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Assessing the potential for expanding vegetable production in Central Province, Papua New Guinea

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Abstract

It has been commonly assumed that most of the vegetable supply in Port Moresby, the capital city of Papua New Guinea, comes from the PNG highlands and from overseas, because Port Moresby and most parts of Central Province are too dry and infertile for vegetable production. However, contrary to that assumption, a market survey conducted in 2008 found that in fact nearly 90% of vegetable supplies come from Central Province, and particularly from smallholders in peri-urban areas around Port Moresby. Demand for fresh produce in Port Moresby has been growing due to population and economic growth and is expected to grow significantly in coming years and into the foreseeable future as a result of the PNG LNG project and other mining and agricultural development projects around the country. The objective of this paper was therefore to assess the potential for increasing vegetable production in Central Province, by carrying out a preliminary feasibility study based on informant interviews, field observations and a literature review.

Our key finding was that none of the four locations (6 Mile, Laloki, Bomana and Brown River), initially selected based on their proximity to Port Moresby, were good candidates for commercial vegetable production because of issues of land capability and land tenure. However, when the scope was extended beyond the initial 30 kilometre radius, we found that several areas warranted further consideration, including the Rigo District, Hiri West and Hiri East. Although they are more distant from Port Moresby, they appear to be potential candidates because: there is no land tenure issue; growing vegetables is their only source of income; and farmers are already working in groups to supply supermarkets. Other areas, such as the Sogeri Plateau, Kupiano, the Vanapa River and Goilala, may have very high agricultural potential and fertile soils, but poor transport infrastructure remains a serious challenge for agricultural development.

Given that increased production can be achieved through improving productivity of existing farmers and/or through opening up new production districts, different strategies will be required for the three different areas identified based on their comparative advantages and disadvantages. In the short term, it appears that production can be increased by improving productivity and access to water of farmers in the peri-urban areas and the Rigo/Hiri Districts. In the medium to longer term, more and more production could, with improved transport and marketing infrastructure, come from areas that are further afield such as Sogeri, Kupiano, the Vanapa River and Goilala. However, the market situation in Port Moresby is in a state of flux, on both the demand and supply fronts. Continued research, and ongoing monitoring of the market situation, is essential to allow informed decision making for the relevant industry and development agencies.

Key words: vegetable demand, vegetable production, feasibility study, Central Province, Papua New Guinea.

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1. Introduction

The US\$15 billion investment in the Papua New Guinea (PNG) Liquefied Natural Gas (LNG) Project has been making headlines since its inception in 2006. The Project made its first deliveries in May 2014, and has been projected to provide a major boost to the PNG economy over the coming 30 years. ACIL Tasman (2009) has predicted that over its life (from 2014 to 2045) the Project will more than double the country's GDP and triple export revenues, and also create significant employment around the country. There are also several other gas and development projects in train. Demand for vegetables will increase substantially as a result, both from the project sites and from sectors that support those projects. A large proportion of this increased demand will occur in Port Moresby, the capital city of PNG, due to an influx of migrant workers and personnel, both PNG nationals and expatriates, to service those projects. The increase in demand for vegetables will be met both by locally-produced and imported products. The question is: to what extent does Central Province have the capacity to supply these growing Port Moresby markets?

A common perception is that most of the vegetable supply in Port Moresby comes either from the PNG highlands or from overseas, because Port Moresby and most parts of Central Province are considered to be too dry and infertile for large-scale commercial vegetable production. However, a market survey conducted in 2008 (FPDA 2008a) has changed that perception somewhat. The "Feeding Port Moresby Market Study" found that approximately 90% of vegetables supplied to Port Moresby came from Central Province, mainly from the peri-urban areas around Port Moresby farmed by smallholders. It was argued that while Central Province may not have the desired agro-climatic conditions suitable for vegetable production all year round (unlike Morobe Province and the PNG Highlands), there are small areas that, with appropriate technology, may be developed into productive lands. It seems, therefore, that a prima facie case for increasing vegetable production in Central Province to supply the Port Moresby markets has been established (FPDA 2008a). The objective of this study was therefore to conduct a preliminary feasibility study to identify potential production zones and policy options for Central Province to meet an increasing demand for vegetables from the Port Moresby markets.

2. Method

Establishing new production areas requires considerable investment and resources, particularly in road infrastructure and irrigation systems. Good planning is therefore a must before any action can be taken. A first step for good planning is a thorough examination of the environment from which potential production areas can be identified and assessed. This study was based on the participatory rural appraisal methodology (Pretty and Vodouhe 1997), and involved informant interviews and field observations as well as desktop research. It assessed both the agricultural potential of, and the enabling environment for, Central Province to produce and supply quality vegetables to the Port Moresby markets. Agricultural potential is assessed based on bio-physical factors that determine land capacity for vegetable production, whereas the enabling environment is assessed based on institutional and socio-economic factors that either promote or hinder farmers' participation in vegetable production and marketing. Together, they determine the development potential or economic feasibility of developing a production area or district for marketing purposes.

Three sets of factors were considered and assessed:

1. bio-physical factors: topography, climate, seasonality, rainfall and soil fertility
2. institutional factors: government and non-government institutions and their policies and programs, provision and accessibility of goods and services, land tenure systems and marketing systems
3. socio-economic factors: demographics, income sources, locations and social groupings

Key informants interviewed in the study included:

- government agencies: Office of Rural Development, Provincial Department of Primary Industries and Hiri District Office;
- research and extension agencies: National Agricultural Research Institute (NARI) (at Bubia and Laloki) and Fresh Produce Development Agency (FPDA);
- farmers' co-operatives: Rigo-Koiari Cooperative Society in Rigo Central and Egala Auna Farmers Co-operative in Aroma;
- commercial farms: City Mission, Arthur Chapman's Farm, Pacific Adventist University (PAU), and commercial farmers at 6 mile and 8/9 mile in the outskirts of Port Moresby;
- farmers in Brown River; and

- institutional buyers: National Catering Services and Boroko Foodworld Supermarket.

Central Province occupies 29 900 km² along the south coast of the PNG mainland. It has four districts: Abau, Goilala, Kairuku-Hiri and Rigo. The city of Port Moresby and the surrounds are part of the National Capital District (NCD) (Figure 1).

