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Final report

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2 Executive summary

This project addressed rising food insecurity amongst smallholder cocoa and oil palm households in Papua New Guinea (PNG). Amongst oil palm growers, falling per capita incomes and declining access to land for food gardening are emerging because of population pressure; amongst cocoa growers, the pest, Cocoa Pod Borer (CPB) (*Conopomorpha cramerella*), is devastating smallholder production and has significantly reduced people's capacity to purchase food. The project conducted a detailed socio-economic and cultural assessment of food insecurity and assessed andimplemented a range of strategies to improve the resilience of households and their capacity to produce and purchase food.

While strongly engaged in export cash crop production, virtually all cocoa and oil palm smallholders with sufficient access to land maintain food gardens for household consumption and cash income. However, oil palm and cocoa smallholder communities face multiple threats to their food security. In Oro and West New Britain (WNB) provinces, oil palm communities on the land settlement schemes (LSSs) and in some villages near Hoskins, WNB, are experiencing severe population and land pressures that are compelling them to cultivate food gardens on environmentally sensitive land or on land over which they have insecure tenure. Rapid population growth leading to declining per capita income from oil palm among LSS smallholders is further undermining food security by reducing people's capacity to purchase store foods to compensate for reduced access to land for food gardening. Cocoa farming households in East New Britain Province (ENB), the Autonomous Region of Bougainville (ARB) and, increasingly, in other provinces, such as East Sepik and Milne Bay, are confronted with the Cocoa Pod Borer (CPB).. In 2010 cocoa production in ENB fell by almost 80%. The significant fall in income has undermined food security through reducing people's capacity to purchase store foods.

Given these threats to food security among oil palm and cocoa communities, the overall aim of the project was to gain a detailed socio-economic and cultural understanding of the farming and livelihood systems of smallholders to develop and evaluate suitable interventions to relieve the stressors on farming systems that make smallholders vulnerable to food and livelihood insecurity. To assess the status of food security, the project examined, at the household level the four key dimensions of food insecurity, which typically form the basis of food security assessments — food availability, access, utilisation and stability.

The project found that despite the pressure on the livelihoods of cocoa smallholders from the Cocoa Pod Borer (CPB) incursion and the land shortages for food gardens amongst oil palm growers, both groups of smallholders are pursuing a range of adaptive strategies to enable them to maintain household food and income security. The study examined two very different scenarios: first, people's adaptation responses to a sudden environmental shock (CPB) which wiped out the primary livelihood activity of large numbers of cocoa farmers in the PNG lowlands; and second, a slow fuse threat of rising population pressure over a relatively long time period in smallholder oil palm communities. In both cases, our results indicate farmers have shown remarkable capacity to adapt to these threats. In cocoa, understandably, adaptation took some time as farmers initially abandoned their cocoa blocks and redirected their efforts to increasing food production and the pursuit of new livelihood activities. Some farmers have successfully managed the transition to high input farming necessary for living with CPB; others are now beginning to modify their production strategies to respond to CPB. However, a large proportion of farmers have not made the transition to high input farming, and continue to live with income levels much lower than in the pre-CPB period. CPB remains a threat to household food and nutritional security for cocoa growers throughout the lowlands.

In oil palm, research results reveal that many families have demonstrated considerable adaptive capacity to respond to the effects of population pressures and land shortages on food production (Koczberski *et al*. 2018). Despite rising land scarcity for food gardens, virtually all smallholder families continue to grow sufficient food to meet their daily nutritional needs. In addition, local marketing of garden foods continues to be women's most important income source after oil palm, and food gardens remain an important buffer against the vagaries of fluctuating oil palm prices. The diverse strategies households have developed to maintain food security include: the intensification

of food garden production; income diversification; increased reliance on purchased food; intercropping of oil palm; gardening in areas not previously used; and importantly new farm and social innovations that have introduced more flexible land access arrangements to a rigid land tenure system. Whilst these strategies appear to be effective in maintaining household food security, the long-term sustainability of the farming systems remains uncertain and there is increasing recognition by industry stakeholders (e.g. PNGOPRA, OPIC and the milling companies) that solutions must be found to ensure the future viability of smallholder production on the LSSs.

One potential solution to address the increasing populations on LSS blocks and the now heavy reliance on replant sections for food gardens, has been to rethink the traditional industry practice of replanting 2 ha of oil palm. Replanting 2 ha of oil palm creates a double disadvantage for smallholders particularly when there are multiple families residing on a block. A liability is incurred when purchasing the replant package and income, and therefore a capacity to repay the loan, is lost. This produces a major disincentive to replant old senile palms. Consequently oil palm production and smallholder incomes decline and block labour is used inefficiently as only a select few can harvest the tall aged palms. Further, whilst the traditional industry practice of replanting 2 ha of oil palm has enabled access to an additional 2 ha of intercropped gardening land for 2 years, the oil palm production cycle of approximately 22 years only allows three 2 ha replants on a 6 ha block. This means that gardening land is available for just 6 years out of the 22.

