing volume (t/year)	1.76		1.14	2.90
III	**Ninh Thuận**				
	Sesame seeds (VND/kg)	22,500			22,500.0
	Purchasing volume (t/year)	2.65			2.65

Table 7.39 Reasons for sesame buying price variation and sources of price information

No	Provinces	Reasons for variation in sesame buying price	Sources of information on sesame buying price
1	Binh Đinh	Cropping season; Market	Fellow traders; television; market
2	Phu Yen	Market; agents notice and quality	Collectors; agents and other farmers
3	Ninh Thuan	Harvest time and production level	Market; agents and collectors

Table 7.40 Collectors selling price for sesame seeds

Kinds	1	2	3	Average/ Total
Bình Định				
Selling price of sesame seeds (VND/kg)	30,167	34,875		31,014.4
Purchased volume (VND/year)	13.667	3.000		16.667
Amount (1,000 dong)	412,292	104,625	0	516,917.4
Phú Yên				
Selling price of sesame seeds (VND/kg)	31,125		25,250	27,969.9
Purchased volume (t/year)	1.175		1.363	2.538
Amount (1,000 VND)	36,572	0	34,416	70,987.6
Ninh Thuận				
Selling price of sesame seeds (VND/kg)	24,583			24,583.0
Purchased volume (t/year)	2.65			2.650
Amount (1,000 VND)	65,145	0	0	65,145.0

Table 7.41. Economic benefits of consumption of 1T of sesame seeds in 2011

No	Criteria	Binh Đinh	Phu Yen	Ninh Thuan	Average
I	**Gross expenses VND**	**29,692,774**	**27,311,493**	**22,840,484**	**26,614,917**
1	Sesame seed purchasing cost	29,310,324	26,721,552	22,500,000	26,177,292
2	Package costs	235,667	296,326	58,334	196,776
3	Transportation costs	120,000	154,063	192,500	155,521
4	Equipment costs	26,783	139,552	89,650	85,328
II	**Gross income VND**	**31,014,423**	**27,969,907**	**24,583,000**	**27,855,777**
III	**Net profit**	**1,321,649**	**658,414**	**1,742,516**	**1,240,860**
	Profit ratio (Net profit/Gross expenses)	0.04	0.02	0.08	0.05
	Average volume purchased (t)	16.667	2.538	2.650	
	Average net profit per collector VND	22,027,924	1,671,055	4,617,667	9,438,882

Table 7.42 Ranking of the main problems that need to be improved for better sesame production and trade

No	Criteria	Binh Đinh	Phu Yen	Ninh Thuan	Average	Priority ranking
1	Variety/ kinds of sesame	100.0	100.0		66.7	1
2	Production technique		12.5		4.2	11
3	Pre and post harvesting technology	83.3	75.0		52.8	3
4	Classification of products	83.3	37.5		40.3	4
5	Focus area	33.3		16.7	16.7	8
6	Humidity measuring instruments	83.3	25.0		36.1	6
7	Capital	100.0		100.0	66.7	1
8	Consumption market	100.0		16.7	38.9	5
9	Market information			16.7	5.6	9
10	Transportation	50.0		50.0	33.3	7
11	High transportation cost			16.7	5.6	9
12	Processing factory		12.5		4.2	11

Channels of purchasing and consuming sesame seeds in the sout central coast.

I	**Bình Định**										
1	Producers (10,8%)	→	Collectors (100,0%)	→	Purchasers						
2	Other collectors (98,2%)	→		→		→	Other collectors				
II	**Phú Yên**										
3	Producers (18,8%)	→	Collectors (100,0%)	→		→	Other collectors				
4	Other collectors (91,2%)	→		→		→		→		→	Processing enterprise
III	**Ninh Thuận**										
5	Purchasers (20,0%)	→	Collectors (100,0%)	→		→	Other collectors				
6	Producers (62,5%)	→		→		→		→	Agency		
7	Other collectors (17,5%)	→									

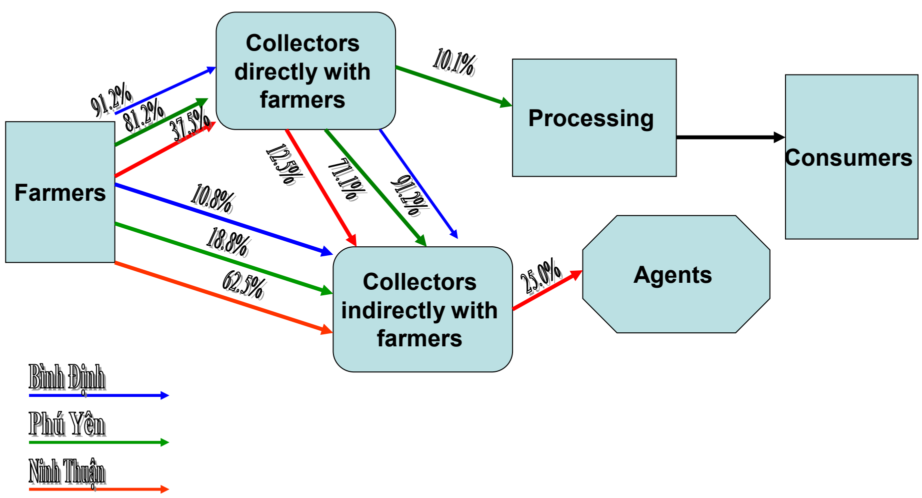
SWOT analysis of farmers cultivating sesame in the sesame value chain in the Southern Central Coast of Viet Nam

Advantage	Disadvantage
1. Good adaptability having drought tolerant ability, simple farming technique, able to keep sesame seeds in normal storage conditions for a long time 2. Seed (good, drought tolerant, short growing season, many pods, wide adaptability, easy practice, many people use) 3. Low investment, less labor 4. Having people to purchase and consume locally	8. Seed mixtures, a lot of pests and diseases, quite weather dependant, low yield and quality; lack of stores providing seed variety 9. Affected by severe weather and climate change 10. Old farming technique, don't yet have a storage technique after harvesting 11. Lack of market information 12. Lack of capital (Farmers have not yet approached loan capital source/ funds to cultivate sesame) 13. Material prices increasing too fast; 14. Selling price decided after harvest (depending on collectors)
Opportunity	**Challenge**
4. Export 5. Domestic consumption: Materials for factories processing oil, for food industry; 6. Under the impact of climate change (increasing drought), there are few crops as sesame with good drought tolerance, remaining land resource to develop sesame 7. Hard-working farmers; 8. Have natural resources (land, climate); 9. Authorities will assist to improve rural livelihoods	8. No plan for increased production (following the crowd); 9. Lack of collecting and purchasing agents 10. Lack of good marketing chain among people growing sesame, collectors and purchasers, agents, and processors 11. Lack of labour (young people leaving rural areas) 12. Farmers forced to sell at low prices, income of farmers growing sesame is lower than that of others 13. Not yet considered as a main crop, few research programs, agricultural extension and development projects on sesame in SCC VN 14. Not competitive with other crops (Cassava is strongly developing, spreading into sesame area)

SWOT analysis of collectors in the sesame value chain in the southern central coast of Vietnam

Advantage	**Disadvantage**
1. Having material source (Farmers have been producing sesame for a long time, because of poor nutrient-land, severe weather, it is difficult to replace sesame with other crops) 2. Collectors have experience in collecting, purchasing and consuming products 3. Having a collecting and consuming system in the localities	1. Quality and seed tastes are not ensured, depending on farmers growing sesame (because of mixture, many varieties, unsure quality, farmers do not classify sesame seeds, process, store after harvest, much mixing of varieties occurs 2. Small production scale, scattered, unfocused, remote areas are difficult to service 3. Lack of market information 4. Lack of capital (collectors, agents); 5. Collecting and purchasing prices are unstable 6. Lack of equipment to measure the humidity of seeds, evaluate the sesame quality
Opportunity	**Challenge**
1. Export 2. Domestic consumption: Materials for factories processing oil, for food industry; 3. Food industry (vegetable oil, food) develops 4. Authorities are concerned to build new rural livelihoods	1. Lack of a mature marketing chain combining people growing sesame, collectors and purchasers, agents, processors, and exporters) ; 2. Difficult to forecast the market 3. Income of farmers growing sesame is lower than those growing others crops 4. Sesame areas change abnormally (Cassava is strongly developing, spreading into sesame growing areas, sesame is not a main crop)

Essential channel acquisition and consumption of sesame seeds mainly in Binh Dinh, Phu Yen, Ninh Thuan



Issues to be addressed for Sesame value chain improvement in the South Central Coast

Farm level issues:

- Some issues in purchasing capital inputs such as seeds, fertilizers,
- New variety with high yield and quality, farming techniques, post harvest technology, are the needs of sesame growers

- Without irrigation the yield of sesame depends on the weather (rain, soil moisture),plus pest and disease levels.

- In recent years, due to high cassava prices, farmers have changed from sesame cultivation into cassava, so the sesame area in Phu Yen and in Ninh Thuan has decreased significantly.

- The consumption of sesame and the decision of the selling price depends on the collector.

Collector/trader level issues:

The biggest difficulty for collectors is capital. Traders also lack capital and bank loans are difficult to obtain, private loans have high interest rates.

Quality is variable and depends on the grower's management.

Equipment to measure the humidity of sesame seeds and transportation are needed by collectors.

Market demand is difficult to assess because there is no close link between sellers and consumers. Although the collectors play an important role, there is no policy supporting pricing and market information in Viet Nam or globally.

Traders need information on processing equipment and storage

Long value chains and loose actor link inhibit progress in quality issues and quality control by collectors, traders and processors

As market demand increases, collectors compete to buy from farmers although moisture content is variable; there are high levels of impurities; the quality is not good.

Local community level issues:

- Research on varieties and sesame cultivation techniques has not been properly addressed by authorities in the south central coastal provinces;

- Sesame is still not considered a potentially important crop in some localities.

As a result of this project work on sesame, local officers and farmers have become more enthusiastic about learning and adopting new technologies such as new varieties and new crop technology. They also realised the importance of post harvest technology and management to obtain better quality and higher market prices.

This sesame value chain analysis was well received by the local academic and policy makers.

7.1.6 Garlic value chain

This rapid value chain assessment was prepared to look at the situation of the garlic sector in Ninh Thuan province. It specifically focused on better understanding current farming techniques, production; analysis of input supplies as well as overall financial viability of small farm holders. The study assessed supply chain aspects that link growers and traders to customers and the enabling forces to determine key competitive advantages as well as constraints. Suggestions were made of appropriate strategies, interventions and actions that will improve sector's value chain, primary focused on improving profitability of smallholders as well as other actors.

The study was conducted during May to October, 2012 and involved interview and group discussion to 33 garlic farm households in three communes of An Hai (Ninh Phuoc district), Van Hai (Phan Rang city) and Nhon Hai (Ninh Hai district). Meetings were held with local sector management, extension and technical staff of Department of Agriculture and Rural Development, Commune People Committee and District Agriculture Section. Other meetings and interviews were held with local collectors, traders in and out side the province (28 people). A workshop was held on 2 November, 2012, with 16 local authority's staff, extension officers, growers and traders to share results and findings to key stakeholders for feedback and recommendations. Consensus was sought on proposed strategies, intervention and actions

The main results and findings of this study, include:

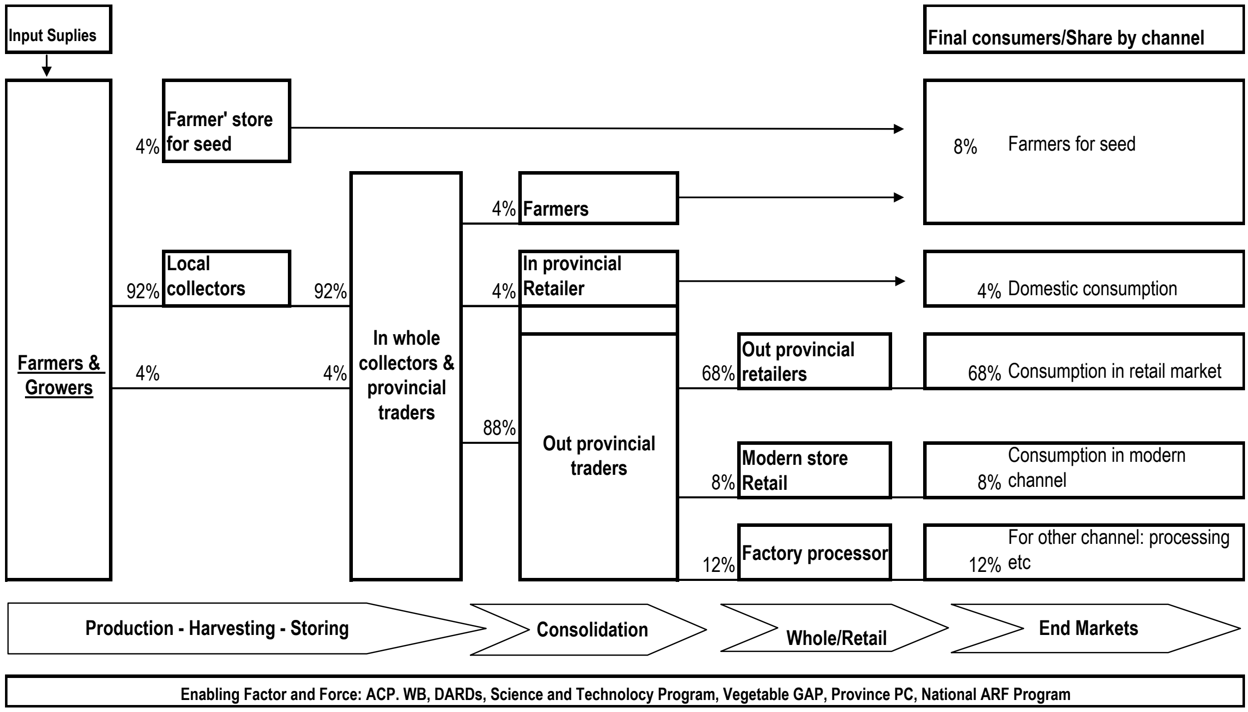
- Ninh Thuan has long tradition on planning garlic, together with Bac Giang and Quang Ngai, is one of the major garlic areas in Vietnam. During the period of 2007-2011, its annual planted area was 162 hectares, with 1,034 t per year of production and average yield was 7.9 t/ha. This yield is about 20% lower than national average yield (9.2 t/ha). In 2011, it had 126 hectares and 1,082t of production, presenting for 18.9% in terms of area 15.4% in terms of production of the nation total. Garlic has been planted in small household farms, at about 0.2 ha on average in sandy districts, including Ninh Hai (56% area), Phan Rang (34% area), Thuan Bac and others (10%). Garlic production showed declining trends. The average reductions of planted area and production within the period 2007-2011 were -21% and –28% respectively. Yield has been unstable and has fallen recently.
- In 2011, the garlic sector value was estimated at about 55 billion VND, representing 1.0% of provincial GDP and 2.5% of gross output of agriculture sector. Garlic has been an important crop that can grow on sandy soil areas in Ninh Thuan. It contributed about 35% of household income pear year in the surveyed sample. Garlic, together with onion and some other vegetables, were major sources of income for smallholders incommunities on sandy soils.
- Growers have had long experience and passion for growing garlic. They are becoming more aware of the role of nutrients, mechanization and cultivation knowledge, which was considered as a positive signal for further suggested action on raising awareness of improved farming practices and quality control. The special eco-climate has led to a diverse composition of vegetable crops and dynamic crop options such as inter-cropping and rotations. There has been technology application and transfer e.g. demonstrations of improved storage systems and garlic cultivation techniques have been introduced by an ongoing program, and those are considered as strengths for improved production. However, many weaknesses appear in the current situation , including: low and unstable yields and poor quality control, overuse of pesticides and fungicides and poor irrigation techniques, which have resulted in high production costs and negative impacts on the environment as well as reducing profits. Yield of Ninh Thuan garlic was about 80.0% of the national average and has appeared to decline in recent years. Production costs on small farm holdings were 30% higher due to cultivation techniques compared to those promoted by current ongoing programs and similar garlic production areas in the region. This situation reflects growers' lack of good farming techniques and farm management ability to cope with emerging and changing conditions such as climate change or new diseases and pest resistance. The seed varieties also appear to be degrading as a result of

current farming practice, use of uncertified seed and until recently lack of breeding improvement.

- NinhThuan's garlic has been considered as specialty product. It receives strong preference and loyalty from a group of customers, who either have high income or look for good quality, taste and special flavour. The main markets of Ninh Thuan's garlic are the Central Coast, the Highlands and parts of South-East region provinces. Large potential markets such as Ho Chi Minh have declined due to the high price of Ninh Thuan garlic and fear competition from Chinese imported garlic. The price of Ninh Thuan garlic is two and half to three times higher than other garlic. The product recently has good presence in some modern stores and this demand still exists. There is also demand from export markets but these require certain standards in terms of quality and large supply volumes. However, current supply is relatively small and has not yet met domestic demand. Low uniformity, mediocre quality and expensive prices are impediments to the long term market expansion and development of the garlic sector in Ninh Thuan.

- Along with a long history of garlic production, Ninh Thuan has strong and experienced collector forces, traders and networks that link local communities to the market. Presently there are individuals and traders who are pioneering and promoting safe production and safe products to market. The value distribution within the chain seemed fair except for a deduction ratio that has long been applied to growers. Review and improvement in this deduction system are recommended.

▪ Many initiatives and programs have been undertaken by local authorities to strengthen the agriculture sector, including garlic production. This included support for safe vegetable production, cultivation techniques, extension training, increased competitive advantage for agriculture, technology transfer, marketing and business development. These efforts and endorsement are high regarded as valuable strengths and opportunities to sector development. The current decline in area, production and quality, seed variety degradation, unstable prices and grower's difficulties in farm management imply that has been a long absence of a platform to connect growers, growers to traders, technical expertise and research for the sector. Ninh Thuan's garlic has been considered as a specialty, which implies local culture needs to build on this and it requires collective action. In addition, the value chain concepts involved diverse stakeholders that require someone to take a coordinating role to facilitate dialogue and mobilize and coordinate resources.



Value chain mapping and distribution of Ninh Thuan's garlic

- In terms of consumption channel (route to market), there 4 basic channels as below
- **1. Farmers → Local collector → Local traders' → Farmers (garlic seed)**
- **2. Farmers → Local collector → Local traders' → Local retailers' → Consumers**
- **3. Farmers → Local collector → Local traders' → National whole traders' → Retailer → Consumers**
- **4. Farmers → Local collector → Local traders' → National whole traders' → Modern Retail**

Many opportunities related to the Ninh Thuan garlic sector are identified, including different cropping seasons, crop rotations and inter-cropping, low cost efficient technology (e.g. sprinkler irrigation), further research and opportunities to increase yield and reduce costs of production. In terms of market improvement, rapid development of modern retail means more consumers of certified and high quality products can be reached. The export market is promising. Current research relating to cultivation techniques, soils and fertilization are available for calibration and adoption to garlic. Based on situation outlined above, this study suggests key strategies and related interventions and actions to improve sector in future. These include:

(1) Improving productivity is the top of priority for the sector. The interventions and actions should be based on basic studies of soils, nutrients, breeding and cultivation techniques and larger demonstration and training support for growers

(2) Increasing production scale to maximize resources and potential, by expanding planted area based on assessment on land and water resources, land use planning, a sector loan program for growers to expand production and development of investment policy to growers and investors

(3) Improved quality standard and increased market coverage. Quality should be a pre-requisite requirement for Ninh Thuan's garlic as it has been perceived and positioned as a high quality product. This requires collective action by growers, traders and enabling actors to achieve this objective. Quality can be improved by improving farming techniques and management as well as through better handling and packaging. Registering and building a trademark and certification of geographical origin along with support for the private sector in quality control

training and initiatives to strengthening packaging, distribution channels, and attending trade fairs would greatly strengthen the ‘brand’ and hence market opportunities.

(4) Registering and building a trademark and certification of geographic origin; support private sector in quality control by trainings and initiatives to strengthen packaging, distribution channels and attending trade fairs.

(5) Improve networking amongst growers to facilitate the exchange of knowledge and skills on farming techniques and market information. A Grower’s association would be an organization to build culture aligning with specialty products and to increase market power.

(6) Better coordination, collective think tanks and enabling policies to facilitate sector development: An effective and dynamic enabling environment will facilitate and stimulate growth of the sector. Successful models in other regions such as growers’ associations, and think tanks that consist of extension practitioners, , researchers and policy makers should be formed to build local knowledge. Regular dialogue to discuss and share timely issues and opportunities within the sector plus available incentive policies for agriculture similar to those for investors in other agricultural sectors.

While the above strategies, interventions and actions are suggested to propel the sector toward short to long-term development, many issues need to be addressed through extension activities which based on currently available technology and best practices. The following are recommended for garlic (Table 7.43).

Table 7.43 Actions for garlic chain improvement.

Problems and Priority needs for garlic value chain improvement	Suggested Extension and actions
1. Overuse of pesticides and fungicides that result in high production costs, low yield and poor quality products and damage to soil and water resources	1.1 Conduct extension training and awareness raising for growers though communication material such as posters, leaflets, field days and radio spots. 1.2. Develop and print leaflets on common diseases, treatment and management to increase grower knowledge
2. Incomplete fertiliser application resulting in high production costs, waste of resources and possible impacts on diseases or farm management	2.1. Conduct extension training to growers 2.2 Produce leaflets or brochures on cultivation techniques to disseminate to small farm garlic producers.
3. Flooding irrigation is still popular but some effective and affordable sprinkler irrigation is available and accepted by some pioneering growers	3.1. Conduct training on water saving irrigation methods. 3.2 Simultaneously, develop finance support scheme to facilitate expansion of sprinkler irrigation
4. Seed quality ensured	4.1. Develop standard criteria for seed, and develop communication material to increase knowledge and awareness amongst growers

5.1. Absence of standards and criteria for a grading system for garlic	5.1. Develop leaflets or brochures that suggest standardized bulb grading to increase knowledge of growers.
6. Facilitate information sharing and promote advantage from collective action	6.1. Form grower associations and train leaders to improve their capacity to run such associations 6.2. Design social activities to create cultural environment amongst growers aligned to producing a specialty product

The strategies and interventions for the garlic value chain suggested in this study should be based on basic research and technology development. For the market related aspects, further research is recommended to build a comprehensive understanding for the garlic sector in Ninh Thuan, including (i) potential for export (ii) research into processing and sub-products e.g. medicine, oil etc (iii) per capita consumption (iv) customer preferences in key potential markets and (v) the Farm Economic Model (FEM) could be used for economic analysis of various cropping scenarios, to give a clearer view of the role of garlic in the profitability of farming systems on sandy soil in Ninh Thuan.

7.1.7 Farm Economic Model

A detailed economic survey of a small number of farms in the 3 focus communes revealed a diverse range of farm enterprises including annual and perennial cropping and livestock production. Comparing farm enterprises by isolated gross margin analysis is of little value in understanding farming systems comprising diverse activities particularly where labour and cash are limited. As part of this project a spreadsheet based Farm Economic Model (FEM) has been constructed to allow comparison of farming systems, to allow desktop scenarios to be analysed and to consider compatible activities with regard to labour utilisation and cash flow. The model has been presented to DARD staff in the 3 provinces and strong positive feedback has resulted in several sessions of training for DARD staff in use of this potentially useful farming systems analysis tool. FEM was created from the need for farmers and researchers to examine farm or enterprise performance. Additionally FEM would enable users to examine and quantify the impact of change. The model provides a whole farm and an enterprise based evaluation. It is intended for the user to capture the current farm business plan and also be able to examine impacts of alternative activities. The model is intended as a “What If?” tool. That is ask a question of the business strategy – “what if I grew watermelon or tomato?” – “what if I buy more fertiliser to increase cashew yield?” These questions can be examined on a whole farm or enterprise basis.

The two critical elements of farm business performance are resource demand and profitability. The farmer aims for the best return from the resources that are accessible. Land and water is the critical underlying resource constraint. Whilst this is so, the farmer can often make little change to these parameters. Finance (cash flows) and labour are the fundamental resource constraints. Farmers can consider and manage these constraints much more readily. The model considers the availability of farm (own/family) labour on a monthly basis. Cost of hired labour, from various sources, is incorporated to substitute for labour deficiencies across the annual production cycle. The physical and financial impact of this business resource is a parameter that requires management and understanding. Finance or cash flows are measured by the model on a monthly basis. Timing and level of incomes and expenses can alter due to changes in the farm business strategy. FEM provides opportunity to project market or seasonal changes and their impact on the farm business. Monthly cash flow measurement can assist in understanding, avoiding or adjusting to these scenarios.

The model has provision for 20 annual crops, 10 tree or perennial crops, 7 livestock activities and 2 “other” labour and cash flow activities. These can be constructed and analysed individually or as a whole of farm plan. Combinations of these can be allocated in the land and cash flow tables. The farm structures such as the land resource, labour details, machinery and overhead (general) costs are incorporated to build a whole of farm analysis.

Whole farm cash flow and labour scenarios can be projected for up to 5 years. This allows for transitional planning of change for the introduction of longer term crops or livestock enterprise development. Individual enterprise scenarios can be also be extracted. Annual crops are presented over the life of the crop. Perennial or tree crops can be evaluated for up to 10 years whilst livestock activities are over a 5 year projection.