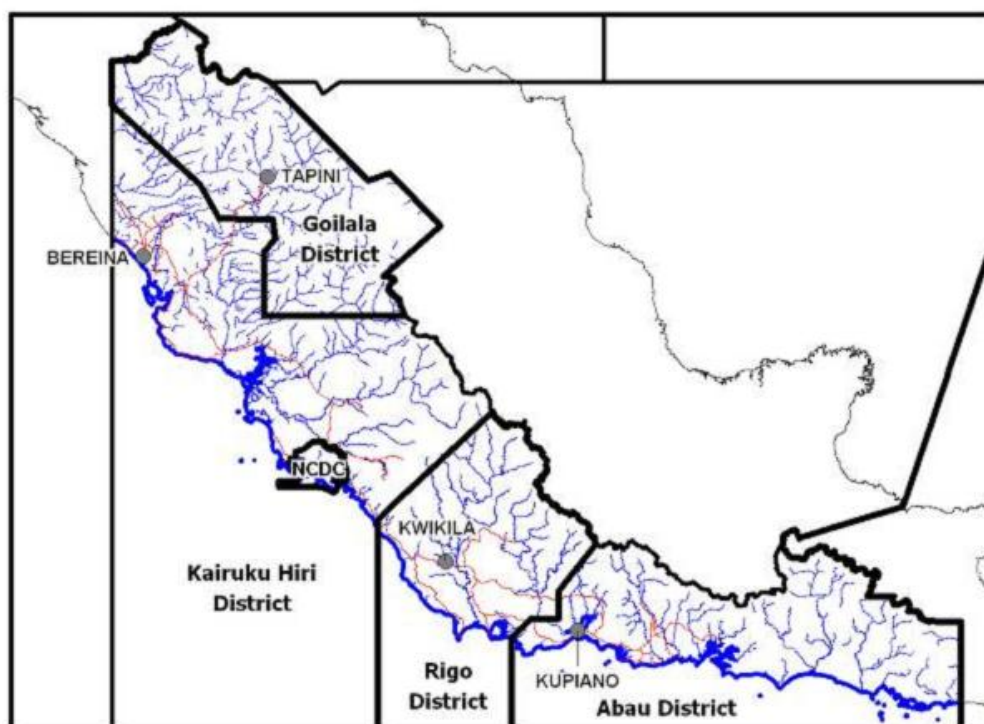


Figure 1. NCD and Districts of Central Province, PNG

Four locations in the Hiri District (6 Mile, Laloki, Bomana and Brown River) were investigated first because of their geographical proximity to Port Moresby. They are within a 30 km radius of Port Moresby. Equally important, large numbers of farmers in the areas were already involved in vegetable production to supply Port Moresby markets. As the study progressed, locations further afield were also considered because of their agricultural potential as identified in Hanson et al. (2001).

3. Vegetable supplies into Port Moresby

Volumes and sources of supply of fresh produce to Port Moresby were estimated based on the market survey conducted by FPDA (2008a) (Table 1). As shown, the major sources of supply were peri-urban production from the settlements (86.54%), followed by domestic arrivals by sea and by air (mainly from the PNG Highlands; 8.31%), and imports (4.33%). Two sources of supply were not accounted for in the study. These were supplies from the Central Island and supplies from home gardens all around Port Moresby.

3.1 Highland vegetables

In the past, fresh produce supply to Port Moresby, especially temperate vegetables, came primarily from the PNG Highlands (mainly the Eastern Highlands, Jiwaka, and Western Highlands provinces). Vegetables that are considered hardier, such as onion, carrot, potato, sweetpotato, English cabbage and avocado, were taken down to Lae via the Highlands Highway, either in 20-foot containers, 3-6 tonne open-back trucks, or in public motor vehicles (PMVs). Road transport of fresh produce from the Highlands to Lae requires 2-3 days, depending on what form of transport is used. They were then transferred to shipping containers and moved to Port Moresby by sea. At the time of writing, the average cargo dwell time² in Lae port was 3.67 days. There is no indicator specifically for fresh produce although shipping company interviewees claimed it was about 2-3

² 'Dwell time' is a port performance indicator. The dwell time of cargo in port is measured in terms of the number of days that a ton of cargo remains in port. The importance of dwell time varies with the nature of cargo.

days. Growers claimed there was considerable variation in this time. From Lae to Port Moresby, the ship must first go south-east, around Milne Bay, then travel north-west along the south coast towards Port Moresby, taking a further 48-52 hours steaming time to Port Moresby, with some variation due to weather or other factors (Figure 2). The whole journey from the Highlands to Port Moresby usually takes 7-10 days (Bonney et al. 2012).

More perishable and higher-value vegetables, such as tomato, broccoli, cauliflower, capsicum, spring onion, French bean, sugar fruit, wombok and lettuce, are in most cases flown directly from the Highlands to Port Moresby on regular passenger flights. The flight takes about an hour. In some cases, they are shipped by road to Lae (without refrigeration) and then in chiller containers from Lae to Port Moresby by sea. Mixed container loads of vegetables are problematic for postharvest quality because of a lack of understanding of differential ethylene production by different vegetables and fruit, as well as inadequate packaging and rough loading into containers (Bonney et al. 2012).

Table 1. Estimates of volumes and sources of supply of fresh produce to Port Moresby, 2008

Source of supply	Tonnes/year	%
International arrivals: by sea and air	2,500	4.33
Domestic arrivals by sea	3,500	6.06
Domestic arrivals by air: as cargo	1,300	2.25
Domestic arrivals by air: as carry-on luggage	130	0.22
Peri-urban production from the settlements	50,000	86.54
Peri-urban production from large farms	350	0.61
Total supply	57,780	100

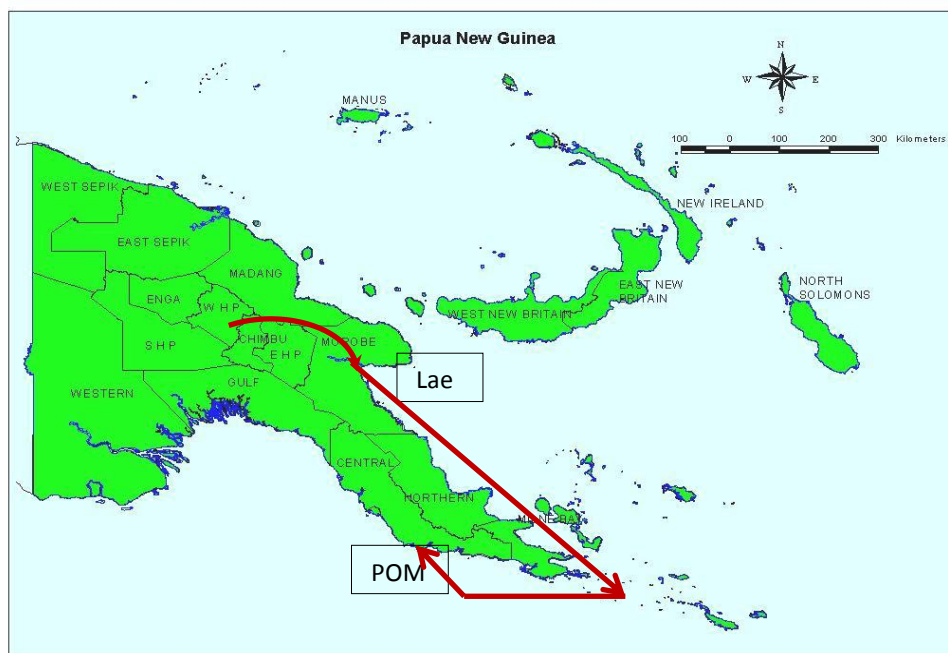


Figure 2. The long journey from the PNG Highlands to Port Moresby

Transport delays are frequent whether by air, by road or by sea, because of lack of cargo space on trucks and aircraft, shipping and flight delays, the poor condition of feeder roads and the Highlands Highway, and congestion at the wharves (Chang and Griffith 2011). Given the current postharvest management system (see Figure 3 for an example), when transport delays are significant,

vegetables can be damaged or completely spoiled when they arrive in Port Moresby. This results in poor quality, inconsistent supply and price fluctuations.