A new innovation trialled and introduced as part of the project, is a 1 ha, or 120 palm, replant option as opposed to the instituted 2 ha, or 240 palm, replant option. This has multiple advantages for the smallholder in terms of oil palm production including staggering the cost of replanting, providing a continual income stream, keeping more palms in production to service debt, enabling greater utilisation of labour and reducing maintenance costs. One of the main advantages of this new innovation is the increased potential to secure gardening land into the future. When using this strategy on an individual block, gardening land could be accessed for 12-18 years, double the time of that of the standard 240 replant. In conjunction with reciprocal land exchange arrangements, that are common among smallholders, there is much greater opportunity for ongoing access to gardening land than under the 240 replant strategy, this being an important element in maintaining food security.

Under the 1 ha replant option the costs of replanting are staggered, making loan servicing less onerous for farmers, and replanting much more financially rewarding to farmers. Instead of a ratio of 2 palms in production to repay the loan for each seedling as under the conventional 2 ha replant practice, the ratio is 5 palms in production for each seedling under the 1 ha replant option.

Increased gardening on-block also takes pressure of environmentally sensitive areas such as buffer and riparian zones. Thus the 1 ha replant option adds considerably to the long-term social, economic and financial sustainability of the smallholder sector.

3 Background

Food security amongst smallholder cocoa and oil palm growers in PNG is being undermined. Following the arrival of CPB in East New Britain in 2007, the pest spread rapidly throughout the province and soon to other cocoa-growing provinces. CPB has since decimated the production and incomes of cocoa growers. Among oil palm growers, especially in WNB, population and land pressures on the oil palm LSSs have contributed to declining per capita incomes and land shortages for food gardening amongst oil palm growers.

Rising food insecurity amongst smallholders is of considerable concern given that nearly all smallholders grow food crops for home consumption and cash income (Koczberski *et al*. 2012a), and like everywhere in PNG, food is of great cultural significance. For the majority of rural women in PNG, local marketing of garden foods is their most important income source after export crops, and gardens provide an important buffer against fluctuating export cash crop prices (Koczberski *et al*. 2001; 2012a). Food production is thus a key strategy for enhancing food and income security. A socio-cultural and economic assessment of the status of food security among smallholders which identifies the key factors that enhance or constrain the capacity of households to adapt and respond to food insecurity is critical to assessing and developing appropriate interventions and policies that will relieve food insecurity among oil palm and cocoa smallholders. Previous ACIAR socio-economic research among cocoa and oil palm smallholders has demonstrated that innovative agricultural extension interventions can be developed when the socio-economic and cultural factors influencing household decision making and agricultural practices are understood and taken into account in the design of new initiatives (Koczberski *et al*. 2001; Curry & Koczberski 2004; Curry *et al.* 2007; Koczberski 2007; Koczberski & Curry 2008; Curry *et al*. 2010).

Approximately 151,000 families in PNG produce cocoa at very low levels of productivity which are even lower now in CPB-affected areas. One of the greatest and current threats to food and nutritional security among cocoa growers is the loss of income due to the rapid spread of the Cocoa Pod Borer which has caused a substantial fall in production in most cocoa growing provinces. Indeed, CPB is the single largest threat to PNG's cocoa industry, and which is now affecting production in most cocoa growing provinces (Curry *et al.* 2009; Curry *et al*. 2015). CPB was first detected in PNG in 2006 in ENB where cocoa was the primary income source for over 23,000 smallholder households (70% of total households in ENB), and was the largest source of income for the province. In ENB in 2007-2008 cocoa generated K144m in export revenue and accounted for almost half of national cocoa production (provincial annual output of over 20,000 t). In 2010 production collapsed to less than 5,000 t. There was a marginal improvement in 2011 with production at 7,000 t then after another decline to 4,000 t 2012 it returned to 7,000 t in 2016.

CPB had caused enormous hardship to cocoa households and communities by undermining people's capacity to earn a living, to meet their education and health needs and to maintain their general quality of life (Curry *et al.* 2009; also Curry *et al*. 2012). In ENB where cocoa provided the primary income source for over 70% of households in the province, production has dropped by over 80%. Likewise in the ARoB, there has been over 70% crop loss. This loss of income has undermined people's capacity to purchase food and has put pressure on food gardening systems as people rely more heavily on garden production for home consumption and household income (Curry *et al.* 2009; Curry *et al*. 2015).

The extent to which increased reliance on garden food production can be absorbed into village agricultural systems where land and population pressures already exist and where land use intensification is occurring is unknown. For example, the northeast Gazelle Peninsula is one of the most densely populated areas of lowlands PNG (Keig 2001) and annual population growth rates remain high. In the Tinputz district of ARoB, similar land pressures are emerging due to rapid rates of population growth. Thus there was a need to assess the status of food security in CPB-affected

areas and the viability of smallholder cocoa holdings and food gardens for meeting household income and food needs.