MENU Version 1.2

Kế hoạch SX hộ Nguyễn văn C. 2013

SETUP	ANNUAL CROPS		TREE CROPS	LIVESTOCK
Inputs	đậu phọng/lạc Đông Xuân	E 11	Xoài ta	Bò thịt
Land & Labour	đậu phọng/lạc Thu Đông	E 12	Annual x3 with irrig	0
Capital & Overheads	Khoai mì/Sắn	E 13	Annual cropx3 no irrg	0
Planning	Lạc Thu Đông	E 14	D	W
Freeform	0	E chổ súc vật ăn cỏ	0	X
OUTPUT & RESULTS	6	M Sắn (trồng xen Lạc ĐX)	0	Y
	7	M 17	G	Z
Annual Cashflows	8	M 18	H	OTHER ACTIVITIES
Analysis	9	M 19	I	Khác x
BCA	10	M 20	J	Khác xx

December 2012 — Language: English — E = Extra input sheet — M = Multi crop sheet

The Farm Economic Model is a Microsoft Office Excel® based tool with the opening menu shown above. This was created in the 2007 version of this product. Due to the size of the model, macro driven navigation has been employed. These appear as buttons that move the user from one spreadsheet to another.

There is greater scope for the use of this tool in the generation and development of a regional or provincial model. This could be used to estimate or project the financial and logistical impact of proposed interventions or changes. DARD and ASISOV staff have shown great interest in this prospect. The key to achieving such a goal are subject to the skills in Excel modelling and proficient understanding of farm management techniques and approaches. Further investment in training would be required to achieve this. Incrementally the collection and collation of enterprise data placed into such a framework would make this a very powerful decision making aid for investors in agricultural farming systems development.

7.2 Sustainable cropping systems

Initially a baseline survey was carried out to determine both the current state of the soils and the environment, cropping systems, limitations and available resources. In general, the major soil and environmental constraints identified were nutrient and water deficiencies, leaching of water and nutrients that had an impact on productivity and poor environment. Lack of resources, infrastructure, non-availability of appropriate technologies and lack of management skills were other limitations that contributed to poverty in these regions.

The constraints/limitations were investigated in depth by conducting a series of experiments designed to understand and identify management practices and or techniques to overcome the limitations. Utilisation of locally available on-farm organic (manure, biochar, crop residues etc) resources through an integrated approach was explored to better manage nutrients and water and to reduce the cost of inputs (inorganic fertilizers, water, labour etc) to increase crop yields and achieve a higher profit margin for the farmers. Finally, the economic impacts of changed practices were evaluated for them to be adopted by farmers if found profitable and sustainable.

Baseline survey:

The survey was conducted for the sandy coastal zone of the South Central region of Vietnam. The survey of 180 households from the three study sites showed that dependence on agriculture was the main means of livelihood. Most agricultural activities were dependent upon rainfall and crop productivity was found to be low in comparison to other parts of Vietnam where soils were more fertile and water availability is higher.

To characterize selected mini-catchments, a detailed SCAMP assessment of 69 sites on the major soils in the study areas (23 in Ninh Thuan; 23 in Phu Yen; 23 in Phu Cat). A full report of the findings is attached (Appendix 2.1.2 (a)). For each profile described, a SCAMP assessment of key limiting factors is reported. In addition, for each Province a synthesis of key limitation in relation to soil types is reported. For the study commune in each Province, a classification of soil types is provided together with a soil-landscape map showing the spatial distribution of soils (e.g. for An Chan commune Figure 7.2). The analysis, which focussed on sands, showed that soils are diverse in their physical and chemical characteristics. In summary:

- Clay content and form varied greatly even among sand profiles and with depth within profiles
- Soil pH, varied from being acidic to alkaline. However, there was no indication of aluminium toxicity risk in the acid sands. Alkaline pH was attributed in Binh Dinh to lime application in peanut fields as a Ca fertiliser and may indicate over-liming with implications for availability of micronutrients. In Phu Yen and Ninh Thuan, alkaline parent material explained the occurrence of high pH;
- Carbon content was very low in most of the sandy soils and ranged from 0-1.9%;
- Cation exchange capacity, was very low and ranged between 1-6.7 cmol/kg;
- Water Holding Capacity ranged from 0-10% indicating low water retention and
- Compaction of soils was apparent in some of the sands, in Binh Dinh especially, below 10 cm depth and may restrict root growth
- In general, the sands have low soil water retention and high potential for nutrient leaching. On the other hand, use of high fertilizer and pesticide inputs for vegetables and peanut grown on sandy and loamy soils over shallow groundwater present a high risk of groundwater contamination on sands (e.g. An Chan- see below for more details).

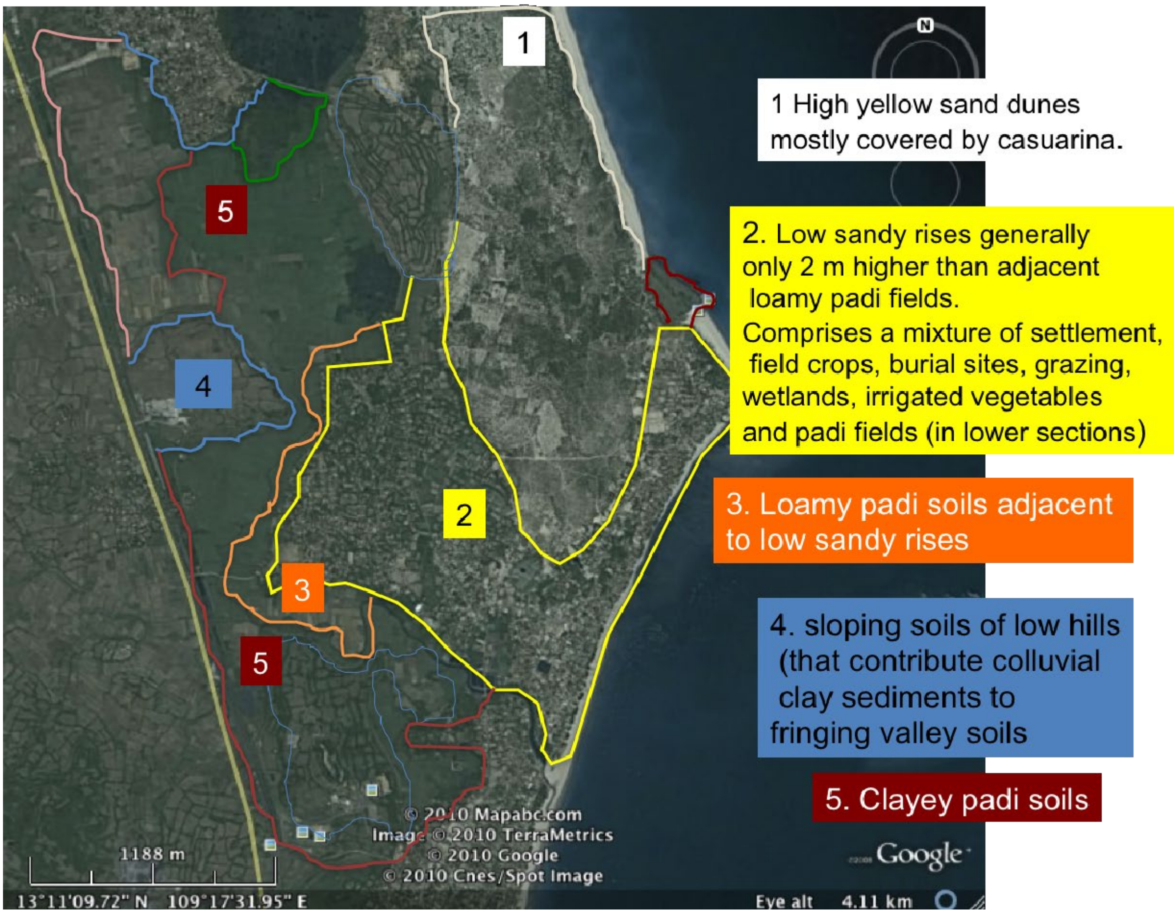


Figure 7.2 Distribution of the major soil-landscape units in An Chan commune Phu Yen province (see Appendix 2.1.1(a) for a full description of soil-landscape units).

A summary of the sands identified in Phu Cat and Ninh Phuoc study districts are shown below (Table 7.44). There was less diversity of sands in An Chan commune.

Table 7.44 Sand profile types by soil-landscape unit and use.

a. Phu Cat District, Binh Dinh province

Soil-landscape unit	Soil type	Profiles	Land form and main land use
Footslope of mountains	Yellow-brown sandy loam	BD12, BD44*	Dissected terrace at footslope of mountains at 29-32 m asl, cashew plantations, grazing and eucalyptus
	Coarse granite sand	BD4, BD5*, BD6	Footslope of mountain, weathered on granite bedrock or its colluvium, 22-33 m asl, relatively shallow groundwater, cashew
Undulating sandplain	Grey loamy sand, increasing clay with depth	BD8, BD9	Undulating plain, 18-33 m asl, cassava-peanut land uses
	Grey sandy loam	BD10, BD11, BD7	Undulating plain, 18-33 m asl, rice fields at 22-23 m asl.
	Pale deep sand	BD13*, BD45*, BD46*	Undulating sandplain (18-33 m asl), prone to stagnant water in lower areas, cassava-peanut

Gently undulating sandplain	Deep grey loamy sand	BD43	Very gently undulating sand plain, above flood level, 35-42 m asl. Rice in low lying drainage connected to main stream
	Deep grey sand	BD14*, BD15*, BD41*, BD42*	Very gently undulating sand plain, on a sandy rise, 34-42 m asl. Mango, grasses.
	Brownish sand with increasing clay over depth	BD2*, BD3*	Very gently undulating sand plain, above flood level, 39-40 m asl. Mango with or without peanut intercrop
	Pale brownish sand with increasing clay	BD1*	Very gently undulating sand plain, 34 m asl. Mango with peanut intercropping

* sites of nutrient management experiments

b. Ninh Phuoc District, Ninh Thuan Province

Soil-landscape unit	Soil type	Profiles	Land form and main land use
Red dune	Red sand	NT1, NT6, NT10, NT11, NT24, NT25, NT26, NT30, NT31	Deep, uniform, stable red dunes up to 100 m elevation with gentle to moderate slopes
	Yellow sand	NT27	Lower elevation strata (70 m asl) underlying red sand occurring on the margins of the Red dunes
	Pale alkaline sand	NT7	Occurs in lower elevation (70 m asl) seepage zones terraced and used for cropping including rice.
Granite	Deep granite sand	NT9, NT28, NT29	The basement geology is granite and on hills and slopes, sandy soils have weathered on granite. The profile depth and form varies with slope and bedrock topography. Grazing land with some use for fruit trees (cashew) and crops
	Shallow granite sand	NT8	Shallow profile with weathered granite at 45 cm depth. Grazing land, prone to waterlogging

Alluvial	Alluvial sand	NT21, NT22	A narrow valley between Red dune to the north and granite hills to the south. Three terraces evident, with the current terrace the lowest. Irrigated vegetables and fruit trees grown on the upper terrace but grazing of pastures is the land use on the middle and lower terraces
	Alluvial loam	NT23	Middle terrace, loam horizon over sands similar in properties to Alluvial sand
White sand	White sand	Not described	Coastal barrier sand dunes, loose unconsolidated sands, mostly used for human settlement, aquaculture ponds and infrastructure

Constraints:

The constraints identified were: acidity, aluminium toxicity high pH, sand texture, low CEC, low organic matter, compaction, low plant available water content and high extractable P. The severity of constraints varies among crops (Moody and Cong 2008). In the present report only a general rating of constraints has been presented rather than a series of crop-specific ratings. Moreover, the constraints are calibrated for aerobic soils and several (such as acidity, compaction) are less relevant to rice grown on the same soils when saturated. Saturation tends to increase soil pH so that acidity and Al toxicity cease to be constraints so long as the soil remains saturated (Seng et al. 1999, 2004). Compaction may improve soil suitability for rice on sands by retaining water and decreasing the risk of loss of soil saturation in the root zone.

In the SCAMP methodology, each constraint has a number of generic management or treatment options listed to ameliorate the limitation for crop production (Moody and Cong 2008). These are discussed below, although at this stage few of them have been specifically tested and validated for the sands of south-central coastal Vietnam. Moreover, the effectiveness of the treatments for tree crops is less well tested than for field crops.

High sand content:

The focus of soil investigation in the present study was on sands although in An Chan commune due to the complex pattern of soil distribution, a number of clay soils were also examined. All the soils examined in Binh Dinh had high sand content and most would classify as Arensols if the soil profile descriptions had extended to 1 m depth. Even the Rice soils had < 20 % clay and hence had a sandy loam texture. Most soils had 90 % sand or more and the Deep sands generally had about 95 % sand. In Ninh Thuan, Red dunal sands had 95 % sand, as did the Granite sands, while Alluvial sands contained only 90 %. The Pale yellow brown sands of An Chan had 99 % sand and were the most extreme of the sands examined. The range of clay content in sands of south-central coastal Vietnam from 0-20 % implies major differences in properties for management. The sands of south-central coastal Vietnam need to be differentiated based on clay content, and on profile trends in clay. While the dunal sands for example in Ninh Thuan and Phu Yen tended to be uniform deep sands, trends for increased clay with depth were noted in some of the sands in Phu Cat district and in the Alkaline sand of An Chan. Moreover, among the Red sands, two profiles had distinct increases in clay with depth. Such differences in clay and clay trends down the profile need to be detected by land managers and recognized for their impact on soil management.

It is common for multiple nutrient deficiencies to occur on sands (e.g. Bell et al. 1990). A key to improving the productivity of sands is to diagnose all the limiting nutrients (Bell and Seng 2004). Failure to diagnose any one of the limiting nutrients or applying a corrective treatment for only one of the deficient elements will limit the response due to the remaining limitation of other elements. However, even after diagnosis and applying corrective treatments it is necessary to monitor crops for nutrient deficiencies over time since many nutrients leach on sands and the inherent nutrient supply capacity is limited. Soil and plant analysis are the main tools that can be used for this purpose (Bell and Seng 2004; Bell and Dell 2008).

Sands are poorly buffered so there is an high acidification risk. As seen in the present study, pH of sands can be easily increased to over 7 even with modest lime rates. Hence the risk of over-liming of sands is high. It is advisable to monitor soil pH regularly on these sands.

Another consequence of high sand content, especially if there is a predominance of fine sand, is wind erosion risk. Low soil cover at times of high wind speed gives rise to wind erosion risk. The South-central coastal region of Vietnam is relatively windy and hence the wind erosion risk warrants further attention in maintaining productivity of sands. Managers should maintain surface plant or crop residue cover or increase surface roughness to reduce wind erosion risk. Those areas with a high density of mango and cashew trees on sands will have satisfactory cover and protection against wind erosion. Wind breaks, crop residue retention and the use of zero tillage are effective tools for reducing wind erosion risk.

Amendment of sands with clay is a treatment that may be worth further investigation. Clay addition to sands in NE Thailand has been highly effective in increasing productivity (Noble et al. 2001, 2004a,b). Clay additions to sands decrease wind erosion risk. The type of clay will influence soil properties with high activity clay application being most desirable, if it is available. In NE Thailand, bentonite clay was effective at 50 t/ha. However, local clays and subsoil clays may be more readily available and hence require lower cost to obtain and spread. Kaolinitic subsoil clays used in south coast region of West Australia are effective amendments of fine sands when added at 6 % clay. This requires additions of 150-300 t of subsoil/ha, depending on the clay % of the material.

pH and associated deficiencies and toxicities:

While many of the sands were acid, few contained significant levels of Al. Aluminium saturation in the range 20-33 % was reported in some profiles, but generally such values were found at 50 cm depth or greater. Hence the risk of Al toxicity was generally low (Dierolf et al. 2001; Moody and Cong 2008). The impact of acidity may be through Mn toxicity or low levels of available Mo or impaired nodulation and N mineralization. Nevertheless, crops sensitive to acidity require lime application to the soil at rates that do not increase soil pH (water) above 6.0 otherwise induced deficiencies of trace elements are likely. Overliming is most likely to induce B, Mn or Zn deficiencies. In general, farmers should incorporate lime as deep as possible to encourage deep root activity. Dolomitic limestone would be preferred if soil Mg status is considered marginal. Liming is already used for peanut production (although a recent survey of peanut farmers in Phu Cat by ASISOV suggested large variability among them in rates used). The rate recommended is 400 kg/ha which is not high but with repeated application could lead to overliming. Already some soils with pH up to 7.9 have been reported.

Organic matter:

As is usual with sands, most of the profiles in the present study were low in organic matter. Mulch and incorporation of 'green manure' crops such as legumes or forage grasses into the topsoil can help to maintain soil organic matter. Similarly, retention of all crop residues as surface cover, avoidance of burning crop residues and minimising cultivation should help to maintain soil organic matter levels. For this reason the development of minimum tillage or zero tillage planters for sands of this region would be beneficial. Application of organic materials such as animal manures, composted material and locally available plant residues, use of alley or strip cropping to increase on-site crop residue production can all help to maintain soil organic matter levels. However, it is difficult to increase soil organic matter on sands since clay is needed to stabilise and protect organic matter against mineralization. Stable organic matter amendments such as biochar may be more effective in the long term as organic matter additions to sands. Alternatively, clay addition, as discussed above, may have a role in protecting soil organic matter on sands and in helping levels to increase over time as reported by Hall et al. (2009) for amended sands in West Australia.

Phosphorus:

As seen in the present study on sands that have been fertilised with P for peanut and vegetables, levels of Olsen extractable P in the topsoil can increase substantially. In addition, large increases in extractable P in the subsoil were evident, suggesting P leaching. Hence there is merit in re-examining the rates of P needed for peanut and vegetables on sands that have a history of P application and already have high Olsen P levels in topsoil and subsoil layers. Moreover, the high rates of leaching suggest that application of water-soluble P fertilisers should be split. In very low P-sorbing soils, such as sands, over-application of soluble P fertilizers may result in P leaching into local groundwater. In these soils, citrate-soluble P fertilizers such as Fused magnesium phosphate/ rock phosphate (FMP) rather than water soluble P fertilizers should be used.

Leaching:

To minimize leaching losses of applied nutrients, farmers should apply soluble fertilizers in split applications (e.g. Sittiphanit et al. 2009). Split applications minimise the risk of loss of nitrate-N, K, Ca and Mg by leaching. Increase in the organic C content of the soil as described above, clay additions and biochar additions may all help to reduce leaching. Where possible, use of organic amendments as nutrient sources should also diminish leaching of nutrients.

Nutrient disorders

Through various investigations, nutrient disorders have been diagnosed on a range of the sands described in the present study. Evidence has been derived from field responses of yield in mango, cashew and peanut, from leaf analysis and from double-pot experiments in the glasshouse. Deficiency of P depends on previous P fertilizer history. On sites that have been fertilized with P for peanut, vegetables or fruit trees, P was generally adequate while on sites on Red sand, Granite sand and Grey sand that had not been fertilized, P deficiency was recorded. On the sands, K and S deficiency were recorded in all cases where these elements were not applied. On Yellow brown sandy loam and Pale brown sand, no S treatments were applied so the question of deficiency has not been tested. Of the micronutrients Cu and B were deficient in all cases except Red sand, Grey sand and Granite sand (only B was deficient). No clear evidence of Zn deficiency was diagnosed in the omission experiments with peanut except on Red sand. While omission of Mo did not depress peanut pod yield, shoot dry matter was depressed at two of the five experimental sites. In another leaf analysis study with forages, Mn concentrations in Green panic were high enough to cause toxicity.

Hence, on sands in Binh Dinh, Phu Yen and Ninh Thuan there is strong evidence that multiple nutrient disorders will limit crop production. In addition to the other constraints discussed, integrated nutrient management to correct deficiencies of all limiting nutrients, and strategies to ensure adequate supply of nutrients in relation to crop demand will need to be developed for sands. The experimental evidences supporting these conclusions are presented below (Table 7.45) and in the appendices.

Table 7.45 Nutrient disorders diagnosed in sands in Phu Cat district, Ninh Phuoc district and An Chan commune, Vietnam.

Sand type	Nutrient disorder	Method	Source
Phu Cat			
Yellow-brown sandy loam	K, (B, Cu, Zn, Mo)[a]	Cashew yield in field trial	Vinh, ASISOV 2012
Pale deep sand	K, S, B, Cu	Peanut pod yield	Nhan, ASISOV 2011
	K, S, (B, Cu)	Peanut pod yield	Nhan, ASISOV 2012
	N, P, K, Mo, Zn	Peanut shoot dry matter	Nhan, ASISOV 2012
	P, K, S, B	Corn, pot experiment (0-20 cm depth)	Hoang, HUAF 2012
	P, K, S, Cu, B, (Zn, Mo)	Corn, pot experiment (20-40 cm depth)	Hoang, HUAF 2012
Deep grey sand	K, S, B, Cu	Peanut pod yield	Nhan, ASISOV 2011
Brownish sand	K, S, B, Cu	Peanut pod yield	Nhan, ASISOV 2010
Pale brown sand	K, (B, Cu, Zn, Mo)	Mango fruit yield	Vinh, ASISOV 2011, 2012
Ninh Phuoc			
Red sand	N, P, K, S, Zn, B	Peanut, pod yield	Nhan, ASISOV, 2012
Red sand	P, K, S, Cu	Corn, pot experiment	Hoang, HUAF 2012
Sand on granite	P, K, S, Cu, B, (Zn, Mo)	Corn, pot experiment	Hoang, HUAF 2012
An Chan			
Grey sand	P, K, S, Cu, B	Corn, pot experiment	Hoang, HUAF 2012

a. Elements enclosed in parentheses were supplied as a combined treatment hence the causal deficiency or deficiencies has not been defined.

Compaction:

Compacted layers in sands were common in Phu Cat district but not reported for either Ninh Thuan or Phu Yen. Except for the sands that were described in padi fields, the cause of compaction is not clear. Nevertheless, compacted layers can be removed by deep cultivation or deep ripping. Treatment should occur when the soil is drier than its plastic limit. Tillage when the soil is above (wetter than) its plastic limit may exacerbate the compaction. In some cases the compaction layer was shallow at 7-17 cm and would be relatively easy to break up by conventional tillage machinery. Where the compaction is at 15-30 cm the effects on crop growth may be less, but the difficulty of treating it by tillage would be correspondingly greater. If possible, farmers could grow tap-rooted crops that have the capacity to penetrate and weaken the hard layer. The effects of sesame, which is an increasingly popular crop in the region, should be investigated.

Anecdotal reports suggest that subsoil compaction is caused by cassava cultivation, but there is no known evidence to support this. The puddling of soil for rice cultivation may account for some instances of a shallow compaction layer (e.g. BD7, BD10, BD11- see Appendix 2.1.2 (a)), but many of the soils have had no recent history of rice cultivation. Hence the compaction observed may be a natural phenomenon. More detailed investigation is needed to quantify the levels of soil strength attained and to verify that such levels act detrimentally on root growth in various crops of interest in Phu Cat district.

Soil and crop research activities:

To overcome limitations identified by SCAMP assessments and to further define soil constraints and their impact on the environment, several soil and crop research activities were planned and executed on farmer's field to assess and confirm findings of SCAMP assessments as listed in section 6 of this report. The results are discussed under different research activities (omission, biochar, minipan, Integrated Nutrient Management (INM), pH and liming, organic resources, minimum tillage, sowing dates, water quality, vegetable production etc) for different crops. In parallel, research was also carried out on sands of Western Australia (WA) to assess the impact of clay and biochar on pasture, wheat and lupin yield

Omission:

Omission trials are conducted to diagnose the impact of a particular nutrient on crop growth and yield by supplying all other nutrients at optimal rates nutrients and the results showed that:

- deficiencies of K, S, Cu, B and Mo were found in peanut at three sites on deep sands in Phu Cat district (Figure 7.6). Omission of either K, S, Cu or B decreased peanut pod yield by 20-30%. Low Mo effects were evident in reduced vegetative growth of peanut but not as reduced yield. This emphasises the need for a complete fertiliser supply rather than reliance on N and P (Figure 7.3).
- in Ninh Thuan, on red sands, deficiencies of N, P, K and S were found in two field trials with peanut while deficiencies of Zn and B each occurred in one of the field trials (Figure 7.4).

