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Final report

Small research and development activity

Sustainable vegetable production in Central province, Papua New Guinea

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2 Executive summary

Vegetables are the staple foods of PNG, and are of major cultural significance to the population. Increasing population, emergence of an urban middle class, and developments such as the natural gas industry and urbanisation, especially in the Port Moresby area, are placing new and increasing demands on food supplies in Central province. This province is expected to provide an increasing proportion of staple food supplies for the Port Moresby basin, with specialist lines being provided from further afield. The highlands areas have been the traditional source of vegetable supplies for Port Moresby and urban areas along the north coast of PNG and in the highlands. This is particularly the case for specialist lines such as temperate vegetables including brassicas, carrots, onions and tomatoes, and locally emphasis is being placed on high-value low-volume products (sweet potato, taro, yams, bananas etc), because transport and other costs have caused the loss of competitive advantage for high volume crops. Infrastructure is more developed in that area, though logistics remain challenging, hence it was a useful model to study.

A scoping study was undertaken, involving a visit to Central province, supported by a visit to the Eastern Highlands. This was followed by a second visit by Dr Richard Doyle to the Central province to provide additional information on the Sogeri Plateau, peri-urban production systems near Port Moresby and alluvial valleys further east of Port Moresby (Map 1). It also provided information on extension and education infrastructure, and allowed for visits to NARI headquarters at Lae, NARI research facilities at Laloki and university research sites and facilities (Pacific Adventist University and the University of Technology in Lae).

The objectives of the scoping study were:

A. To provide the basis for development of a full research and development (R&D) proposal

B. To provide a report containing recommendations to ACIAR for future R&D activities to ensure sustainable and profitable vegetable production in the Central province of PNG, and capacity building in communities and PNG institutions

C. To develop a full research proposal involving University of Tasmania (TIAR, School of Agricultural Science), Fresh Product Development Agency (FPDA), PNG Department of Agriculture and Livestock, other potential private sector partners in PNG and other contributors.

This report addresses A and B above, with C to be addressed subsequently.

The project brief required the research team to gain: 1) an understanding of the environment and natural resources; 2) production systems; 3) infrastructure; 4) market structure and linkages between production and consumption; 5) inspection of smallholder practices; and 6) operations and business structures. Rapid Supply Chain Appraisal Methodology for scoping overseas development assistance projects was used with a systems orientation to ensure the behaviour and performance of the system as a whole was addressed. Farms, business, government bodies and research sites were visited, and several meetings and workshops held. These were supported by literature searches and interviews of key personnel. However, gaps in information remain, as some key personnel, businesses, research sites and facilities and production locations were unavailable or not included for logistic reasons. Information gathered was analysed using a range of tools (Strengths, Weaknesses, Opportunities and Threats (SWOT) and Value Chain Analyses) and repeating themes assessed to identify researchable areas, from which research priorities were identified.

A wide range of researchable topics were identified, including:

- land management practices (tillage, erosion control, soil fertility management, rotations, irrigation, soil drainage and potential soil compaction) for long-term resource conservation
- sustainable vegetable production systems for smallholders
- constraints to the adoption of technological solutions to land management (soil conservation, soil fertility management, salinity and drainage)
- genetic diversity, crop species, cultivars and crop improvement
- integrated pest management for smallholders
- functioning of the marketing system and value chains
- effectiveness of delivery of extension to smallholders
- effective business structures for delivery of vegetables from smallholders to consumers

Research priorities for a major project emerging from this study are identified as:

- (i) soil, land and water management for production and sustainability
- (ii) soil fertility management
- (iii) integrated pest management
- (iv) crop adaptation, cultivar selection, and seed supply and quality
- (v) marketing systems, business structures and economic return
- (vi) effectiveness of delivery of information and extension services

It is recommended that:

1. A detailed proposal for research in the priority areas (i), (ii) (v) and (vi) above be developed consistent with current and foreseeable socio-economic conditions
2. Consideration be given to development of projects in research priority areas (iii) and (iv) as additional proposals outside that referred to in 2 above
3. As part of 2 above, research partners in PNG and Australia be identified and their participation described.

3 Introduction

PNG society is not yet industrialised, with 82 per cent of citizens over 10 years of age engaging in agriculture for a living, agriculture provides income and employment opportunities to the rural populace. Most of these people obtain a large proportion of their domestic food requirements from the use of their own customary land.

Agriculture, excluding forestry and fisheries, accounted for 21 per cent of GDP and 17 per cent of total exports (Coppel 2004), despite the pessimistic view of resource suitability for agriculture expressed in Bleeker (1975). The sector is seen as a basic source of economic growth, sustainable development and wellbeing of people and nation because it enables rural people to meet family needs and commitments, and contributes to reducing unemployment, poverty, law and order, and urban drift problems (Ministry of Agriculture and Livestock 2006).

PNG is highly culturally diverse with the highlands being patrilineal and the Central province generally also being patrilineal. This places women in an inferior position in decision making, particularly with regard to money, while promoting male dominance. Customary land tenure is concerned with networks of kin and the obligations of clan and community. As long as society is constructed within the framework of kinship, external interventions must be careful to maintain the balance of men's and women's roles in the household and in resource management (Gustafsson 2004).

There has been long-standing concern about the adequacy of Port Moresby's fresh food supplies. Importation of Australian rice, fruit and vegetables is a symbol of continuing dependence on Australia as well as being difficult for the balance of payments (Benediktsson 1998).

Smallholder vegetable producers in Central province produce a range of vegetables for the fresh market and for sale through supermarkets. Vegetable crops are traditional staple foods in PNG, and have been the major contributor to food supply and security for many years. However, production and yields are declining, with consequent adverse outcomes for the population's diet and economic wellbeing. Suitability of land resources and their management, soil fertility decline, pressure on land and renewable resources from population increase, pests and diseases and lack of market information are some of the major constraints to improving the vegetable industry. Central province has a potential to produce a wide range of vegetables but current production is not adequate to meet increasing demand. The principal vegetable crops remain sweet potato and taro, but there is interest in expanding production of brassica crops, (e.g. 'ball' cabbage) and onions, though expansion in other crops is also expected. Also, research on these additional vegetable crops would benefit existing crops as the constraints that limit productivity, marketing, profitability and sustainability are likely to be similar.

There appears to be a lack of any long-term commitment and consistency of the smallholder growers and, whilst there are a few producers who have become dedicated and specialised market gardeners, most suppliers are intermittent in commercial vegetable growing. This occurs because of competing demands from such activities as customary social obligations and coffee growing and other lucrative tree crops. Subsistence needs are still met to a large extent by the household's own production on its own land and households are therefore not compelled to rely on regular sales to obtain daily necessities. This results in opportunistic behaviour and a lack of consistent supply by smallholders (Benediktsson 1998).

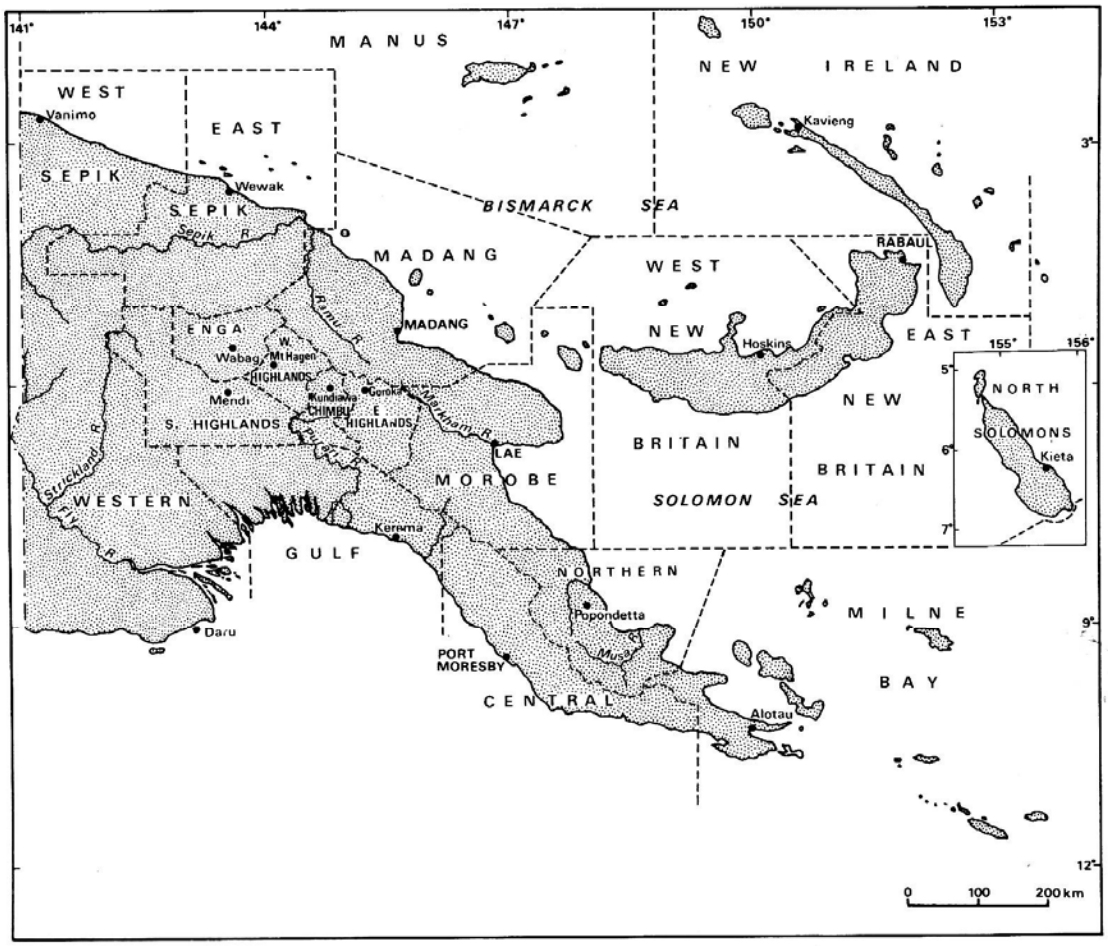
There is a growing proportion of smallholders who are interested in vegetable growing. Many already work multiple gardens growing up to 4–5 different crops for market. They cite pests and diseases, the high price or shortage of chemicals, fertiliser and seed, bad weather, a shortage of labour and issues relating to security as well as problems with marketing fresh produce due to post-harvest quality losses, transport and road conditions,

oversupply, low and variable prices, and waste from surplus and oversupply (Spriggs & Chambers 2007; Wilson & Hehona 2008).

Women are substantially involved in production but many are also engaged in the marketing of fresh produce, particularly in the local informal markets. They face considerable problems with appropriate transport and other facilities, with harassment and bullying as well as with retaining enough income for family purposes (Benediktsson 1998; Spriggs & Chambers 2007).

Generally, the marketing system in PNG is grouped into two types: the open or 'informal' market and the direct market. In the informal market farmers are mainly supplied by the 'self marketers' (farmers are mostly women) who sell their produce in small stalls to buyers, such as in municipal (controlled by the local level governments) or road-side markets, but they do not have any long-term relationships. Direct markets include supermarkets, hotels, restaurants and direct marketing to institutions and mining camps who buy direct from the suppliers rather than buying in open markets and where there is some established relationship between the buyers and sellers (Spriggs & Chambers 2007).

Size of markets is unknown although a number of studies have attempted to estimate it. Imports to PNG were 9,000 tonnes in 2003 and there is evidence that current markets cannot meet the Port Moresby demand (Liripu 2008; Worinu 2007).