Figure 3. Cabbage and sweetpotato at the Lae wharf waiting to be shipped to Port Moresby.

Long, inefficient and high-cost supply chains from the Highlands to Port Moresby have resulted in declining shares of produce drawn from the Highlands, relative to total supply. Demand shortfalls have been met increasingly by vegetables produced locally, especially from the peri-urban areas around Port Moresby, as well as imports from Australia and New Zealand (FPDA 2008a). Transport issues comprise by far the most significant constraint for the PNG Highlands in supplying vegetables to the Port Moresby markets.

3.2 Peri-urban production around Port Moresby

The majority of the peri-urban vegetable production comes from migrants, mostly from the Highlands, living in peri-urban settlements (Demerua et al. 2006). Because these settlers do not have access to their own land, they tend to grow their vegetables on hillsides or vacant lands on public and private properties, often without consent from the landowners. Unsecured land tenure is undoubtedly a major constraint to expanding production to meet increasing demand. Hillside farming also raises concern about soil erosion and environmental sustainability.

3.3 Commercial farms

There are several commercial farms in Central Province supplying vegetables to Port Moresby by the traditional soil-based production methods. They include: Pacific Adventist University, the City Mission and Chapman's Family Farm. However, hydroponics has expanded in recent years. Unlike a traditional farm, where vegetables would be grown in the ground, hydroponic vegetables are being grown in materials which feed the root system with necessary nutrients, and in a controlled environment.

The main hydroponic farms supplying Port Moresby supermarkets include: Sogeri Primary Produce at Sogeri, CPL at Gerehu Stage 6, and the Innovative Agro Industry hydroponic vegetable farm at 9 mile. Sogeri Primary Produce has been in operation since 2002. It produces and supplies supermarkets in Port Moresby with tomato, lettuce and a variety of herbs. CPL started in late 2010, supplying to Stop 'N Shop supermarkets in Port Moresby and focusing on lettuce (Malum Nalu 2012). The entire process from seed to harvest takes about two months. There are plans to supply hotels and resource projects as well.

The latest addition to hydroponics was the Innovative Agro Industry hydroponic vegetable farm, which was established in October 2012 and began production in September 2013 (Creagh 2014). The 11-hectare farm, costing K28 million, was a partnership between the Innovative Agro Industry (an Israeli company), the Jesus Christ Halfway House and the Western Highlands Development Corporation. At the time of writing, it focused on tomato, cucumber, capsicum, zucchini and lettuce production for supermarkets. It was claimed that, at full capacity, the farm could produce up to 15 tonnes of vegetables per week from its six-hectare production area (Creagh 2014). There are plans to open up a similar project at the Ilimo Poultry Farm in the Markham Plains in Central Province (Post Courier/PACNEWS 2014). The impact of large-scale hydroponic vegetable production on local producers and smallholder farmers has not been, but should be, monitored closely and evaluated soon.

3.4 Imports

As shown in Table 1, vegetable imports accounted for less than 5% of the total volume estimated. PNG imports fruit and vegetables mainly from Australia and New Zealand (Bourke et al. 2009). The major commodities imported are Irish potato, onion, apple and citrus.³ In contrast to cereal and meat imports, fruit and vegetables account for only a small proportion of the total value of imported food, and are insignificant compared with the scale of domestic production. Although the PNG Highlands have the capacity to supply supermarkets and mining camps, the main reasons for importing vegetables are quality, consistency in supply, and variety (Chang 2011; Chang and Griffith 2011; Chang et al. 2013).

4. Bio-physical factors

Aspects of the physical environment that have the greatest influence on plant growth are rainfall, temperature, day length and soil fertility. Jointly, they determine land quality and the potential to produce good quality products. In this section, we look at the topography, climate and seasonal patterns of rainfall and temperature in Central Province and the four selected areas of Central Province, in order to assess their suitability for fresh vegetable production.

4.1 Topography, climate and seasonality

Most of Central Province is classified as lowlands, with altitudes ranging from sea level to 600m. It is made up of floodplains (22%) and mountains and hills (70%). Temperatures in Central Province range from 19-23°C to 30-32°C, with very high temperatures during the long dry season (June-October).

Rainfall has a direct influence on plant growth, and seasonal patterns must be taken into account in any discussion of agriculture. A number of aspects of rainfall influence plant production, including total annual rainfall, seasonal distribution, variability between years, extremes (drought, or periods of particularly high rainfall) and intensity (mm per hour) (Hanson et al. 2001). The optimum annual rainfall for many crops in PNG is said to be between 1500 and 3000mm per year (or 125 to 250 mm per month).

In Port Moresby, most rain falls between December and April, with an average rainfall of between 100 mm and 300 mm per month, which is suitable for crop growth (Figure 4).

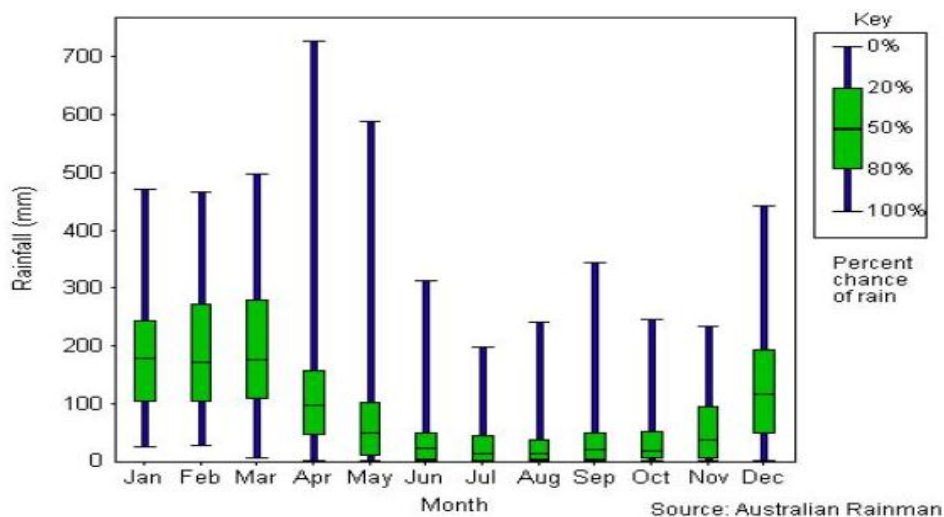


Figure 4. Rainfall patterns in Port Moresby

However, between June and October the rainfall is less than 50 mm per month, which is far too dry for crop growth. To make matters worse, during the wet season the floodplains near Laloki/

³ Domestic production of Irish potato and onion has increased significantly in recent years, and can be increased further. These are the two major commodities promoted by FPDA under the Public Investment Projects funded by the PNG government.