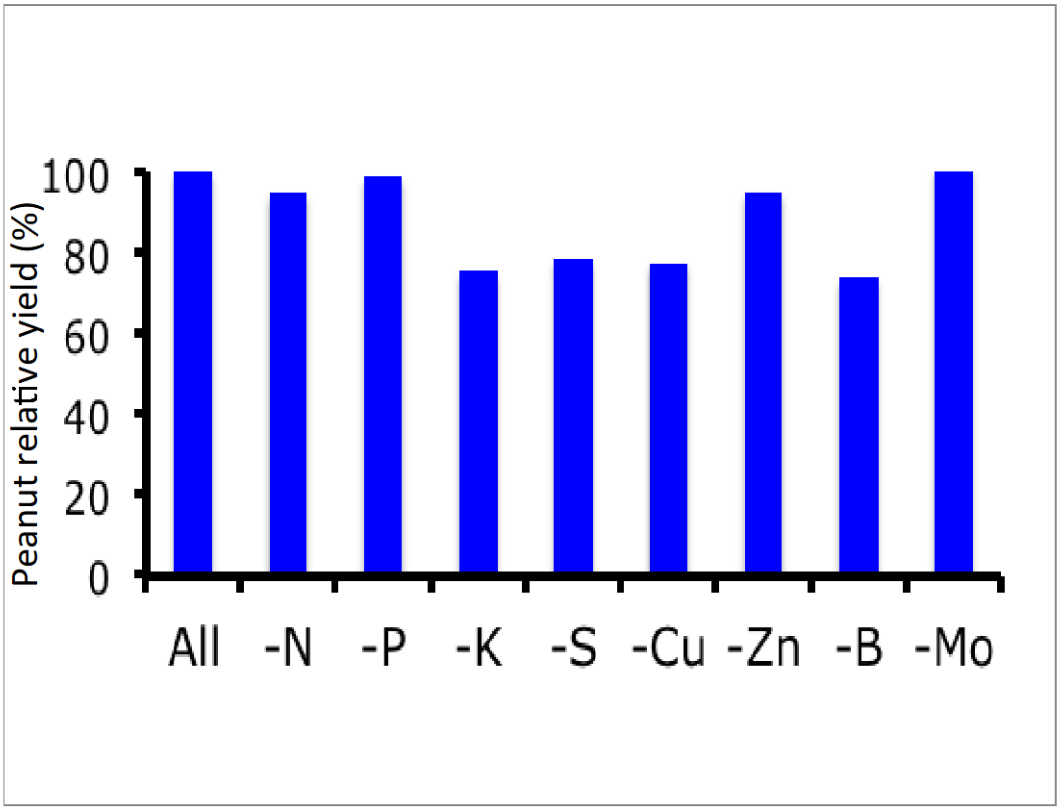


Figure 7.3 Relative yield of peanut, as a % of maximum, in Phu Cat averaged across 3 experiment. Treatments compare yield with complete nutrient application (All) to that with the ommission of single nutrients.

- A double pot experiment was conducted to assess the potential for nutrient deficiencies in a wider range of soils than the field experiments. The omission of P, K, S, Cu, B, and (Zn, Mo) from the nutrient solution resulted in lower dry matter yield of corn after 50 days compared to the +All treatment (Figure 7.5), indicating that soil is not providing enough of the 7 nutrients, with order of deficiency being K>S>Cu, B>P>Zn+Mo. Potassium is the most limiting nutrient on dry matter yield of corn in the six studied sandy soils. While P, K and S were clearly deficient on all soils, for Cu, B and (Zn, Mo) omission, the effects on yield were more varied among soils.

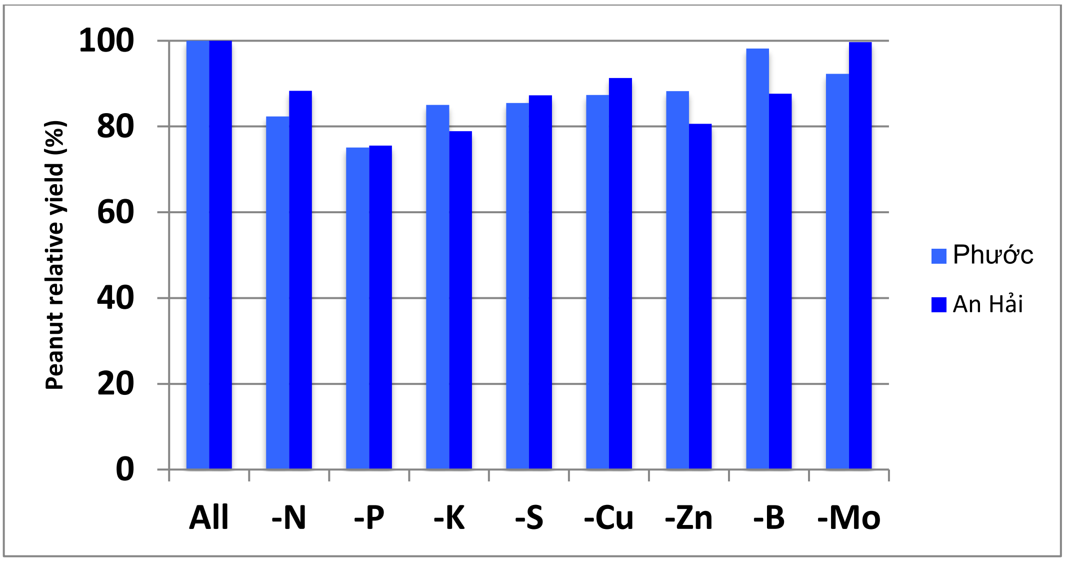


Figure 7.4 Relative yield of peanut, as a % of maximum, in Ninh Thuan in two experiments in 2012. Treatments compare yield with complete nutrient application (All) compared to the omission of single nutrients.

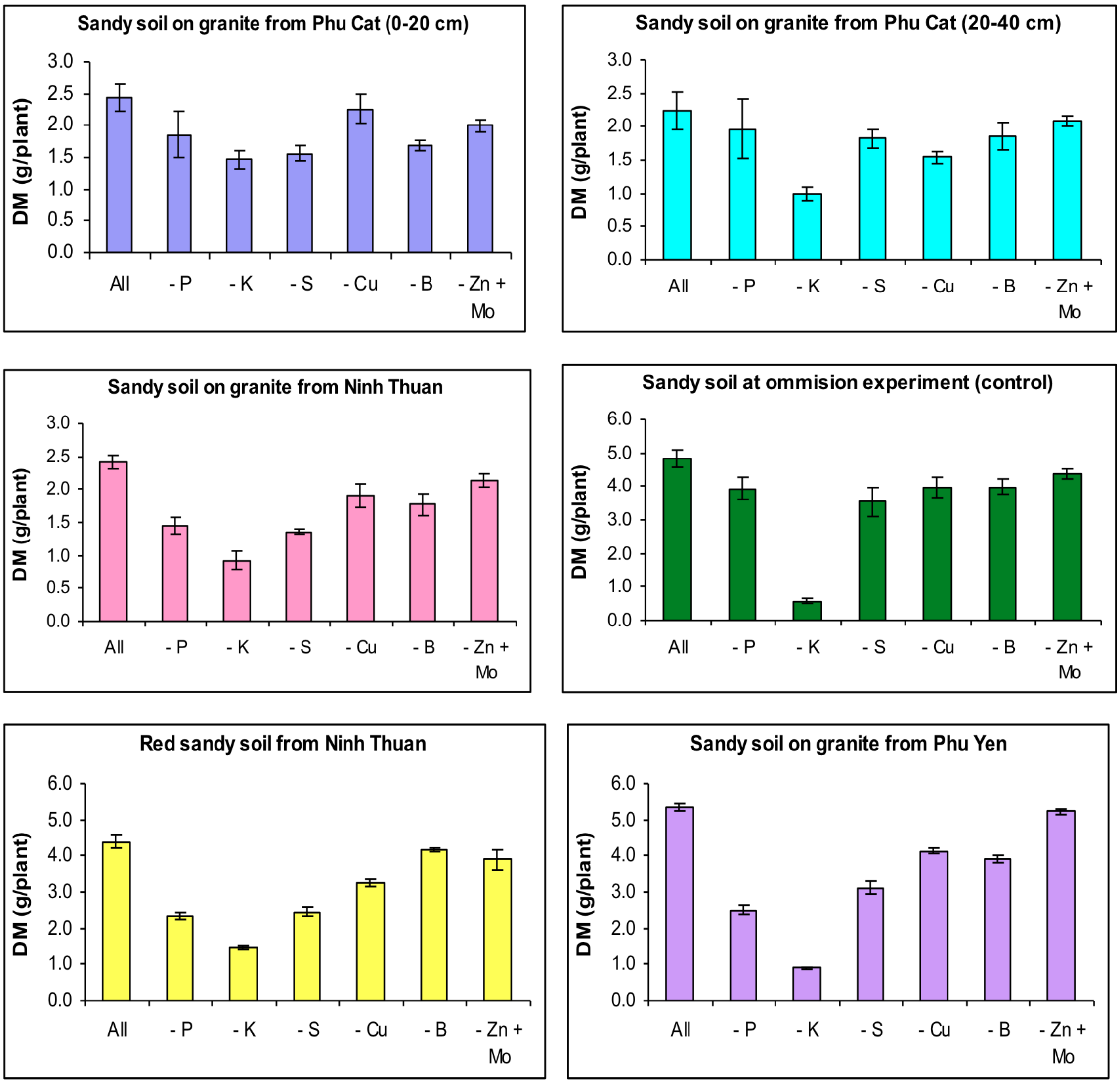


Figure 7.5 Dry matter yield of corn at 50 day harvesting of different treatments. Values are means of 3 replicates.

Biochar:

Biochar is a product of crop residues after pyrolysis at a certain temperature and is normally used by farmers as fuel for cooking and also as an amendment material to supply nutrients to soils.

Rice husk bio-char had positive effects on pod yield of peanut on a sand. Yield increases were sustained for 4 successive crops as illustrated for the fourth crop in Figure 7.6. The initial response was replicated in an additional one-year trial with peanut. Cashew yields also increased in response to bio-char application. Additive yield benefits were obtained from combined application of bio-char, NPK fertiliser and manure. This supports the value of including bio-char in an integrated nutrient management programme for crop production on sands.

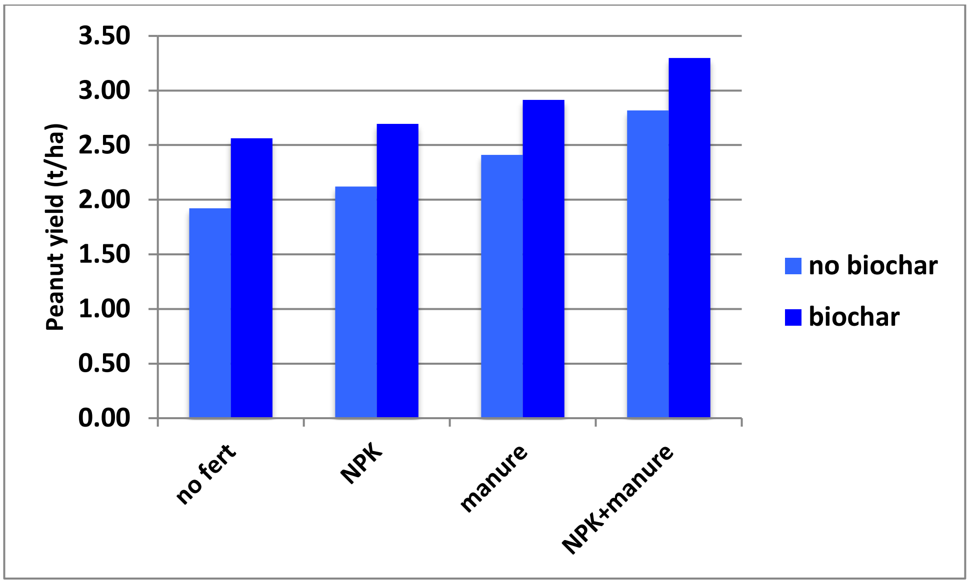


Figure 7.6 Effect of biochar amendment with and without NPK or manure on peanut yield on spring-summer of 2010 (4th crop after application of biochar) (LSD 0.79).

Rhizobium inoculation was not able to overcome the need for 30 kg N/ha as a basal N application for peanut (Figure 7.7). In the high rainfall Binh Dinh province the use of rhizobium strains, Mo and bio-char were investigated and results suggest that use of the commercial strain of inoculant, NC92, could improve peanut dry matter at flowering only when coupled with low applications of N fertiliser. However, overall, 30 kg N/ha was the best treatment, out yielding Mo supply and or Rhizobium inoculation. Nodule formation on peanut, even with inoculation by NC92 and Mo supply, was slow on these sands.

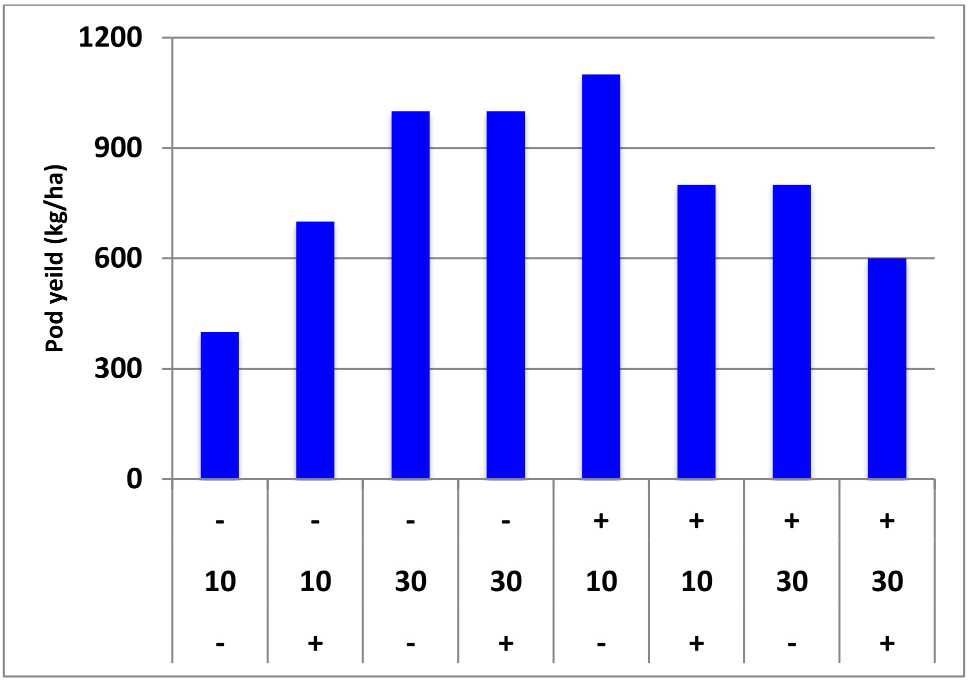


Figure 7.7 Effect of rhizobium inoculation (-/+), N application rate (10, 30 kg N/ha) and Mo application (-/+) on peanut yield (LSD 2.73).

Mini-pan:

Mini pan is a water scheduling technique based on evaporation that is able to guide the farmers to select the optimum time to irrigate the crops. This technique can save water, reduce leaching of nutrients, save electricity and labour costs by avoiding irrigation when it is not required.

Irrigation of peanut using the mini pan to guide irrigation frequency and amount of water to apply increased peanut yield in Cat Hanh commune on sands. In 2010 and 2012, peanut crop was sown in summer and peanut yield in summers is generally low. For example, the increase in peanut yield for 2010 and 2012 was from 1.02 to 1.52 and 1.2 to 1.35 t of pods/ha, respectively (Figure 7.8) while in 2011 the increase was from 3.28 to 3.68 t of pods/ha when grown in the main peanut season. The results suggest that substantial improvements in yield can be gained by better irrigation techniques (minipan) for peanut.

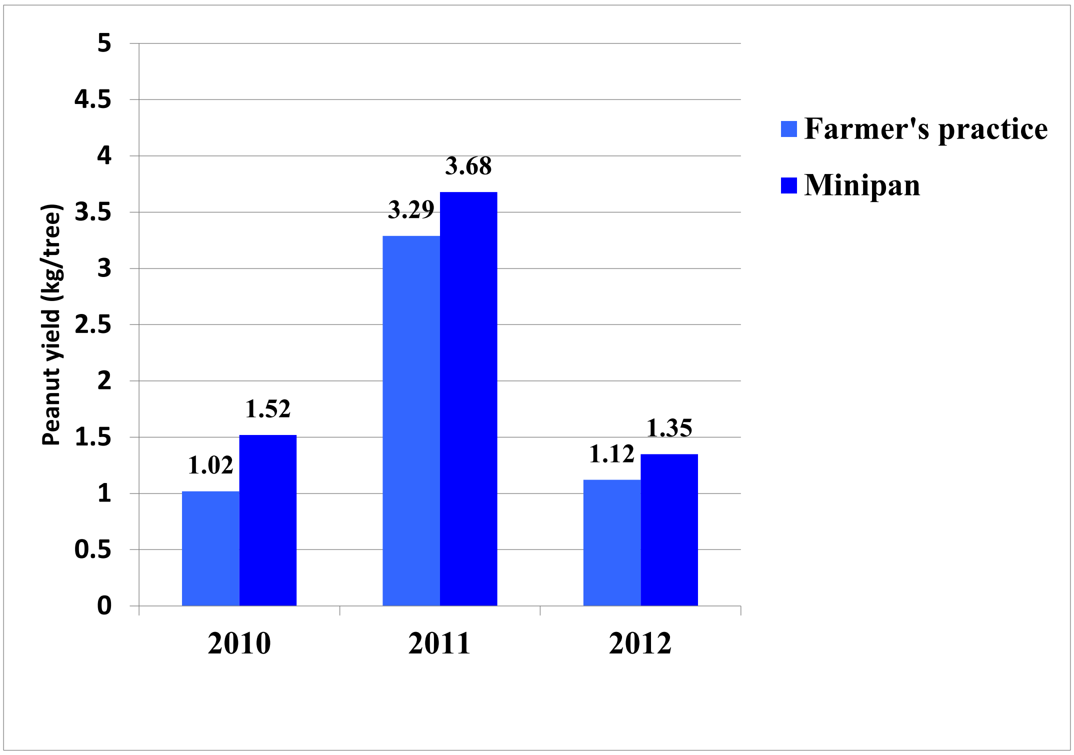


Figure 7.8 Impact of irrigation using mini-pan scheduling on peanut yield in Phu-Cat district for 2010, 2011 and 2012 compared with farmer's practice.

Irrigation guided by mini-pan had no significant effect on cashew production, due in part to the frequency of rainfall events, fog and high disease infestation resulting in late flowering and low yield in 2011 in comparison to 2012 in Cat Trinh (Figure 7.9). While the irrigation method had no significant effects overall on cashew yields in this location (near the mountains where dry season rainfall is common), supply of K plus micronutrients (B, Cu, Mo, Zn) increased cashew yield in 2012 by 45% compared to the farmer's fertiliser application.

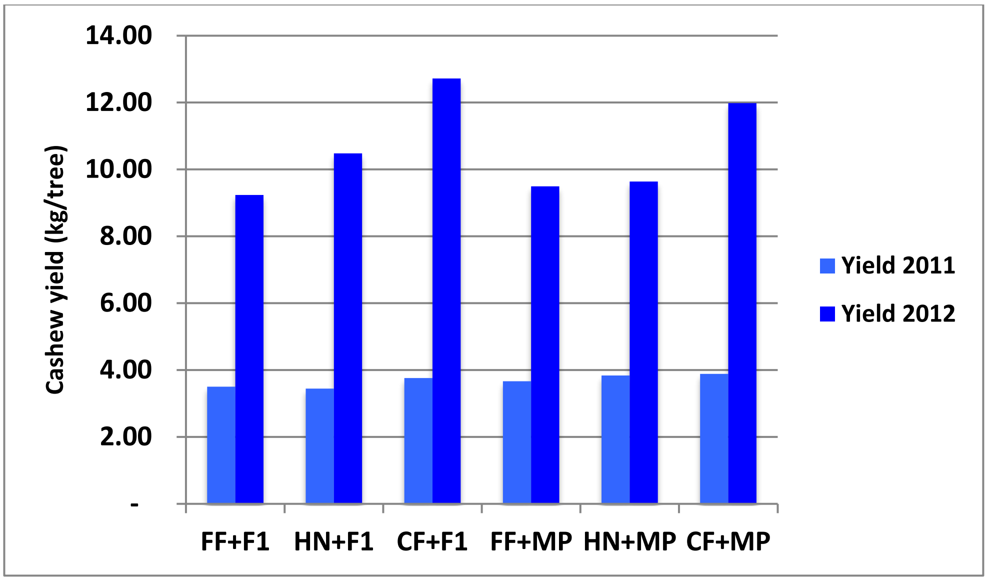


Figure 7.9 Effect of farmer's irrigation (FI) vs mini-pan irrigation (MP) on fruit yield of cashew with farmer's fertiliser (FF), high N fertiliser (HN) and NPKS+Cu, Zn, B and Mo (CF). Values are means of 4 replicates for 2011 experiment in Cat Hanh LSD (0.05) = 4.

By contrast, in the first experiment on mango with the mini-pan to guide irrigation, yields declined by about 4% compared to the farmer's irrigation practice (Figure 7.10). The mini-pan irrigation resulted in 4 irrigation events rather than 8, but allowed greater depletion in soil water levels between irrigation events. This suggests that mini-pan calibration is required for each individual crop depending on water demand. Mango yield increased by 19% after adding extra K, plus S, Cu, B, Zn and Mo. By contrast adding extra N relative to farmers' fertiliser use had no significant effect on yield but decreased the percentage of class 1 fruits from 45 to 38% and increased the percentage of Class 2 and 3 fruits. Hence the extra N fertiliser was detrimental to fruit quality for markets emphasising the need to optimise N fertiliser supply for yield and quality.

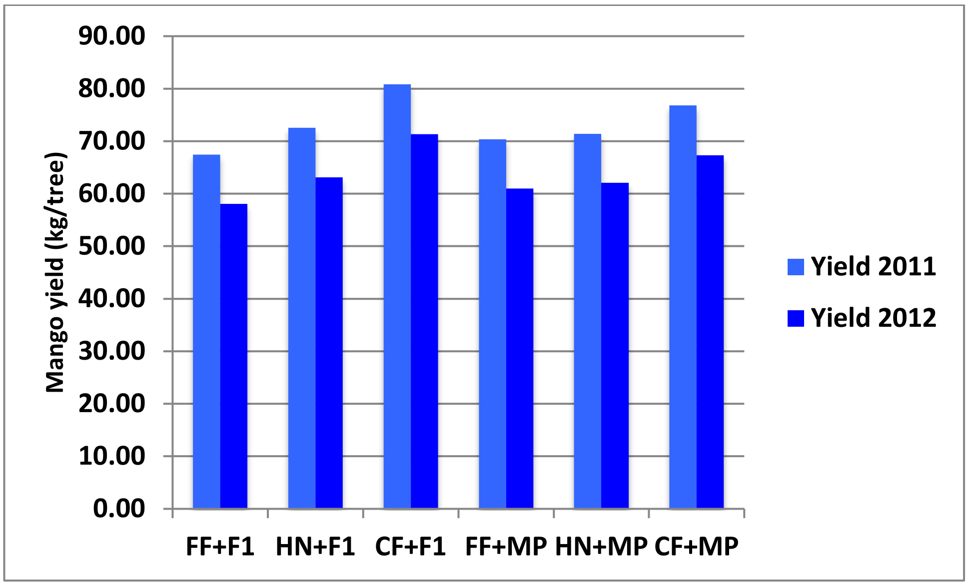


Figure 7.10 Effect of farmer's irrigation (FI) vs mini-pan irrigation (MP) on fruit yield of mango with farmer's fertiliser (FF), high N fertiliser (HN) and NPKS+Cu, Zn B and Mo (CF) in 2011 and 2012.

Integrated Nutrient Management (INM):

Farm products like crop residues, manure, biochar and other waste materials can be re-used for crop production system and may help reduce the cost of fertilizer input. For example, the INM trials showed that biochar and manure were able to boost peanut yield by 21 and 17% if inorganic fertilizers are integrated with biochar and manure (Figure 7.11). In another experiment (see above), the impact of biochar lasted for four consecutive peanut crops. From other trials on cashew, biochar had a positive residual effect on yield for at least four years.

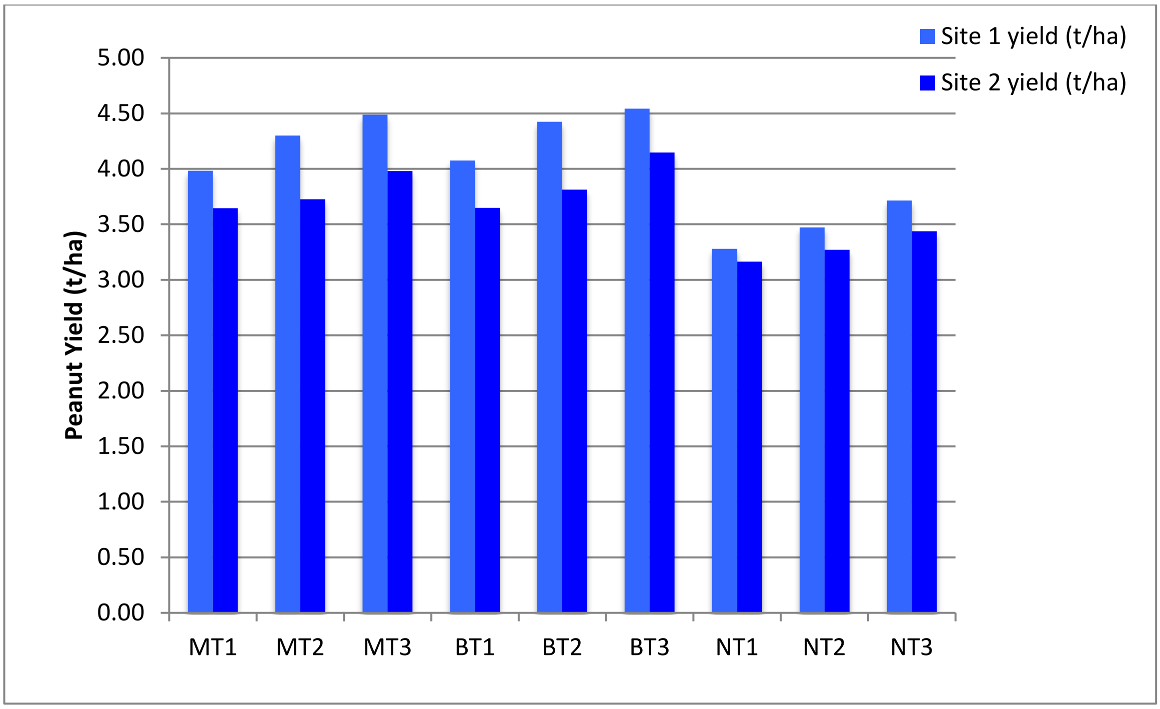


Figure 7.11 Effect of Intergrated Nutrient Management with amendment treatments of manure (M), biochar (B) and inorganic fertilizers (N) with nutrients N, P, K (T1), N, P, K, S (T2) and N, P, K, S and mircronutrients (T3) on peanut yield at two sites in Binh Dinh.

pH and liming:

Profile pH analysis indicated that peanut farmers in Phu Cat district may be using lime (CaO not $CaCO_3$) for crop production even in soils that have high pH (see Appendix 2.1.2 (a)). Over- application of lime may lead to nutrient deficiency in plants and may affect crop yield. Sands have a very poor pH buffering capacity and pH of such soils can be altered in a short period and is dependent on the rates of lime application. Figure 7.12 shows that it took less than 24 hours for lime to react with soil.