There was also a need to understand the constraints that prevent a significant proportion of farmers from adopting more intensive CPB management strategies which leave them more food insecure than other farmers. ASEM/2006/127 concluded that the NGIP-Agmark model of smallholder engagement was successful in facilitating the transition to high input farming for some farmers. A combination of intensive training in block upkeep and CPB control techniques, together with credit for farm inputs, regular fermentary maintenance, rotational replanting programmes and regular transport of crop all helped farmers make the transition to high input farming and the effective control of CPB. There are no half measures in managing CPB. Farmers must adopt high input farming strategies if they are to keep CPB at a manageable level. However, ASEM/2006/127 found that whilst the CPB training provided by NGIP-Agmark had helped many cocoa growers to make the transition to the high input farming strategy, numerous farmers struggled to farm in a CBP environment while others gave up cocoa production (Curry *et al.* 2009). Farmers who persist with the foraging strategy of low inputs would harvest very little or no cocoa as CPB losses approach 100%. Preliminary research has found these smallholders have increased their reliance on food production for home consumption and sale at local markets (Curry *et al*. 2012). Growers who are not adopting more intensive cocoa farm management will be part of the study, to allow the project to identify those households that are more vulnerable to food insecurity.

In oil palm, there are 5,130 LSS smallholders (over 60,000 people) and over 12,000 village oil palm growers. LSS smallholders are experiencing a per capita income decline with a more than doubling of the population. Land pressures for food gardening are also rising because nearly all LSS blocks are now fully planted to oil palm. ASEM/1999/084 first identified food insecurity as an emerging problem among LSS growers as population density rose and blocks were fully planted to oil palm. Preliminary research by a John Allwright-funded PhD student working on food security and intensification of land use amongst oil palm growers in Hoskins has shown that many LSS households do not have enough land to meet their food production needs, and this situation is worsening. While on-block intensification of food production has occurred through the adoption of faster maturing crop varieties, extended cultivation periods and reduced fallow periods, gardens are being displaced off-block to land over which they have insecure tenure and to environmentally sensitive land in contravention of RSPO criteria for certification (Koczberski *et al*. 2012b). The long-term sustainability of the LSSs is under threat and there is increasing recognition by industry stakeholders (e.g. PNGOPRA, OPIC and the milling companies) that solutions must be found to ensure the future viability of smallholder production on the LSSs. Similar pressures on gardening land are emerging in densely populated oil palm villages in the Hoskins area of WNB.

The first research priority therefore was to understand the current status of household food security and vulnerability on the LSS and VOP blocks. The research sought to understand what livelihood strategies women were pursuing to maintain access to land for food gardening and/or to minimise impacts on food and income security from the loss of gardening land? Other research questions included: how is declining access to garden land affecting agricultural practices and household food consumption patterns and incomes? By providing answers to these questions, the project aimed to provide information to assist in devising extension strategies that have the potential to generate substantial economic, social, and cultural benefits for a large and growing group of oil palm smallholders.

In PNG there has been no research on the intercropping of smallholder oil palm or cocoa with food crops, with the exception of recently established trials by PNGOPRA in WNB and Popondetta (PNGOPRA Annual Research Report 2011). Whilst oil palm intercropping studies have been conducted elsewhere in the tropics (Cheyns & Rafflegeau 2005; Putra *et al*. 2012) these studies are limited to assessing intercropping when the oil palm is in the immature stage and none has trialled different oil palm planting arrangements to allow intercropping to continue past the immature phase.

Hence this study trialled and monitored intercropping on smallholder oil palm holdings. In cocoa, there have been some studies in Africa that show intercropping cocoa with food crops is beneficial in increasing yields and reducing weeds, and is more efficient than a monoculture of cocoa (Osei-Bonsu *et al*. 1998; Adeyemi 1999; Ofori-Bah and Asafu-Adjaye, 2011; Opoku-Ameyaw *et al*. 2012). NGIP-Agmark promotes rotational replanting of cocoa among smallholders which enables intercropping of cocoa with food crops. This is a component of their high input farming strategy which they are promoting amongst farmers to address CPB. Under a rotational replanting strategy, 10% of the block is replanted each year so that cocoa stands are maintained in the high production stage, which also provides land for food gardening, thereby enhancing both food and income security. By working in partnership with NGIP-Agmark to monitor and assess the introduction of a rotational replanting system, the project will provide crucial data for assessing its potential for enhancing food security, increasing productivity and strengthening the overall viability of smallholder cocoa-based farming systems. It will also identify the constraints on adoption of rotational replanting.

4 Objectives

Objectives:

1. Assess the status of food security among cocoa and oil palm households.
2. Determine the key factors that enhance or constrain the capacity of cocoa and oil palm households to adapt and respond to food insecurity.
3. Assess and implement a range of strategies to improve the capacity of smallholders to produce and purchase food.
4. Increase the capacity of smallholder households and extension providers to address food and livelihood security through improved access to training, information and ICT innovations.

Expected outputs for cocoa and oil palm industries:

1. Knowledge of the status of household food and livelihood security and the factors that enhance or constrain the capacity of smallholders to cope with food and livelihood insecurity;
2. Set of indicators to delineate levels of household food security and which identify vulnerable and resilient smallholder households;
3. Identification of suitable interventions to relieve the stressors on farming systems that render smallholders vulnerable to food and livelihood insecurity; and
4. Increased capacity of industry stakeholders to use ICT to deliver extension and improved access to financial services to enhance household food security.