Bomana/ Brown River are subject to flooding and inundation. And rainfall patterns have become less predictable in recent decades due to climate change.

In comparison, most parts of Western Highlands, Jiwaka, Eastern Highlands and Morobe province do not have discernible rainfall patterns, and rain is received all year round. Therefore, it is fair to say that the most serious constraint for agricultural production in most of Central Province (including the four areas targeted in this survey) is the low/no rainfall periods during the long, hot dry season.

Most informants interviewed claimed that Central Province could grow all types of vegetables anytime of the year. However, this kind of statement can only be true if quality, yield or consistency of supply is not of major concern, as is the case in subsistence farming. For commercial farming, suitable topography, soils and climate are important to produce good quality produce all year round (Birch et al. 2010). For example, good quality (temperate) vegetables can come only from areas with cooler climates, such as the Highlands or the higher altitude districts such as Goilala in Central Province (altitude 1,200 m), and when they are in season. On the other hand, vegetables, such as cucumber, pumpkins and all types of squash, and fruit, such as mango, watermelon, lychee, guava, wax fruit, durian, etc, tend to grow well in hot climates. It is therefore important to choose the most appropriate types and varieties of crops to grow. It does appear that some fruit would have good agricultural potential in Central Province.

4.2 Production system

Production systems and principal agricultural commodities produced are determined to a great extent by the seasonal distribution of rainfall, as villagers adapt their agricultural systems to avoid interruptions to food supply (Hanson et al. 2001). For example, where rainfall is well distributed throughout the year, taro is generally the main staple food in the lowlands. In more seasonal environments, people rely to a greater extent on banana and yam. Where rainfall distribution is markedly seasonal, the agricultural system is based on a combination of taro, yam and banana, sometimes with sago being used for part of the year so that food supply is spread more evenly throughout the year, hence ensuring food security.

In Central Province, sweetpotato and banana are the two most important staple crops. Major cash crops in Central Province include: betel nut, rubber, coffee, coconut and fresh produce, as well as fish and seafood in the coastal areas. People in the Bereina area have very high incomes derived from the sale of betel nut and fresh food, while people in part of the Sogeri Plateau and Cape Rodney land settlement schemes earn high incomes from the sale of fresh produce and rubber. People living within a 40 km radius of Port Moresby earn moderate incomes from the sale of fresh produce, in addition to wage employment and small business activities such as running PMVs and trade stores. When there are alternative sources of income, people are generally not as interested in vegetables (e.g. betel nut is said to be a lazy man's crop in Bereina) (Hanson et al. 2001). This perception, and the lack of a commercial approach to vegetable production because farming is still widely regarded as a subsistence activity, have contributed to inconsistency in the supply of fresh produce to Port Moresby.

4.3 Agricultural potential

In this section, we focus on assessing the agricultural potential (i.e., land capability) of Central Province, based on GIS studies conducted in PNG for sweetpotato production⁴ (Hanson et al. 2000). This assessment was carried out using:

- altitude (as a proxy for temperature);
- inundation or flooding;
- slope;
- soil type;
- annual rainfall; and
- light (measured as cloud cover).

Based on GIS data⁵ for Central Province, nearly 90% of the land was assessed to be of 'very low' to 'moderate' land quality (Hanson et al. 2001), mainly due to serious constraints with respect to

⁴Sweetpotato was chosen because it is grown in almost all inhabited parts of PNG, it is the staple food for more than 60% of the population and a lot is known about the constraints to its optimal growth.

the long dry season throughout Central Province, and occasional flooding on the floodplains. This means that most of Central Province is not suitable for commercial vegetable production without substantial modifications to the existing agricultural environment and production systems. At a more disaggregate level, Hanson et al. (2001) also claimed that most areas north and northwest of Port Moresby were considered to have low to very low agricultural potential due to combinations of poor soils, low rainfall, seasonal inundation, a long dry season, steep slopes and frequent cloud cover. These assessments are applicable to Laloki, Bomana and Brown River.

However, there are some exceptions:

- Rigo District;
- Sogeri Plateau;
- the plains and hills inland of Kupiano;
- the tributary valleys of the Vanapa River; and
- Goilala.

Goilala is characterised by steep slopes and high rainfall, but has patches of fertile soils suitable for a wide range of vegetable production. Despite having high quality land, the tributary valleys of the Vanapa River and Goilala are not yet suitable for agricultural development because of the current state of the transport system, as well as lack of access to markets and basic services necessary to provide a stable basis for coordinated, commercial supply chains (Hanson et al. 2001; Birch et al. 2013). This means that only the Rigo District around the township of Kwikila, the inland of Kupiano around the Cape Rodney land settlement schemes, and some areas of the Sogeri Plateau are potential candidates for agricultural development at the present time.

Land most suited to agriculture in Central Province based on radar imagery is shown in Figure 5. This shows that the best land capability (yellow areas) is quite fragmented close to Port Moresby, with the largest concentrations near Brown River, Sogeri and in the Rigo District around Kwikila. However, as indicated by Doyle and Dell (2011), survey and soil testing are necessary to provide more accurate information for production planning. For example, when Birch et al (2013) conducted soil testing at some specific sites in these areas, high levels of Manganese was a potential problem for vegetable growing.

Access to market and services, and other enabling environmental factors that impact on the development potential, are discussed in the following sections. First we look at the institutional factors, then the socio-economic factors.

5. Institutional factors

For a private sector to flourish, it must be supported by an enabling environment, with appropriate institutions, as well as government regulations and policies which facilitate well-functioning markets. These institutional factors are crucial to agricultural development, because they impact on farmers' access to market and production inputs (land, capital, labour, water, electricity, extension, seeds, fertilisers, farm chemicals, etc) and input and output prices. In this section we review the key agricultural development institutions and policies in PNG at the national, provincial and district levels, as well as provision of goods and services.

5.1 Agricultural development agencies

The key agricultural development agencies in PNG are the Department of National Planning and Monitoring (DNPM), National Department of Agriculture and Livestock (NDAL), and Office of Rural Development (ORD) at the national level, and the main policy documents are the Medium Term

⁵ Dell et al. (2014) combined GIS and radar imagery in a method which is ideal for mapping large areas of mixed land cover, particularly in tropical areas such as PNG, and is vastly superior to that available from the Papua New Guinea Resource Information System (PNGRIS) for assessing Central Province soils and land capability. Base data were provided by the Defence Imagery and Geospatial Organisation with a spacing of 2.5 metres, and were gridded to a mosaic of 10m Digital Elevation Model (DEM) surfaces using the ArcGIS "3D Analyst" extension. This assessed stoniness, depth of soil 50cm – 1m, drainage, texture, low anion fixation, Cation Exchange Capacity (CEC) – moderate to high, available P, Ex K, base saturation, total N, slope - <100, and aspect. This data provides a more accurate and higher resolution representation of the local topography than the publicly available 30 and 90 metre Shuttle Radar Topography Mission (SRTM) data for the study area.