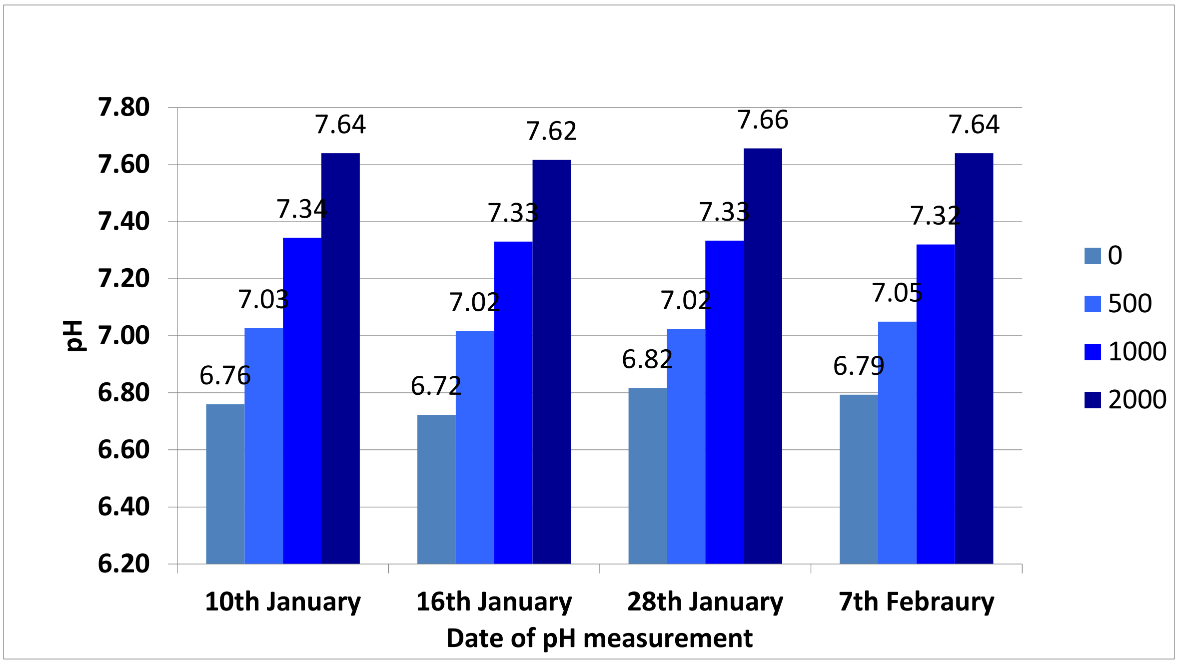


Figure 7.12 Effect of different rates of lime application on pH (H_2O) of sandy soil with time.

Organic Resources:

Improvement of soil fertility based on the locally available organic resources in combination with appropriate farming systems in the sandy zone has the potential for increasing farm productivity and farmers' income. Hence, 91 organic materials were collected from the three communes in 2009 to examine the existing practices of using organic manures, characteristics of local organic materials and to assess their potential for supplying nutrients to crops. The samples included: cattle manure, buffalo manure, pig manure, sheep manure, crop residues (peanut stem, cassava leaf, corn leaf, straw) and ash from crops. Farmers in the selected communes utilize organic materials for various purposes such as fuel, soil amendment or animal feed, or else they are burnt on the fields. The surveyed households apply farmyard manure (FYM) for crops; however, amounts of FYM used for crops are very low and are insufficient to meet crop nutrient requirements. There were no significant differences in characteristics (C, total P) of organic samples used by farmers in the 3 surveyed communes. However, each kind of manure and organic material had different characteristics and was dependent upon animal type, amount of added material, method of composting (pit vs heap) and time of storage. In summary, the results showed that:

- pig manure had highest nutrient content followed by cattle manure;
- manure composted with peanut residues had better nutrient value as compared to other plant residues;
- method of composting manure in 1 m^3 pits by mixing lime, phosphorus and different type of crop residues in Binh Dinh was better than composting in heap;
- yield of peanut was significantly higher when compost was applied in rows in comparison to surface application.
-

The highest gross margins were found with an application rate of 10 t ha^{-1} of manure after storage in a pit (28,190,000 VND and 26,440,000 VND) in row and surface application. Variable Cost Ratio (VCR) and agronomic efficiency were the highest with these treatments also. Such results indicate that the application of organic amendments in these trials could bring higher profit for peanut growers especially with row application.

Maintaining or building carbon in soils is one of the parameters to measure sustainability. Most of the sands assessed through SCAMP have very low C (SOC). Promising results for crop yield from adding biochar suggest that this soil amendment could be a pathway to increased SOC. The widespread use of on-farm organic resources including manures and composts will further help build or maintain SOC.

Minimum Tillage:

In order to improve the levels of soil organic carbon (SOC) minimum tillage operations have been recommended. A Versatile Multi-crop Planter (VMP) from Bangladesh that was imported in November 2011 was assembled and tested at ASISOV premises. Technicians and scientists were trained to operate the planter by Dr Enamul Haque, IDE, Bangladesh, a collaborative partner for another ACIAR project. The planter was tested for various crops (soyabean and peanut) in 2012. Soyabean planting was successfully established by both single pass shallow tillage and strip tillage modes of planting. However, the seed meter was not able to deliver the high rate of seed normally used for soybean in SS+CC Vietnam. The planter performed well for most of the seeds (soyabean, cowpea, rice etc), however was unable to sow peanut due to its large seed size and cylindrical shape. Aperture adjustments were made, however, peanut seeds were still damaged by the seed meter. Further modification of the seed meter and seed delivery mechanism would be required for peanut planting.

Partial nutrient budgets:

Nutrient-balance calculations are considered useful indicators for the sustainability of agricultural systems. Studies were undertaken at field plot and farm levels in farming systems of South Central provinces to quantify inputs and outputs of macronutrients (NPK) in 30 farms (10 in each study province) over one year duration. The results indicate that the N balances at the 30 studied farms were positive showing that 50 to 70% of imported N, mainly as fertilizer, was retained on the farm. Phosphorus balance was also always positive at farm level, accounting for 40 to 75% of P input. Potassium balance was negative in most of the farms.

More detailed N-P-K balances were established for field plots representing the following cropping patterns over two growing seasons: rice - rice, rice - fallow, peanut - fallow, peanut + cassava, hot pepper, eggplant, forage. Nitrogen balance was largely positive for rice-rice plots; by contrast N imports were less than exports in the other cropping patterns. P imports exceeded P exports in all studied plots, whereas K exports always exceeded K imports, especially for rice-rice and hot pepper, eggplant and forage. These results suggest that macronutrient losses occur in farms, out of the fields, especially for K. Potassium transfers from fields are likely to be in crop residues, farmyard manures processing, and in animal excreta.

The economic and environmental consequences of nutrient imbalances warrant further attention to optimize nutrient cycling, and utilisation of organic resources, in local farming systems. In the case of K, negative balances at field level raise the question of impact of this element in limiting crop yield, and the mechanism of K loss. Other studies on composting of manures suggest that losses of K occur between K excretion by cattle and collection of manure outside the shed for composting. Hence, improved K recovery seems feasible and may be beneficial for crop production on sands.

Sowing time and alternative crops:

In the low rainfall region of Ninh Thuan, two field experiments evaluated optimal sowing times for crop legume species intercropped with cashew on granite sands. Results for 2009 suggested that early September was the optimum window to intercrop legumes within cashew fields, and peanut crop yield was consistently higher across the 4 sowing dates than cowpea and mung bean (although cowpea showed good potential). In 2010, the early September sowing was also best for mung bean and cowpea, but not for peanut. Cowpea appears to be the most promising legume for this cropping system, but at least another year’s testing was required to validate these findings. Severe drought in 2011 prevented re-planting of the experiment and later the farm land dispute prevented further testing of these crops.

Water quality:

The impacts of agricultural practices on water quality were assessed in 2011-12 in An Chan commune. Ms Truc from IAS monitored quality of water for all seasons since April 2011 by sampling streams and irrigation channels flowing through An Chan commune, and by sampling bores and wells in the sands of An Chan commune. The aim was to assess the impact of land use and season on water quality (Figure 7.13). Water from these bodies is used for irrigation as well as for human consumption. Concentrations were assessed relative to ANZECC guidelines and the Vietnamese standards for ground and surface water quality (TCXD 233:1999, Table 7.46).

Table 7.46 Groundwater quality standard table for Vietnam. TCXD 233:1999. Values in mg/L except for pH.

Level	Parameters				
	pH	N-NO_3^-	SO_4^{2-}	PO_4^{3-}	Cl^-
A	6.8 - 7.5	0	<25	0	<25
B	6.0 - 8.0	<6	<250	<1.5	<200
C		<10	<400	<2	<400

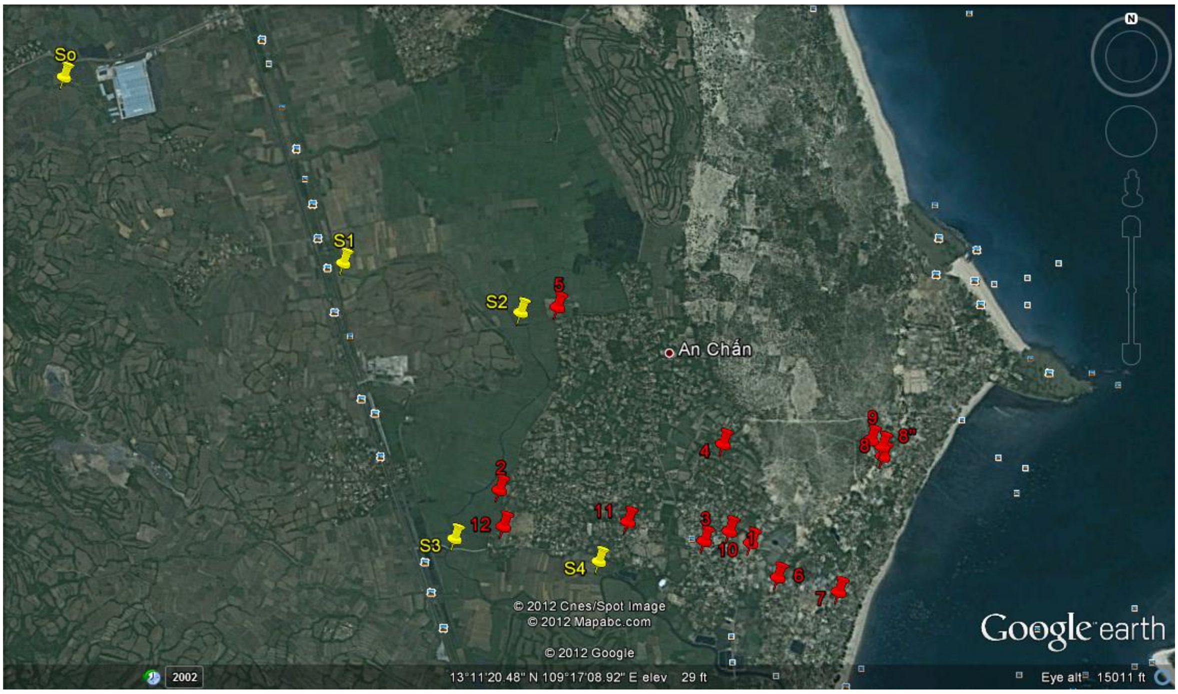


Figure 7.13 Sampling points of water from stream flowing from hills towards the ocean and of wells and bores from settlement areas of An Chan.

The concentration of nutrients fluctuates with season with stream samples having lower nutrient concentrations during the wet season. Overall, stream water had lower NO_3 and PO_4 concentrations than groundwater. The results suggest high levels of NO_3 (>10 mg/L) and PO_4 (>2 mg/L) in well water at several sites.

Groundwater samples were less variable with seasons than stream water but many well/ bore samples were high in P and in nitrate (Figure 7.14). Indeed nitrate concentrations greatly exceeded WHO health limits for water consumption (10 mg NO_3/L) in some bores and wells. Further sampling is planned to verify these findings. Sample preparation is being checked to verify that the high values are accurate. The likely source of high concentrations will also be investigated: possible sources include domestic waste disposal, cattle holding sheds and fertilisers.

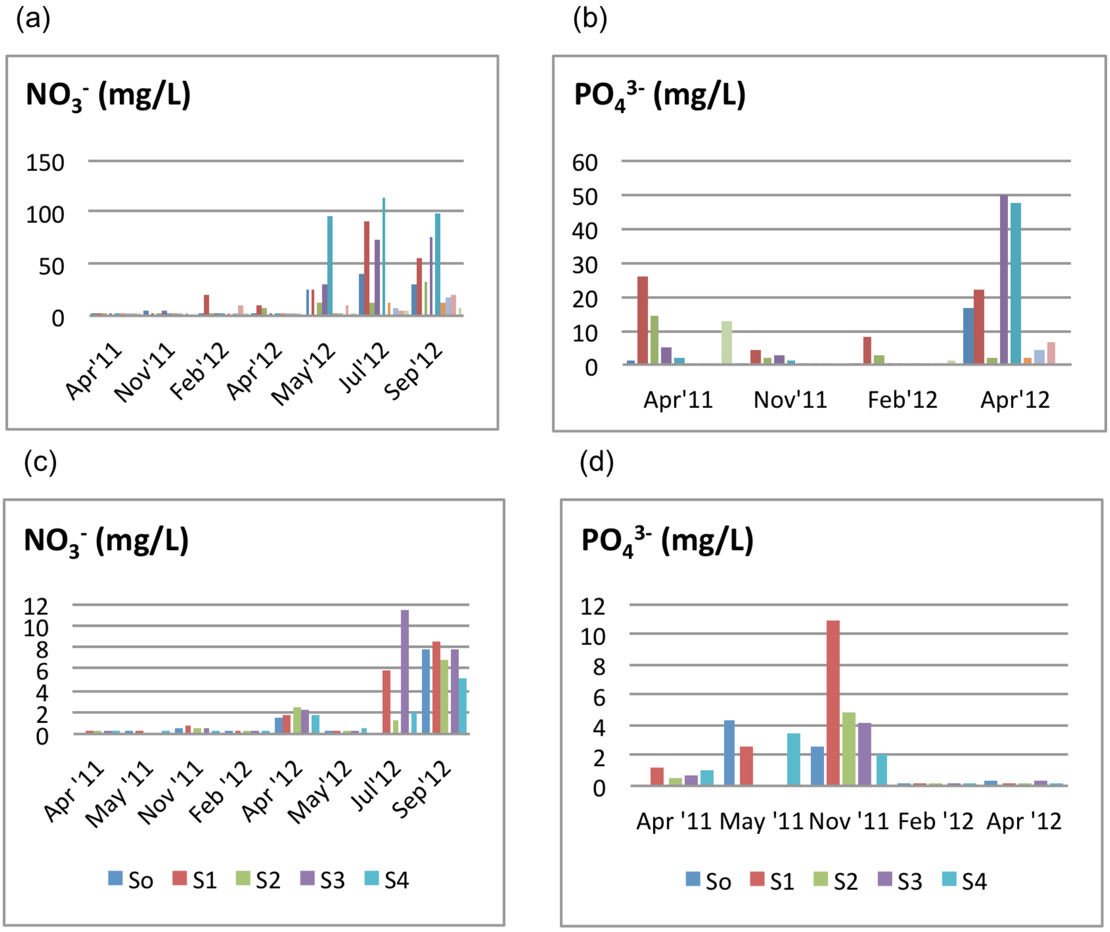


Figure 7.14 Nitrate (a, c) and PO3 (b, d) values of water in open wells (a, b) and in stream/canal in 2012.

Vegetable production:

A field trial on vegetables (pumpkin) was carried out in 2012 with amendment materials incorporated in the sand. Although yields were similar under different treatments, lining of plastic at 20-25 cm depth was very effective and decreased water use by more than 50 % (Figure 7.15). A follow-up experiment in 2013 will assess the impact of different amendment materials (local clay, bentonite, biochar, manure etc) in retaining water and nutrients to increase water and nutrient use efficiency.

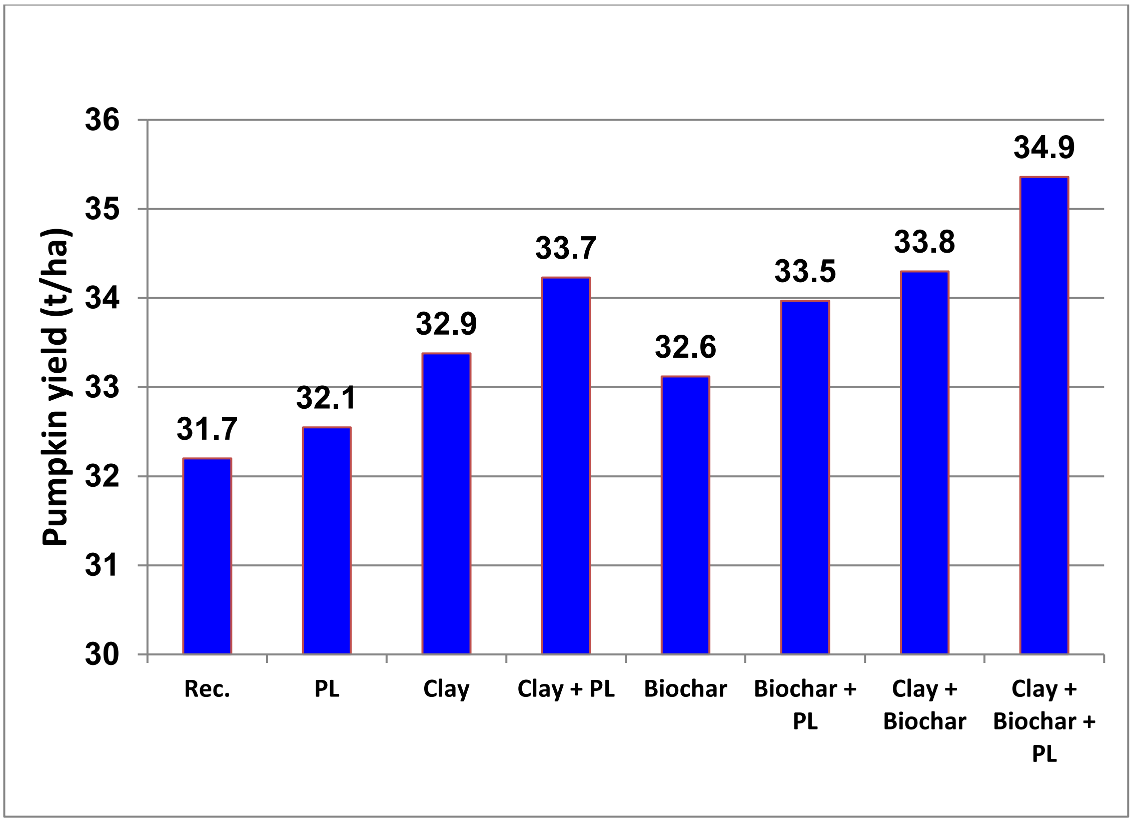


Figure 7.15 Effect of different amendment materials [plastic lining (PL), clay and biochar] on pumpkin yield compared with the recommended farmer practice (Rec.).

Forages:

Forage nurseries were established in January/February 2010 in Phu Cat district, Binh Dinh. Twelve forage species were included in the nurseries: 4 perennial grasses, 4 perennial legumes, 3 annual legumes and 1 tree legume. The perennial grasses, Mulato II and Signal, the perennial legume, Siratro and the annual legumes, Lab lab and Cavalcade, showed good establishment and initial vigour. After 15 months and 5 cuts, Mulato II and *Paspalaum atratum* were the most productive forages. None of the legumes forages produced harvestable dry matter after the third cut due to severe waterlogging effects in the wet season, and Leucanea produced limited shoot biomass after being initially harvested too severely. The forage nursery is now being used as a resource for producing plant material for cattle best-bet activities.

Research activities in Western Australia:

In Western Australia, research by the Department of Agriculture and Food, WA and Murdoch University has focussed on soil organic carbon (SOC) accumulation, and on bio-char and clay amendments of sands. A survey of 100 sites was completed in the south coastal region of Western Australia to understand the effect of land use on SOC in sands. A comparison of SOC between perennial (> 10 years age) and annual pastures in the high rainfall zone of the south coast showed no difference in SOC. Modelling with Roth-C indicated that the perennial pasture system would need to be retained for 30 years or more before measureable increases in SOC were obtained (Figure 7.16). This suggests very slow accumulation of SOC on these sands.

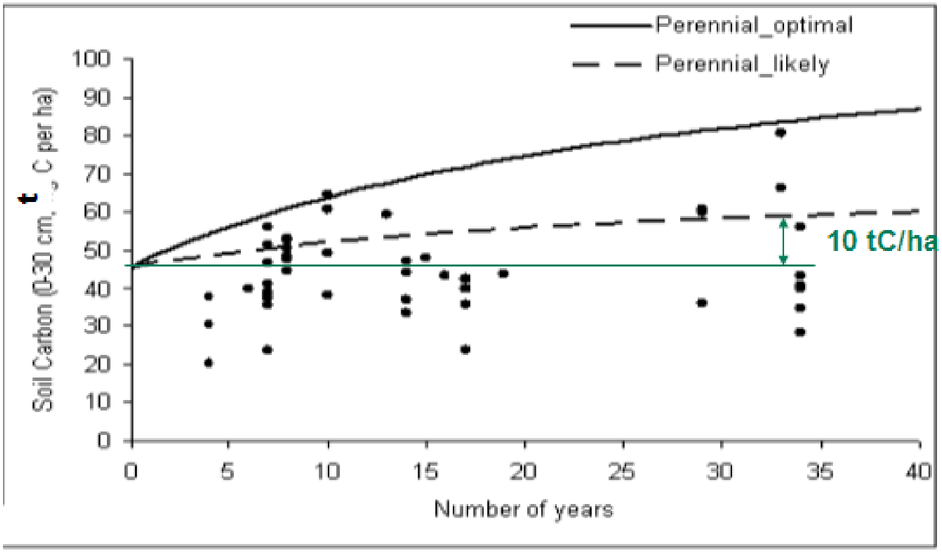


Figure 7.16 Modelled (line) and actual (dot) carbon stored for Kikuyu pastures on the south coast of Western Australia. Two scenarios were modelled assuming 100% water use efficiency (Perennial_optimal) and input parameters based on current conditions (Perennial_likely). (F Hoyle pers comm).

Soil carbon was found to be highly variable across the sites sampled with values ranging from <1 to > 3% SOC regardless of treatment. SOC did not vary significantly between pasture and soil type treatments when measured in 95 paddocks across the Esperance sandplain.Carbon values across alll sites averaged 45 t c/ha and potentially could achieve 55 t C/ha if maintained as a permanent pasture for 40 years. These values are 10 – 20 t C/ha higher than those measured on land that was regularly croppped. This suggests that the rate of carbon loss and gain in pasture paddocks is at or near equilibrium. Assuming no constraints to pasture production and nitrogen availability then an additional 40 t C/ha could be stored, however attaining this is highly unlikely.

The ratio of carbon to nitrogen was constant within the organic fractions analysed. For every 1% increase in organic carbon (1% SOC = 13 t C/ha assuming a bulk density of 1.3) then 1 tonne/ha of nitrogen also needs to be sequestered. It stands to reason that where the C:N ratio of the matterial being added to the soil is higher than 12:1 then the additional carbon will be lost in the process of SOC production.