5 Methodology

This study was conducted among 375 oil palm households in West New Britain (WNB) and Oro Province (278 WNB and 97 in Popondetta) and 249 cocoa growers in East New Britain (ENB), Bougainville (ARoB) and Milne Bay. Data were collected in a total of 21 villages across five provinces (Figure 5.1). The oil palm research was carried out among smallholder households in Bialla, Hoskins and Popondetta residing on oil palm land settlement schemes (LSSs) and in villages in the Hoskins LLG area, WNB. Cocoa research was conducted amongst CPB-affected and non-affected communities in three villages in each of three cocoa growing provinces: on the Gazelle Peninsula, ENB, Tinputz area, ARoB and in Milne Bay.

The research was informed by participatory and action research approaches with researchers working closely with smallholders' households – both men and women. An interdisciplinary approach was adopted that encompassed qualitative and quantitative methods. The merits of multiple methods approaches are well recognised for socio-economic and livelihood studies and have proven successful in other ASEM research (e.g ASEM/1999/084, ASEM/2002/014 and ASEM/2006/127).

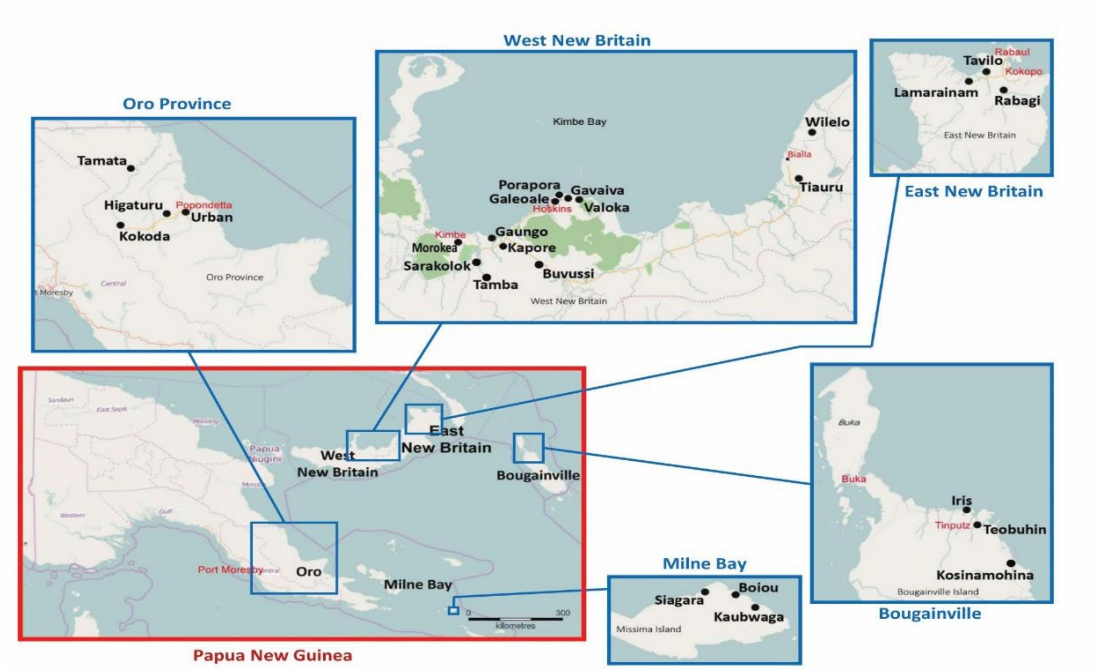

Figure 5.1: Study sites

Objective 1: **Assess the status of food security among cocoa and oil palm households.**

A detailed socio-economic and cultural assessment of household food security was undertaken in all the study sites. The assessment and data collection methods drew on a well-established literature on the design of food security assessments (e.g. Maxwell & Frankenberger 1992; International Federation of Red Cross 2006; Coates *et al*. 2007) and focussed on the four key dimensions of food insecurity which typically form the basis of food security assessments. These include:

- Food availability. This is the food that is physically available because it is grown in household gardens or produced locally, or imported. Food availability can be affected by seasonal or climatic factors (e.g. drought), pests and diseases, the supply of household labour to grow food, and soil nutrient status, to name a few.
- Access to food. This is concerned with how people access the food available. Is it accessed from their own gardens, by borrowing, exchanging, purchasing, foraging, hunting or

stealing? Access is determined by a household's resources – their access to land and labour to cultivate gardens, access to social and kinship networks, and access to money to purchase nutritious food. Also, food access is affected by the distribution of income within a family, one's social position in the family, the coping strategies of households to adjust to pressures, the price of store foods and access to markets and stores. Food access can be negatively influenced by conflicts over land, loss or drop in income and the collapse of, or restrictions on, social safety nets.

- Utilisation. This is the way people use the food for a healthy life: the consumption of adequate nutritional food. It can depend on the quality of the food, how it is prepared (e.g. sanitation, cooking skills), how the food is stored, food taboos (e.g. during pregnancy), cultural preferences for particular crops, nutritional knowledge, as well as the health status of the individual consuming the food.
- Stability. There must be a continuous supply of nutritious food at all times to ensure food security. Thus, the stability of the three key dimensions above – availability of food, access to food and stability of the intake of nutritional food are needed for a household to be food secure.