Map 1: Papua New Guinea showing key areas visited marked in red (1 Eastern Highlands, 2 Lae, 3 Port Moresby – Soregi–Laloki, 4 Cloudy Bay)

4 Objectives

The overall objective of the study is to identify key research areas where there is a potential to improve the productivity, profitability and sustainability of the vegetable production systems in the Central province. The output of the small R&D activity will provide the design of a large project ($2 million) addressing the needs of key stakeholders in the PNG vegetable industry. The specific objectives are:

A. To carry out a scoping study in PNG to provide the basis for development of a full R&D proposal

B. To provide a report containing recommendations to ACIAR for future R&D activities to ensure sustainable and profitable vegetable production in the Central province of PNG, and capacity building in communities and PNG institutions

C. To develop a full research proposal involving University of Tasmania (TIAR, School of Agricultural Science), Fresh Product Development Agency (FPDA), PNG Department of Agriculture and Livestock, other potential private sector partners in PNG and other contributors.

4.1 Terms of Reference

1. Review previous R&D activities in the vegetable sector and compile an annotated bibliography of the relevant literature
2. Review current vegetable farm management practices in the Central province and identify the constraints to increasing vegetable production that can be addressed through a well structured research program with main focus on natural resource management practices, socio-economic conditions and marketing
3. Formulate a detailed research proposal for ACIAR with the main focus to enhance productivity and livelihoods of Central province smallholder vegetable growers
4. Provide recommendations and criteria for selection of appropriate field sites and partners for the proposed study

5 Methodology

The project brief required the research team to gain an understanding of the environment, vegetable production systems, natural resources, infrastructure, market structure and linkages between production and consumption, and inspection of smallholder practices, operations and business structures. The Rapid Supply Chain Appraisal Methodology (RSCA) of Collins and Dunne (2007), a tool for scoping overseas development assistance projects, was selected as an appropriate methodology for undertaking an investigation of the whole smallholder vegetable production system. A systems orientation maintains the focus on the behaviour and performance of the system as a whole on the basis that just understanding the parts cannot lead to an understanding of the system.

5.1 The approach

RSCA is an adaptation of Value Chain Analysis (VCA), an approach that comprises the main analytical method in the field of value chain management. It provides a framework that enables a rapid overview of a whole value chain system to be gained from the perspective of value in the eyes of the chain members, and most critically in the eyes of the end consumer of a product or family of products. Typically VCA can be used to identify the critical issues in four sub-systems of a value chain:

- The product integrity subsystem that includes technical aspects of the production, harvesting and post-harvest processes, including packing, storage, handling and transport
- The communication subsystem that determines the accuracy, timeliness and relevance of the information exchanged among members of the value chain
- The value subsystem that identifies where customer and consumer value was either created or diminished within the chain
- The governance subsystem that determines how the activities of the value chain are coordinated and how the value created from the sum of the chain's activities is distributed among its participants.

In development projects RSCA has the advantages of:

1. Focusing on the supply chain as a complete system
2. Addressing the limiting factors in order of their likely impact
3. Developing support amongst all stakeholders from primary producers and their marketers through to government extension, research and development agencies.

The outputs of VCA are usually in the form of an integrated set of 'chain improvement projects' (collectively a chain improvement program) which are high priority projects for deeper investigation and remedial intervention by collaborative teams that include chain partners. Essentially this focuses research and development on those areas and issues within the chain that will have the most impact on creating value for the end consumer.

5.2 Implementation of the methodology

Application of the RSCA to a vegetable chain in the Central province involved the following:

5.2.1 Gaining an initial industry perspective and understanding the chain dynamics

The large urban vegetable consumption associated with Port Moresby (population c. 500,000) in the National Capital District (NCD) is the focus of subsistence surplus marketing and commercial production from the Central province as well as other provinces such as the Eastern Highlands. Increases in population associated with developments such as the natural gas development to the west of Port Moresby will add to demand as new urban centres emerge. As there are powerful socio-cultural dynamics behind PNG agriculture, it was regarded as being critical to understanding Central province value chains that the TIAR research team visit the Eastern Highlands. This was followed by a second visit by Dr Doyle to examine the land resources and vegetable production systems in the Central province, especially the alluvial land systems to the east of Port Moresby and on the Sogeri Plateau.

The team visited the Goroka and Aiyura areas in the Eastern Highlands to meet and discuss with main stakeholders to gain understanding of the physical and social environment, vegetable production systems, natural resources, infrastructure (including cool chain), market structure and linkages between production and consumption, and to inspect smallholder practices, operations and business structures. In doing so, the team also experienced first-hand the nature of the primary and secondary road system, electronic communications and the airport/air freight service via Air Nuigini.

Extensive notes by each member to enable cross referencing of data and a large number of photographs were taken to record land systems, soil resources, cropping systems, pests and diseases (where possible), industry and public R&D and commercial infrastructure, and comparative vegetable quality and pricing in the various market outlets.

Literature searches were conducted by all team members to support the above processes and gain published information including government reports on past vegetable production research, natural resources, climate, political and economic pressures and land tenure.

Throughout all visits, a systems approach to understanding the farming systems from a low input perspective was adopted. Landscape observations and soil profiling were employed to identify management and biotic limitations as well as subsoil issues (e.g. waterlogging and drainage) affecting system potential. Cropping systems for indigenous and introduced crops were observed with a view to identifying the constraints and possibilities with respect to varieties, agronomy, crop protection, harvesting and post-harvest factors.

The team held a workshop in Goroka attended by 20 farmers from the highlands and four government representatives (FPDA – three, Agriculture Investment Grants Scheme of DAL – one) and two representatives of the private wholesale sector (Allele Pty Ltd) to discuss issues associated with fresh vegetable production and marketing.

In the Central province, the research team visited a local open market, the Gordons Market and two supermarkets servicing different demographics in Port Moresby. We observed the extent of women's involvement in agricultural production and marketing. In late July 2009 Dr Doyle visited a NARI farming cooperative at Cloudy Bay, and toured smallholders on the Sogari Plateau and in the peri-urban areas of Port Moresby with staff of the FPDA. Dr Doyle also visited the NARI research station at Laloki, the vegetable production areas at the Pacific Adventist University and the Port Moresby Farmer Training Centre of KOME Agricultural Services Ltd at Boroko.

Associate Professor Birch, Dr Doyle and Dr Sparrow visited local farms to the south-east of Port Moresby. Soil profiles and drainage constraints were examined and a local farmer was interviewed who serviced a local tourist operation, Port Moresby open markets and supermarkets.

5.2.2 Mapping the chain

PNG vegetable producers have a complex range of channels to market (Findings, Figure 1). The TIAR team undertook a preliminary investigation of material flows, communication, value and relationships or governance to gain sufficient understanding to enable a selection of a focal chain to be made for further investigation.

5.2.3 Understanding the role of government stakeholders

In Port Moresby the team met with Port Moresby-based DAL, AusAID, NADP, and FPDA staff to discuss Central province production systems and their opportunities and constraints. In July 2009, Dr Doyle met for a second time with Central province government officers and AusAID, and also the Rigo District Government Officers, the General Manager of Trukai Industries Ltd, the Leader of the Taiwan Technical Mission to PNG and visited both the NARI head office and the University of Technology located in Lae. In meetings with the Provincial Government it was made clear that the District Plans, which are currently under development, and the increased financing of Local Level Government (LLG) were the preferred funding methods for driving agricultural development at the village and coop level. To this effect it was instructive to see the Cloudy Bay Resource Centre and extension program conducted by NARI in this most eastern part of the province which is now being connected by greatly improved roads to Port Moresby.

5.2.4 Sense making

Attaining a progressive shared understanding within the research team during the project as well as identifying the gaps in the data gathered are necessary elements of the RSCA methodology. The TIAR team achieved this by:

1. Regular debriefings during the course of the in-country research
2. Allocating time to collate and review data against the diagnostic framework at a mid-point during the in-country research week.

This involved recapping and sorting through key issues from each of the individual and group meetings using reflective and evaluation techniques. From these we identified consistencies of message, gaps in information and negotiated and made changes to the program to meet additional requirements.

Unintentionally we carried out quite a lot of extension due to the breadth of the team (soils, pests, agronomy, value chain analysis) and this drew out further issues and resulted in meeting more people than we might have otherwise have done.

6 Achievements against activities and outputs/milestones

Objective 1: To carry out a scoping study in PNG to provide the basis for development of a full R&D proposal

no.	activity	outputs/ milestones	completion date	comments
1.1	Visit PNG, site inspections, interviews and information collection	Recording of large amount of interview notes, photographs and collecting reference material	23/5/09 and 27-31/7/09	A very fruitful visit that provided the opportunity to become informed of local conditions and constraints, though some significant information gaps remain
1.2	Analysis of data, assessment of key points from interviews inspections and printed sources	SWOT Analyses' Identification of key constraints using Value Chain Analysis	3/6/09	These analyses are the basis of this report
1.3	Gather additional reference material	Numerous references have been collected and annotated bibliography developed	22/6/09	Web search and library material for inclusion in annotated bibliography

PC = partner country, A = Australia

Objective 2: To provide a report containing recommendations to ACIAR for future R&D activities to ensure sustainable and profitable vegetable production in the Central province, and capacity building in communities and PNG institutions

no.	activity	outputs/ milestones	completion date	comments
2.1	SWOT and value chain analyses	A progressive step in preparation of report	3/6/09	Incorporated in this report
2.2	Preparation of draft report	Draft report	16/6/09	For use at debriefing in Canberra
2.3	Debriefing session, ACIAR, Canberra	Debriefing meeting	17/6/09	To contribute to finalisation of report
2.4	Return visit to further scope Central province	Findings incorporated in phase 1 application	27-31/7/09	Dr Doyle completed this trip and his expanded contacts and site visits have been used in the development of the Phase 1 project proposal and in this scoping report
2.5	Finalisation of report	Final report	30/9/09	The final report should be complete by this date

PC = partner country, A = Australia

Objective 3: To develop a full research proposal involving University of Tasmania (TIAR, School of Agricultural Science), Fresh Produce Development Agency (FPDA), PNG Department of Agriculture and Livestock, other potential private sector partners in PNG and other contributors

no.	activity	outputs/ milestones	completion date	comments
3.1	Development of full proposal	Full proposal	Target date is August 2009	To follow acceptance and approval of scoping study report

7 Key findings

7.1 Constraints on PNG agricultural production

7.1.1 Climate and climatic constraints on agriculture

Detailed historical climate data for PNG is relatively scarce, with only a few stations (Daru, Wewak, Madang, Lae, Port Moresby) collecting comprehensive data, and only for a limited number of years. About 40 other stations collect a limited range of data. However, the Koppen Climate Classification for PNG is Af, a hot, humid tropical climate with all months above 18 °C. Unfortunately, data quality is often unsatisfactory for a range of operational and equipment reasons (AusAID 2007). Port Moresby, a representative site for the coastal lowlands of Central province, has 35 years of data, but Goroka in the Eastern Highlands has only 9 years of data to 2007. Port Moresby lies in the rain shadow of the Owen Stanley Ranges, and therefore receives less rain (899 mm) than the nearby highlands, for example Goroka (1722 mm). Port Moresby rainfall is highly seasonal, being concentrated in December to April (61 per cent of annual total), while Goroka has only three relatively low rainfall months (June–August). However rainfall increases in the eastern parts of the Central province and this increase improves the mapped land use suitability significantly, especially in alluvial valleys (Bleeker, 1975 and 1983). Temperatures are high at Port Moresby, with monthly mean maxima of 31.4-32.5 °C and mean monthly minima of 22.4-23.7 °C. Respective figures for Goroka are 25.5-27.5 °C and 14.9-16.2 °C.