Field experiments were established near Esperance in the south coastal region of West Australia on fine sands (Table 7.47). Compost prepared locally was compared with biochar made from straw or manure to examine their impacts on soil biology and the uptake of nutrients from P fertiliser. Both P and biochar application increased wheat yield in 2010 but their effects were additive (Table 7.48). Biochars increased wheat yield from 4 to 4.5 t/ha as did the compost. The positive response to biochar was again recorded in lupin harvest in 2011, but did not persist in 2012 when another wheat crop was grown. By contrast, crops responded to P fertiliser in each of the 3 winter crops. Only the first of the summer crops of sorghum responded to biochar.

Table 7.47 Characteristics of soil and biochar used in the Esperance field trial, Western Australia.

Bio-char type	OC %	pH ($CaCl_2$)	N (mg/L)	P (mg/kg)	K (mg/kg)	S (mg/kg)	CEC (cmol/kg)	Zn (mg/kg)	Cu (mg/kg)
Wheat straw	53	8.3	2	4150	33700	2040	42	54	10
Chicken manure	38	7.3	18	11600	13800	3550	36	334	59
Soil	1.1	5.1	5	14	58	9.5	3.4	0.4	0.7

Table 7.48 Wheat and lupin grain yields (t/ha) and forage sorghum (BettaGraze) dry matter yields (t/ha) as affected by the phosphorus (P) and organic amendment main treatments.

Main Treatment	Wheat 2010 Grain t/ha	Forage 2010 -11 t/ha	Lupin 2011 Grain t/ha	Forage 2011-12 t/ha	Wheat 2012 Grain t/ha
-P	4.9a	1.28	2.54a	4.07	3.50a
+P	5.3b	1.37	2.91b	4.24	3.82b
Prob	P<0.001	ns	P<0.001	ns	P<0.001
C	4.8a	1.16 a	2.68a	3.75	3.66
Cmpst	5.1b	1.23ab	2.65a	4.26	3.73
WSchar	5.1b	1.54 c	2.50a	4.15	3.62
CMchar	5.2b	1.36 b	3.06b	4.45	3.63
Prob	P=0.005	P<0.001	P<0.002	ns	**ns**

Spading was applied in 2010 as a treatment to an existing claying trial that had been running for 11 years. The clay rates originally applied were 0, 50, 100, 200, 300 t/ha of sub-soil materials containing 31-40% clay. Spading was applied to 0, 15 or 30 cm depth. Spading to mix clay into sandy soils was most effective in increasing serradella pasture yield when incorporated to 15 cm depth in 2010 (Table 7.49). The effect of sub-soil amendment at 200-300 t/ha almost doubled dry matter yields of serradella but at 50-100 t/ha there was no measurable effects. In the following years, depth of spading had no effect on serradella yield, while positive responses to clay persisted. Indeed, the response of plant production to claying has been consistent throughout the 13 years since incorporation, although responses at 50 or 100 t/ha were intermittent and sometimes negative (Figure 7.17).

Table 7.49 Pasture dry matter (t/ha) production as affected by clay rate (0, 50, 100, 200 and 300 t/ha) and spading depth (0, 15, 30 cm)

Main Treatment	2010 Total t/ha	Aug 2012 t/ha	Oct 2012 t/ha	2012 Total t/ha
Control	0.72 a	2.32	1.43	3.80
Spade15	1.05 b	2.21	1.45	3.66
Spade30	0.89ab	2.04	1.54	3.57
Sig	P<0.048	ns	ns	ns
Clay0	0.63a	1.68 a	1.25	2.93
Clay50	0.75a	1.51 a	1.59	3.10
Clay100	0.74a	1.95ab	1.53	3.48
Clay200	1.08b	2.69 b	1.50	4.19
Clay300	1.17b	3.11 b	1.56	4.67
Sig	P<0.001	P<0.014)	ns	P=0.058

Treatments means followed by differing letters were significantly different (P<0.05)

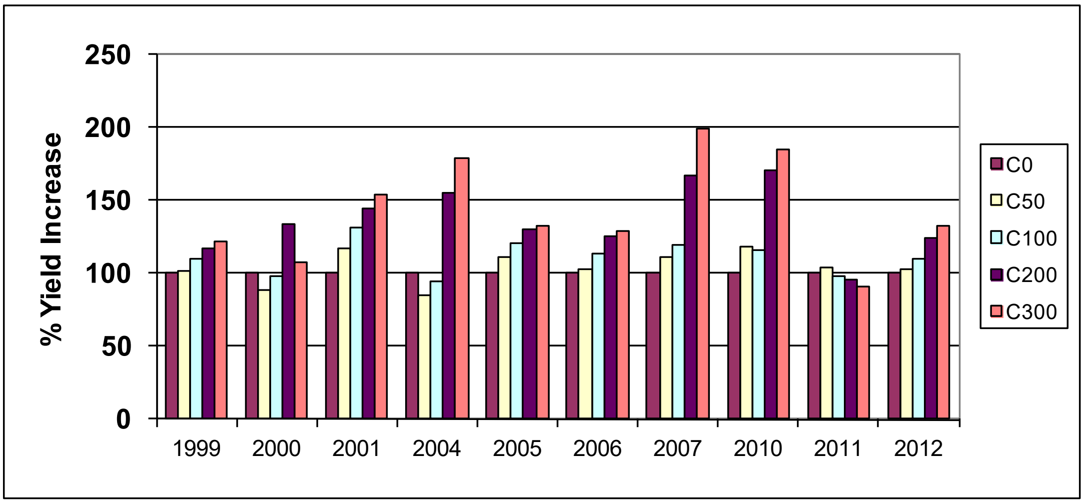


Figure 7.17 Long term yield trends for the clayed treatments (0, 50, 100, 200 and 300 t/ha). Yields are presented as a 100% of the control between 1999 and 2012. Data for 2011 is included but sampling techniques in that year did not adequately represent growth.

Managing phosphorus (P) supply on sands remains a challenge because of the propensity of P to leach while reducing P rates may lead to P deficiency in crops. Biochar and clay are two amendments with potential to improve the retention and availability of P to crops. A PhD study by Fariba Mokhtari investigated the effect of biochar (produced from wheat straw (WS) or chicken manure (CM)) and clay (kaolin or clay-rich subsoil) on P in soil solution and leachate and on P uptake by wheat on a grey sand from the south coast of West Australia. We hypothesized that P leaching will decrease with the addition of biochar and clay together to sands. More P was released during desorption by WS biochar than by the CM biochar. After 5 successive desorption steps, solution P concentration was 10 mg/L with CM biochar but declined to only 2 mg/L with WS biochar. This suggested that P in WS & CM biochar is readily soluble with more rapid release from WS biochar. Adding either kaolin or subsoil clay (50 t of clay/ha) with WS biochar or CM biochar (10t/ha) decreased the amount of P leached with or without P fertiliser added, however the decline in P leached and in soil solution P concentration was most pronounced with subsoil clay addition. In summary, subsoil clay had a greater effect than kaolin in reducing soluble P in soil solution and in leachate particularly with CM biochar but the soil solution P concentrations still remained above 0.2 mg P/L, and hence were maintained at concentrations adequate for plant growth. However, P uptake was depressed by addition of sub-soil to the sand. This suggests that the Fe oxyhydroxides in the subsoil material were effective in reducing P leaching by P sorption (Figure 7.18).

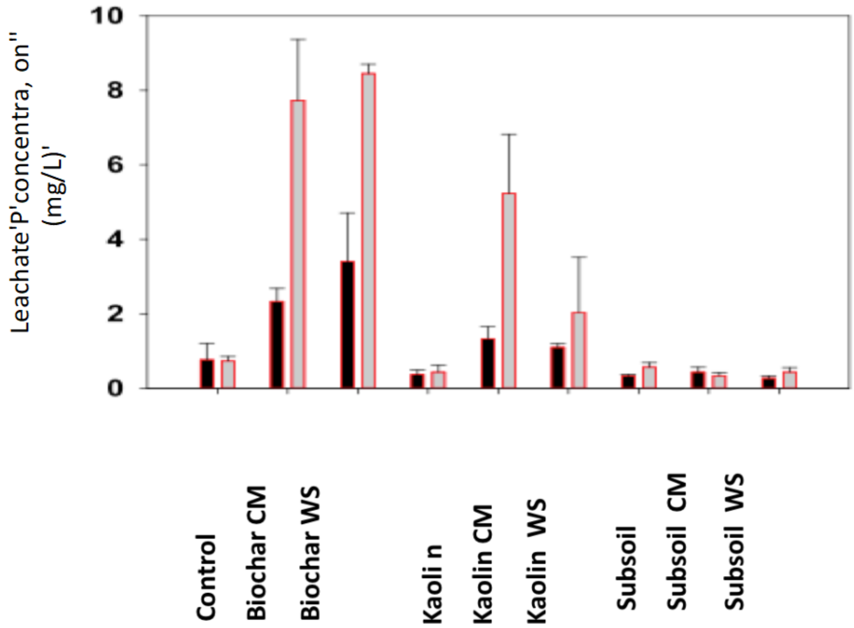


Figure 7.18 Effect of biochar (CM- chicken manure biochar; WS- wheat straw biochar) and clay materials (kaolin, sub-soil from Esperance) and P fertiliser application (low P for dark shaded columns and high P for pale shaded columns) on P concentration in leachate from columns of Fleming sand. Values are means of four replicates with vertical bars denoting standard errors of the mean.

7.3 Livestock integration

Baseline assessment and benchmarking of farming systems

The objective was to describe different aspects of cattle production in South Central Coastal Vietnam including: farming resources, herd structure, feed resources, feed and feeding management, and constraints to cattle production. Secondary and primary data on cattle production systems were collected by both quantitative and qualitative research methods. Participatory meetings at the commune level were organised to collect qualitative information. In addition, 180 households were interviewed using a structured questionnaire to assess their cattle production systems.

Households in Ninh Thuan were found to have advantages in raising cattle compared with Binh Dinh and Phu Yen in terms of available labour and land area; however they were more limited by lower rainfall. Households in Ninh Thuan typically had twice the number of cattle than households in Binh Dinh and Phu Yen, but a lower percentage of cross-bred cattle (Figure 7.19 Average cattle numbers separated by breed, for three south central coastal communes.). The method of raising cattle of surveyed households in Ninh Thuan was more extensive than in Binh Dinh and Phu Yen (Figure 7.20), although most farmers use supplementation, either with grazing or stall feeding. Farmers in Binh Dinh and Phu Yen were also more intensive in their methods of cattle management, including cultivating forages, storing agricultural by-products, supplying concentrate, cutting naturalized grass, and restricting the number of cattle.

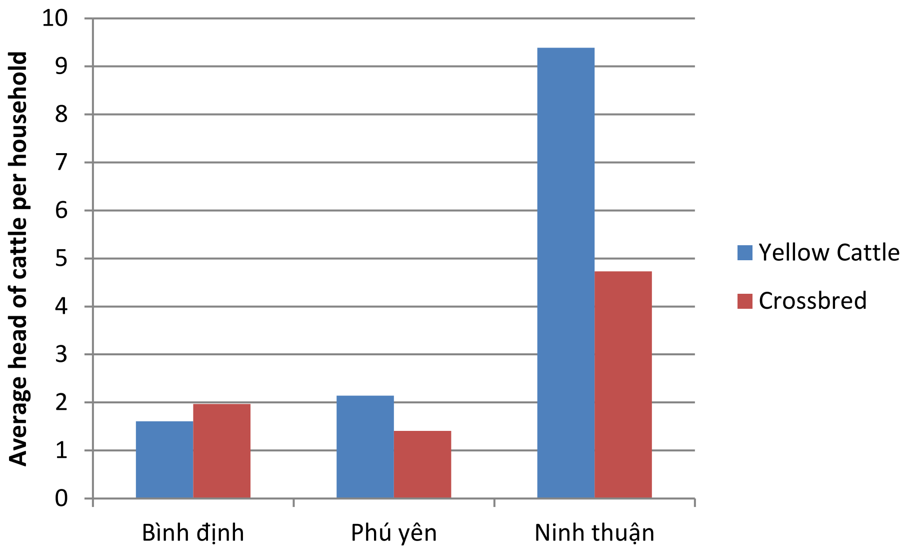


Figure 7.19 Average cattle numbers separated by breed, for three south central coastal communes.

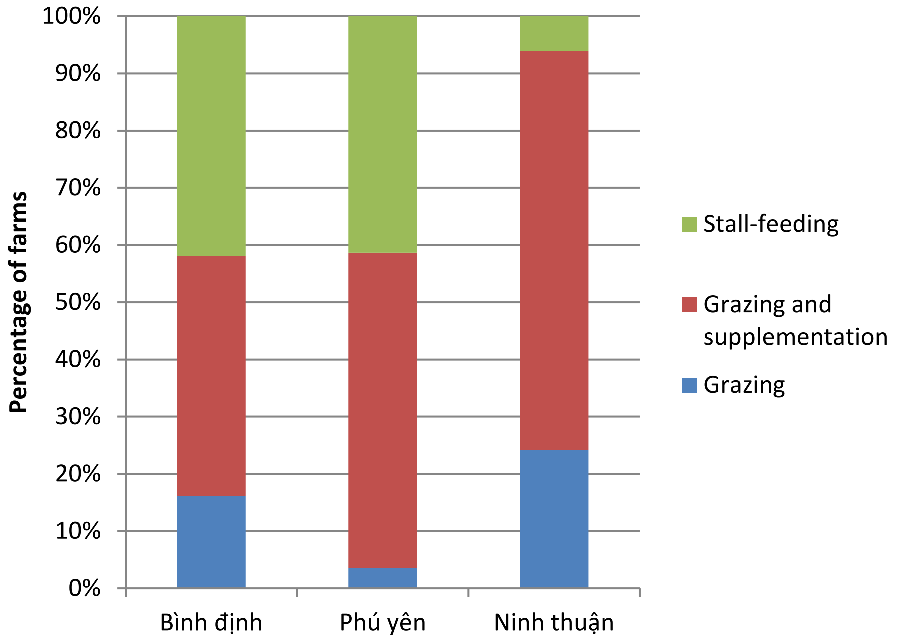


Figure 7.20 Modes of cattle production of three south central coastal communes

'Biophysical monitoring' activities were concluded in the three study provinces. Information collected from 10 households/province included cattle monitoring, feed monitoring, and household data (particularly information on income and labour for cattle production). In Cat Trinh (Binh Dinh) and An Chan (Phu Yen), cattle systems included cow-calf, growing, and fattening, and was mainly undertaken by adults. In contrast, cattle production in Phuoc Dinh is predominantly the cow-calf system, and the children provide much of the labour for cattle husbandry. Cattle in Cat Trinh and An Chan typically lose weight in the dry season from April-June, when feed is scarce and of poor quality. There are many types of feed for cattle. The roughages include rice straw, native grasses, sown grasses, peanut straw, water spinach, and maize stover. Supplements are also used, including cassava powder, rice bran, corn meal, rice grain, fishmeal, and urea. Cattle are often provided feed in their stalls after grazing. In Phuoc Dinh less crop residues are available, and even though some crop residues such as rice straw are transported into the commune, feed is often limiting, and cattle weight is seasonally dependent.

The benchmarking process involved group discussions and interviews, including farmers, DARD representatives and commune leaders. A current farming calendar for Cat Trinh is presented in Figure 7.21. The main crops grown are rice (up to three crops), two in the dry season on irrigated lowland and one in the wet season on rainfed upland; cassava, one crop sown at the end of the rainy season; peanut, a winter-spring main crop and sometimes a second summer-autumn crop; and cashew, with the main harvest in May. Farmers often earn extra income by labouring, mostly outside the commune and from March to September. The typical farmer has around 3 cattle (e.g. 1 cow, 1 calf, and at times, a young steer or heifer). Most farmers use natural weaning at 10-12 months. Cattle are typically sold at 3 years old at 300kg. The most common forms of cattle production are exclusive stall-feeding, or grazing with supplementation; grazing with no supplementation is less common. Most farmers offer rice straw (4.5 kg/cow/day), some of which is purchased off-farm, and supplement with cassava powder and rice bran; limited cut and carry native grass is used. Some farmers grow elephant grass (*Pennisetum* sp.) in the backyard (~150 m^2); and required labour for three animals is approximately 3 hours/day.

	J	F	M	A	M	J	J	A	S	O	N	D
Rainfall	Drizzling rain			Dry Season					Very high rainfall			Rain
Main crops												
Rice	Winter – Spring rice crop			Summer-Autumn rice crop				Third rice crop				
Cassava	Growing season											
Peanut	Winter - Spring crop				Summer - Autumn crop							
Cashew	Harvesting								Planting		Harvesting	
Cattle activities												
Breeding	Calving			Mating								
Grazing	Grazing			Less grazing				More grazing				
Rice Straw use	More in ration							Less in ration				
Cultivated grass use												
Cut and carry grass												
Peanut vine use												
Body condition	Low			High						Low		
Prices	High											

Figure 7.21 *Seasonal farming calendar for Cat Trinh Commune, Binh Dinh Province, Vietnam.*

Best-bet activities

Approximately fifteen farmers in each province were chosen to be involved in the 'best-bet' research process. A plan was developed for each household, based on their resources, interests, and aspirations. All households receive regular visits to check on progress, help the farmers, provide encouragement, and answer questions. Best-bet activities include introduction of new forages, improved forage management and use, tree legume fences, forage preservation, controlled mating, preferential feeding, fattening techniques, and manure use. In addition to individual training, workshops were held to address these activities.

Observations and farmer interviews indicate good progress in uptake of best bet options by participating farmers across all three regions. In the opinion of Jeff Corfield the progress is equal to or better than that achieved in comparable Indonesian projects at similar points in the best bet cycle.

Of farmers currently active in the best bet program (i.e. not dropped out for various reasons) well over half (67% in Cat Trinh, 78% in An Chan and 61% in Phuoc Dinh) have progressed beyond initial new forage planting and expansion and improved forage management to regular feeding of new forages. Around 40% of best bet farmers are now applying some form of targeted (preferential) feeding for either freshly calved cows or young males within fattening systems, while some in each commune (7-13%) are now trying or planning to start early weaning especially following the cattle nutrition workshops held in September 2011.

Early outcomes and impacts arising from these best bet uptake include:

- Significant (average >70%) reduction in time and labour spent supplying feed for cattle via grazing/herding, cut and carry native and planted grass, supplement preparation (more detail in the impact assessment section).
- Significant increase in area and production of high quality fresh forage.
- A small but significant trend to replace some purchased supplements and rice/peanut straw with new fresh forages.
- Significant improvement in average cow condition within cow-calf systems over time (farmer and researcher perceptions).
- A small shift amongst best bet farmers away from cattle keeping/selling as money is needed to selling at a targeted age/size and/or market price.

While *Brachiaria* x cv. mulato is probably the most popular across the board there is quite a range in preferences amongst best bet farmers. Generally those with cow-calf systems prefer mulato and *Panicum maximum* cv. TD58 because they are "softer" and more palatable and have higher leaf stem ratios, meaning less wastage. However farmers operating buy and sell male only fattening systems often prefer *Pennisetum* sp. cv. VAO6 because it provides more bulk to compliment concentrate feeding, despite being more N demanding and producing more residue.

While farmers have embraced these new forage grasses and some have replaced some or all of their local king grass (*Pennisetum* sp) with the new introductions, many farmers have also continued to expand their king grass and elephant grass areas at the same time. This is not uncommon in such best bet programs, partly because participating farmers increasingly recognise the value of well managed planted forages and planting material of king grass is readily available compared with new forages in the early stages of such programs.

Several farmers in all three communes now have enough well grown *Leucaena leucocephala* cv. Tarramba hedgerows to begin feeding to cattle and for some Tarramba is now providing a significant high protein supplement to cattle diets. As Tarramba plantings develop further on other best bet farms more farmers will realise the same benefits. Already in Phuoc Dinh there has been considerable scaleout of Tarramba seed among local non best bet farmers from Mr Trang's hedgerows and the Tarramba seed supply is now self sustaining there.

However a potential threat has developed in the form of *Leucaena* psyllid outbreaks which have occurred across all 3 provinces. Psyllid attacks have cause significant but temporary damage to Tarramba leaf production, but so far plants have survived well and recovered quickly once the pest has departed (in around 1-2 weeks). We have advised farmers with psyllid affected Taramba to cut their plants back to remove affected foliage. Some farmers have already done this with good affect in the course of their cutting cycle.

As with Tarramba seed supply in Phuoc Dinh, supply of new grass cuttings to farmers is now virtually self-sustainable within each commune, from best bet farmer and old forage trial sources. The An Chan commune extension officer reports that over 1.3 t of new grass cuttings have been acquired by Phu Yen DARD from best bet farmers and old forage trials for distribution to other farmers. This has provided a small income source for some farmers there. There has also been considerable informal sharing of planting material within communes and beyond to the extent that some new farmers now have larger areas of new forages than many best bet farmers. It is critical that forage management and feeding knowledge accompanies scale-out of forage material.

Several best bet farmers located close to common lands along the river or hills in Son Hai have experienced problems with uncontrolled grazing of their newly established forages by other farmers' cattle, due to inadequate fencing or supervision. Such uncontrolled heavy grazing has deprived these farmers of important forage sources from otherwise well managed forage banks. The extent of uncontrolled common grazing and the associated expense in fencing to prevent it may well be a significant constraint to fresh forage development in this area.

Impact assessment of best-bet activities

Best-bet activities were assessed at farms across three communes. Activities included new forage species/cultivars, improved forage management, forage conservation, and tree legumes/living fences. The tools for impact assessment included secondary data review, observation, in-depth interview, and household interview by questionnaire. Questionnaires were used to collect data on expenditure of cattle production monthly and other quantitative data every two months. The results indicated that 96% of best-bet farms adopted forage species cultivation and improved forage management. 64.4% of best-bet farms practiced forage conservation and 73.3% had adopted tree legumes into their feeding system.

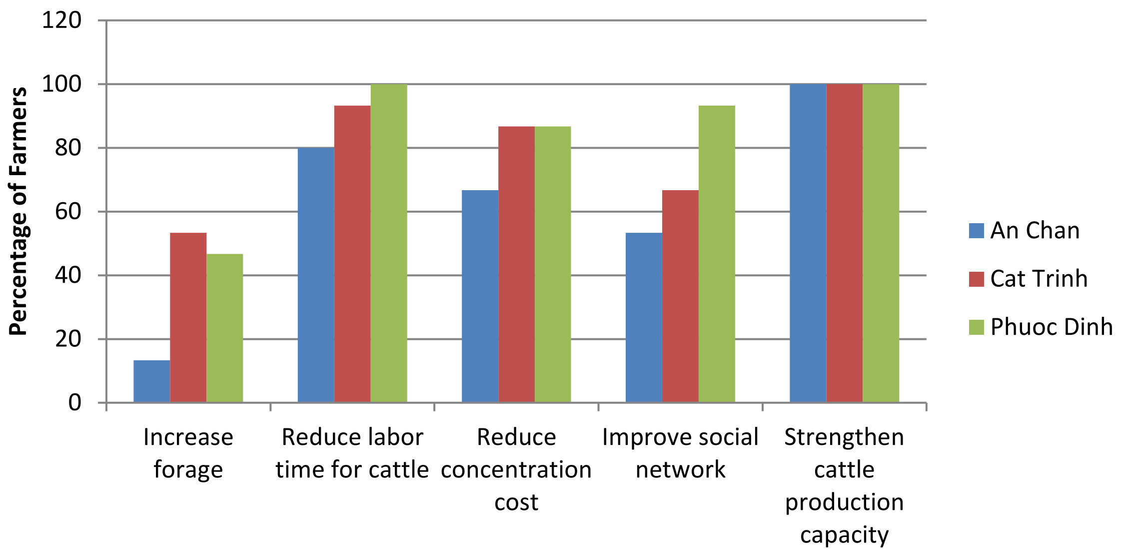


Figure 7.22 Farmers' perceptions on the impact of best-bet activities, sourced from in-depth farmer interviews

The impact of best bet activities has been manifested through an increase of land planted to forage, the reduction in labour time needed for cattle production, expenditure on cattle production, improved social networks among farmers, and increased capacity for forage cultivation and management. Farmer perceptions of the impacts of best-bet activities are shown in Figure 7.22.

The increase in area of forage land was achieved by the conversion of unused and infertile maize and cassava land into forage land. As a result, the forage land increased by approximately 3.6% in An Chan, 15.4% in Cat Trinh, and 21% in Phuoc Dinh communes. The increased area of forage supplies readily available feed for cattle, and consequently results in labour savings as farmers can save time cutting and carrying natural grass or tending their grazing animals.

91% of farmers reported a reduction in labour time compared to the benchmarking data. Farmers reduced the time spent managing cattle by 55% in An Chan, 45% in Cat Trinh and 41% in Phuoc Dinh commune. Instead of managing cattle, farmers predominantly use their saved time to do housework (78% of female farmers) and to look after crop production (62% of male farmers).

A reduction in the total cost of cattle production/month was realized by 80% of households. The cost of production was reduced by 23% in An Chan, 49% in Cat Trinh, and 24% in Phuoc Dinh. This was achieved by a decrease in purchase of concentrates (including rice grain) and forage, due to more available cultivated forage. The total cost of purchased concentrate of 15 households reduced from 6.3 million VND/month to 4.1 million VND/month in An Chan commune and from 15.4 million VND/month to 8.7 million VND/month in Cat Trinh commune.