Development Strategy (MTDS) and the National Agricultural Development Plan (NADP). ORD is under the direction of the Secretary for National Planning and Monitoring. At the regional level, there are provincial governments, district administration and local level governments (LLGs). Most regional (provincial and district) development objectives and strategies are set out in the Provincial and District Five-year Development Plans, and are related to MTDS and NADP.

In addition to development projects funded by the national and regional governments, projects are also undertaken by NGOs (Hope World Wide, Salvation Army, City Mission, church groups, National Volunteer Services, World Vision, CARE International, etc). Furthermore, agricultural research and development projects are funded by PNG Sustainable Development, AusAID, NZAID, EU, the International Finance Corporation (World Bank) and other foreign donors. Most of these projects interlink in the social and health areas.

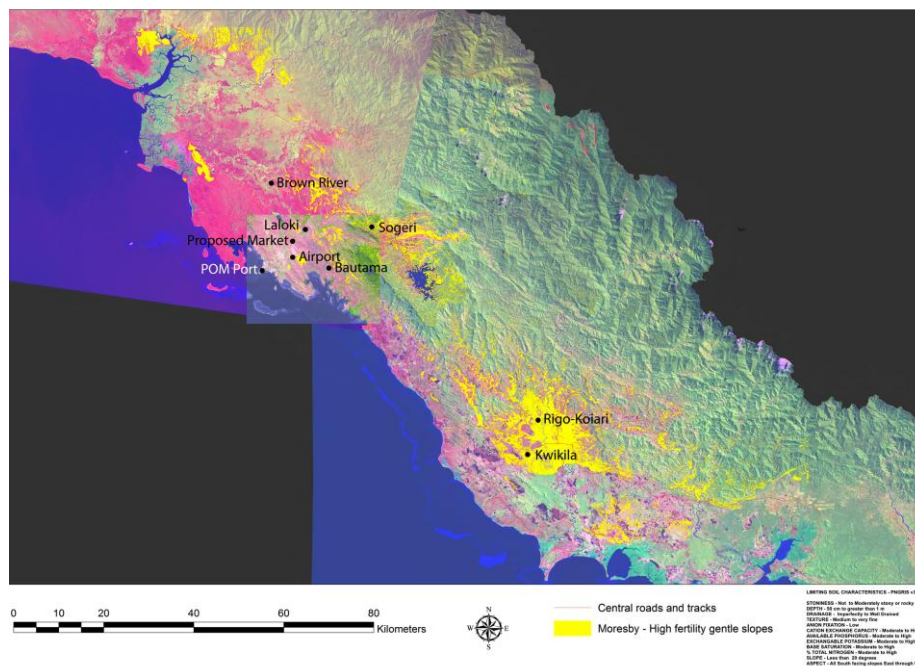


Figure 5. Land capacity in Central Province (Dell et al. 2014)

5.2 Agricultural support services (research, development, extension, and credit)

FPDA, NARI and NDAL are the main research and extension agencies for fresh produce and food crops in PNG. While FPDA has a mandate to undertake fresh produce extension, NARI focuses on research on staple food crops. NDAL, on the other hand, covers research and extension across all areas of agriculture (though mainly rice and livestock). Most of the research on vegetable production and marketing conducted was funded by external agencies. The most relevant one to this research was the project “Increasing vegetable production in Central Province, PNG, to supply Port Moresby markets” (Birch et al. 2013), funded by the Australian Centre for International Agricultural Research (ACIAR).

In that project, attempts were made to establish two new vegetable value chains at Gerabu Village, near Kwikila in Rigo District, and at Tapini in the Goilala District. An initial Rapid Value Chain Analysis (RVCA) identified many problems with current production and marketing methods, including that inappropriate, southern Australian vegetable varieties were being used by farmers, that high cost production inputs were being used inappropriately, that marketing lacked coordination and that there was poor post-harvest handling. Agronomic trials were conducted to select new, appropriate varieties of six high-value cool temperate vegetables, and to identify the most appropriate vegetable production system in the local circumstances. Training in agronomy and business management was conducted. In the case of Tapini, this was the first time the population had received training for farming. New coordinated targeted marketing was established from Rigo with early successes. However, whilst Tapini was found to be very capable of growing crucifer crops, English potatoes and other high-value crops, the region had major problems establishing coordinated marketing due to poor road infrastructure and social problems. Late in the

project, governance and social issues also resulted in the demise of the Rigo chains and these have since reverted to an uncoordinated state. These experiences highlight the importance of governance and social issues to the effective establishment of more commercial production practices.

Extension is very important for agricultural development. However, the general view is that extension service delivery is not widely provided (Sitapai 2012). The extension systems are not working because of lack of coordination between National and Provincial DAL, and lack of resources, both financial and human. During the recent restructuring of DAL and DPI, many of the experienced extension officers have been retrenched. As a result, FPDA is now the main source of expertise for production and marketing of fresh produce. Whilst their mandate is the whole value chain, in reality their resourcing and expertise is largely focused on farm extension, and they lack the downstream business expertise that could facilitate change in whole supply chains (Bonney et al. 2012). Although successful, the Village Extension Workers (VEW) model employed by FPDA since 1999 has limited outreach nation-wide (Chang et al. 2014). If it is adopted by the provincial and district governments, the VEW model, along with a business approach to farming, has the potential to improve the effectiveness of the extension system in PNG. During this research, we learned that the Governor of Central Province was keen to increase the supply of fresh produce. However, the main problem was that young farmers have not received the same good training as their fathers did, which was exacerbated by the lack of planning at the district level through which the development funding was channeled.

Access to credit is also important to agricultural development and economic growth. In PNG, the mainstream banks require freehold tenure, a relatively high security threshold and short payback periods. Such policies discriminate against smallholder farmers with customary or usufruct tenure⁶ (The Land Summit Coordinating Committee 2005). Further, the majority of farmers do not know how to obtain credit, are risk averse, or are reluctant to deal with the financial institutions because of previous bad experiences (Bonney et al. 2012). Many microcredit and microfinance schemes that targeted the poor and smallholders have been trialled and failed in the past few decades in PNG due to mismanagement, unsustainable practices, and political interference (Kavanamur and Turare 1999). Currently, there are two licenced microbanks in PNG:

1. PNG Microfinance Limited, which is owned by the PNG Sustainable Development (49%), Bank of South Pacific Limited (32%) and International Finance Corporation (19%); and
2. Nationwide Microbank Limited (previously Wau Microbank), which is funded by the Asian Development Bank and the Government of PNG (GoPNG) (Kamit 2008; Chang et al. 2013).