The lowlands has a more limiting temperature (higher) and rainfall (lower, strongly seasonal) than the highlands. However, there will be variations in both areas, with greater variability due to altitude and topography in the highlands.

No reliable data appears to be available for Sogeri Plateau, however, it would be expected to be more like Goroka than Port Moresby (i.e. cooler and wetter than Port Moresby). However, with an elevation of 600–800 m, it would be about 3 °C warmer than Goroka, on average.

Implications of climatic characteristics for vegetable production in the Eastern Highlands

Temperatures are generally moderate, though days on which temperature exceeds 25 °C would limit the growth of vegetables adapted to cool temperate conditions, but not be so limiting as to prevent their production. Temperatures are generally favourable for tropical vegetables, though the occasional cool night may reduce growth rate or physiological development for short periods. Water supplies would rarely be a major limitation, though short-term deficits may occur in crops with a full canopy in June, July and August. A wide range of vegetables are able to be produced, with local temperature and rainfall variations associated with altitude and topography determining which will be the most appropriate. Also, there should be few climate related constraints to crop quality, though interaction with other resource characteristics and crop management e.g. inadequate crop nutrition could result in inferior quality produce.

Implications of climatic characteristics for vegetable production in Central province – lowlands, including peri-urban Port Moresby

Both water supply and high temperature stress can be expected to limit plant growth during the 'dry' season, sharing characteristics with coastal and sub-coastal areas of north-western Australia (Bureau of Meteorology 2009), particularly as evaporation exceeds rainfall by a factor of 1.5 to 2.2 (Hall 1984). Temperature and soil water indices calculated as in Hackett (1988), show temperature to be limiting for C3 plants (based on

calculations for C3 grasses) for all months. Temperature indices range from 0.79 (November and December) to 0.89 (July) (on a 0 to 1.0 scale). Soil water is limiting in all months except January to April, and is severely limiting from June to November (Soil Water Index <0.2 on a 0 to 1.0 scale). These values may not be directly applicable to vegetable crops for specific edaphic reasons, but give a clear indication of both temperature and water limitations. Irrigation from either underground water or purpose built dams will need to be considered for dry season production, as will careful selection of plants to minimise the impact of temperature stress.

Excess water is likely to limit production during the wet season (December to April), necessitating enhanced drainage in low lying areas, while on hillsides in the lowlands, the risk of erosion will require soil conservation measures.

Crop selection would be somewhat constrained, especially for temperate vegetables, though it is known that they have been produced in the area, and currently spring onions, white radish, onions and shallot are being grown near Port Moresby. While outside their preferred climatic range, it is evident that production is possible. Quality is of concern and though we have no substantial data on yield and quality, observations suggest shelf life is limited. This, though, may be partly explained by deficiencies in various components of the post harvest system, in addition to the potential impact of weather conditions (particularly temperature) and crop management.

Implications of climatic characteristics for production in Central province – Sogeri Plateau

Without specific climatic data, the best that can be done is to extrapolate from data for Goroka or other highlands locations. This would suggest that there are few climate related constraints.

7.1.2 Soils and topography

Land management techniques in PNG range from low-input techniques such as long bush fallows and burning, to high-input techniques such as planted fallows, legume rotations, composting, mounding, drainage, soil retention barriers and mechanised tillage and irrigation (Hanson et al, 2001).

Land degradation issues raised by researchers and noted in the field during our visit in both the Eastern Highlands and the urban fringes of Port Moresby included soil erosion by water which in cases was accelerated by drainage networks, slumping and other forms of mass movement, soil structure decline and soil fertility decline (Bailey, 2009 pers. comm).

The various regions examined during our visit and also future regions of interest are briefly reviewed below.

Soils in the highlands

Two days were spent in the Eastern Highlands examining soils and land use systems. The key arable soil in the highlands is the Andisol. These are fine textured, well to imperfectly drained soils formed from volcanic ash. They have high levels of surface organic matter, very favourable physical properties and they tend to develop on lower slopes where volcanic ash has accumulated. These factors have seen them preferentially selected for cultivation in the highlands (Radcliffe and Kanua, 1998). Their chemical fertility is generally low (Radcliffe and Kanua, 1998) with low CEC dominated by exchangeable aluminium (toxic) and low potassium levels.

They are also very highly P fixing and tend to be acidic to strongly acidic (Harding and Hombunaka, 1998). High levels of organic matter mean N levels are usually high but then high C:N ratios may limit N supply during the growing season. Boron deficiency is considered widespread (Radcliffe and Kanua, 1998) while local deficiencies of zinc, molybdenum, copper and manganese have also been noted (Harding and Hombunaka,

1998). The low fertility is managed with the use of fallowing, mounding, manuring and composts. Pigs may be tethered in old potato fields to forage and manure the soils.

The long history of cultivation on Andisols, often on significant slopes, indicates a high level of sustainable land management. This is no doubt due to their excellent soil structure and high rate of water infiltration. The soil structure provides a resistance to erosion and structural degradation. However Andisols are not immune to degradation. Increasing population pressure is shortening fallow periods and hence reducing organic inputs and soil fertility and forcing production on to poorer soils (Radcliffe and Kanua, 1998). Land sliding (slumping) was an issue in the highlands and at some sites we visited topsoil erosion was an issue which has long-term consequences for soil sustainability.

Radcliffe and Kanua (1998) indicated several research directions for these soils including:

The role of vesicular arbuscular mychorrizae in P uptake

Trace element responses

Composting in mounds; temperature effects and influence on microbial activity, nutrient mobilisation and crop yield

Bailey (2009, pers comm) indicated several others:

Use of natural limestone deposits and pyro-technology to produce burn lime for acid soil amendment

Use of organic wastes such as coffee pulp and chicken manures

Ash collection and storage for later use

Reducing the amount of burning of gardens so as to reduce N and S loss

Mixed responses to fertilisers have been reported and a balanced and locally relevant application is critical to success.

Sogeri Plateau

The land potential on the dissected Sogeri Plateau is listed as very high by Hanson et al. (2001). Some improved land management practices from the highlands such as small terraces for gardens have been adopted at Sogeri. Photographs by Turvey (1974) show logs laid across the slopes to from barriers in gardens. Dr Doyle visited the area in July 2009 and while the soils are certainly well structured deep Ferrosols, the limits of slope with the potential for soil erosion remain very high. These soils are likely to be very high P fixing and acidic which will require both nutrient and erosion management for increased production (Figure 1). Doyle noted very widespread death of rubber plantations though a cause has not been identified (FPDA pers. comm.).

The Sogeri Plateau and tributary valleys of the Vanapa River have potential for agricultural development given the deep well structured soils. The steepness of the topography is the key land use limitation with vegetable production restricted to small gentler components of slopes such as ridge lines and lower slopes. Access to Sogeri is good, but much of the Vanapa River area has no roads and is very sparsely occupied by squatters and settlers. Fresh food and betel nut have potential for development in this area (Hanson et al, 2001).

Hanson et al. (2001) indicate people in parts of the Sogeri Plateau land settlement schemes earn high incomes from the sale of fresh food and rubber although Dr Doyle noted the extensive death of rubber plantations. In particular, sweet potatoes, pineapples and peanuts are sold in Port Moresby fresh food markets. Other important sources of cash are informal rents from settlers from elsewhere in PNG (Allen et al. 2002).

Figure 1: Gardens on steep and moderate slopes at Owens Corner near Sogeri. The soils are deep, well-structured Ferrosols but the erosion risks of arable use without well designed soil conservation measures are significant. Soil acidity and the associated issues of Al and Mn toxicity and P fixation are also likely to be land use limitations. However, small pockets of flatter land would moderately suitable for arable use. Note dead rubber plantation in upper right of photograph and single dead tree in centre left.

Goilala District

"Overall, people in Goilala District are seriously disadvantaged relative to people in other districts of PNG". Land potential is very low, access to services is moderate and cash incomes are low (Hanson et al., 2001).

The Goilala district is located in the north-west of Central province. It covers the mountains and valleys of the Owen Stanley Range around the headwaters of several major rivers. Average annual rainfall ranges between 2200 to 3200 mm. There is a moderate dry season. Most people live between 1000 and 2200 metres (Hanson et al., 2001).

Hanson et al. (2001) indicates the lands of the Goilala District have very low potential due to steep slopes and poor soils. Other issues which limit production are the high cloud cover and lower temperatures which are combined with a long dry season. The area is vulnerable to drought, frost and food shortages. Child malnutrition in the district is serious (Hanson et al., 2001).

The low incomes mean people are unable to purchase supplementary food. Such poor environments limit the potential for cash crop development to increase incomes (Hanson et al., 2001).

Hanson et al. (2001) indicate the lower Kunimaipa Valley is the only area in the district with potential for significant agricultural development. However transport to the Hiritano Highway is only possible by canoe or speed boat.

Areas around Port Moresby

One of the key issues in the immediate vicinity of the city is the intensive production on the moderate to steep slopes with associated issues of soil erosion and drought. There is also agricultural pressure on the floodplains around the settlement areas north of Port Moresby, resulting from high intensity agriculture being practised in environments prone to

drought. There is thus a significant potential for soil nutrient decline in the shallow soils developed from siliceous sedimentary rocks. This risk would be lower on the alluvial soils which commonly are dark (mafic parent materials) and deep.

Farmers consider soil fertility decline including nutrient losses through erosion as an important production limitation. Indigenous, improved or alternative soil management systems need to be tested in partnership with farmers and NGOs to ensure adoption of more sustainable systems (Hanson et al., 2001).

Hanson et al. (2001) indicates most areas north and north-west of Port Moresby have very low to low potential due to combinations of poor soils, low rainfall, seasonal inundation, a long dry season and steep slopes. To the south-east of Port Moresby, field inspections revealed areas of soils with desirable physical characteristics (well drained) on stream levees, but areas of impeded drainage and perched water tables further from streams. The former offers potential for wet season production, while the latter would require improved drainage and irrigation for dry season production.

Figure 2: Deep, moderately structured, medium textured alluvial soils under very intensive use at Pacific Adventist University, adjacent to the Lakoki River. These soils are becoming structurally degraded and nutrient levels are very low and require amendments (PAU, written comm.).

Alluvial soils further east of Port Moresby

River valleys north and east of Port Moresby were visited including the Laloki River floodplain and first terrace, the Kemp Welsh Valley and the flood plains of rivers entering Cloudy Bay (Figures 1 and 2). The soil auger borings and stream sections indicated the presence of many pockets of deep alluvial soils of medium to fine texture derived from mixed alluvium. The parent materials being basic volcanic materials and various sedimentary rocks. These materials are likely to have a high natural fertility though soil fertility and structural decline appear to be increasing issues where rotations have been long and intensive (Pacific Adventist University, pers comm.).