Additionally, the network among best bet farmers and other farmers has improved through more frequent meetings, the sharing of forage and legume planting material, and mutual support in techniques of forage and legume planting.

On-farm forage variety selection

A forage experiment was established in May 2010 in 3 communes with sandy soils in Binh Dinh, Phu Yen, and Ninh Thuan. The objective was to assess on-farm seasonal production of the most promising forages and expose farmers to using the species. The experiment was located on 15 farms, with each farm as a replicate. In addition to the researcher controlled plots, an area of each forage was available for farmer use and experimentation. The five forage varieties used in the experiment included: *Brachiaria* cv. Mulato II, *Paspalum atratum*, *Panicum maximum* cv. TD58, *Pennisetum purpureum* cv. VA06, and *Stylosanthes guianensis* cv. CIAT 184. The plots were irrigated and cut 7-8 times/year with the time between cutting ranging from 30-60 days, depending on the weather.

The leaf fraction ratio was significantly different between varieties ($P<0.001$), and *P. atratum* and Mulato II had the greatest leaf fraction. The biomass DM yields were relatively high and similar between regions (Table 7.50). The greatest yield was obtained from Panicum maximum TD58 (34-50 t DM/ha/year) and *Mulato II* (25-38 t DM/ha/year).

There were significant differences ($P<0.05$) in crude protein yield between species at Binh Dinh and Phu Yen (Table 7.50). Protein yield was greatest for TD 58 at Binh Dinh. At Phu Yen and Ninh Thuan protein yield was similar for all grasses. The crude protein content tended to be less during dry and hot periods. The greatest protein concentration was from CIAT 184 (14.7-17.9%). Of the grasses, Mulato II had the greatest protein concentration (10.5-13.7%, $P<0.05$) (data not shown).

Based on biomass yield, agronomic characteristics and chemical composition, all of the grasses, and possibly the legume, have a potential role in SCC farming systems. In well-drained soils TD58*, Mulato* II, VA06 and CIAT 184 are the best suited. For areas prone to waterlogging the best species is *P. atratum*, which was typically the most resistant to waterlogging during the wet season. The farmers in these communes preferred Mulato II, TD 58, and VA06 for forage development in their area.

Table 7.50 Biomass (t/ha) and protein yields of species in three South Central Coastal provinces of Vietnam.

Species	**Binh Dinh**		**Phu Yen**		**Ninh Thuan**	
	Dry matter yield	Crude protein yield	Dry matter yield	Crude protein yield	Dry matter yield	Crude protein yield
	——— t DM ha^{-1} yr^{-1} ———					
Mulato 2	25.7^{b}	3.51^{b}	37.3^{a}	4.63^{abc}	24.4^{ab}	2.58
Paspalum	27.2^{b}	2.92^{b}	42.1^{a}	4.01^{abc}	38.6^{a}	2.66
TD58	40.0^{a}	4.95^{a}	50.3^{a}	5.15^{a}	33.9^{a}	3.26
VA06	26.4^{b}	3.37^{b}	39.4^{a}	4.42^{abc}	39.0^{a}	3.2
Stylo 184	11.5^{c}	2.02^{c}	17.0^{b}	3.04^{c}	15.8^{b}	2.33
SEM	1.9	0.26	4.1	0.4	3.6	0.3
P	0.001	0.001	0.001	0.05	0.005	0.269

SEM: Standard Error of Mean; P: Probability

^{a,b,c}: Means within columns with different superscripts differ significantly (P<0.05)

Nitrogen fertilizer management to improve forage production

The objective of this field experiment was to assess the effect of nitrogen (N) fertilization from composted cattle manure and urea on forage yield in tropical sandy soils of SCC Vietnam. *Brachiaria* cv. Mulato II was established in summer 2010 on six farms in Binh Dinh Province. Experimental design was a randomized complete block with five levels of manure N (0, 40, 80, 120, 240 kg N/ha/yr) and three levels of urea N (0, 60, and 120 kg N/ha/yr), balanced for forage N demand. Canopy height, maximum height, live tiller count, and dry matter (DM) yield were measured monthly. Cumulative DM yield data until January 2012 were analyzed using a linear mixed model. Coefficient of determination was 0.78. Fixed effects included urea (P<0.0001), manure (P=0.8387), and their interaction (P=0.0994), as well as additional covariates (pre-experiment soil pH, month, and plant count). Random effects included block and block x treatment, which explained 52.4% and 4.1% of residual variance. Mean differences for fixed effects were evaluated using Tukey's test. Urea significantly impacted yield. Manure x urea interaction effects were unclear (Figure 7.23). However, least square means patterns suggest yield response for urea at 120 kg N/ha/yr at increasing levels of manure. Yield response to urea at 60 kg N/ha/yr across manure levels suggests net N immobilization when the C:N ratio is high. A manure response was absent without urea. Model results for tiller count response were qualitatively similar to the yield model. Preliminary results suggest that high forage yield requires sufficient inorganic N, and organic matter in composted manure may decrease N available for plant uptake.

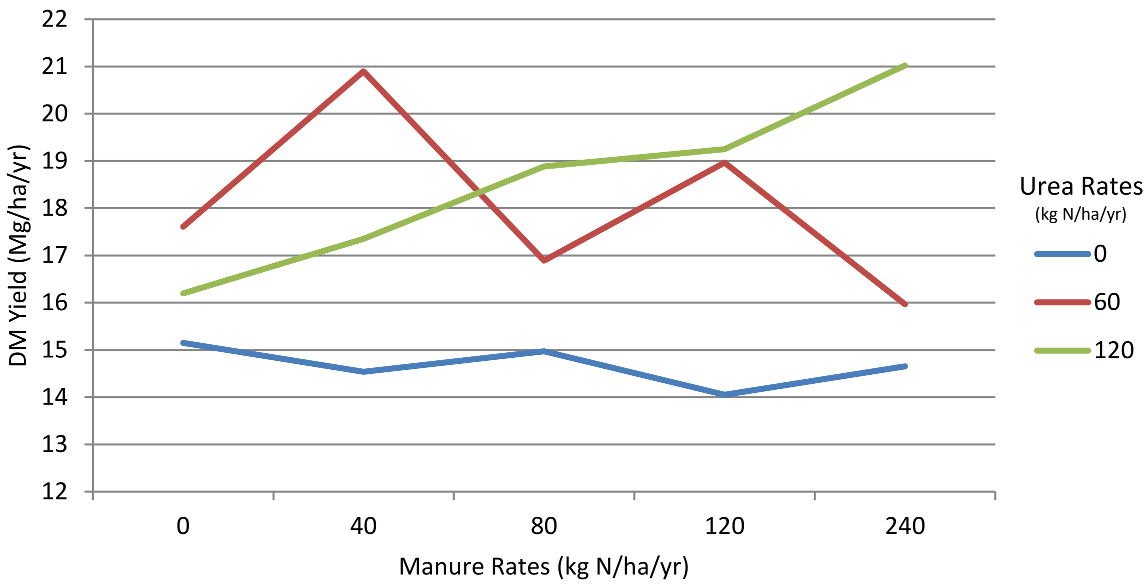


Figure 7.23 Least squared means of yield of Brachiaria cv. Mulato II, with five levels of manure and three levels of urea.

Cattle nutrition research priorities

Dr Peter Doyle was assigned, in collaboration with all project partners, to develop recommendations for a cattle nutrition research program that could ultimately impact on cattle production and profitability in South Central Coastal Vietnam. Recommendations were based on existing literature, previous studies in Central Vietnam, a visit to IAS, farm visits in Binh Dinh and Phu Yen, and discussions developed during a planning workshop.

It was agreed that:

- Dose response experiments provide more meaningful data (from the point of view of relevance to resource allocation on farms as well as scientific understanding) than those that compare different supplements at a single level of feeding.
- The use of yellow-cross cattle would be most relevant to the type of farmer ('producers') who might adopt the results from the research.
- Ingredients for supplementation would include those commonly used or available in the region, with rice straw and forage as a basal diet.
- The focus would be to examine responses in growth during the growing phase of ~200 kg bulls.
- A following experiment could focus on mature bulls.

Effect of supplementation on growing yellow-Brahman bulls

A cattle feeding experiment was undertaken at IAS Ruminant Research and Training Centre (RRTC) in late 2010 and early 2011. The aim of the research was to assess the growth and nutrient digestibility responses of Brahman-cross cattle to concentrate supplementation. Twenty ~200 kg Brahman-cross bulls were fed a basal diet (rice straw and Guinea grass) and supplement at 0 - 2.4% of live weight. The supplement consisted of cassava chips, rice bran, crushed rice, fish meal, urea, and salt.

Intake (Figure 7.24) of rice straw decreased with increasing levels of supplementation. Intake of Guinea grass also decreased but to a lesser extent. Intake of concentrate increased up to 2.4% of live weight, whereas total intake only increased up to 1.8% of live weight.

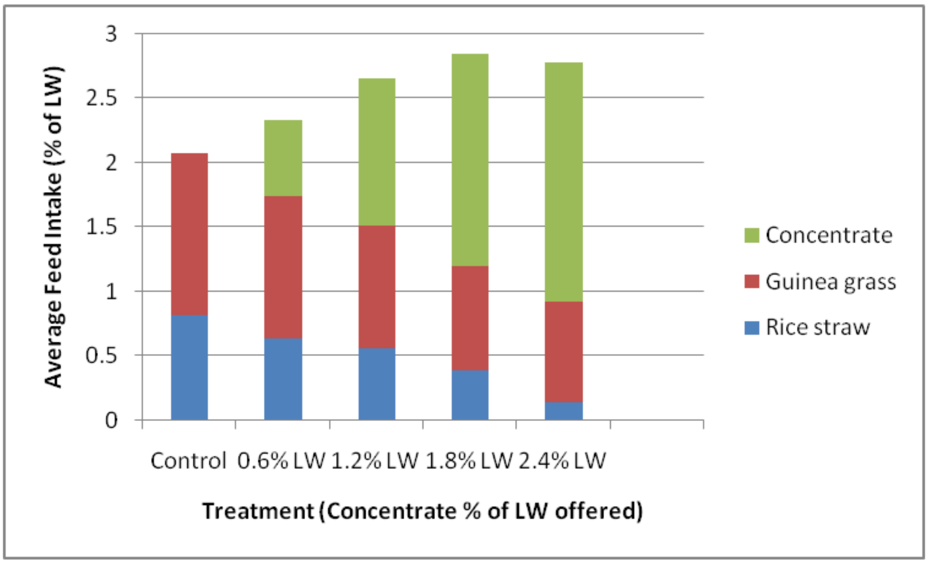


Figure 7.24 Feed intake of Brahman-cross cattle fed increasing levels of supplement.

Live-weight gain (Figure 7.25) increased rapidly with supplementation up to 1.2% of live weight, and plateaued at greater levels of supplementation. Because supplying supplement at 1.8% or 2.4% of bodyweight is more expensive, the 1.2% ration was a good balance between production and cost, and consequently resulted in the greatest net profit. All concentration treatments were more profitable than the control treatment.

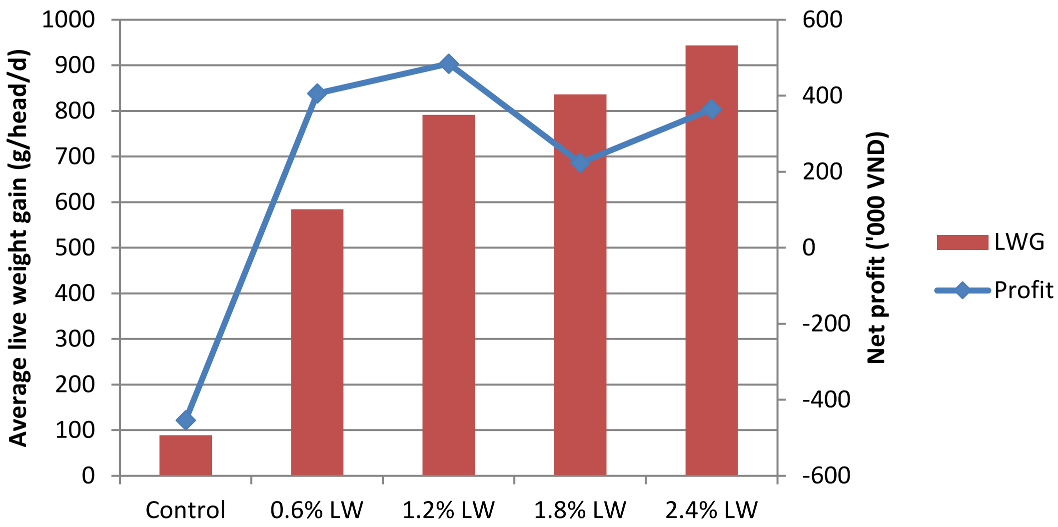


Figure 7.25 Average daily live weight gain of Brahman-cross cattle fed increasing levels of supplement.

Cattle nutrition modelling

The data from five cattle feeding experiments undertaken at HUAF were compared with simulation results using the Large Ruminant Nutrition System (LRNS). The objective of this study was to evaluate the predictions of dry matter intake (DMI) and average daily gain (ADG) of Vietnamese Yellow (Vang) purebred and crossbred (Vang with Red Sindhi or Brahman) bulls fed under Vietnamese conditions using two levels of solution (1 and 2) of the Large Ruminant Nutrition System (LRNS) model. The initial mean body weight (BW) of the animals was 186, with standard deviation ± 33.2 kg. Animals were fed *ad libitum* commonly available feedstuffs, including cassava powder, corn grain, Napier grass, rice straw and bran, and minerals and vitamins, for 50 to 80 days. Adequacy of the predictions was assessed with the Model Evaluation System using the root of mean square error of prediction (RMSEP), accuracy (Cb), coefficient of determination (r^2), and mean bias (MB). Both levels of solution predicted DMI similarly with low precision (r^2 of 0.40 and 0.45 for level 1 and 2, respectively) and medium accuracy (Cb of 0.827 and 0.859, respectively, Figure 7.26). Metabolisable protein was limiting average daily gain (ADG) for more than 68% of the treatment averages. The LRNS level 2 predictions of ADG (Figure 7.26) were satisfactory and better than those of level 1. The results suggest that the LRNS model is able to sufficiently predict weight gain of such Vietnamese cattle.

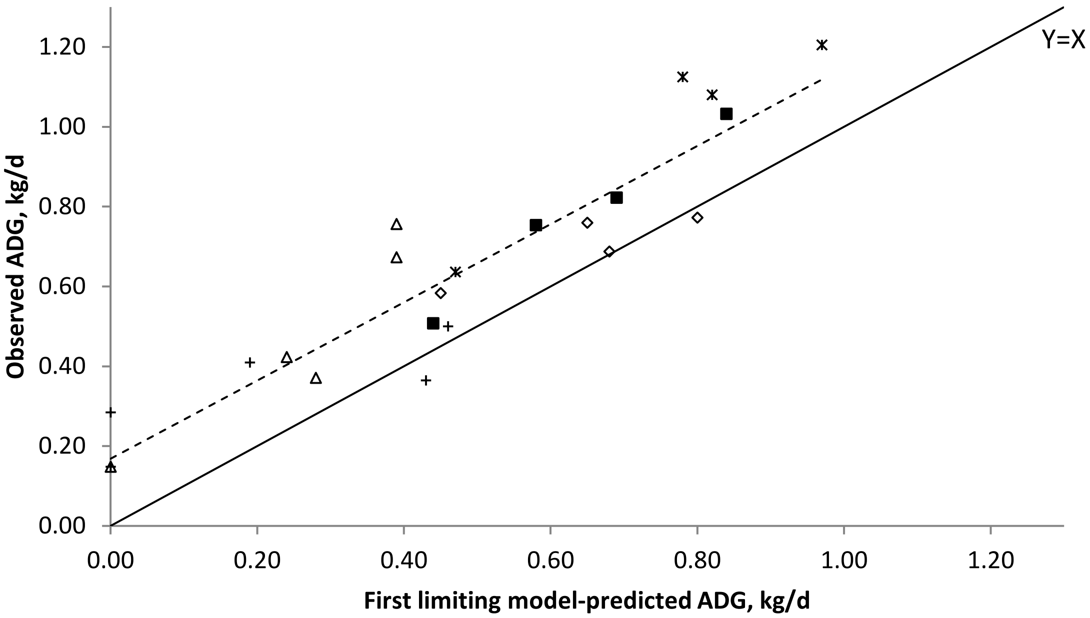


Figure 7.26 Relationship between observed and first-limiting model-predicted average daily gain (ADG) using the level 2 solution of the Large Ruminant Nutrition System. Symbols are studies 1 (◇), 2 (■), 3 (△), 4 (+), and 5 (∗). Solid line is the Y = X and the dotted line is the linear regression.

8 Impacts

8.1 Scientific impacts – now and in 5 years

While sands cover over 330,000 ha in coastal central Vietnam, limited soil characterisation of these soils has occurred before the present project. In the present project 69 profiles have been described, characterised for chemical and physical properties and key limiting factors identified. Soil profile descriptions and SCAMP analysis for Binh Dinh, Phu Yen and Ninh Thuan provide a solid platform for improved understanding of the properties and constraints of the sandy soils in study provinces and can be used to develop management recommendations for the sands of SCC Vietnam. Important scientific findings are the presence of compaction layers in the sub-soil of sands in Phu Cat district, evidence of P movement down sand profiles particularly where peanut and vegetable production occurs, strong soil acidity but limited levels of exchangeable Al, very low plant available levels of many nutrients (including N, P, K, S, B, Cu, Zn and Mo- but not all in each of the sands examined) and low water holding contents. A detailed report of these findings has been prepared (Appendix 2.1.2 (a)) and an abbreviated version of this will be made more widely available in Vietnam for soil scientists and agronomists.

Field trials with peanut in Phu Cat district and Ninh Thuan province have indicated deficiencies of P, K, S, Cu, Zn and B for pod yield and deficiency of Mo for shoot growth. Whereas K and S deficiency occurred in all five field trials, others were more soil type or location specific. This is the first time that S and a diverse range of micronutrient deficiencies for peanut have been confirmed in the field in SCC Vietnam. These findings will be reported in a journal article and also communicated to next users in Vietnam.

Given the consistency of the response to K, Cu, S and B in peanut in Phu Cat distict, we anticipated comparable responses in the tree crops. Indeed the 2-year's results in mango suggest a positive yield response to addition of micronutrients and K. Moreover, a positive yield response to K and micronutrients (B, Cu, Mo and Zn) was obtained in cashew in 2012. The findings on micronutrient response in mango and cashew are again novel finding for SCC Vietnam and will be reported in a journal article.

Our results suggest the need for a more systematic programme to determine the impact of K, S and micronutrient deficiencies on agricultural productivity (including animal nutrition) in SCC Vietnam, and to determine effective and profitable corrective practices in combination with NP supply as part of an integrated nutrient management programme.

Rice husk bio-char had positive effects on pod yield of peanut on a sandy soil. Yield increases were sustained for 4 successive crops, and the initial response was replicated in an additional trial with peanut. Additive yield benefits were obtained from combined application of biochar, NPK fertiliser and manure. Biochar also had positive effects on cashew yields for 4 consecutive years. This supports the value of including biochar in an integrated nutrient management programme for crop production on sands. ASISOV had already expanded bio-char trials to other SCC provinces, and the results are considered a promising new technology for SCC Vietnam led by ASISOV. In Vietnam, nearly 11 million tonnes of rice husk is produced each year that can be converted to biochar and used for crop production.

All the experiments on irrigation of peanut using the mini pan to guide irrigation frequency and amounts, have increased peanut yield and reduced water use in Phu Cat district on sands. These results are the first in SCC Vietnam to suggest that substantial improvements in water use efficiency can be gained by better irrigation technique for peanut. Tests with mini-pan irrigation of cashew were inconclusive because of frequent rainfall during the dry season at the study site in two consecutive years. An initial experiment using the mini-pan with mango was less successful than farmer's irrigation indicating the need to develop species-specific calibrations to achieve optimal water use efficiency for each crop.

Most farmers tend to integrate livestock and crop production to make their living and this practice generates an on-farm organic resource that is utilised to recycle nutrients. Nutrient export has been a growing concern worldwide and replacement by addition of inorganic fertilizers is expensive. Poor farmers have reduced capacity to buy inorganic fertilizers, hence application of compost from pits is a viable option for crop production. In addition, negative balances of K as has been observed from nutrient budget studies and low soil K levels from SCAMP analyses of these soils suggest an important role for compost use to maintain K supply for crop production. This practice can contribute to the annual flux of organic carbon in these soils and provide a better media for nutrient and water supply.

- Manure storage in pits under cover produced better quality compost than the farmers' practice of open storage in heaps, however, N and K content of the compost could be further increased if manure can be collected from the cattle holding pens for composting. Peanut crop yield using the manure stored in pits also tended to be higher. Field studies found improved peanut yield response from in-row application of manures compared to broadcast application.

While it is still premature to report scientific impacts from experiments as they require further validation:

- The time of planting assessment showed cowpea performance in Ninh Thuan was promising when sown in early September;

Current monitoring of the impact of agricultural practices on water quality, in vegetable growing areas of Phu Yen, is novel research for Vietnam. On coastal sands where high fertiliser rates are being used there is a concern about impacts on surface water and groundwater quality since this water is used for household purposes. However, other potential impacts on quality of water used by households come from cattle holding pens and domestic waste disposal. Conclusions from this work require additional monitoring to identify impacts and sources of contamination. These will be reported in the Master's thesis by Ms Truc in 2014.

The Versatile Multi-crop Planter (VMP) from Bangladesh was imported by Component 2 and initial testing has been conducted. This is a novel planter suitable for minimum tillage crop establishment when mounted on 2-wheel tractors. While it is premature to comment on the scientific outcomes of this Component 2 activity, minimum tillage elsewhere in the world has helped to build resilience in sandy soils by reducing wind erosion risk and increasing surface soil structure. Initial tests with soybean planting were satisfactory, but further modification of the planter would be needed for planting large peanut seed.

Evaluation of forage grasses and legumes has demonstrated that Mulato II and Paspalum are most productive on sands. They survive both wet season waterlogging and dry season drought conditions. None of the legumes were sufficiently promising to recommend for farmers. Findings from this work have informed the on-farm forage demonstrations in Component 3.

A number of suitable grasses are now available to fit various niche situations, and to appeal to the individual preferences of farmers. Although farmers are familiar with and like *Pennisetum* species because of their apparent superior biomass production, they are experimenting with Panicum maximum (TD58), Paspalum atratum, and Mulato II. Rather than recommend forages to farmers, we are encouraging farmers to select the forages that appeal to them. As expected, the herbaceous forage legumes are unlikely to make an impact. However, *Leucaena leucocephala* is appealing to a number of farmers who have begun to plant it as a living fence and a feed source.

An experiment at IAS examined the growth and nutrient digestibility response of Brahman crossbred bulls to increasing levels of concentrate supplementation. They found that live weight gain increased with supplementation up to 2.4% of live weight.

The data from five cattle feeding experiments were compared with simulation results using the Large Ruminant Nutrition System (LRNS). The results showed that the model is able to sufficiently predict weight gain of Vietnamese cattle and is thus useful as a tool for assessing options for improving production and efficiency.

Two experiments at UQ showed how Brahman crossbred steers at different physiological stages of development respond to supplement intake and feed type. In general, they found that young steers do not always gain weight faster than mature steers on the same diet.

The participatory and farming systems approaches used to foster uptake of livestock improvement technologies and developing institutional capacity are proving to be effective, and can likely be applied more broadly to SCC farming systems, and other areas of Vietnam.

8.2 Capacity impacts – now and in 5 years

C1

Staff of component 1 have improved their knowledge, skill and capacity in conducting value chain analyses through training and practical application of methodology.

Dr Phan Thi Giac Tam travelled to Adelaide in February 2010 to speak at the ACIAR organised workshop on The Role of Value Chain Research in Agriculture and Food Policy and attend the Australian Agricultural and Resource Economics Society (ARRES) conference.

Ms San Tram Anh of SIAEP was awarded a John Allwright scholarship for a Ph.D. program commencing in June 2012 at the University of Queensland studying mango fruit quality.

DARD extension staff from Binh Dinh, Phu Yen and Ninh Thuan were trained in the use of the Farm Economic Model at an introductory level in mid 2012 and later in 2012 after taking the model and applying locally. Training was carried out by Dr Phan Thi Giac Tam with assistance from the model developer, Peter Gartrell.

IAS staff delivered value chain training to regional DARD staff (total 46 participants) in the 3 provinces November 2012

A group of 24 mango growers from Cat Trinh and Cat Hanh communes in Binh Dinh province received introductory GAP training from SOFRI staff in January 2013

C2

Mr. Do Thanh Nhan, researcher of ASISOV (Soil and Environment Department) was awarded a Crawford Fellowship for one month training in analytical chemistry, glasshouse and field trials at Murdoch University (Aug/Sept 2012).

Mrs Giang Nguyen Thuong, researcher of ASISOV (Soil and Environment Department) was awarded Crawford Fellowship for one month training in analytical chemistry, glasshouse and field trials at Murdoch University (Aug/Sept 2012).

Mr. Nguyen Viet Vinh, Master student (HUAF) undertook his research project on nutrient budget at field and farm level in three provinces under Component 2.