Assessing these four components of food security are considered to be the most appropriate methods to determine the level of household food insecurity and identifying how households maintain a food secure environment. These four components of food security were assessed among oil palm and cocoa households using a mix of methods that encompassed:

1. *Household socio-economic questionnaire surveys*. In total 624 farmers were interviewed (Table 5.1). Questionnaire surveys focused on the main household socio-economic characteristics that are linked to the availability and access to food at the household level. For example, income, number and sources of income, control of household income, educational levels, household size and number of dependents, access to garden land and land tenure, food production, asset/resource base, impacts of and responses to CPB/land pressures.

2. *Household dietary intake surveys*. For each family member a 24 hour dietary recall gathered information on: the number of meals eaten in the previous 24 hours; what foods were eaten as part of the main meals; and the source of the meal ingredients (food procurement).

   Household food consumption data was collected at two levels:

   - A one-off 24 hour food recall question among all 624 plus oil palm and cocoa households. Households were asked the question "*Yesterday evening/night what did you and the family eat?* Information was collected on the type of food ingredients making up meals, itemised for each household family member (e.g. Mother, father, child 1, etc.) over a period of 24 hours. For each ingredient recorded people were asked where that ingredient was sourced - e.g. the garden, store, market, gift, etc.

   - Over a 7 day period (among a subgroup of households). A 24-hour food intake recall done over seven consecutive days among a subgroup of the 634 households (Table 5.2). A total of 129 households participated in this recall during the 2015/2016 period. In the oil palm growing regions of Bialla and Hoskins, 42 households were surveyed (12 households in Bialla and 30 in Hoskins). In cocoa growing regions Bougainville, East New Britain Province and Milne Bay, 89 households were surveyed (30 households in Bougainville, 29 in ENBP and 30 in Milne Bay). Food intake was recorded for each family member for the main meals in the preceding 24 hours, for 7 consecutive days. Each ingredient was recorded and the source recorded.

The dietary surveys were to determine if cocoa and oil palm smallholders had regular access to nutritious and sufficient quality food to meet their daily dietary. Both methods provide a

'snapshot'/picture of the types and diversity of foods eaten, and where the food is sourced. Although both a one-day or 7-day assessment of food consumption doesn't provide an indication of seasonal differences in diets or an individual's habitual diet, it does provide a good assessment of the range of the different food groups consumed at a particular point in time. The seven-day survey data, although a smaller sample, allowed for a more detailed assessment of the diets which could not be done from a one-off dietary recall. During the 7 day 24 hour dietary recall visits we also collected information on the income earned and expenditure by the household in the last week – especially expenditure on food.

Table 5.1. Household baseline socio-economic surveys

Province	Study site	Tenure	Subdivision/ LLG/ Village	Date (2014)	No. households	Sub-Total
Oil palm						
West New Britain	Bialla	LSS	Tiauru	May-Jun	54	
			Wilelo	May-Jun	36	90
	Hoskins	LSS	Buvussi	Oct	21	
			Kapore	Oct	20	
			Sarakolok	Oct-Nov	37	
			Tamba	Oct	13	91
		VOP	Galeoale	Nov	13	
			Gavaiva	Nov	11	
			Porapora	Nov	10	
			Valoka	Nov	25	59
		CRP	Morokea	Oct	19	
			Gaungo	Oct	19	38
Oro	Popondetta	LSS	Higaturu	Aug	44	
			Popondetta Urban	Aug	19	63
		VOP	Higaturu	Aug-Sep	15	
			Kokoda	Aug	13	
			Tamata	Sep	6	34
Cocoa						
East New Britain	Gazelle Peninsula		Lamarainam	Jul-Aug	26	
			Rabagi #1	Aug	31	
			Tavilo	Jul-Aug	31	88
Autonomous Region of Bougainville	Tinputz		Iris	Jul	32	
			Kosinamohina	Jul	32	
			Teobuin	Jul	34	98
Milne Bay	Misima Island		Boiou	Sep	33	
			Kaubwaga	Sep	23	
			Siagara	Sep	7	63
Total Surveys						624

Table 5.2 Households participating in the one-day and seven-day dietary recall surveys.

Province	Ward	One-day 'previous meal'	Seven-days 'all meals'
West New Britain	***Bialla***		
	Tiaru	54	12
	Wilelo	36	-
	Hoskins		
	Buvussi	21	
	Kapore	20	
	Sarakolok	37	13
	Tamba	13	-
	Galeoale	13	-
	Gavaiva	11	3
	Porapora	10	-
	Valoka	25	3
	Gaungo	19	10
	Morokea	19	-
Oro	Higaturu (LSS)	44	-
	Popondetta Urban (LSS)	19	-
	Higaturu (VOP)	15	-
	Kokoda (VOP)	13	-
	Tomata (VOP)	6	-
Bougainville	Iris	32	14
	Kosinamohina	32	-
	Teobuin	34	15
East New Britain Province	Lamarainam	26	9
	Tavilo	31	9
	Rabagi	31	11
Milne Bay	Siagara	7	-
	Boiou	33	15
	Kaubwaga	23	15
TOTALS		624	129

3. Household garden surveys. These surveys were conducted on gardens belonging to the 129 household subsample selected for the 7 day dietary (Table 5.3). The garden surveys had four main components:

    - A survey questionnaire. This recorded for each food garden: site description, garden cultivation cycle, garden type and function, dominant food crops grown for consumption and marketing, fallowing, soil fertility and maintenance; ownership and land tenure, land disputes, theft, pest and diseases, and cultural practices.
    - Informal household interviews. Visiting gardens with the garden owners allowed an opportunity to collect information, in a free flowing manner, on topics such as perceptions and knowledge of soil fertility, changes in gardening practices over time, pressures on the gardening systems and food security issues.
    - Garden sketch. This showed garden layout, garden boundaries, food crops, crop intensity, boundary crops, intercropping with cash crops, and dominant agricultural techniques such as ash beds and mounding.
    - Garden location and measurement of garden area. Location of gardens and distance from house was recorded with a Global Positioning System (GPS). To measure garden area, GPS coordinates were recorded around the perimeter of each garden using a hand held GPS device[1]. The GPS coordinates were used to calculate garden area using Google Earth and Earthpoint[2]. If gardens were too small for obtaining accurate GPS coordinates a tape measure was used to obtain the distances required for manual calculation of area.

Table 5.3. Household food garden surveys

Province	Study site	Tenure	Subdivision / Village	Date	No. households	No. gardens
Oil palm						
West New Britain	Bialla	LSS	Tiauru	Jun & Dec 2015	20	47
	Hoskins	LSS	Sarakolok	Jul-Oct 2015	20	46
		VOP	Gavaiva	Aug-Sep 2015	4	10
			Valoka	Sep 2105	4	7
		CRP	Gaungo	Mar-Jun 2015	10	18
Cocoa						
East New Britain	Gazelle Peninsula		Lamarainam	Apr 2015	10	24
			Rabagi #1	May 2015	11	27
			Tavilo	Jun 2015	9	14
Autonomous Region of Bougainville	Tinputz		Iris	Aug-Sep 2015	15	37
			Teobuhin	Sep 2015	14	25
Milne Bay	Misima Island		Boiou	Aug 2016	15	37
			Kaubwaga	Aug 2016	15	40
Total Surveys						332

[1] Garmin eTrex® 10 recorded geospatial data (GPS coordinates)

[2] Using the geospatial data the Earth Point file conversion software was used in conjunction with Google Earth to view gardens on Google Earth as well as calculate garden areas.

Together the above methods provided data on three key aspects:

i) socio-economic factors affecting the availability of and access to food;

ii) access to garden land and food gardening practices; and

iii) food consumption and diets.

Objective 2: **Determine the key factors that enhance or constrain the capacity of cocoa and oil palm households to adapt and respond to food insecurity.**

Data collected under Objective 1 was complemented with informal interview data collected from smallholder households. The interview data were largely gathered among the 129 subsample households who were selected for the dietary intake and garden surveys, and households who participated in the household socio-economic baseline survey. Interviews aimed to identify the key factors that influence the capacity of households to adapt to food insecurity and to elicit the range of livelihood responses to food and income insecurity. In ENB, ARoB and Milne Bay, interviews focussed on responses to CPB; in WNB and Popondetta, discussions concentrated on changes in household food security over time. More general discussion topics covered changing food gardening practices, access to resources, household coping and adaptive strategies, the political, economic and socio-cultural contexts influencing their livelihood adaptation strategies, household decision-making processes, and barriers to achieving sustainable farming systems.

Data collected as part of Objective 1 and 2 helped form the basis of a typology that highlighted the main household responses to food and income insecurity and the combination of farm management and livelihood strategies most likely to support viable cocoa and oil palm farming systems to meet household food and income needs.

Objective 3: **Assess and implement a range of strategies to improve the capacity of smallholders to produce and purchase food.**

The 1 ha Replant Trial

A 120 palm replant trial was undertaken on seven blocks in the Wilelo LSS subdivision at Bialla between 2016 and 2017. Wilelo subdivision was selected because previous visits to the subdivision indicated that many growers were harvesting less than half of their tall over-aged palms and were reluctant to replant. The trial was done in collaboration with Hargy Oil Palms Ltd (HOPL) with the aim to assess the advantages and disadvantages for smallholders to undertake a 120 replant option and evaluate its potential to improve the long-term status of household food and income security among smallholders.

Given no previous studies exist on intercropping food crops with oil palm in PNG, detailed garden assessments were conducted as part of the trial. Due to time and financial constraints, a scientific analysis of the effect of food cropping intensity and management on food crop productivity and oil palm productivity was not conducted as part of the trial. However, in a related study on two smallholder blocks at Hoskins LSS, data were collected to determine whether food crops and oil palm complemented or competed with each other.

Fieldwork for the trial began with a series of awareness programs on the 1 ha replant option, held in conjunction with farmer extension field days. Presentations to smallholders explained how the 1 ha (120 palms) option would operate and its potential benefits for smallholders, especially in terms of gardening (clear benefits for women) and income and loan repayments (benefits for both men and women). Pamphlets in Melanesian Pidgin explaining the 120 option were distributed to smallholders present at these field days. The awareness programs and pamphlets gave the opportunity to promote the trial among smallholders and recruit interested farmers to participate in the trial.