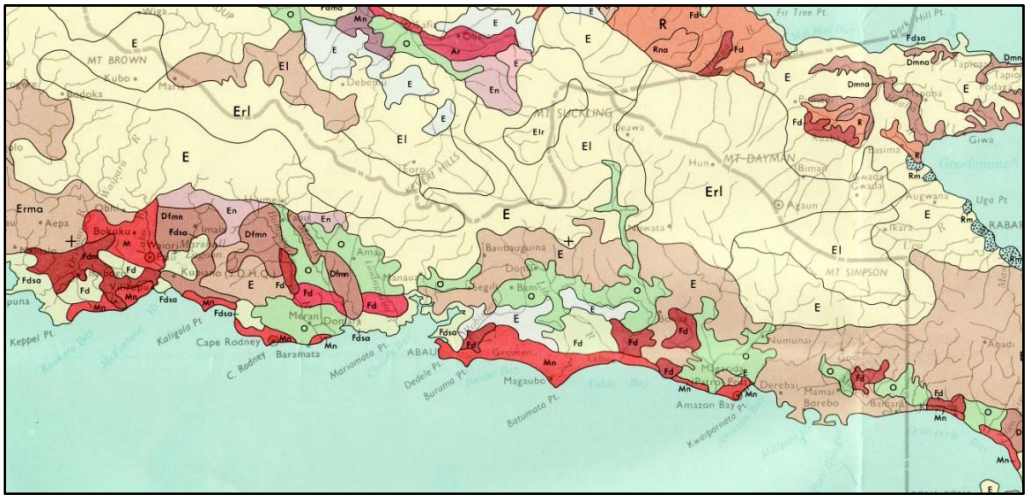


Figure 3: Land use limitations map of the eastern part of the Central province indicating areas of land with "O – No Land Use Limitations" (Bleeker 1973). A farmer cooperative at Cloudy Bay on this land class was visited and the site inspection indicated deep fine-textured alluvial soils of high natural fertility – see image below.

Figure 4: Deep, well structured, fine textured alluvial soils with high native fertility at Cloudy Bay Central province. These soils may become susceptible to both structural decline and nutrient decline under mechanised or intensive use. NARI are demonstrating mulching treatments to enhance chemical and physical fertility on soil beds.

7.1.3 Land tenure

Land as a resource is abundant in PNG. However, problems with the land tenure system restrict land from being utilised as a factor of production and an asset to create wealth. Mainstream financial institutions do not regard customary land as acceptable as loan collateral and so state land is, except under certain conditions, 'dead capital'. This is why PNG is land rich, land tenure confused and asset poor (The Land Summit Coordinating Committee 2005). The term 'communal' to describe land tenure in PNG strictly applies only to the natural forests that cover 77 per cent of the country's land area, and

'customary tenure' strictly applies only to the 20 per cent taken up by rural homes and gardens where individual usufruct[1] rights apply, and not at all to the natural forest, which is a commons open to undifferentiated access by all. Both communal and customary title have the inalienability that may well afford more social security and cohesion than fully alienable leases or freehold but at considerable opportunity cost in terms of lower incomes than could emerge from more efficient land use (Curtin & Lea 2006). Curtin & Lea argue that without the necessary infrastructure for commercial transport, communications and access to finance, to replace customary land rights with well-defined property rights would be a recipe for greater inequality because it assigns an economic value to the ability of land to undertake commerce. They argue for the parallel development of infrastructure with land reform by undertaking a comprehensive land survey and title registration as the first step (Curtin & Lea 2006).

7.1.4 Agronomic practices and constraints

Considerable detail on agronomic constraints was obtained – a summary of the key points is provided below.

The vegetable industry is dominated by smallholders and thus mechanisation is rare, and dependant on contractors or village-owned equipment that is available for hire, or small equipment such as knapsack sprayers. Most land preparation, planting, fertilising, weed control, some insect control, harvesting and on-farm packing is carried out by hand. Seedlings are often produced on-farm rather than purchased from specialist seedling suppliers. In the highlands, labour-intensive production systems are expected to remain dominant because of topographical constraints to mechanisation. However, on the lowlands, there are opportunities for larger scale, mechanised operations.

The main agronomic constraints are related to soil management—erosion, low pH and nutrient supply and, where excess water is present as surface water or perched water tables, inadequate drainage. Crop rotation is practised, as is shifting from one area of land to another. Land tenure in PNG can be to the detriment of sound land management. The lack of security of tenure and the capacity to move to 'new' land areas mean that soil and land management are often compromised and resource degradation likely (see land tenure section).

Technical solutions to soil and topography constraints such as low pH, soil erosion and soil fertility decline are known. Macro (nitrogen, phosphorus, calcium and potassium) and micro nutrient (boron, molybdenum especially) deficiencies are relatively widespread. Modification of practices used in advanced agricultural systems will be needed for a smallholder dominated production system, for example, on-site preparation of liming agents from locally available limestone, and recycling of plant material and other 'wastes' as compost and low analysis fertilisers. Inputs of artificial fertilisers are constrained by cost and availability of appropriate products. The opportunity to enhance sustainability exists, but will require some cultural shift—for example, from burning organic matter to returning it to soil and concurrently changing rotations for disease control.

Quality and supply of seed is a significant constraint, and will need addressing through local production and improved supply from overseas, coupled with improved storage and handling prior to planting to ensure farmers receive high quality seed. Availability of planting material for vegetatively propagated crops e. g. sweet potatoes can be problematic at times, due to the impact of adverse weather events such as cyclones.

Plant population is frequently lower than optimum in most crops observed—most populations being half or less than half of those used in Australia and elsewhere. This may partly be attributed to the need for ease of access for manual weeding, spraying for

[1] *The legal right to use and derive profit or benefit from property that belongs to another person, as long as the property is not damaged.*

insect and disease control using small equipment carried by people and hand harvesting. There may also be inadequate resources e.g. nutrients for a higher population. Nevertheless, low crop densities reduce potential yield and profitability of the crops.

7.1.5 Plant protection

Plant protection is a significant concern, especially for insect and disease control. Weed control is mainly by hand weeding, but current chemical based practices for insect, nematode and disease control appear overly reliant on a narrow range of products, risking development of resistance (it may already be present). Genetic resistance to disease is used e.g. in tomato and taro, however, there are other crops with no genetic resistance in which disease outbreaks could occur. Rotations and shifting cultivation appear to be relatively effective in minimising incidence of some pests, however, as food demand increases as population increases, pressure on land will intensify, creating conditions that could favour disease outbreaks.

A particularly severe pest is Oribius weevil, which reduces yield by 50 per cent or more in the highlands, requiring a range of cultural and chemical control strategies (Clarke 2001). It appears that a substantial amount of development and extension work is needed to optimise control of this widespread pest.

7.1.6 Roads and transport

Isolation contributes to rural poverty. Without a minimum of reliable and efficient access to basic social and economic services, rural life stagnates and local development prospects remain limited. Providing and maintaining a minimum level of access, referred to in this paper as basic access, is therefore a necessary element of any rural development strategy (Lebo & Schelling 2008).

The national road infrastructure is not linked and is in a parlous state due to the frequently rough terrain and the impact of the climate, especially the high rainfall, on the quality of roads. Only 11 per cent of the nation's roads are classed as being in 'good' condition and 42 per cent are classed as 'poor'. Fifty two per cent of people live within 5 kilometres of a road and they are heavily used for foot as well as vehicular access. The deteriorating state of the roads has forced up freight costs by 90–170 per cent in the last 5 years and the impost on the PNG economy is significant as roads are the largest single item of expenditure (Gannon, Kapa & Unas 2006).

Importantly, Port Moresby is not linked by road to the Highlands, where many of the fresh vegetables are grown, or the north coast which currently acts as a transport hub for shipping Highland and Island fresh produce to Port Moresby.

The Central province, in which the NCD is situated, has the largest network of roads and one of the lowest per capita spending of all the provinces on road maintenance and development. Therefore, the state of its road system is poor and some districts are serviced only by four-wheel drive tracks. Goilala is the only district effectively without road transport (National Economic and Fiscal Commission 2006).

The Trans-Island Highway Project and roads associated with oil, LNG and mineral exploitation will improve the road system in the medium term. A road associated with the ExxonMobil PNG LNG pipeline from the Southern Highlands to Kirkora on the Gulf of Papua is planned to eventually link to Kerema and the 'Trans-Island Highway' Project further east at Malalaua. The Trans-Island Highway Project will forge a road north from Malalaua to Aseki or Wau and on to Lae, the second largest population centre on the northern coast. A first stage of this project, funded by the Japan International Cooperation Agency, has already completed an 80 km section from Bereina, on the coast 200 km north-west of Port Moresby, to Malalaua (Hashimoto 2008).

However, whilst these developments will provide same-day road access from the Eastern Highlands to Port Moresby, they will not provide improved access to the Goilala District which is further to the south-east of the proposed Trans-Island Highway.

Areas within 40 km radius of Port Moresby have a travelling time of about an hour on sealed roads whilst those further north-west, south-east or inland towards the Owen Stanley Ranges have travel of a day or more, often combining foot access with vehicular access on barely passable unmade tracks or poorly maintained roads. Road transport for commercial access to vegetable markets in the Central province was effectively restricted to those areas within 40 km of Port Moresby (Hanson et al. 2001) however this has improved as the road east has improved and been extended.

In some instances, the more remote parts of the Central province have air freight access to Port Moresby fresh markets that may be utilised for high-value, low-volume products through numerous small and some larger airports. The PNG Government would like to privatise the main carrier, Air Nuigini, but has failed to find a partner. This may be due to its poor financial performance, an excess of 200–300 staff, low load factors, poor selection of aircraft, lack of investment, heavy debt repayment obligations, poor management and the difficulty of meeting dollar-denominated costs with revenues largely in devalued Kina (World Bank 2009).

Air Nuigini currently provides the main air freight services and appears to favour passenger services over freight as freight prices are twice those for passengers on a weight basis. An FPDA survey of the source of fresh produce supplied to Port Moresby has demonstrated that 'carry-on' freight that accompanies passengers to the city is ten times that of pure freight, but is still only 1 per cent of the total volume. In any event, with the volume of the current demand for fresh produce in Port Moresby and the projected growth associated with LNG developments in the nearby Central province, the current air freight infrastructure will be unable to cope (Liripu 2008).

With its dispersed population, PNG’s coastal shipping services take on special significance in providing access to rural communities. Seventeen commercial ports, mostly very small, and innumerable small wharves, jetties and beach landings provide the basic infrastructure for maritime services, but the majority of these are in poor condition and carry very little traffic. Lae is the main import/export point for the populous highlands region, the goods moved from/to the port by road. Annual throughput by the major ports has been growing at about the rate of population growth with import/export tonnages (increasingly containerised, but also including a growing logging trade) accounting for about a third of the total throughput and most of the growth (World Bank 2009).

7.1.7 Climate change

The potential impact of climate change was mentioned by several interviewees, and will need to be considered as part of ongoing research, development and extension programs.

7.1.8 Summary of constraints

The table that follows contains a listing of main resource, agronomic, and sociological and organisational constraints, and value chain issues identified in this study. At this point of the report, no attempt at priority setting is made, or to identify them with particular geographical areas, as most seem fairly widely applicable. In addition to constraints and issues identified in Table 1, it is worth noting that export is not really an opportunity in the foreseeable future because of low shelf life of most products, and imports from efficient and/or low cost producers are a significant threat. As examples, PNG sweet potatoes will be unable to compete with efficiently produced Australian sweet potatoes in the Australian market, and the team saw high-quality carrots and broccoli from Tasmania and Queensland respectively in PNG supermarkets at a competitive price.