Le Hoai Lam Master student (HUAF) undertook his project on manure research under Component 2.

Mr. Do Thanh Nhan, researcher of ASISOV (Soil and Environment Department), participated in the nutrient and omission (ground nut) trials under Component 2 and successfully completed his MSc thesis.

Ms Fariba Mokhtari obtained a PhD scholarship from Murdoch University, and is undertaking research on the role of bio-char and clay in improving nutrient use efficiency on sandy soils. This work is being conducted in collaboration with the ACIAR project including the Esperance field trials and focuses on P.

Ms Do Thi Thanh Truc of IAS was awarded a John Allwright Fellowship for a Master of Philosophy at Murdoch University. She passed the IELTS English entry and joined Murdoch and is now pursuing her Master's under the supervision of Prof. Bell with co-supervision of Dr Mann. She has been monitoring water quality in An Chan over the past 18 months. She has also completed a field experiment on vegetables (pumpkin) in An Chan with the help of Dr Chon of IAS and is continuing with this research to complete her Master's in 2014.

Nguyen Huu Trung of HUAF was awarded a John Allwright Fellowship for a Master of Philosophy at Murdoch University commencing in 2011. However, he declined after being awarded a Fullbright Fellowship to go to the USA.

Mr Nguyen Thai Thinh of ASISOV was awarded a John Allwright Fellowship for a Doctor of Philosophy at Murdoch University commencing in 2012. He commenced English language preparation in December 2011. He will be joining Murdoch English course in January 2013 and later, after he fulfils his IELTS requirement, join his Ph.D program at Murdoch University under the supervision of Prof. R.Bell and co-supervision of Dr Mann and Dr Tam.

Through Annual Meetings and regular visits, all participants have improved capacity to contribute effectively to an international collaborative, multi-partner project: this includes interpretation of data, presentation skills, project planning and negotiation.

C3

Component 3 has endeavoured to provide opportunities for its team members to improve their skills through a range of capacity building activities.

- Nguyen Huu Van received a John Dillon Memorial Fellowship and spent 6 weeks in Australia in 2010 undertaking training in research management.
- Nguyen Xuan Ba and Le Dinh Phung visited UTAS for professional development in 2010. Their visit included developing an understanding of the UTAS teaching and research farm (enterprises and management arrangement), visiting a large scale sheep farm, a beef feedlot, and learning about farming systems. An MOU between HUAF and UTAS was subsequently developed to facilitate future exchange for staff and students.
- David Parsons and Le Dinh Phung visited ACIAR-funded cattle projects in Cambodia, to provide an opportunity for transfer of knowledge between projects.
- In May 2011 a small group visited a long-standing forage development project in Dak Lak province. The results of their project, achieved largely through on-farm participatory research, were impressive, and clearly demonstrated to the team what could be achieved in SCC.

Component 3 has also involved students in the project in a number of ways:

- Nguyen Hai Quan received a JAF scholarship to study at UTAS, and began in August 2011.
- Tran Thanh Hai also received a JAF scholarship and will begin his Masters at UTAS in the second half of 2012.

- Joshua Scandrett (UTAS) spent 11 months in Quy Nhon as an Australian Youth Ambassador for Development (AYAD). Another AYAD position is currently being advertised.
- Russel Whitmore, a third-year agricultural science student at UTAS based his industry project on activities in SCC Vietnam
- Edward Patterson, a fourth-year agricultural science student at UTAS based his honours research project on activities in SCC Vietnam.
- Keenan McRoberts, a Cornell University Ph.D. student is conducting an on-farm experiment in Cat Trinh, examining the effects of increasing rates of urea and manure on forages.
- Cuong Hung Pham completed his Masters Degree at the University of Queensland, investigating 'Growth response of young and mature steers with respect to feed type (grain or forage) and supplement type (energy or protein-based supplement).
- HUAF Masters students Tong Vinh Trung and undergraduate student Dong Si Trung focused their research on project related activities. In addition, one Masters student and four undergraduate students are currently working on project related activities.

Training for project team members:

- A seminar presentation by Dr Aduli Malau-Aduli at HUAF in 2010 on the impacts of genetics-nutrition interactions on beef cattle and sheep production.
- A training course on cattle nutrition and use of the CNCPS model was conducted at HUAF for project staff and people from Faculty of Animal Sciences, and the Faculty of Extension and Rural Development. Approximately 40 people attended the workshop, including both staff and students. The workshop was presented by Dr Luis Tedeschi from Texas A&M University. Following this workshop a two-day small group workshop was led by Dr Tedeschi, which focused on using the CNCPS model for predicting growth of Vietnamese cattle.
- A Farming systems training workshop was held at HUAF and presented by Shaun Lisson, Cam McDonald, and Le Dinh Phung. Approximately 40 project team members and HUAF faculty and students attended.

Extension capacity of RDCAH, commune extension, and DARD staff has been enhanced through participation in on-farm activities and field days. The project has resulted in increased capacity of farmers, project team members and extensionists, through training activities (forage management, forage variety selection, ruminant management and breeding, and cattle fattening).

The Vietnamese scientists in the team have typically received promotion and/or increased responsibilities during the course of the project. This demonstrates increased influence in their organisations and increased capacity to undertake this type of complex project. We expect that current project participants will be involved in and leading similar projects in the future.

8.3 Community impacts – now and in 5 years

The capacity of the project to make an impact on the community has been increased by the appointment of 3 Australian Youth Ambassadors to the region with a particular emphasis on the assessment of the effectiveness of the project and assisting in field trials. The tenure of these projects has varied between 3 and 12 months and all have assisted in both clarifying the purpose and methods of the project and importantly resulted in greatly improved English skills of research staff.

8.3.1 Economic impacts

The potential for improved economic advice has been greatly enhanced by development of the Farm Economic Model (FEM) tool over the course of the project. The regional advisory staff are now able to evaluate the economic impact of different mixes of enterprises options allowing a greater understanding of outcomes and the effect of changes in commodity pricing.

The Project Evaluation workshop of September 2009 was used to identify next users and end users so that economic impacts can be maximised. Final users identified through this process were: cashew farmers in Ninh Thuan including those with livestock; cashew, peanut and mango farmers in Binh Dinh including those with livestock; vegetable-rice farmers in Phu Yen, including those with livestock, and; farmers in neighbouring provinces with sandy soils (Binh Thuan and Khan Hoa) producing similar crop commodities.

No direct economic impacts from Component 2 have yet been identified. However, economic analysis of peanuts, cashew and mango carried out from experiments conducted on farmer's field under Component 2 indicates that profits can be increased by i) supplying deficient nutrients, especially S and micronutrients (Figure 8.1), ii) utilizing available farm organic resources like biochar, manure, crop residues (Figure 8.1), iii) saving cost of labour and water by using mini-pan to guide time of irrigation (Figure 8.2; Figure 8.3). Of all the crops tested, mango (Figure 8.5) seems to be the most profitable crop in Binh Dinh followed by peanut and cashew (Figure 8.4). However, mango takes nearly 8 years to reach optimum production. Intercropping of annual crops (peanut, cowpea, mung bean etc) during the time of mango establishment may be an option for farmers to earn some income till it starts to fruit.

The yield increases from addition of bio-char and of adding K, S and micronutrient fertilisers will certainly increase gross margins of peanut, cashew and mango crops. In addition, savings from reduced P fertiliser application in Phu Cat district could further improve profitability of peanut production. Similarly, labour savings from the use of the mini-pan should improve profitability of peanut. Effects on profits will have to be determined after farmer's start to adopt these practices.

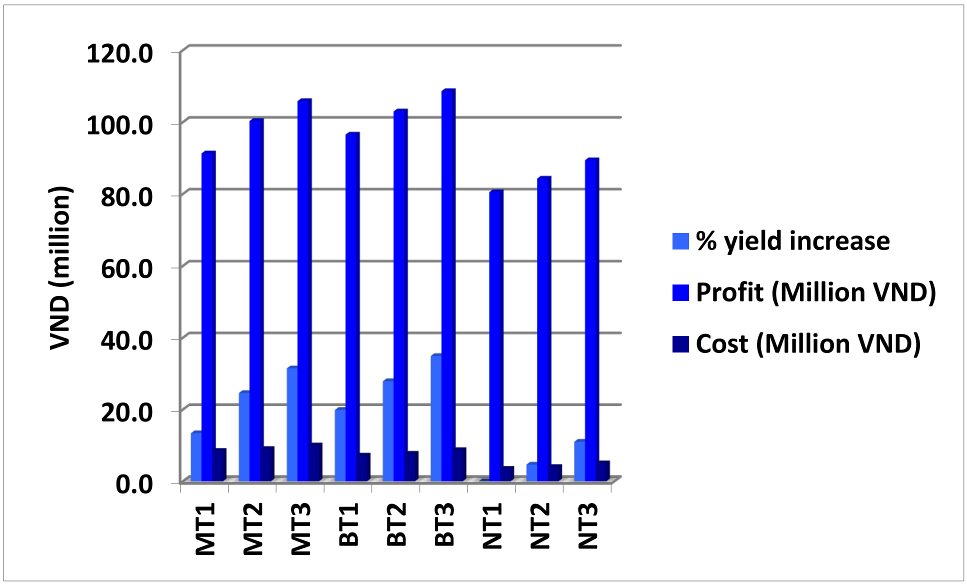


Figure 8.1 Economic benefits as a result of Integrated Nutrient Management with amendment treatments of manure (M), biochar (B) and inorganic fertilisers (N) with nutrients N, P, K (T1), N, P, K, S (T2) and N, P, K, S and micronutrients (T3) on peanut yield at two sites in Binh Dinh.

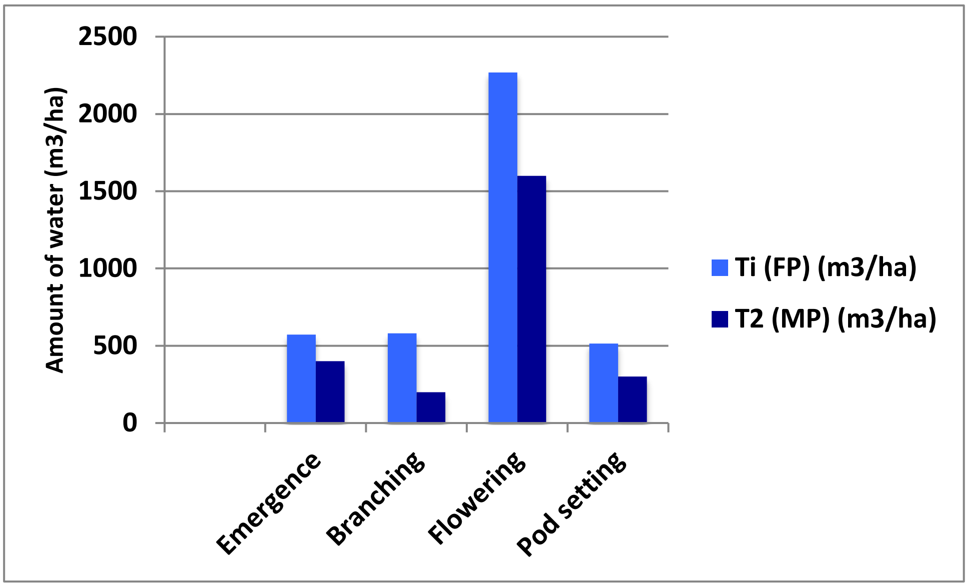


Figure 8.2 Water savings at different stages of peanut growth as guided by mini-pan (T2) compared with farmer's practice (T1).

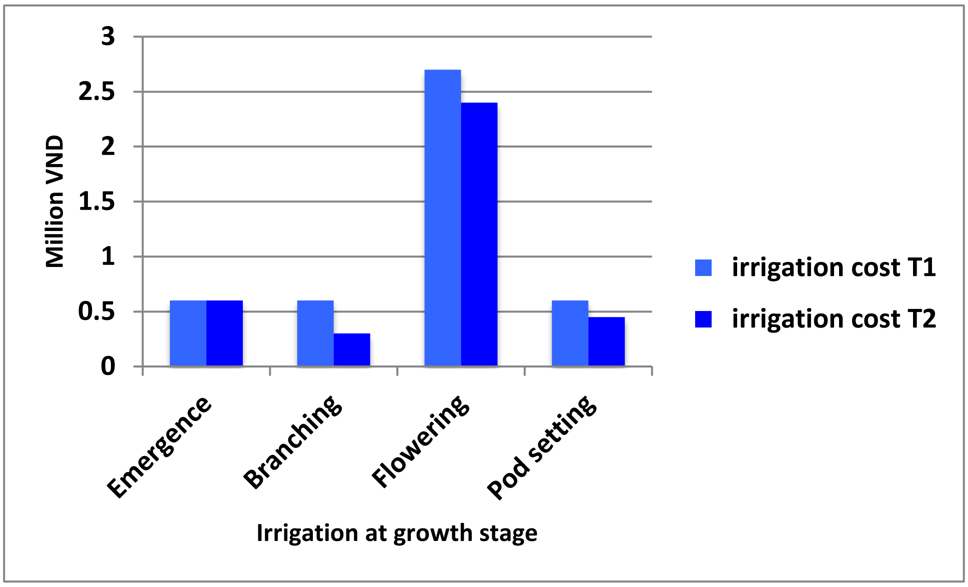


Figure 8.3 Labour cost for irrigation by mini-pan (T2) vs farmer's practice (T1) showing savings possible with mini-pan.

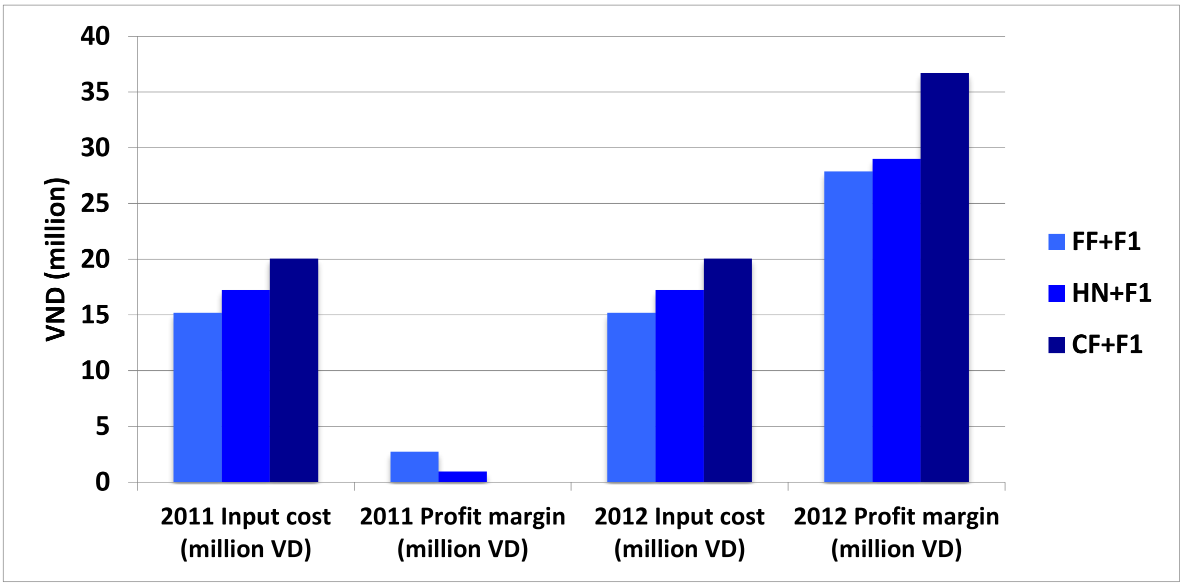


Figure 8.4 Cost and profit for cashew crop based on farmer's irrigation (F1) with farmer's fertiliser (FF), high N fertiliser (HN) and NPKS+ Cu, Zn, B and Mo (CF) in 2011 and 2012.

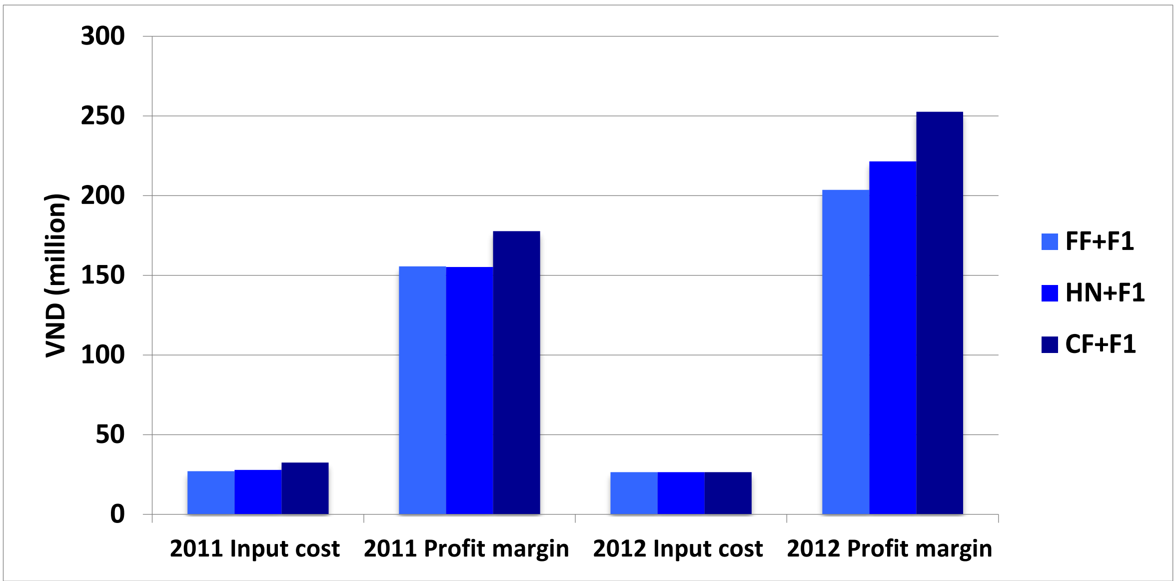


Figure 8.5 Cost and profit of mango comparing farmer's irrigation (FI) and mini-pan (MP) with fermer's fertiliser (FF), high N fertiliser (HN) and NPKS+Cu, Zn, B and Mo (FC) in 2011 and 2012.

Although it is early to assess economic impact of livestock activities, results to date are encouraging based on the rapid uptake of forage grasses, suggesting that farmers can reduce production costs through reduced purchased feed. This will be further assessed through continued impact assessment of best-bet activities.

8.3.2 Social impacts

It is too early to quantify definite social impacts of the project. However, impact assessment suggests that best-bet farmers in all provinces have reported labour savings as a consequence of expanding their fresh forage areas since the project began. While this is now only a minor impact, it is an example of what we hope to see with other best-bet farmers, and represents a good early result which we might attribute at least partly to project engagement.

The project component has been designed to benefit households involved in cattle production enterprises, and measurable impacts are forecast in the short to medium term.

The technologies introduced are expected to deliver benefits to households across different wealth classes, but are aimed predominantly at resource-poor smallholders. The project component is examining social issues associated with livestock production, including labour constraints and the roles played by women, children and the elderly in farming activities. This evaluation of social impacts is an integral part of the research process.

The leaching of nitrate from under livestock housing areas adjacent to households needs more intensive examination. There is a risk that on sands over shallow groundwater, that this water resource could be contaminated with nitrate (and possibly pathogens) and represent a health risk for household use. More evidence of the likelihood of such a risk will be reported in the MPhil thesis of Ms Do Thi Thanh Truc.

8.3.3 Environmental impacts

Initial water sampling of stream water and shallow groundwater has begun in An Chan commune. It reveals high P concentrations in surface water and groundwater but more importantly nitrate levels were above acceptable levels for household use in groundwater from wells or bores in several cases in 2011-12. A shrimp pond operation in An Chan commune was found to cause substantial increases in electrical conductivity of downstream groundwater. This water quality sampling programme continues through 2012-13 and may include measurements of pesticides and pathogen levels as well as nutrients in stream and ground water. The aim is to identify impacts of agriculture including vegetable production and livestock housing on water quality in the sandy coastal zone where water tables are quite shallow. Field experiments undertaken by Do Thi Thanh Truc will explore treatments that can reduce nutrient loss from fertilised vegetable crops and improve water use efficiency.

Environmental health benefits from better manure handling and storage are expected from the uptake of covered manure systems, especially the case in most communes where the livestock are in close proximity to residences.

Positive environmental impacts are envisaged as farmers change from extensive to semi-intensive production systems that focus on utilization of local feeds. Converting crop residues and by-products into manure for use in vegetable and cropping systems at a scale appropriate to smallholder systems will provide benefits in minimizing synthetic fertilizer use. Increasing the integration of cattle production systems with cropping can improve cattle production whilst minimizing the potential negative environmental impacts often associated with intensive livestock production.

8.4 Communication and dissemination activities

Workshop by Deborah Templeton on Evaluation training for agricultural research projects: Orientating and designing projects to make a difference. Sept 21-22 Quy Nhon

A 3 day value chain training workshop was conducted for Component 1 staff and invited regional DARD staff in HCMC in August 2010

Two workshops were held in early December 2011 to discuss value chain findings and the Farm Economic Model with regional DARD staff. One workshop for DARD staff from Binh Dinh and Phu Yen was held at ASISOV while the other was held at the Ninh Thuan DARD office in Phan Rang.

Two Farm Economic Model workshops were held on-site for the DARD staff from Binh Dinh, Phu Yen and Ninh Thuan in 2012 and further training has been requested for the final workshop in March 2013.

Three value chain training courses (1 in each province) were conducted by IAS staff for regional DARD staff in November 2012.

Mango GAP training for 24 mango growers from Cat Trinh and Cat Hanh and 4 regional extension staff conducted by project and other SOFRI staff in January 2013.

SCAMP training workshop provided by IAS to ASISOV staff in June 2009.

Several QA/QC training sessions have been undertaken with ASISOV including the development of a leaf sampling protocol for Component 2 and IAS staff travelled to Qui Nhon in January 2011 to provide in-the-field training on the correct leaf sampling and handling procedure. Subsequent leaf sampling has been undertaken by ASISOV which was previously provided by IAS from HCMC.

A soil sampling exercise was conducted with ASISOV staff in the field in September 2011 to build in house capacity to sample and prepare soils for chemical analysis. This included training in measuring field capacity in the labs at ASISOV to build in house capacity.

Two one- day plant analysis seminar/ workshops by Richard Bell in November 2010. This was followed by seminars at IAS and ASISOV in July 2012 on Management of tropical sandy soils.

Specific communication and dissemination activities for Component 3 include the following:

- Workshops on planning of best bet practice on cattle production July, 2010
- 2 nutrition scenario modelling workshops were held with local farmers in July 2010.
- Forage establishment management workshops (3) were held for farmers in 2011. Approximately 30 farmers attended each workshop.
- 3 Forage selection ‘on-farm’ workshops (3) were held for Provincial and District DARD, with excellent feedback of their usefulness.
- Ruminant nutrition and breeding workshops for farmers (3 workshops).
- Cattle fattening training for farmers (3 workshops).
- Cattle fattening demonstrations in each province.

DARD workshops in Binh Dinh and Phu Yen Dec 2011

- Two videos, featuring forage management and cattle fattening, produced and featured on National television.
- A trip, funded by the Crawford fund, involving taking approximately 70 farmers, extension officers, and researchers from the SCC to Dak Lak to meet with and learn from successful cattle farmers.

A Final Project seminar is planned for March 2013, to deliver key findings and recommendations to the next users.

For Component 2, this will be followed by publication of a series of papers on key findings of the research:

Nutritional constraints to peanut production on sands of coastal Vietnam
Improving water use efficiency in irrigated crops on sands in small holder farms

Resource utilisation and nutrient balance in smallholder farms in sandy terrain

Increasing effectiveness of manure as a soil amendment in sands

Integrated nutrient management for crop production on sands

Biochar for crop production in WA

Effects of land use on soil organic carbon in sands of the south coast region of WA

Sands of coastal central Vietnam

Nutrient forms and mobility in sands amended with biochar and clay

Effects of claying sand on crop production

Degradation in surface and groundwater quality in coastal central Vietnam

Nutrient use efficiency in vegetables

9 Conclusions and recommendations

9.1 Conclusions

The present project has developed a clearer understanding of key value chains for agricultural commodities, characterised the constraints on the sands of SCC Vietnam, demonstrated the productivity gains from balanced nutrient inputs, soils amendments and better irrigation scheduling and shown improved profitability of beef cattle management through better quality forages and programmes to improve on-farm practices. Many interventions for improved market access and profitability of cropping and beef cattle enterprises have been identified and partially tested. Sustainability of groundwater resources was identified as a significant issue for the SCC region of Vietnam. More details of these findings are outlined below.

Value chain analysis of some key agricultural products (viz, peanuts, mangoes, cashews, cassava, beef, sesame and garlic) reveals a wide range of potential chain improvements that would benefit farmers in the SCC region. There are clear opportunities to boost productivity and profitability within the common low input farming systems. Many of these are the subject of soil fertility, crop and animal nutrition and irrigation research within the project. Progress has been made on understanding and facilitating improvements in a range of product quality related issues More specific conclusions related to value chain analyses are:

Farming systems incorporating peanuts are well suited to intensive cultivation on poor sands, particularly in Binh Dinh province. These farming systems help poverty reduction and soil improvement. However, the development of these farming systems has resulted in the depletion of groundwater in the dry season, due to overexploitation and possibly exacerbated by climate variability. Recognizing the severity of water depletion, farmers have begun to apply water-saving measures such as sprinklers while biochar made from rice straw is another input with potential for increased water use efficiency.