In addition, the National Development Bank (NDB) and some Savings and Loan Societies provide microfinance to farmers. While most microfinance institutions make loans to both individuals and groups, NDB's microfinance is available to groups only. All of these financial institutions have branch offices in Port Moresby. Also, the High Commissions of Australia and New Zealand have discretionary funds for which individual farmers can apply to support specific projects. FPDA have previously assisted some of their farmers to successfully access such grants.

Overall, it is fair to say that opportunities exist for farmers to access credit. However, there are some structural implementation barriers. Farmers need to be better educated about the pros and cons of accessing credit, and about their responsibilities and liabilities, before applying for a loan. Given that access to credit may be necessary for small businesses (including semi-commercial farmers), educating farmers on money management, agricultural loans and micro-financing should be an integral part of extension services, to complement training in production techniques and marketing.

5.3 Access to basic services (transport, water and electricity)

The coastal areas of Central Province have a network of good arterial roads, though the minor roads tend to be in poor condition, frequently restricting travel and transport of fresh produce during the wet season. There are three main roads out of Port Moresby: the Magi Highway (from 6 mile to Kwikila/Kupiano); the Hiritano Highway (from Laloki to Tapini and to Bereina/Kerema); and the Sogeri Highway (from Laloki to the Sogeri Plateau) (Figure 7). People within 40 km radius of Port Moresby require less than one hour's travel to reach the city, while most others on the coastal plains and hills require less than four hours' travel. All farmers and their produce commute by PMVs, though these are usually reliable. However, there is also a problem of loading produce onto the PMV when it stops, because people get priority.

⁶ The right enabling profit or benefit to be derived from property that is held in common ownership.



Figure 7. Arterial roads in Central Province

Access to town water and electricity is limited, except for people living within and close to NCD. The exceptions are Rigo District (Rigo Central and Rigo Coast) and Hiri District (Hiri East and Hiri West), though only for electricity. Where available, electricity can be supplied to individuals, but it costs K500 to get connected. Some people are connected to both water and electricity illegally in settlements. Some villages have their own generators.

Access to irrigation water is a serious problem for vegetable growers, even for those who live close to a river. Fetching water for gardening is laborious and time-consuming, and so most people grow vegetables only during the wet season. Currently, water can be pumped from the river with no restrictions, but most people do not have water pumps.

5.4 Input supply and costs

Farmers must go to Port Moresby to buy agricultural inputs, because there are no outlets in their local areas. There are three main input suppliers in PNG – Brian Bell, Farmset and Chemica. Some chemists sell a limited range of vegetable seeds, but not other inputs. There are complaints about lack of seed availability, high seed cost, or seeds that are inappropriate for Port Moresby conditions, because they are F1 Hybrid varieties suited to southern Australia and seed produced cannot be used for the next season's planting (Birch et al. 2013). For example, because of the demand for open pollinated corn seed, stocks frequently run out: seed orders from PNG may not be filled because the order quantities are small, and hence a low priority. NARI was interested in local seed production to meet farmers' needs, and at the time of writing was working on a project proposal to produce seeds at Laloki. The quality of fertilizers has also been questioned. It was suggested that fertilisers need to be tested and certified to ensure quality. Research on optimum fertiliser rates and placement is also needed to maximise yields.

5.5 Land tenure arrangements

The peri-urban areas around Port Moresby are densely settled (often illegally) with people from all parts of the country.⁷ The 2002 study of hillside farming in peri-urban NCD by Demerua et al. (2006) found that 77% of the farmers surveyed were squatting on the land they farmed, 20% had the approval of the legal landowners to use the land at no cost, 2% were on their own traditional land, and 1% paid rent or leased the areas they farmed.

All four areas in Central Province that were selected to be part of this study are either under traditional ownership or are state land, and as such there are serious squatter issues. It has been said that locals get concerned and upset about new settlers coming in. It was suggested that one way to avoid land dispute and get access to land is to tap into the Incorporated Landowner Groups

⁷Tribal fights in the Highlands are causing people to flee to Port Moresby. Port Moresby cannot produce the same range of crops as the Highlands; however, Highlanders work the hills and gardens around their houses and in their backyard to survive while they are in town.

(ILGs). ILGs are formed and registered with the Department of Lands. This arrangement may help interested farmers to form partnerships with like-minded private sector partners to farm land for fruit and vegetable production. The ILG process presents possibilities of leasing land or obtaining permission from the traditional owners, as suggested in Demerua et al. (2006). Two groups of farmers interviewed by the team (one near the 8/9 mile boundary and one in Brown River) indicated that they have the permission of the landowners to use the land at no cost. However, the land can be used only for agricultural production, and no permanent structure is allowed. Because ownership of customary land is often disputed, in either case there is a need to find out who the real landowners are before starting any development.

The problem with short-term or insecure land tenure is that farmers are unlikely to invest in improving soil fertility or to have an interest in preventing soil erosion and land degradation, since there is no long-term economic benefit from them doing so. Hillside farming, as witnessed around NCD, will therefore clearly result in serious environmental problems at some stage.

5.6 Marketing

In Port Moresby, most produce (about 90%) is sold at the open markets, with the remaining sold at the supermarkets, international hotels and kai bars (fast food outlets) in the city. Fresh produce marketing in Port Moresby has been found to be highly problematic in several major studies (UN Women 2011; Bonney et al. 2012; Jimenez et al. 2012;). The eight open markets are poorly managed, lack essential infrastructure, are unhygienic, and have tribalised security resulting in frequent intimidation and violence, particularly towards women who make up the majority of sellers in the markets.

Farmers tend to bring produce to the open markets and either market it themselves or sell to middlemen, frequently due to intimidation.⁸ Some farmers also hawk their produce around the back door of local supermarkets, although supermarkets and catering services are increasingly making arrangements to simplify and secure supply arrangements, usually with larger suppliers such as PAU and Sogeri Primary Produce, or with wholesalers such as City Pharmacy Ltd (CPL). CPL supplies to its own Stop 'N Shops, as well as National Catering Services in Port Moresby. CPL, in turn, obtains its vegetables from wholesalers and contract buyers in Mt Hagen.

However, a modern retail sector is developing rapidly in PNG, as international retail investors seek opportunities outside the hypercompetitive markets found in most developed countries. Several multi-national companies have already invested in PNG, both in retail and in supply. The challenge for small PNG agrifood suppliers is to develop their capacity to meet the competitive needs of the large retailers and major food outlets (e.g. institutions, large hotels etc). Fundamentally, these are a consistent quality and volume at an agreed price in a manner which reduces supply risk and avoids the complexity that adds cost. Challenges include the required scale of operations, the need to adopt modern management techniques, ensuring the integrity of supply agreements to enable price surety, undertaking appropriate forward planning and delivering value for consumers. Modern supermarkets, for example, do not want to have to deal every day with scores of small farmers selling their produce at the back door of each of their stores; they would prefer a very small number of larger suppliers with whom they can have a professional relationship, to reduce the high level of wastage in current supply (25-50%) and thus the real cost of local produce.