Table 1: Main resource, agronomic, sociological and organisational constraints, and value chain issues

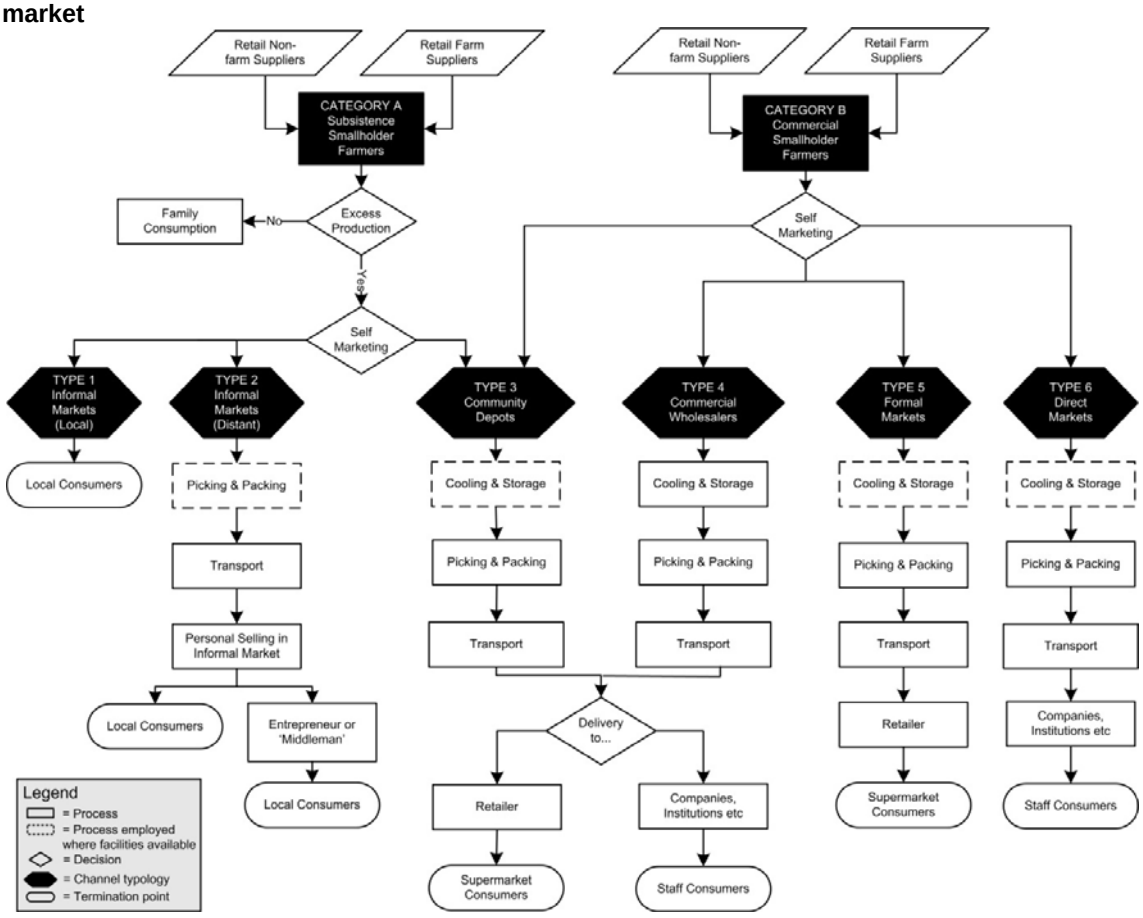
Resource constraints	Agronomic constraints	Sociological and organisational constraints	Value chain issues
Land tenure constrains growth in both individual and group enterprises Climate - high temperature, seasonal low rainfall (esp. in central and western CP lowland areas) Climate change Topography of some cropped slopes around Port Moresby Soil suitability and fertility (multiple deficiencies) Soil acidity, Al toxicity, P fixation on high iron oxide soils (Ferrosols) Soil erosion, water-logging Amount and reliability of water supplies for irrigation unknown Soil drainage in some areas and potential for compaction and soil structure decline	***Currently*** system is low input but ***needs*** to be a low input sustainable system and/or high input system Limited uptake of technology Inadequate use of legumes Inadequate crop rotations Inadequate resource recovery (manures, composts and burnt-lime) Soil acidity in some places but more widespread soil fertility decline Al toxicity, P fixation in red (oxide rich) soils Inadequate fertiliser use Water supplies for irrigation on shallow soils on slopes Irrigation infrastructure and technology Genetic material and suitability of varieties Seed and vegetative planting material supply and quality Crop protection esp. control of insects, nematodes and diseases Suitability of pesticides and application practices Specialisation of two or three crops that can be cooperatively rotated among farmers Mechanisation of operations constrained by topography away from alluvial valleys	Political issues Culture - must work with the active cultural rules and rites. Women do most of the marketing, risk of exploitation and abuse Dietary preference limits adoption of improved quality cultivars e.g. of sweet potatoes Few long term business relationships so basic information flows inadequate Trust-delegation - confidence Reliability of input suppliers Availability and affordability of finance Few locally led and coordinated enterprises and co-operatives Coordination and communication Population growth and food supplies (implies need for high input systems) Information availability and accessibility Professional human capital - professional agriculturalists few and far between Inadequate capacity for training and extension Drift of labour to other industries	Value chains are long Value chains have some significant weaknesses Post harvest management of produce Chemical residues in produce Logistics and infrastructure inadequate High value low volume products needed Difficulties in maintaining quality of high volume, low value products Many chains end at ad hoc spot markets Few long term relationships and basic information flows Financial and managerial constraints of small enterprise and local co-operatives Consistency of supply Lack of adequate cool chain stores and vehicles (containers)

7.2 Channels to vegetable markets used by PNG smallholder farmers

Smallholder farmers in PNG were found to fall into two broad categories based on their intent and behaviour towards vegetable production (Figure 1). ***Category A Subsistence Smallholder Farmers*** primarily operated at a subsistence level producing food for their family group and selling any surpluses in the nearby local markets (roadside, ad hoc communal or those provided by the Local Level Government [LLG]), to similar markets in distant locations either within or outside their province or to 'community depots' that supplied retailers or institutions. Category A smallholders were generally focused on 'subsistence' and producing small surpluses to provide some cash income but do not exhibit the behaviours focused on producing much larger surpluses on a consistent basis with the prime goal of marketing on a larger scale.

Category B Commercial Smallholder Farmers on the other hand, were clearly intent on producing one or a small number of vegetable types for specific markets, usually more distant and formalised such as supermarkets, kai bars and institutions in the larger population centres. These farmers acted more entrepreneurially, had a good understanding of consumer value, and often engaged in distant self-marketing and accompanying their produce to market to monitor the treatment of their produce and its quality at point-of-sale. They used ingenuity to gain a critical mass of produce on a more sustainable basis which ranged from farming multiple gardens through leasing extra land to aggregating produce from other families and villages or even making arrangements with growers outside their own province. The most important attribute of this category was a singular focus on their scale of production in order to penetrate larger markets.

Figure 1: Categories of smallholder vegetable producers and their alternative channels to market



Further, six channels to market were identified although there are many variations based on individual circumstances and the methods employed are ephemeral and dynamic. ***Type 1–3 Channels*** were largely associated with Category A Subsistence Smallholder Farmers. ***Type 4–6 Channels*** were generally the focus of the Category B Commercial Smallholder Farmers. It should be noted that for most of these channels cool storage and 'picking and packing' facilities do not exist except where the large wholesalers are involved or there have been local projects to provide such facilities (e.g. NZAID's facility in Asuro District near Goroka or the partly constructed facility at Kainantu, in the Eastern Highlands).

Type 1 Channels appeared to be the most common with ad hoc roadside markets, either individual or communal, being very frequent.

Type 2 Channels occurred where a smallholder was starting to market on a larger scale in distant centres, either to consumers or to 'middlemen' entrepreneurs who in turn would sell at mark-ups often around 100 per cent to consumers possibly making K20–100 per day. It is in these channels where inter-tribal or regional and social pressure is frequently applied to the disadvantage of the smallholder producer. In many instances this involves the harassment of women who frequently play a major role in the marketing of produce.

Type 3 Channels exist where either a local entrepreneur engages in collaborative behaviour with his family or other villages or an international assistance project has built a cool store facility.

Type 4 Channels involve formal, large-scale commercial wholesalers such as Allele Pty Ltd who, because they are involved in supplying the formal and direct markets with higher quality produce, and are more likely to have cooling, picking and packing facilities in regional locations.

Type 5 Channels supply higher quality produce to supermarkets with more consistency and long-term arrangements and are more likely to have cooling, picking and packing facilities. Type 6 Channels are similar but supply direct markets such as hospitals and mines with high quality produce for expatriate and higher income workers.

There are virtually no exports due to the low shelf life of produce or because stable products like sweet potatoes cannot compete with the same product grown elsewhere, e.g. Australia.

Crops currently grown

For completeness a list of vegetable crops observed or known to be grown in the Eastern Highlands and Central province Lowlands is provided (Table 2). The table excludes the many 'non-root' indigenous vegetables known to be produced for home consumption or sale through local, roadside and ad-hoc markets.

Table 2: List of vegetables known to grown in the Eastern Highlands and Central province lowlands (excluding 'non-root' indigenous vegetables)

Eastern Highlands		Central province – Lowlands	
Sweet potatoes (Kai Kau)	English Potatoes	Sweet potatoes	Yams
Taro		Taro	Cassava
Cabbage	Cassava	Spring Onions	Bulb Onions
Chinese Cabbage	Cauliflower	Tomatoes	Abica
Lettuce	Other Asian Leafy Vegetable	Chillies	
Broccoli		Capsicums	
Spring onions		Cucumbers	
Shallots	Broccolini	White Radish	
Tomatoes	Bulb Onions	Sweet Corn	
Beans	Garlic	Coconuts	
Carrot	Peppers	Melons	
Pumpkins	Peas/Snow Peas	Snap beans	
Corn	Radish		
	Zucchini		

* Crops on Sogeri and Goilala plateaux are expected to be similar to Eastern Highlands

8 Discussion

This study has shown that there are numerous constraints to sustainability of vegetable production in the areas visited. This is not to detract from the yield and quality of crops achieved at the farm gate, given the limitations and usually low intensity systems under which production occurs. Quality in the market place, though, is affected by difficulties in the supply chain. Increasing population pressure is placing increasing demands—with population increasing at around 5 per cent per year and food production increasing at only about 1 per cent per year. Clearly, such a situation is unsustainable. In addition to looming food shortages, diet is inadequate, with insufficient protein and Vitamin B and perhaps some minerals as well. Continuing and probably increasing reliance on carbohydrate and starch sources (e.g. sweet potato, yams, cassava) which are low to very low in protein and vitamins will mean the dietary imbalances will persist or intensify. Clearly, foods with high concentrations of proteins and vitamins are needed in the diet—these include legumes, animal proteins and functional foods such as broccoli and 'golden' sweet potato that deliver specific nutritional components. Assessment of indigenous vegetables may reveal a number of equally effective, well adapted indigenous vegetables that could meet specific dietary needs.

Evidence gathered shows a complex situation, meaning 'whole-of-system' analysis was necessary—to take into account the 'hard system' biophysical components (resource and agronomic) and the 'soft system' (sociological, economic and value chain) factors (Table 1). While gaps remain in information, especially for Goilala and peri-urban slopes, and in some aspects of research, development and extension infrastructure and services, considerable progress has been made in understanding the systems from farm to consumer and constraints related to resources, land tenure and management, crop agronomy, marketing, logistics and value chain function. There is some inconsistency in information, for instance in relation to roads, with some reports suggesting roads are passable, while others refer to the 'same' roads as impassable. Nevertheless, transport infrastructure is a major constraint.

From a biophysical viewpoint, there is considerable potential to increase production through expanded area of production and increased intensity of land use. Intensification will require enhanced land management practices for sustainability, including shifts in practice e.g. use of terraces rather than 'up-and-down-the-slope' rows which increase soil erosion. Increased nutrient inputs and enhanced pest management are required, and in alluvial valleys closer to Port Moresby, irrigation during the dry season (May to November) will be integral to production systems and continuity of supply although this requirement reduces with distance east from Port Moresby.

With the exception of the lowland alluvial plains, areas suitable for large-scale mechanised production are limited. Small-scale mechanisation (small machines, and a limited range of them) is all that will be feasible in other areas because of topographic limitations, a challenge in the face of drift of labour to other industries.