To be selected for the trial, interested smallholders had to meet two or more of the following characteristics:

- The block had over-aged palms with the full 6 hectares planted to oil palm.
- At least two households were residing on block. This was a likely indication that the block was experiencing population and income pressures.
- Located in the interior of the subdivision. These blocks had no access to adjoining reserve or buffer zone land on the edge of the subdivision.
- Oil palm was the main source of income for the household.
- Practice *skelim hecta* or *makim mun* production strategies (strategies adopted on farms where population and income pressures exist).

All seven blocks selected had more than two co-resident households. Of the seven blocks, four practised the 1 ha (120 palm) strategy and three used the conventional 2 ha (240 palm) replant strategy. All four, 1 ha replant trial blocks, practised either *makim mun* or *skelim hectare* harvesting strategies. Prior to the trial's commencement, trial farmers signed an agreement to allow researchers on their blocks during the trial.

Data collection incorporated both quantitative and qualitative techniques, namely:

- Household questionnaire surveys and informal interviews.
- Garden monitoring surveys by household.
- Quarterly assessment of palm physiological parameters.
- Monthly assessments of block condition.
- Monthly loan repayments.

Household questionnaire surveys and informal interviews

The purpose of the household questionnaire survey was to gain a picture of the socio-economic and demographic situation of participating blocks. The survey covered household demographics, the range of livelihood activities and household assets, access to garden land, number of gardens per household and food sources other than garden foods. A questionnaire survey on the replant section was also conducted to provide a snapshot of the replant at the beginning of the trial. This questionnaire collected information on each garden in the replant area, including the names and residence location of gardeners (either living on- or off-block), their relationships to the blockholder and the gardening arrangement each gardener had with the blockholder. The current pest and disease status was also recorded.

Initial interviews with trial participants gathered information on the reasons why the family took up the 1 ha replant option and what advantages they perceived the 120 replant would provide for the family (e.g. smaller loan repayments, less labour burden, etc.). Questions concerning current debt levels with the company were also asked.

Household garden monitoring surveys

At regular monthly intervals throughout the trial a garden monitoring survey was conducted in the replant section. Parameters assessed included:

1. Number and area of garden plots
2. Number of gardeners
3. Owners of gardens and their residence (on- or off-block)
4. Block owner-gardener relationship (e.g. kinship, friend, church member, etc)
5. Current gardening round (stage of cropping cycle)
6. Incidence of pests and diseases
7. Use of pesticides and fertilisers
8. Crop varieties and area per crop

The first garden survey was conducted at the initial visit to the trial participant's block in 2016. This initial survey occurred on different dates for each block ranging from July to November. In 2017 all blocks were surveyed at three monthly intervals starting in January then April, July and October.

The garden monitoring survey was composed of two sections: Part A for the block owner; and Part B for each garden in the replant. In Part A the block owner provided information on the date the oil palm seedlings were planted, the number of gardeners that were gardening on their replants, including those residing on and off-block, and the arrangement they had made with them. In Part B, for each individual garden, information was recorded on the residence location of the gardener and their relationship to the block holder. The crops grown and the proportions of each garden area occupied by the most dominant crops were also documented.

For each monitoring visit, a sketch of the whole replant area and each garden within it provided spatial information on cropping patterns. The sketch map was drawn in relation to the planted oil palm as a matrix that provided a tool to calculate garden plot area (Appendix 1). Across all seven replants, the maximum number of gardens surveyed during a field visit was 69 in April 2017.

The garden monitoring surveys were used to establish:

- Who gardens on the replants.
- The proportions of gardeners who resided on-block and gardeners residing off-block.
- Off-block gardeners relationships to the host blockholder.
- The distance between off-block residents' homes and their gardens.
- A comparison of the food crops cultivated in replant and non-replant areas.
- The number of cropping rounds undertaken prior to the oil palm canopy closing or prior to the gardeners moving on to new gardening land.
- A comparison of garden characteristics between the 1 ha and 2 ha replants.

Trial to assess competition for light and water by oil palm and food crops during the immature phase of a replanted smallholder oil palm block

To complement the information gathered on the 120 replant trial, a study was carried out on mature and recently replanted sections of two LSS blocks at Kapore subdivision, Hoskins. In Block #372 the mature section was planted in 1994 and the replant section in 2014. In Block #260, the mature section was planted in 2006 and the replant section in May 2016. A garden plot survey was undertaken in half of the replant section of Block 372 at approximately 3-month intervals. All food crops were recorded. More detailed measurements of crop and soil characteristics were carried out on transects in both blocks.

In each block, 6 transects were marked out; 3 in the replant section and 3 in the mature section. Each transect was approximately 44 m long and traversed 4 oil palm rows, at an angle of >60° to the rows, to provide representative coverage. Measurements were taken approximately every 3 months. The plant species present (up to 3, replant section only) were recorded at every 1 m along the transect. Soil water content (0-20 cm depth) was also measured at each point. Canopy characteristics were measured for the oil palms at the end of each transect, every 3 months in the replant section, and once in the mature section. Soil samples (0-15 cm depth) were taken from the transects in Feb 2017 and analysed for chemical properties.