As living standards rise with the flow-on benefits from the resources boom, and the modern retailing revolution moves from upper and middle incomes to the working poor, as well as from large urban centres to regional towns and from processed food to fresh produce (Reardon and Timmer 2007), the pressure on supply will increase considerably. Currently, there are few industrial-scale fresh produce farms in PNG to meet this emerging demand, although the recent establishment of a large hydroponic, protected cropping operation at Laloki is perhaps a glimpse of the future.

As outlined earlier, Port Moresby's food supplies predominantly come from Central Province and the Highlands. In an analysis of this supply system, Bonney et al. (2012) found that future supply will most likely increase the dominance of Central Province. The land capability, institutional and socio-economic factors outlined in this paper indicate a considerable latent capacity to produce commercial fresh vegetables within an hour's drive of the National Capital District (NCD), and the

⁸ Disputes, violence and intimidation are facilitated by the lack of independent security forces; the guards are Wabags (Enga Province) and the vendors are largely Goilalans (NW Central Province) and Taris (Southern Highlands). As a result, farmers from Central Province are often intimidated into selling to the 'black marketers' at low prices at the gate, or are frequently kept out of the covered areas by the strong cohesion, organisation and aggressiveness of Highland vendors.

capacity to provide expanded future supply. As road infrastructure and air freight services improve into more remote highland areas such as Tapini, the reliance of the NCD on the Western and Eastern Highlands provinces for cool temperate fresh produce will also reduce, although overall volume from all sources will increase quite significantly to meet the demands of a rapidly growing capital city.

In coping with the demands of the rapidly developing modern retailing system in PNG, there is a pressing need to aggregate fresh produce at all levels of the supply chain to promote economies of scale, encourage private sector investment in dedicated fresh produce freight services, improve the quality and security of supply, and drive down freight costs. Significant changes to the current production and marketing behaviour of smallholders, as well as developing collaborative marketing skills to achieve consistency and volume, will be required. Smallholder collaboration, as well as developing long term supply arrangements which forego opportunistic selling behaviours, will be the foundation for achieving appropriate scale and consistency of supply. The new marketing practices include chain coordination to improve supply, improved post-harvest practices, and the use of dedicated freight vehicles rather than PMVs to reduce wastage associated with transit damage. Such changes can already be identified amongst a few of the larger farmers, traders and retailers who have identified the beneficial effects for their business.

6. Socio-economic factors

Based on data from Central Province from a recent socio-economic survey (FPDA 2008b), the picture of semi-commercial farmers that emerged was:

1. they tended to be above the survey average in terms of sales of fresh produce, while sales of livestock and other cash crops were around the average. A minority of farmers in Central Province had access to off-farm sources of income. Their mean garden area was similar to the survey average;
2. they mostly had plans to expand their production of fresh produce, despite around one third saying that marketing had become more difficult in the last five years;
3. their use of some well-recognised farm management tools and strategies was low, such as keeping farm records, using mobile phones to get market information, and membership of a farmers' cooperative or marketing group; and
4. the most frequently mentioned production problems in Central Province were pests and diseases, a lack of irrigation water, and bad weather. The most frequently mentioned marketing problems were transport and road conditions, competition, low market power and a lack of markets and lack of a wholesale market.

During the course of our investigation, more specific information about the demographics of the farms and farmers in the four targeted areas was obtained, including the numbers of semi-commercial farmers, their average garden areas, and principal commodities produced.

In the initial four areas we investigated in Central Province, there were close to 1000 semi-commercial farmers. Most farms were small with an average garden area between 0.1 and 0.2 hectare. In addition, there were a dozen or so commercial farmers that work on areas from around one to three hectares. The estimated numbers of semi-commercial farmers in the four areas were:

- 6 mile: 50, who mainly farmed on illegal settlements;
- Bomana: 300-400, who farmed on both illegal settlement and traditional land;
- Laloki: 250, who farmed on both illegal settlement and traditional land; and
- Brown River: 300-400, who farmed on both illegal settlement and traditional land.

Farmers in these areas tended to work independently, gardening and attending the market by themselves, not as groups. However, we found that in remote areas further away from the city, farmers tended to work together as a group. Among them some were informal community groups or self-help groups, and some registered co-operatives. FPDA has played a significant role in helping set up some of the groups, and in providing basic training in fresh produce production and marketing to most groups.

Several other socio-economic factors may have a negative impact on promoting vegetable production in Central Province. First, coastal people who are traditionally fishermen and hold large blocks of land may not necessarily have the skills or interest to engage in semi-commercial or commercial vegetable production. Second, people living within a 40 km radius of Port Moresby

often have alternative sources of income other than from the sale of fresh produce, including salaried employment and small business activities such as running PMVs and trade stores. When there are alternative sources of income, people are generally not as interested in vegetable production. Third, some buyers and input suppliers currently exploit the individualistic behaviour of smallholder farmers, as well as their relative lack of information, knowledge and skills. They will need to engage in trustworthy behaviour to build long-term relationships, such as by buying on the basis of weight rather than visual assessment (white poly bags), applying quality standards through the use of visual grading guides, not engaging in opportunistic or intimidating behaviour themselves and, most importantly, by providing smallholders (and others in the chain) with incentives to change their behaviour. Incentives may include sharing the additional value created from improved practices with those who have created that value, and forming long-term, trust-based relationships that facilitate collaborative innovation to solve shared problems. Fundamentally there need to be major changes in behaviour at every stage of the supply chain, not just for smallholder farmers.

7. Overall assessment

Nearly 90% of the land was assessed to be of 'very low' to 'moderate' land quality based on GIS data (Hanson et al. 2001), mainly due to serious constraints with respect to the long dry season throughout Central Province, and occasional flooding on the floodplains. This means that most of Central Province is not suitable for commercial vegetable production without substantial modifications to the existing agricultural environment and production systems.

The four areas (6 mile, Laloki, Bomana and Brown River) that are within 30 km radius of Port Moresby have good access to market and services (a network of good roads, electricity and running water), and there are around 1,000 semi-commercial farmers already operating in the areas. However, their potential to expand vegetable production is limited due to lack of access to water during the dry season, flooding and water-logging during the wet season and land ownership issues.

Rigo district, Hiri West and Hiri East appear to have the most development potential with some well-developed marketing cooperatives and between 300-500 families experienced in semi-commercial production in collaborative groups, with potentially another 1,000 families to be involved. The extension agency, FPDA, has had a strong presence in these areas. However, they are approximately 85 – 100 km or 1.5 – 2 hours' drive from Port Moresby. Even though the Magi Highway is an excellent, all-weather arterial road, the access roads to the main villages are frequently very poor and inaccessible during the wet season. Local transport is therefore a major constraint to supplying the Port Moresby markets timely and consistently. This is also true for farmers in the Sogeri areas.