To overcome the increasing effects of storms due to climate variability, Binh Dinh authorities have supported fall-winter peanut cropping to replace cassava in the rainy season. This peanut crop, despite low productivity due to post-harvest damage, is still economically viable for farmers because of high prices. The postharvest problem is potentially solved by the introduction of grain dryers trialled in this project.

Cashew plantations are significant in agricultural production in the SCC although many policies and technical problems need to be solved for higher productivity. Constraints in cashew production include lack of improved varieties, poor site selection and lack of good grafted trees for planting. There are many unproductive orchards where yields are low due to a low-input production approach. Yields can be increased by adoption of more intensive production methods in plantations of suitable grafted varieties. Balanced crop nutrition including micronutrients has been show to boost yields. Domestic cashew nut supply is inadequate to fulfil the requirements of processors. The cashew processing industry is, however, a potential major source of jobs for the population in the SCC region. Phu Yen and Ninh Thuan cannot supply enough raw cashews to meet processor demand and processors are dependent on importing raw cashews.

While cashew yields and profitability can be improved, it is suggested that cashew should not be considered as a crop in Phu Yen and Ninh Thuan provinces that is capable of improving the standard living of farmer. However cashew trees are adapted to soil and climate conditions in other areas of Vietnam and cashews generate high export revenue so that it is important that a clear cashew industry development strategy is available.

Mango production in the three focus villages (Cat Trinh, An Chan and Phuoc Dinh) is small-scale with low investment and productivity. The number of fruit traders is low and linkages between mango growers, collectors, wholesalers and retailers is still limited.

Growers receive a high proportion of the profit in the mango value chain however lack of capital often limits inputs such fertilizers. A significant market opportunity currently exists for SCC mango producers because their main season is later than the main season in the Mekong Delta region. However, it is important to note that increasing 'off-season' production of mangoes from the Mekong Delta is occurring via the use of growth regulators to manipulate flowering time. To capture mango market opportunities, SCC mango quality and postharvest will need to be improved.

Cattle husbandry makes an important contribution to family income of farm households in the SCC region. Price of live cattle and beef meat has tended to move upward, and demand for beef is strong in the south and city markets. Farmer's attitudes to cattle production are changing rapidly with more focus on intensive management and breed improvement. Government policies and private enterprise will improve both quality and quantity of cattle herds in the three provinces by supporting the establishment of slaughter facilities, veterinary services, programs of artificial insemination, and expanded pasture and forage production.

Cassava products and by-products are important feed sources for cattle especially during the dry season. Cattle manure is an important source of nutrients for cropping land. Cattle husbandry is an important and increasing source of income and cash-flow. Income from cattle fed on cassava by-products is a source of capital for cassava cultivation and vice versa in the farming system.

In recent years, high variation in the cassava price influenced farmer income. Reduced selling prices (at farm-gate by 20%) combined with increasing input costs led to 2011 cassava profits about 30% lower than in 2010. Small-scale cassava processing units (sticky and dried starch processing) generate more stable income and help mitigate risks of falling prices. The storage of cassava roots by traditional methods and use as a feed for fattening the cattle or as a source of modified feed in the dry season is a high-efficiency option for the farmer households in the context of falling fresh root prices. Production of cassava chips is also highly efficient but this depends on good weather, having only small-scale capacity and needs high labour input. Starch processing factories still play an important role in the cassava value chain however dependence on the Chinese market is risky.

Sesame is a drought tolerant, short season, high value crop, although yields are generally low under rainfed conditions on sandy soils in the South Central Coast. Sesame is a good fit in rotation with peanuts in this region. For sesame production, farmers often lack access to capital to increase scale and adopt improved production technology. New varieties of sesame with higher yield and quality are a high priority for industry development. The biggest issue for sesame collectors is access to capital. Traders also lack capital and bank loans are difficult to source, so private loans with high interest rates are common. Equipment to measure moisture content of sesame seeds and suitable transportation are needed by sesame collectors. Assessment of market demand is difficult because there are not close links between sellers and consumers. Although the collectors play an important role, there is no policy or system supporting price information. For sesame, the long value chain and loose linkages don't encourage focus on quality control along the chain.

The small garlic produced in Ninh Thuan a reputation for superior flavour in Vietnam . It is a relatively minor crop but important in that is one of only a few crops that can be profitably produced on sandy soils in Ninh Thuan. Together with onions, garlic has contributed significantly to household income. The sector in the province appears to be declining in area and production. Yield has been unstable in recent years because of a combination of unfavourable weather and poor farming practices. Ninh Thanh garlic is still well-known and perceived as a specialty item, and still attracts the highest price amongst current garlic on the market. Demand from both domestic and foreign markets appears still viable as supply has not met demand yet. The relatively small production scale causes some disadvantages in terms of price forecasting and setting.

With regard to garlic production, high levels of inputs and associated high production costs are major problems. These are associated with overuse of pesticides and incomplete fertiliser application. While growers in Ninh Thuan have long had experience with growing garlic they appear to lack technical knowledge and skills to cope with emerging conditions such as climate extremes and disease incursion. Resulting low yields and poor quality are reducing growers' profits.

Due to its long association with garlic, the province had a strong and experienced collector force, traders and a network that links from local production to market. The fact that there are presently individuals and traders who are pioneering and promoting safe production and safe products to market is considered to be a strength. The value distribution within the chain seemed fair except for the deduction ratio that has long been applied to growers. It is recommended that this undergo further testing and improvement.

Many initiatives and programs have been undertaken by local authorities to strengthen the agricultural sector, including garlic. This has included support for safe vegetable production, improved cultivation techniques, extension training, increased competitive advantage for agriculture, technology transfer, and marketing and business development. These efforts and endorsement are highly evaluated as valuable strengths and opportunities to sector development. The current situation requires a platform to forge linkages amongst growers, growers to traders, technician expertise and research for the sector. The value chain concept involves diverse stakeholders and requires a coordination role for a platform to facilitate dialogue, and mobilise and coordinate resources. Ninh Thuan's garlic is considered as a specialty, which implies that local culture needs to build on this and requires collective action.

From the situation analysis, this study defines key constraints and bottlenecks in the sector's value chain. These include (1) Low productivity, improvement of which should be the top priority to improve the sector within the province; (2) Small production scale although land resources are still available; (3) Low garlic quality and its control is another critical factor to improve Ninh Thuan garlic since it already has the advantage of being positioning as a specialty product; (4) Weak networking amongst growers to facilitate the exchange of knowledge and skills of farming techniques as well as market information; (5) Unofficial trademarks could impact on quality and product credibility as a whole because there is no collective action nor quality control protocol, and (6) A platform is needed for better coordination, collective action, 'think tanks' and development of policies to facilitate sector development. Based on successful models in other regions such as growers' associations, 'think tanks' that consist of practitioners, expertise, researchers and policy makers should be formed to build local resources. Regular dialogue should be organised to discuss and share timely issues and opportunities across the sector and making available an incentive policy for agriculture similar to that for agriculture investors would be of great benefit to sector development.

A set of strategies, interventions and action are proposed based on the situation analysis of the garlic sector in Ninh Thuan, primarily to tackle the constraints and bottlenecks defined above. The interventions and actions should start with basic research and testing and scale up to large scale demonstrations at the farm level. The actions are aimed at building the entire logistics and supply chain from growers to market. Moreover, Ninh Thuan garlic has been considered a specialty, which implies recognition of a local feature and culture. Benefiting from this to develop the local garlic industry requires collective action and coordination. We recommend the establishment of a local garlic association.

Sands occupy over 0.5 million hectares in Vietnam, with over two-thirds of that area in central coastal Vietnam. A range of constraints limit agricultural productivity on these coastal sands. The present project determined the range of sand profile types in SCC Vietnam, their origin and distribution, and key limiting properties. Study areas were located in Phu Cat district Binh Dinh province, Tuy Hoa district Phu Yen province and Ninh Phuoc district Ninh Thuan province to capture the main variation in types of sands and climatic influence on land use. The sands were diverse in their: clay content, soil colour, pH and texture trend with depth. Most of these difference can be attributed to parent material which comprised aeolian sands (from white and red dunes), alluvial terraces, marine sediments, colluvial sediments (mostly from granite) and *in situ* weathered granite with or without surface re-working of sands by aeolian, fluvial or slope processes. Most of the sands were acid, but even when strongly acid contained little extractable Al. Alkaline sands in restricted areas were also identified in Ninh Thuan and Phu Yen. Organic carbon, CEC and water retention at -0.1 bars were generally very low but clearly increased with clay content that varied from 0 to close to 20 %. Management influences on sand properties were also evident. On acid sand that have been used for crop and vegetable production there was evidence of P leaching down profiles. Peanut fields in Binh Dinh often had elevated near-surface pH attributed to repeated lime applications. In Binh Dinh there was evidence of compaction of sands in the rooting zone for crops. Strategies for improved management of the sands including clay enhancement are discussed in Appendix 2.1.2(a).

In addition to the constraints identified in the SCAMP assessment of 69 profiles, a diverse range of nutrient disorders were diagnosed in sands in Phu Cat district, Ninh Phuoc district and An Chan commune, Vietnam. On most of the sands, multiple deficiencies were identified. While K and S were deficient on all sands tested, the suite of deficient micronutrient deficiencies varied among types of sands. Hence, it is concluded that nutrient deficiencies need to be systematically diagnosed in SCC Vietnam in order to develop productive and profitable cropping systems. An initial summary of deficiencies diagnosed in the present project is as follows:

Sand type	Nutrient disorder	Experimental evidence
Phu Cat district		
Yellow-brown sandy loam	K, (B, Cu, Zn, Mo)[a]	Cashew yield in field trial
Pale deep sand	K, S, B, Cu	Peanut pod yield
	P, K, S, Cu, B, (Zn, Mo)	Corn, pot experiment (sub-soil)
Deep grey sand	K, S, B, Cu	Peanut pod yield
Brownish sand	K, S, B, Cu	Peanut pod yield
Pale brown sand	K, (B, Cu, Zn, Mo)	Mango fruit yield
Ninh Phuoc district		
Red sand	N, P, K, S, Zn, B	Peanut, pod yield
Sand on granite	P, K, S, Cu, B, (Zn, Mo)	Corn, pot experiment
An Chan commune		
Grey sand	P, K, S, Cu, B	Corn, pot experiment

a. Elements enclosed in parentheses were supplied as a combined treatment hence the causal deficiency or deficiencies has not been defined.

Irrigation is essential for peanut production in the dry season in Binh Dinh province. Using the mini pan to guide irrigation frequency and amount of water to apply increased peanut yield in Phu Cat district on sands compared to the farmer's irrigation practice. The yield increase varied from 0.23 to 0.5 t/ha in the three years, 2010-2012. Importantly, the number of irrigation events required decreased by 50 % with substantial labour savings from the use of the mini-pan to schedule irrigation. The results suggest that substantial improvements in water use efficiency can be gained by better irrigation techniques (mini-pan) for peanut. However, further experiments to validate these findings across a wider range of sites on farmers' fields are needed, together with a programme to demonstrate profitability on a larger field scale. In addition, more efficient water delivery and labour savings may be possible with alternatives to the current practice of watering by hand-held hoses.

Water resources have been identified as being under threat through a combination of over-utilisation, drought or climate change, and contamination throughout the study area. Hence the present findings suggest that irrigation efficiency can be greatly improved in some crops at least, but that more systematic evaluation of the best technologies for farmers in SCC Vietnam is urgently needed.

In summary, there appear to be multiple nutrient deficiencies in many of the crops studied, and opportunities for considerable savings in water through improved irrigation practices on sands of SCC Vietnam. Hence, significant productivity, profitability and sustainability gains are possible through integrated nutrient, soil and water management in this region. However, systematic programmes of research are needed to design packages of practices suitable for farmers in SCC Vietnam. These need to be supplemented by programs to test recommendations and investigate further options for adoption by farmers. Better management of organic by-products in the farm system (e.g. manure, biochar, crop residues) and inclusion of livestock in the on-farm studies should be integral to such investigations.

Increasing nutrient retention and fertilizer use efficiency in sands is an important issue both on the south coast of WA and on the coastal sandy soils of SCC Vietnam. In many respects the soils are similar chemically and physically. Clay and organic matter are key sources of cation and anion exchange in soils. Technically it is possible to increase organic carbon in soils so long as the carbon inputs exceed that lost through microbial respiration and through erosion. On the south coast of WA, an increase of 10 t/ha is possible using perennial pastures. This equates to an increase in organic carbon of 0.6% within the 0-10 cm layer and potentially an increase in CEC of 2 cmol/kg. However it has been shown that this may take > 30 years to achieve.

The application of carbon in stable forms such as charcoal (biochar) and compost has been shown in this Project to increase crop yields on sands in the south coast region of WA. While the definitive cause of the yield increases is not known the evidence suggests that nutrient addition is the primary cause as opposed to synergistic relationships with mycorrhiza. The benefits from chars diminish with time which is consistent with the nutrient addition conclusion presented. That chars increase the soils' CEC is possible given that the chars are stable. In theory the increase in CEC achieved through the addition of 5 t/ha of biochar was 0.2 cmol/kg on the site in Western Australia. The application of biochar to sands in Vietnam soils would appear to have potential given; the stability of chars in soils relative to organic matter, the nutrient value of chars and comparative simplicity of its manufacture. However there are also the competing issues between using crop residues for livestock feedstock as opposed to char manufacture. To improve nutrient retention in SCC Vietnam may require chars to be applied regularly over many years.

The addition of clay to sands has in Western Australia consistently increased crop yields. These increases have been attribute to more even wetting of the soil resulting in improved crop emergence, nutrient addition (in particular K) and nutrient retention due to the higher CEC of clay compared to sand. The addition of 300 t/ha of clay rich subsoil increased soil

CEC by 1.7 cmol/kg while also increasing soil carbon by 0.2%. The addition of clays to soils is not currently practiced in Vietnam although the benefits of clay addition have been demonstrated in Thailand. The benefit of clay is that it results in a permanent increase in water and nutrient retention. However the availability of clay for amendment of sands will depend on location. Investigations are continuing on the merits of adding clay to sands in An Chan commune, Phu Yen for improved vegetable production.

Substantial improvement in beef cattle production can be achieved through better feed management and benchmarking studies of efficient practices show they vary greatly. Participatory research has been very successful in livestock and fodder species work resulting in substantial uptake of practices as a direct result of trials and workshops. Emphasis on sheep and goats would be valuable in the livestock studies in southern provinces of Ninh Thuan if further investigation were to continue.

Several of the practices in fodder management and irrigation can have a great impact on labour saving.

Demonstration and pilot studies are an important and necessary requirement for widespread adoption of practices by regional authorities and extension staff.

Inclusion of exchange staff into the program has had very positive impacts on research understanding and communications.

9.2 Recommendations

The project has identified key interventions for value chains, particularly for peanut, cashew, mango and beef cattle production that would increase profitability and market access for producers in SCC Vietnam.

To increase the competitiveness of the peanut value chain in SCC Vietnam, better market facilities and upgraded mechanization for harvesting, threshing, grading and drying are needed. Traders play a very important role in the peanut value chain and policy support is needed in terms of access to credit and capacity building (i.e. training in post harvest technology, food safety, business management) and provision of world market information. Greater input to the technology transfer process is needed to lift farmer awareness and aid adoption. Significant profitability increases can be achieved through balanced nutrient supply including K, S and micronutrients but fertiliser application packages that are profitable for farmers need to be designed and demonstrated in the region for farmer adoption.

For cashew, careful consideration of the suitability and viability of tree production on sandy soils in SCC Vietnam is needed. For identified areas, a selection program to identify large kernel, disease-tolerant varieties that are suited to local conditions is needed. A strategy for the way forward for the cashew nut industry (varieties, technology requirements, investment etc.) should be developed through collective decision-making processes that will take into account risks faced by each participant in the value chain. Improved crop management practices for nutrient, irrigation and disease control need to be widely extended to improve yields of existing plantations. Detailed consideration needs to be given to staged replacement of old seedling plantations with improved grafted varieties or replacement with other farm enterprises in order to raise farmer income in the SCC of Vietnam.

For mango in the SCC region, an assessment of the market opportunities needs to be undertaken so that rapid industry expansion does not result in oversupply. Training and extension of improved cultural practices for farmers is required. Consideration should be given to establishing a mango cooperative particularly if an improved differentiated mango variety becomes available.

For cassava it is recommended that a plan be developed for processing factories in the region, focusing on cassava chip production. Cassava processing factories would diversify the market and avoid dependence on the Chinese starch market. There is a need to select and release high-starch (>30%), short-season cassava varieties that are well adapted to lowland conditions. Scaling up and establishment of small-scale cassava processing units by groups of farmers would be useful for improving market options and returns from cassava. Wider adoption of the method of traditional storage of roots in the rainy season, combined with its use as a modified feed source for fattening cattle in dry season should also be considered.

For cattle it is recommended that the support program be strengthened, focusing on remote areas, where farmers face difficulties in accessing veterinary services and animal husbandry training. Pasture areas could be increased by introducing new high productivity drought-tolerant grass varieties. Efforts should be made to commence a pilot program of animal households and local middlemen organised into a vertical coordination for supplying higher quality beef. Planning is needed to increase slaughter and processing capacity in the SCC region in order to supply beef meat and other processing products to large city markets. Training for farmers and extension staff on marketing skill and knowledge is also needed.

For sesame a better understanding of the yield potential of improved gentoypes that meet high value end uses is needed under both rainfed and irrigated production on sandy soils in the SCC. This could be conducted in conjunction with some rotation studies with other annual crops such as peanuts and cassava and should include crop nutrition and soil amendment studies. There is a need to provide market and price information for sesame growers. Publication and extension of research findings for sesame in the SCC would act as an aid to industry development. Australian support could be directed to help local authorities implement strategies recommended by the project component. Continued monitoring of the impacts of these technical interventions is also required.

For garlic and onions in Ninh Thuan, further investigation into the constraints of crop productivity on sandy soils are required. There appears to be deterioration in garlic yield and quality in Ninh Thuan. Investigation of the caused and remedies is suggested including assessing the quality and virus status of planting material. Some government-sponsored programs are already underway to assist farmers to improve productivity. A assessment of the focus and impact of this work should precede any future work on these crops. There is strong need for coordination information sharing in the garlic chain. Future work should occur under the framework of collective action, including a grower association and consideration cooperative marketing, a GAP system, quality management and regional branding.

The Farm Economic Model (FEM) is potentially highly useful tool for assessing the profitability of farming systems involving annual and perennial cropping as well livestock enterprises. The model has received good support from regional DARD staff. Further training of ASISOV and regional DARD staff in both basic economic enterprise analysis and use of the model would support more informed crop and farming system decision making by farmers enabling them to respond more rapidly to market signals within the constraints of available resources such as land, labour and credit.

There is greater scope for the use of this tool in the generation and development of a regional or provincial model. This could be used to estimate or project the financial and logistical impact of proposed interventions or changes. DARD and ASISOV staff have shown great interest in this prospect. The key to achieving such a goal are subject to the skills in Excel modelling and proficient understanding of farm management techniques and approaches. Further investment in training would be required to achieve this. Incrementally the collection and collation of enterprise data placed into such a framework would make this a very powerful decision making aid for investors in agricultural farming systems development.

There are significant knowledge gaps in the agricultural sector about the groundwater resources of the study area. Widespread dependence on groundwater for irrigation in

SCC Vietnam suggests that greater understanding of this resource is needed by farmers and agricultural offices at commune to provincial level. Critical information requirements for agriculture in SCC Vietnam include: size of the groundwater resource; annual recharge rates and; the underlying hydrogeological structure of the aquifers. Further study should examine the sustainability of this resource given current and projected future rates of exploitation. The risk from pollution of groundwater and surface water by fertiliser, animal waste and agricultural chemicals and from saline intrusion due to over pumping on the coastal zone needs more thorough investigation.

The occurrence of K and S deficiencies on all the sands tested in SCC Vietnam suggests that these elements need greater emphasis in crop nutrient management. However, research on optimising rates, forms, methods of placement and timing of application should underpin the development of recommendations. This needs to be supplemented by on-farm demonstration of efficacy of the packages designed.

The discovery of micronutrients deficiencies on all the sands investigated in SCCV opens new opportunities for increased crop productivity. However, accurate diagnosis is needed to determine which micronutrients will be deficient is needed since the suite of deficient micronutrients varies among sand types. As with K and S, research on optimising rates, forms, methods of placement and timing of application should underpin the development of recommendations. Crop differences in sensitivity to micronutrients will also need to be determined. Fertiliser companies should be involved also in designing appropriate micronutrient fertiliser products for sands. This needs to be supplemented by on-farm demonstration of the efficacy and profitability of the crop nutrition packages designed.

The positive responses of peanut on sandy soils in Phu Cat to a range of nutrients (K, S, Cu, B, Mo), to biochar and to manure suggests that optimising nutrient supply will depend on an integrated nutrient management approach. Given the range of variables that affect nutrient supply, and their interaction with irrigation management, a systematic research programme is required over the next several years to optimise nutrient and water supply for annual and perennial crops on sands of SCC Vietnam. The implications of this research for other provinces in SCC Vietnam (Binh Thuan, Kanh Hoa, Quang Nam, Quang Nghai) need to be considered. It is clear that improvements in yield and profit can be achieved in better managing nutrients and water for crop production but further work is needed on designing and demonstrating profitable packages of practices for farmers.

In both Australia and Vietnam, promising results from biochar application suggest it could be a profitable soil amendment that boosts crop productivity on sands. Positive effects of biochar on nutrient supply need to be balanced against the risk of increased P leaching, particularly from the wheat straw biochar. The underlying mechanism behind crop responses to biochar on sands in WA need further study. Promising results with biochar application on sands in Phu Cat district suggest that a value chain analysis of this product would be worthwhile to understand how research can intervene to commercialise this technology so that products are available to farmers.

The mini-pan technique is a valuable tool for simple scheduling of irrigation water, however, it must be calibrated for each crop and there is considerable potential for reduction in water use and labour if further work is directed at this. Already, substantial reductions in water use to grow peanut has been demonstrated. A strategy to take this finding forward for adoption by farmers is needed. Labour saving and more efficient water delivery methods need to be explored as alternatives to the present reliance on hand-held hoses to irrigated crops. On-farm evaluation of a range of technologies such as sprinklers, sprayers, drippers is needed to identify the methods most suitable for farmers in SCC Vietnam.

The low rainfall zone in Ninh Thuan and Binh Thuan remains a challenge for research and for agricultural productivity. The unpredictable rainfall regime suggests that long term research programmes are needed to explore new options. A more opportunistic and flexible approach to rainfed cropping should be pursued in the coastal zone of these provinces, supplemented by animal production, agroforestry and small-scale irrigation where water resources permit. Consideration also needs to be given to institutional capability to mount and maintain a long term research and development programme in these provinces.

The addition of clay to sands has in Western Australia consistently increased crop yields by 20-80 %. These increases have been attributed to more even wetting of the soil resulting in improved crop emergence, nutrient addition (in particular K) and nutrient retention due to the higher CEC of clay compared to sand. The addition of 100 t of clay/ha increased soil CEC by 1.7 cmol/kg while also increasing soil carbon by 0.2%. The addition of clays to soils is not currently practiced in Vietnam although the benefits of clay addition have been demonstrated on sands in Northeast Thailand. The attraction of clay amendment of sands is that it results in a permanent increase in water and nutrient retention. However sourcing sufficient quantities of suitable clay from on-farm or off-farm sources and demonstrating their efficacy in SCC Vietnam requires more thorough investigation.

Innovations, which can release labour for other work, should be a high priority and savings have been seen in irrigation and fodder management. Aside from the obvious economic considerations there are implications for social impacts where labour can be better directed.

Component 3 activities have achieved much, and there is enormous opportunity to build on these achievements with further investment. Particular areas of need include:

- The project has focused only on cattle, however small ruminants (sheep and goats) also have great potential, due to their smaller body size and consequent affordability for smallholders.
- Supplemental feeding options could be further explored with a combination of feeding experiments and modelling. A decision support tool needs to be developed to help extensionists make decisions given a range of available feeding options and prices.
- As the issues with feeding limitations become less widespread, there will be a need to focus on other areas of cattle production including breeds and meat quality.
- The project focused on encouraging farmers to move cattle from extensive grazing to semi-intensive stall-feeding, in order to reduce labour, increase production, and relieve pressure on common lands. However, in some areas, particularly Ninh Thuan, there is opportunity to develop land management strategies for extensive areas of privately owned dryland areas.
- Mineral deficiencies, particularly in sheep, remain a largely unexplored area of research, and could be impacting on production.
- Leucaena is proving to be highly adapted to SCC climate and soils, and will play a major role in providing protein for ruminant production. It is essential that we remain in control of any issues which may threaten its success, such as variety selection, pests, and toxicity.

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11 Appendixes

Appendices are labelled and ordered based upon the relevant output(s) that they address. See section 6 Achievement against activities and outputs/milestones.