There is considerable documented and experiential knowledge and understanding of requirements for sustainable vegetable production. However, adoption is inadequate, with exploitive practices ultimately leading to resource degradation. Requirements for greater food supplies mean such practices cannot continue. There seems little need for research on the fundamental processes of land management for sustainability, plant nutrition, and plant protection, for example, though solutions to local constraints using locally available resources, including organic and other wastes, and ongoing effective management of natural resources need to be sought. In addition, continuing to develop and assess indigenous and imported genetic material for superior performance in smallholder production systems is essential. While some of these require thinking in the context of locally available resources and cultural norms, they are conceptually relatively straight forward. The largest challenge is to integrate existing and new knowledge into packages

that are suitable for smallholder adoption, and deliver them in a way that is personally (to individual producers) and culturally (to the community) acceptable. Associated research would focus on the 'soft systems' part of the 'whole system'.

Status of vegetable value chains

Vegetable value chains of all types (refer Figure 1) appear to be at a very basic stage of development as the vast majority of produce is channelled through ‘open markets’ where there are few or no long-term relationships. Succinctly, value chains appear to be largely inefficient, uncoordinated, with opportunistic and often exploitative behaviour based on the exercise of economic or even physical power, and lacking in trust, commitment, communication and information. There is little understanding of consumer value or even the quantum of demand, and supply is largely based on subsistence surpluses serendipitously produced rather than generated by any commercial response to ‘demand pull’. Further, there is little understanding of how markets operate, price mechanisms or risk management. This situation is driven by a number of significant cross-cutting factors including the country’s topography, climate, culture, infrastructure (particularly transport and communications), limited micro-finance availability and lack of business and agronomic knowledge and skills amongst the general population. These combine to produce three fundamental problems that are limiting the growth of the fresh vegetable industry in PNG: 1) a lack of critical mass to be able to supply more distant and/or larger markets; 2) a lack of ability to consistently and reliably supply a specific market over a sustained period; 3) a lack of ability to meet the most basic quality requisites inherent in the notion of value reportedly held by formal market consumers.

This will now be discussed in more detail employing the four subsystems outlined in the Methodology. It should be noted that the status of each is highly variable depending on which of the six types of marketing channels is being examined and, indeed, is different for every specific chain within each of those channels. Thus, the following are generalisations about the PNG vegetable marketing system.

Firstly, the product integrity subsystem or material flow is highly problematic. The bio-physical aspects of production have been detailed earlier in this section, however there are also very significant problems arising from inadequate harvesting, handling and cool chain practices. These are largely driven by a lack of cool chain infrastructure, skills and knowledge through the whole chain and combine with the poor state of the national transport infrastructure to result in the low quality of produce in the various markets and possible high levels of wastage. Further, the highly variable broken nature of the landscape, customary land tenure and traditional land management practices, so well suited to a family unit subsistence existence over the millennia, also mean that there are a vast number of potential small producers for the range of markets that currently exist.

Secondly, the flow of information both up and down chains is very limited, largely because of the inadequacy of the national telecommunications infrastructure in the rugged, isolated interior regions, but also due to the lack of trust and commitment generated by perceptions of inconsistency on the part of smallholder producers and opportunistic, exploitative behaviour on the part of the commercial wholesalers, buyers and ‘middlemen’ in the system. Apart from immediate face-to-face feedback during negotiations for the sale of produce, there appears to be little flow of either demand or supply data.

Thirdly, there is no objective understanding of consumer (or customer) value perceptions per se, apart from a vague anecdotal notion that ‘consumers want quality’ with inferred attributes of price, size, taste, blemish-free and shelf-life. Certainly this does not extend to understanding the value attributes for specific vegetables. Without such information it is impossible to know where in the chain value is created or where the potential lies for more value to be created and which chain partners might be involved in creating it.

Fourthly, the governance subsystem, often simply referred to as ‘relationships’ is almost non-existent, although it may be more prevalent amongst the Category B commercial smallholder farmers channels. Smallholder mistrust of wholesalers and buyers stems from

perceptions of their opportunistic behaviour, lack of communication, failure to share an adequate portion of the value created (price) and, in some instances a failure to even pay for produce received. Conversely, some wholesalers and buyers appear to be exploiting the large numbers of smallholders, their commercial naïveté and the lack of competitors by exercising their monopsonistic (few buyers, many sellers) power to their own advantage. Frequently, there is also a cultural, tribal or gender basis to this behaviour which exacerbates smallholder risk in selling in distant markets and acts as a significant disincentive to wider participation in commercial vegetable marketing. These factors make the progression from an open markets system to cooperation, coordination and collaboration (Spekman, Kamauff Jr. & Myhr 1998) and longer term relationships particularly difficult. They combine with cultural factors and competing means of generating the cash needs of families to mean that if vegetable marketing is too difficult, even the more commercial producers will return to a subsistence lifestyle.

The apparent problems identified in PNG's vegetable chains need to be investigated in more depth for a specific product chain. Selecting the appropriate product, site of production, ultimate market and segment of consumers to exemplify what value chain management can achieve for all the participants in that chain, is critical to achieving the overall project outcomes. The chain to be developed, the focal chain, must 'raise the bar' of production and marketing practices. To do so, it must be based on a chain where there is the potential to not only coordinate production on an increased scale and standard of quality to meet a market demand, but one where there is an opportunity to substitute local production for imports; that is, to 'grow the pie'.

Such coordination requires the capacity for developing longer term, more open relationships which suggests that it should focus on a formal or direct market for a cool temperate vegetable and some of the more commercial stakeholders in the system. Formal and direct markets, whilst not currently providing long term, stable economic relationships, offer the potential for these to develop through the improvement of communication, collaboration and the stabilisation of material flows and price.

Focusing on a more precisely targetable formal or direct market, such as supermarkets or mine sites, may enhance the likelihood of achieving improved product quality and consistency of product flows in the focal chain and generating the ancillary benefits of raising the general quality of produce flowing to the informal markets. Formal markets may also generate improved buy-in by the smallholder farmers because of the market and financial capacity of the market operators as well as the potential of developing longer term, more stable arrangements.

Targeting formal markets through a collaborative, community-based chain system will reduce the complexity of the marketplace for the formal and direct market participants and reduce the barriers of smallholder access to such markets because buyers will only have to negotiate with one seller rather than the current arrangements with many individual smallholders.

Dissemination of production and chain management principles and practice is more likely to occur from formal market chains to informal market chains than the reverse because of the 'Big Man' syndrome.

Therefore, it is concluded that choosing a focal chain supplying a formal or direct market will enhance the likelihood of achieving successful outcomes for the project and provide the best dissemination into informal market chains.

8.1 Researchable topics

A very wide range of researchable topics have been identified in this study. Though the study involved visits to farms and infrastructure in the Eastern Highlands, the topics listed below relate to Central province, which has both coastal lowlands and elevated areas (e.g. Sogeri Plateau, 600–800 m above sea level.

Researchable topics are grouped into natural resource management, agronomic, and socioeconomic, organisational and marketing topics.

Natural resource management topics

- land management practices (tillage and soil structure, erosion control, soil fertility management, rotations irrigation, salinity, drainage) for long term resource conservation
- sustainable vegetable production systems for smallholders
- identification of suitable arable lands capable of long term low input productions systems
- constraints to the adoption of technological solutions to land management (soil conservation, soil fertility management, salinity)

Agronomic topics

- genetic diversity, crop species, cultivars and crop improvement
- integrated pest management for smallholders

Socioeconomic, organisational and marketing topics

- functioning of the marketing system and value chains
- effectiveness of delivery of extension to smallholders
- effective business structures for delivery of vegetables from smallholders to consumers

8.2 Priorities for research

There are many areas in which research could be proposed under the terms of reference and within the context of current and foreseeable socioeconomic conditions. However, the greatest opportunities for enhancement of production to meet increasing demands and enhance productivity and improve the livelihoods of smallholder vegetable farmers lie in natural resource management and agronomy, marketing systems, and information and extension services.

Research priorities for a major project emerging from this study are identified as:

(i) soil, land and water resource management for production and sustainability

(ii) soil fertility management

(iii) integrated pest management

(iv) crop adaptation, cultivar selection, and seed supply and quality

(v) marketing systems, business structures and economic return

(vi) effectiveness of delivery of information and extension services

Within each of these, there will be a wide range of potential projects, some of which may be best addressed by modifications to existing programs in institutions such as NARI and the universities in PNG e.g. some specific projects on crop adaptation, cultivar selection

and seed supply and quality, or in collaboration with other bodies such as the Asian Vegetable Research and Development Centre.

8.3 Phasing of research and key milestones

1. Completion of this scoping study report – June 2009
2. Development of a full project proposal – by date to be agreed with ACIAR
3. Inclusion of detail of phases of research and key milestones in full project proposal – see 2 above

9 Impacts

9.1 Scientific impacts – now and in 5 years

To be addressed in large project proposal.

9.2 Capacity impacts – now and in 5 years

To be addressed in large project proposal.

9.3 Community impacts – now and in 5 years

To be addressed in large project proposal.

9.4 Economic impacts

To be addressed in large project proposal.

9.5 Social impacts

To be addressed in large project proposal.

9.6 Environmental impacts

To be addressed in large project proposal.

9.7 Proposal communication and dissemination activities

It is imperative that a strategy for communication among stakeholders and to disseminate results and associated information to the wider community be developed as part of the large project to emerge from this scoping study.

10 Conclusions and recommendations

10.1 Conclusions

The vegetable production and marketing systems in Central province and more widely in PNG are diverse and in a state of transition, especially in the proximity of large urban centres and areas where developments and population increase associated with mining are occurring. There is clear evidence of a productive landscape, and with increasing population, harnessing this capacity will be essential. However, there are challenges arising from the expectations of the population, and hence socio-economic dimensions, as they affect research and development in agricultural activities, must be considered.

The analysis undertaken here has provided invaluable insights into the many activities involved in vegetable production systems and delivery to consumers in PNG through a range of value chains. Nevertheless, some gaps in information remain, and some revision of conclusions and recommendations may be necessary following further investigation. The insights gained here have guided the identification of researchable topics and research priorities. It is, though, recognised that substantial local variation in resource quality, resource management and production and marketing practices exist, and in some areas, topics and priorities may differ. This report provides guidance to those topics and priorities that are expected to provide the greatest benefits in a reasonable time frame.

10.2 Recommendations

It is recommended that:

1. A detailed proposal for research in the priority areas 8.2 (i), (ii) (v) and (vi) above be developed consistent with current and foreseeable socio-economic conditions
2. Consideration be given to development of projects in research priority areas 8.2 (iii) and (iv) as additional proposals outside that referred to in 2 above
3. As part of 2 above, research partners in PNG and Australia be identified and their participation described.