For production areas, such as Kupiano, the tributary valleys of the Vanapa River and Goilala, despite their good agricultural potential, access to market is a major constraint due to the long distances to market, and associated transport and postharvest issues.

8 Policy Implications

It is now widely accepted that agricultural development in developing countries has multiple functions in accelerating development, by triggering GDP growth in early stage development, reducing poverty, reducing income disparities, providing food security, and delivering environmental services (Byerlee, De Janvry and Sadoulet 2009). Thus, interventions facilitated by government and by public or private investment in key enabling capabilities and infrastructure for the produce supply system will produce major improvements, not only improving the volume and quality of supply, but also alleviating poverty and contributing to broad-scale agricultural development.

Training and extension. There is considerable scope within Central Province for existing farmers to significantly improve the volume, quality and consistency of supply by improving farming and postharvest management practices, and by consolidating supply and coordinating supply processes. Extension and training must be a priority for these farmers. In the short term, extension should focus on existing groups in Rigo district, Hiri East and Hiri West. In the longer term, more consideration should be given to Sogeri and Goilala. According to our investigation, these areas appear to have both agricultural and development potential to meet increasing demand for fresh produce in Port Moresby. In addition, most of these groups have received support and assistance from their local Members of Parliament in establishing the groups, as well as receiving basic training from FPDA in vegetable production and marketing. It appears that considerable

opportunities exist for groups in those areas to expand their production, particularly if further assistance can be provided to keep the momentum going.

Capacity building in strategic planning. Given the great diversity in land capability and agricultural development potential in Central Province, it makes sense that the decision on whether and how vegetable production can be developed or expanded is made at the district level. Based on our investigations, it is clear that there is substantial interest in agricultural development in Central Province from the provincial and local governments. However, development plans often lack details and analytical rigour. Agricultural advisors at all levels of government (provincial, district and LLG) will benefit from training to build and strengthen their capacity in strategic planning, to set priorities and analytical tools such as participatory rural appraisal to identify needs of their constituencies, and to assess the feasibility of each of the proposed plans.

Water management. More research is required to identify long-term and short-term solutions to water supply problems. It is clear from our investigation that access to water during the long dry season is the number one issue facing most production areas in Central Province. Ready access to water is a pre-requisite for transforming from subsistence to semi-commercial and commercial farming, because of the advantage of being able to produce year round on a large scale. In the past, subsistence farmers have adapted their agricultural systems to suit the natural environment, especially rainfall patterns. However, this approach is no longer adequate for a semi-commercial or commercial farmer, because the market demands consistency in supply, both in volume and quality. Therefore, research into low-cost, small-scale irrigation methods, as well as larger-scale irrigation schemes, is required to resolve this major issue for fresh vegetable production in Central Province.

Soil testing. More technical data is needed (such as on soil fertility, varieties, yields, gross margins, and supply chain configuration) to provide farmers with sufficient advice on how to satisfy market requirements for quality and consistency in supply. During the investigation, there appeared to be a common belief that fresh produce, with the exception of some temperate vegetables, could be grown almost anywhere around Port Moresby and in Central Province. This may be the case for subsistence farmers, when their main objective is to meet their own household food consumption needs, and when yields and quality are not a major concern. However, both yields and quality are crucial for semi-commercial and commercial farmers if they are to meet stringent market requirements for consistency in supply. Due to the fragmented, highly dynamic landscape, it will be necessary to determine whether a potential production area has the land capacity required to produce certain high quality produce for the market. Scientific evidence is needed, and will require systematic soil surveying and soil testing to be conducted, to complement the new GIS and radar technology now available.

Collective action. Collaboration will be the central element in future agricultural development. PNG is likely to be reliant on smallholders for many decades to come, due to the nature of its landscape and the predominant customary land tenure system. The ability to maintain chain governance arrangements, particularly in landholder cooperatives, will be essential for this collaboration to occur, and will require significant effort in training, mentoring and monitoring probity. More research is required on the socio-economic factors affecting group dynamics and performance. Both the economics literature and provincial and district development plans suggest that collective action is one of the most effective ways to achieve community and agricultural development, because of the limited resources of individual farmers. However, there are known problems associated with groups (and co-operatives), notably free-riding, opportunism, and management issues. These potential problems should be kept in mind when developing extension and marketing strategies.

Hydroponics. Increasing supply from hydroponic operations is a potential threat to smallholder farmers, especially in the production of tomato, lettuce, capsicum, zucchini and cucumber. Their impact must be monitored and evaluated closely, and farmers be advised of their development, and appropriate strategies to steer away from head-on competition.

Intervention strategies. Experience indicates that implementing any strategy to improve fresh produce infrastructure and marketing practices needs to be carefully considered for its context and flow-on effects (Bonney et al. 2012). In some areas in PNG, international assistance has led to construction of fresh produce cool-stores in villages, to improve quality and to provide a village focus for the critical aggregation function. Bonney et al. (2012) surveyed seventeen such facilities around the country, and found all but one not functioning due to land disputes or various forms of mal-administration. They concluded that village level infrastructure needed to be built by local people using low-cost local materials to avoid those problems, and as a demonstration of their commitment to commercial production development. Further, they concluded when investigating

the feasibility of establishing a wholesale produce market in Port Moresby that such interventions must also adopt a systems perspective, which considers possible unanticipated consequences as the intervention ripples throughout the fresh produce system (Chroneer and Mirijamdotter 2009; Jain et al. 2006; Knoppen and Christiaanse 2007). There were a number of positive and negative flow-on effects associated with upstream infrastructure improvement and wholesaling and retailing marketing process improvements in Port Moresby. Whilst these improvements could benefit competition and produce quality they also increased the costs of operating the system, thereby increasing the cost of goods sold which may have further excluded poorer consumers (Bonney et al. 2012).

9. Conclusions

Demand for vegetables in Port Moresby will continue to increase, due to population and economic growth. This demand will be met by supplies from a variety of sources, including NCD and Central Province, PNG Highlands, and imports, depending on the ability of these production areas to meet different market requirements for price, quality, consistency in supply and variety. Domestic production areas have the potential to increase production, but each is faced with their own constraints and policy options. For smallholders in the peri-urban areas around Port Moresby, and in the Rigo/Hiri and Sogeri districts of Central Province, increasing production will require training and extension in farm and postharvest management, to improve on-farm productivity and product quality. For suppliers in the PNG Highlands, transport issues are the major constraint. They also face the threat of an increasing supply of temperate vegetables from the hydroponic commercial farms around Port Moresby, and possibly from Goilala if transport infrastructure to Port Moresby can be improved. Without significant improvements in the Highlands Highway and associated road and sea transport, and in air cargo space, their market share will continue to fall. Vegetable imports will continue to make up a small percentage of total supply, with a focus on servicing the mining camps and supermarkets. We conclude that the market situation in Port Moresby is in a state of flux, on both the demand and supply fronts. Continued research, and ongoing monitoring of the market situation, is essential to allow informed decision making for the relevant industry and development agencies.

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