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12 Appendixes

12.1 Appendix 1: Schedule of interviews and activities

Table A1: List of activities and interviews undertaken as part of scoping study

Day	Time to Start	Time to Finish	Activity/Interview	Organisation	Place
16-May-2009	1250	1525	Fly Hobart - Brisbane in transit to Goroka, PNG		
17-May-2009	0800	2100	Fly Brisbane to Goroka, PNG. Meeting with Provincial Governor.		Goroka, Eastern Highlands
18-May-2009	0900	2100	Meetings with FPDA.	FPDA	Goroka, Eastern Highlands
	1300	1700	Meeting & farm visit with Rocky Aino contact smallholder farmer.	FPDA	Mando Village, Asuro District
	1700	1945	Travel to Aiyura to visit NARI Research Station.	FPDA	Aiyura, Eastern Highlands
19-May-2009	0800	1300	Inspection of facilities & meetings with NARI Research staff.	FPDA	Aiyura, Eastern Highlands
	1300	1730	Travel to Goroka. Visit smallholders en route. Visit Ruben, commercial tomato grower & contact smallholder farmer.	FPDA	Goroka, Eastern Highlands
	1800	2130	Dinner meeting with Graham and Robert Ross, Allele Pty Ltd, a large vegetable producer & wholesaler.		Central Province
20-May-2009	0800	1400	Meeting with smallholder farmers (approx. 20) plus FPDA staff.	FPDA, DAL.	Goroka, Eastern Highlands
	1625	1735	Return Port Moresby in preparation for stakeholder & smallholder meetings		Central Province
21-May-2009	0800	0930	FPDA - Central province staff meeting.	FPDA	Hanuabada, NCD
	1000	1300	Debriefing with Manager, ACIAR - PNG	ACIAR	Waigani, NCD
	1400	1700	Government stakeholder meeting at Australian High Commission.	AusAID	Waigani, NCD
22-May-2009	0800	930	Inspection of Gordon's Market.		Central Province
	930	1030	Inspection of local Supermarkets.		NCD, Central Province
	1100	1530	Attend meetings with Dept. Education, and AusAid officers.	AusAID	NCD, Central Province
	1100	1530	Inspect smallholders & NARI - Loloko.		Central Province
	1530	1700	Meeting with DAL Central Province Administration.	DAL	Hanuabada, NCD
23-May-2009	0830	2100	Drafting Preliminary report. Dinner with ACIAR-PNG Manager.		
24-May-2009	0730	2000	Fly Port Moresby - Cairns - Melbourne - Hobart		
26-July-2009	0900	1200	Doyle - meeting with Provincial Government Officers and Aus-AID	CP & AusAID	Port Moresby
26-July-2009	1300	1500	Doyle - meeting with Rosa Kambuou at NARI Research Station Laloki	NARI	Laloki Research Station CP
26-July-2009	1500	1700	Doyle - meeting with Pacific Adventist University and farm tour	PAU	Port Moresby
27-July-2009	0900	1300	Doyle - meeting with William Tseng of Taiwan Technical Mission to PNG followed by meetings at NARI HQ - R Ghodake, A Ramakrishna and S Bang	NARI and Taiwan Technical Mission	NARI Research Station, Lae
27-July-2009	1400	1600	Doyle - meeting with University of Technology Teaching Staff	Uni Technology Lae	Lae
28-July-2009	0900	1600	Doyle - field trip to peri-urban areas with officers from FPDA	FPDA	Port Moresby
28-July-2009	1600	1800	Doyle - meeting with retired agricultural officers from the Rigo district	Rigo District	Port Moresby
29-July-2009	0600	1800	Doyle - Field trip to Cloudy Bay farmer group with NARI staff	NARI	Cloudy Bay
30-July-2009	0900	1500	Doyle - field trip to Sogari Plateau with officers from FPDA	FPDA	Sogeri Plateau

12.2 Appendix 2: People interviewed

Table A2: List of people interviewed and their affiliation. Groups (farmers, research support staff) are not included, but are noted in the text

Lastname	Firstname	Position	Organisation	Place	Province
Smith	Mal	Provincial Governor	PNG Government	Goroka	
Lutalelli	Robert	Manager	FPDA	Goroka	
Launa	Mewie	Corporate Services Manager	FPDA	Goroka	
Woruba	Moses	Coordinator Marketing Infrastructure	FPDA	Goroka	
Liripu	Greg	A/General Manager	FPDA	Goroka	
Aino	Rocky	Smallholder, Case Study Farm	FPDA	Mando Village	Asuro District
	Ruben	Smallholder, Case Study Farm	FPDA		
Kapila	Dr Rakesh	Principal Crop Breeder	NARI	Aiyura	
Bailey	Dr John	Research Program Leader	NARI	Aiyura	
Ero	Mark	Entomologist	NARI	Aiyura	
Kapal	Debbie	Soil Scientist	NARI	Aiyura	
Saese	Humphrey	Agronomist	NARI	Aiyura	
Ivahupa	Sharryl	Principal Agronomist	NARI	Aiyura	
Plak	Robert	Crop Improvement Scientist	NARI	Aiyura	
Maino	Gus	Marketing Adviser	FPDA	Boroko	NCD
Utanea	Poela	Extension Adviser	FPDA	Boroko	NCD
Nisiel	Sarah	Marketing Assistant	FPDA	Boroko	NCD
Fagan	Gary	Coordinator Publications & Information	FPDA	Boroko	NCD
Kraip	James	Horticultural Adviser, Southern Region	FPDA	Boroko	NCD
Atuai	Michael	Horticultural Adviser, Southern Region	FPDA	Boroko	NDC
Worinu	Mark	OIC, Port Moresby Office Coordinator, Market Support Programme	FPDA	Boroko	NCD
Ramakrishna	Dr A	Research Programme Leader, Wet Lowlands Mainland Programme	NARI	Bubia	Morobe Province
Wiltshire	Colin	Strategy	AusAID	Waigani	NCD
Graham	Chris	Second Secretary, Education	AusAID	Waigani	NCD
Dekuku	Dr R Chris	Chief Scientific Editor, Agricultural Information Branch	DAL	Port Moresby	NCD
Choe	Joanne	Program Director, Agriculture	AusAID	Waigani	NCD
Waki	Romias	Deputy Director, Agriculture	AusAID	Waigani	NCD
Groeger	Christine	Second Secretary, Economics	AusAID	Waigani	NCD
Lahis	Dr Sam	Extension Adviser	AusAID	Waigani	NCD
Daink	Francis	DAL	DAL	Port Moresby	NCD
Kambori	Dr Valentine	Executive Director, NAPD	DAL	Port Moresby	NCD
Hapa	Shelley	Women's Adviser	DAL	Port Moresby	NCD
Chambers	Mark	Development Adviser	DAL	Port Moresby	NCD
Vaira	Tabu	LLG Adviser	DAL	Port Moresby	NCD
Aisi	Michael	Provincial Livestock Adviser	DAL	Port Moresby	NCD
Arua	Morea	LLG Planning	DAL	Port Moresby	NCD
Haro	Arilla	Research & Planning	DAL	Port Moresby	NCD
John	Mebil	Principal Director	Farmer Training	Laloki	NCD
Ross	Graham	Director	Allele Pty Ltd		Central Province
Ghodake	Raghunath	Director General	NARI	Lae	Morobe
Bang	Sergi	Research Director	NARI	Lae	Morobe
Ovia	Tony	Farmer Production Manager	NARI - Laloki	Port Moresby	NCD
Kambuou	Rosa	Programme Leader	NARI - Laloki	Port Moresby	NCD
Paotu	Janette	PGR National Curator	NARI - Laloki	Port Moresby	NCD
Gwabu	Cliffton	Farm Budgeting Officer	NARI - Laloki	Port Moresby	NCD
Fahey	Geoff	General Manager	Trukai Industries Ltd	Lae	Morobe
Tseng	William	Leader	Taiwain Mission	Lae	Morobe
Kunea	William	Lectruer - University of Technology	PNG-UT	Lae	Morebe
Schubert	Dr Branimir	Vice Chancellor	Pacific Adventist Uni	Port Moresby	NCD
Siu-Damai	Isoa	Director - Farmer Coop	Cloudy Bay Co-op	Cloudy Bay	CP
Wohuinangu	Joseph	Retired Agricultural Officer	Rigo District Office	Port Moresby	NDC
Rova	Uvenama	Retired Agricultural Officer	Rigo District Office	Port Moresby	NDC
Henao	Salema	Farmer Cooperative Director		Port Moresby	NDC
Tau	Agie	Farmer Cooperative Director		Port Moresby	NDC

12.3 Appendix 3: Summary of farmers perceptions key issues (Goroka meeting)

Table A3 provides a summary of issues raised by the farmer groups in Goroka. It is interesting to note that the highest ranked issue was 'pests and diseases' closely followed by 'seed/variety'. These were ranked well ahead of marketing, which was followed by education/technical training.

Table A3: Summary of issues derived from farmers' contributions to meeting at Goroka

Table of Farmer Issues (20 farmers)																	
TECHNICAL ISSUES																	
Climate Change impacting production				1			1										2
Soil management - fertility	1																1
Pest and Diseases	1		1			1	1		1			1	1			1	8
Seed supply/selection			1	1		1		1			1	1				1	7
Technical Training/Education	1											1			1		3
Post harvest issues/packaging														1			1
																	22
SOCIO-ECONOMIC ISSUES																	
Labour supply	1																1
Increasing costs of inputs (fertilisers, sprays)				1		1		1				1					4
Financial services/loans		1															1
Bad deals (owed money)										1					1		2
																	8
COMMUNICATION																	
Coordination - wholesaler issues					1										1		2
Transport networks					1												1
Marketing (communication)	1	1			1					1						1	5
																	8

12.4 Appendix 4: SWOT analyses

Table A4 provides a detailed SWOT analysis for each of the provinces and regions/ districts considered in this report.

Table A4: SWOT analyses for the regions considered (A) Whole of Eastern Highlands and Central provinces (B) Regional Scale – Eastern Highlands province (C) Regional Scale – Sogeri Plateau (D) Regional Scale – Port Moresby peri-urban (E) Central province – Lowland (F) Goilala district

A. Whole of Eastern Highlands and Central province scale

Strengths	Weaknesses
Good supply of fertile production soils/lands Airports in key regions Year round cropping of tropical and temperate vegetables though drier seasons in some areas Traditional production systems have the basic elements of sustainability	Highly variable, dissected topography Poor quality of transport infrastructure Poor quality of ITC infrastructure Decline in soil fertility and erosion Land tenure and lack security Small holdings Public vs private sector conflicts Wontok system Socio-economic disparity (have and have nots) Trust, confidence and delegation Shortage of effective production leaders Producers operating in isolation Very limited supply of professional agricultural researchers and advisers Finance – supply, cost and conditions Social constraints Institutional communication with supply chain participants Local communication Gender issues Cool chain infrastructure Training system Capacity and costs of airports (freight) Traditional production systems vulnerable to lack of sustainability (shortage of available land, exploitation, population pressure) Data reliability – statistics production, population and market Poor social cohesion Tenure laws – customary and new laws/insecurity

Opportunities	Threats
Potential to increase production using natural assets (arable soils and major river systems)	Failure of either public or private projects will further reinforce traditional approaches to marketing
Capacity to increase quality	Failure to develop will increase reliance on imports and may cause local food shortages
Consolidation of number of products for chain efficiency	Population growth
High value low volume products e.g. strawberries and snow peas	Internal migration
Develop cooperatives	Lack of infrastructure and administrative capacity to manage development funds
Innovative microfinance	Regulation and interference in business/markets
Maximise the throughput of existing infrastructure	Civil unrest or unease due to socio-economic disparity
Develop better/cheaper air freight services	Economic disadvantage
To modify organisational and local communication networks and relationships	Competition for labour e.g. mining sector (leaves women to sustain population)
Develop motivated leaders throughout the industry	Poor documentation (lack of availability and distribution of practical reports in forms usable by farmers)
Enhance the existing infrastructure	Infrastructure failure
Coordinate and better manage existing LLC markets	Market failure(s)
Export to overseas markets	
Organic production?	
Niche market opportunities	
Chance to improve infrastructure	
Greater employment potential	
Capacity building in research and extension	

B. Regional scale – Eastern Highlands

Strengths	Weaknesses
Entrepreneurial individuals (private and public)	Reliance on too few motivated key individuals
Good extension staff, methods and exemplars	Unknown depth of extension quality
Talented and productive male/female R&D staff at NARI-Aiyura	Patchy ITC communications
Good active scientific /technical infrastructure in NARI-Aiyura	Long chain to market
Suitable climate for year round vegetable production	Significant road, sea and air transport issues, e.g. poorer sub arterial roads
Some existing cool-stores in infrastructure chain	Transferability of extension model to other provinces
Good arterial roads	Unknown ability of extension staff to accept new ways of working/methods
Some existing supply chains into Port Moresby, Lae, Weiwak, Madang, Vonimo	NARI capacity and flexibility limited by funding
Generally productive arable soils	Short rotations leading to declining fertility
Quick uptake of successful innovations	Evidence of erosion due to soil management practices
	Pest diversity and inadequate pest management strategies
	Topography limits scaling up
	Variability quality and non-availability of genetic/seed inputs
	Supply of inputs to system (fertilisers, pesticides, seed)

Opportunities	Threats
Huge potential to increase production using natural assets Maximise the throughput of existing infrastructure Air transport of high value/low volume temperate vegetables to formal and direct markets Export to overseas markets of more robust crops (cooking bananas, sweet potatoes, carrots) To develop robust ICM strategies	Commercial interests will fragment the existing critical mass Failure of either public or private projects will further reinforce traditional approaches to marketing Capacity of the private and public sectors to work in a mutually supporting manner Appearance of intractable pest problems Infrastructure failure Market failure/s Personal insecurity Business insecurity

C. Regional scale – Sogeri Plateau

Strengths	Weaknesses
Generally good deep structured soils though on sloping terrain Shorter, apparently less complicated chain to market A base of extension staff, methods and exemplars Some good regional market research Potential research capacity at NARI - Laloki Warmer climate than Eastern Highlands, cooler than Lowlands Some existing chains into Port Moresby Existing commercial operator in the region	Less entrepreneurial experience Lacks provincial government and FPDA research and extension facilities Patchy ITC communications Limited and challenging road transport network Seasonal water constraint, though less than lowlands Soil and land suitability variable Acidic and P fixing soils Variability in quality and non-availability of genetic/seed inputs Pest diversity and inadequate pest management strategies No cool chain infrastructure No NARI research sites at Sogeri Unknown depth of extension quality Unknown agronomic practices Unknown ability of extension staff to accept new ways of working/methods Unknown water resources and irrigation capacity
Opportunities	**Threats**
Potential to increase production using natural assets (good soils) Enhance marketing and delivery infrastructure Coordinate and better manage existing LLC markets Produce an expanded range of temperate vegetable products Export to overseas markets To develop robust ICM strategies Work with existing commercial operator	Continuing reliance on traditional approaches to marketing Increased reliance by supermarkets on imports Infrastructure failure Market failure/s Personal insecurity Business insecurity Appearance of intractable pest problems

D. Regional scale – Coastal Lowlands

Strengths	Weaknesses
Generally good soils in mid reaches of key river valleys	Less entrepreneurial activity
Shorter, apparently less complicated chain to market	Limited FPDA facilities
A base of extension staff, methods and exemplars	Patchy ITC communications
Some regional market research	Seasonal water constraints in central and western parts of province
Location of NARI - Laloki	NARI capacity and flexibility limited by funding
Warmer climate, though drier in central and west	Under -resourced research capacity at NARI - Laloki
Shorter road transport to Port Moresby	Variable soil/land suitability (drainage, structure, fertility)
Existing chains into Port Moresby	Variability quality and non-availability of genetic/seed inputs
Groundwater supplies exist	Pest diversity and inadequate pest management strategies
	Products limited to traditional commodity crops
	Drainage limits the utilisation of land in some parts, others with better drainage
	Cultural conflict in markets with highland entrepreneurs
	No existing cool chain infrastructure
	Need for increased extension quality
	Largely unknown agronomic practices
	Unknown ability of extension staff to accept new ways of working/methods
	Unknown water resources and irrigation capacity during the dry season
Opportunities	**Threats**
Potential to increase production using natural assets especially in the wetter eastern parts of province	Traditional approaches to marketing mean supermarkets will increase reliance on imports of temperate vegetables
Maximise the throughput of existing infrastructure	Appearance of intractable pest problems
Coordinate and better manage existing LLC markets	Traditional approach to land use
Enhance research and support capacity at NARI – Laloki	Subsistence approach is entrenched
Capacity to tap into NARI extension program at Cloudy Bay	Tribalism
Capacity to utilise Rigo District Plan as tool for extension and project selection	Personal insecurity
Capacity to produce an expanded range of vegetable products	Infrastructure failure
To develop robust ICM strategies	Market failure/s
Irrigation from underground water and rivers	
Export potential to overseas markets	

E. Regional scale – Port Moresby peri-urban region

Strengths	Weaknesses
Short less complicated chain to market	Many areas of current production are on shallow hill soils prone to drought and erosion
Freshness at time of sale	Provincial government and FPDA facilities for research and development projects
Location of NARI - Laloki	Patchy ITC communications
Shorter road and foot transport to Port Moresby	Seasonal water and temperature constraints
Existing chains into Port Moresby	NARI capacity and flexibility limited by funding
Entrepreneurial people/work ethic	Under resourced research capacity at NARI - Laloki
Significant existing production	Variable soil/land suitability (sloping lands, soil depth, drainage, structure, fertility)
Grow more that the traditional crops	Variability quality and non-availability of genetic/seed inputs
Some current mechanisation of tillage and irrigation	Drainage limits the utilisation of the flat lands (only part of lands)
	Pest diversity and inadequate pest management strategies
	Cultural conflicts
	No existing cool chain infrastructure
	Land insecurity due to urban expansion, cultural conflict and legal changes
	Unknown scientific /technical infrastructure in NARI - Laloki
	Need to expand extension quality
	Unknown agronomic practices
	Unknown water resources and irrigation capacity during the dry season
Opportunities	**Threats**
Potential to increase production using natural assets	Traditional approaches to marketing mean supermarkets will increase reliance on imports
Become involved in supermarket supply	Challenge from traditional land owners
Coordinate and better manage existing LLC markets	Personal insecurity
Enhance research and support capacity at NARI - Laloki	Infrastructure failure
Produce an expanded range of vegetable products	Market failure/s
To develop robust ICM strategies	Appearance of intractable pest problems
Irrigation from underground water and rivers	The very proximal peri-urban areas may exploit the reticulated water supplies
	Land degradation and associated impacts on water courses

F. Regional scale – Goilala District, Central province

Strengths	Weaknesses
Some moderately good soils (?) Climate suitable for cool season vegetables Entrepreneurial spirit of people Proposed Trans Highland Hwy route is through Goilala	No road transport to Port Moresby No base of extension staff Poor provincial and district government (located in Port Moresby) and FPDA facilities Patchy ITC communications Variable soil/land suitability Variability quality and non-availability of genetic/seed inputs No existing cool chain infrastructure Government workers will not live there Unknown agronomic practices
Opportunities	**Threats**
Potential to increase production using natural assets Capacity to produce an expanded range of vegetable products Develop a marketing strategy and chain/s Take advantage of Trans Highland Hwy To develop robust ICM strategies	Traditional approach to land use Subsistence approach is entrenched Trans Highland Hwy not constructed or rerouted Infrastructure failure Market failure/s Appearance of intractable pest problems

12.5 Appendix 5: Reflections on where possible projects might focus

The notes that follow consider the markets into which products of the vegetable industries are delivered. It is included to provide some enhancement to the context of the value chain analysis, much of it being already covered, though in much less detail in the body of the report

12.5.1 Which market?

Value chain management focuses on generating value in the eyes of the consumer from collaborative innovation to solve common problems by improved chain behaviour fostering improved, longer term relationships and greater certainty of demand and price.

The apparent lack of comprehensive market data on the actual size and nature of the current Port Moresby food market, its sources and the relativities between vegetable products consumed makes this decision difficult. The following rationale is based on the project goal of improving the productive and market behaviour of a smallholder value chain and the assumption that the principles demonstrated to a specific collaborative group will be disseminated by formal and informal processes into the surrounding community and region.

Informal markets are large diverse dynamic ‘spot markets’ subject to highly uncontrolled variation due to their inherent lack of manageability. It is difficult to identify who the market participants are and whether they offer the potential for long term, stable relationships for a chain with greater capacity to deliver product. Currently, it appears they are comprised of serendipitous, tribally-based, entrepreneurial and often aggressive market interaction that would be very difficult to engage with and manage. This apparent situation however, may not be as chaotic as might first appear as it is not known to what degree stable relationships have evolved between smallholder producers and the small middlemen that often purchase their produce to sell in the informal markets.

It is unlikely that informal markets would be able to handle substantial increases in the volume of a particular product (e.g. tomatoes) that might be generated from even a small chain improvement project.

On the other hand, formal and direct markets, whilst not currently providing long-term stable economic relationships, offer the potential for these to develop through the improvement of communication, collaboration and the stabilisation of material flows and price.

Focusing on a more precisely targetable formal or direct market, such as supermarkets or mine sites, may enhance the likelihood of achieving improved product quality and consistency of product flows in the focal chain and generating the ancillary benefits of raising the general quality of produce flowing to the informal markets.

Formal markets may also generate improved buy-in by the smallholder farmers because of the market and financial capacity of the market operators as well as the potential of developing longer term, more stable arrangements.

Dissemination of production and chain management principles and practice is more likely to occur from formal market chains to informal market chains than the reverse because of the ‘Big Man’ syndrome.

Targeting formal markets through a collaborative, community-based chain system will reduce the complexity of the marketplace for the formal and direct market participants and reduce the barriers of smallholder access to such markets because buyers will only have to negotiate with one seller rather than the current arrangements with many individual smallholders.

Therefore, it is concluded that choosing a focal chain supplying a formal or direct market will enhance the likelihood of achieving successful outcomes for the project and provide the best dissemination into informal market chains.

12.5.2 Which product?

Value chains that produce commodities are destined to compete on price because they cannot be differentiated from competing or substitutable products. Commodities produced in PNG may be subject to competition from similar products from more efficient (e.g. English potatoes from Australia) or economies with a lower wage/cost structure (e.g. rice from Thailand or the Philippines). Thus, selecting a commodity chain for this project introduces the possibility that the project outcomes will not be achieved because the chain's products will be out-competed in the marketplace.

Therefore, the selection of a vegetable product or family of products should be a high-value, low-volume product that will be suitable for transport and produce a relatively higher income for the smallholder farmers.

12.5.3 What improvement projects?

The following chain improvement projects are suggested. Every value chain is different due to the different players operating in different social, economic and environmental circumstances. Thus, the conduct of a detailed value chain analysis should precede the other listed projects. Following the choice of the specific chain a detailed analysis of that chain's specific needs will be required and this will determine the relative order, emphasis and duration of those other projects.

Value chain analysis of the selected chain

A community-based, collaborative value chain improvement project encompassing:

- The development of extension and training materials for use at the secondary school, vocational, short course and train-the-trainer levels
- Train-the-trainer training of selected NARI and FPDA operatives in the community-based, collaborative extension method
- Skills training for smallholders and their families
- Development and incorporation of a gender-based strategy.

Identification and assessment of key soil management issues for sustainable production in the smallholder context:

- Development of extension materials that address the issues raised
- Training and development of the extension staff both in-country and in Australia.

Identification and assessment of key crop protection issues for sustainable production in the smallholder context:

- Development of extension materials that address the issues raised
- Training and development of the extension staff both in-country and in Australia.

Agronomy

Irrigation

Seed production:

- Development of extension materials that address the issues raised
- Training and development of the extension staff both in-country and in Australia.

Post-harvest handling:

- Development of extension materials that address the issues raised
- Training and development of the extension staff both in-country and in Australia.