Assessment of the relationship between food production on cocoa plots (intercropping) and management of the cocoa crop.

Sample cocoa plots were selected to represent three different age groups, where the owner had intercropped the cocoa with food crops at varying levels, from no food intercropping to extensive intercropping. The age groups were newly planted cocoa plots, where the cocoa plot had been planted with a shade crop, but not yet with cocoa seedlings, prime production plots, where the cocoa plants were between 0 and 9 years old, and senile production plots, where the cocoa was 10 years and older. 35 newly planted plots, 21 prime production plots and 21 senile production plots where selected.

Nearly all cocoa plots are planted with a shade crop to shade the cocoa seedlings. Species commonly used are Gliricidia, banana, coconut, betel nut and mango. Because several of these are food crops, the presence or absence of these crops was not used as evidence of intercropping with food crops for this study. Instead the presence or absence of vegetables was used as an indicator of intercropping.

General information collected

Researchers interviewed each plot owner, visited each plot, mapped the plot and made an analysis of food crop species present and cocoa management practices. Researchers used two standard questionnaires for conducting the interviews and analysis. The same questionnaire was used for the prime production and senile production plots, and a slightly different questionnaire was used for the newly planted plots.

For the prime production and senile production plots, the interviewer recorded the date that the cocoa was planted, the shade crops used, from most to least common, whether the plot was currently or previously planted to food crops and why. If the owner was planting food crops, the interviewer recorded how long the plot had been under food cultivation and the current gardening round, whether there were any other families gardening on the plot and whether the food crops were grown mainly for marketing or consumption (including when any food crops had last been sold). The owner was also asked whether they intended to plant more food crops after the current gardening round and why or why not.

For the newly planted cocoa plots, the interviewer recorded the name of the plot, the date planted and type of shade trees planted, the number and type (hybrid clones, CPB tolerant big or small clones or a mix) of cocoa seedlings the owner intended to plant, the type of land ownership under the plot, what the plot had previously been planted to and whether or not the land had been planted to food crops either at the time of interview or previously. The owner was also questioned about any other cocoa plots they owned and whether these were planted with food crops as well. Plot owners who were food cropping were asked how long the plot had been under food crops and what gardening round they were currently on, the purpose of the garden (for home consumption or marketing and when the last sale had been made), if any other families were also gardening on the plot and if the owner intended to continue gardening after planting cocoa seedlings.

Garden species diversity and intensity

For all cocoa plots in the study, interviewers observed and marked a list of 109 garden species including bananas, root crops, vegetables, fruit, nuts, stimulants and trees, with species present among the cocoa plot. The interviewer recorded what percentage of the total plot area was planted to food crops. The four most prominent food crops were also listed, and the percentage of the plot planted to each crop was recorded.

Crop management practices

For the prime production and senile production plots, researchers recorded data on several aspects representative of plot management practice, including harvest practices, pest control methods and general plot maintenance practices.

The interviewer performed cocoa plot post-harvest assessment on each plot. The interviewer recorded the date and harvest yield of the plot owner's most recent cocoa harvest, and surveyed the cocoa trees to record the numbers of ripe unharvested pods, unripe healthy pods, black pods, dry pods, pods infected with cocoa pod borer, the number of trees flowering and the number of trees showing symptoms of Vascular Streak Dieback. These numbers were observed and recorded as an average over ten cocoa trees.

The interviewer asked questions about and observed evidence of cocoa pod borer control methods used on each plot. Plot owners were asked if they used insecticides and/or target spraying on their plot, and for the date they last sprayed. Owners were also asked whether they sprayed heaped pod skins after harvest, and the last date that this was done. The interviewer observed weather there was evidence of centralised pod breaking or pod burial on the plot.

The interviewer noted harvest practices on each plot and rated them as either poor, adequate or good, based on whether pods were ripped off roughly or cleanly cut off the tree in harvest. The interviewer also noted general comments about harvesting, block management and pest and disease management.

The interviewer observed and rated aspects of plot condition including weed control, pruning, shade control, sanitation and pest control on the plot from 1 to 5, 1 being very poor with no maintenance performed and 5 being very good with a level of maintenance like that on cocoa plantations.

Assessment of the marketing of dry coconuts

A component of Objective 3 was to investigate the potential to expand the local marketing of dry coconuts in ENB, WNB ARoB and Milne Bay as a source of income and income diversification. As part of the investigation, market surveys were conducted among market vendors in three provinces: ENB, Milne Bay and WNB. The ENB markets were located in cocoa growing districts on the Gazelle Peninsula although there is some oil palm grown in this region as well. Those in Milne Bay were in locations growing both oil palm and cocoa. The WNB markets were in predominantly oil palm growing districts around Hoskins, with the exception of Kulungi where both cocoa and oil palm are similarly important.

For the whole dry coconut market to be represented, the study incorporated two types of markets: large markets including urban and oil palm estate markets and small village based markets. The surveys conducted at each type of market included the following:

1. Coconut vendor surveys. Detailed vendor surveys were conducted on just those marketers selling dry coconuts to identify who was selling dry coconuts, the reason for selling them, the process involved in getting the coconuts to market and how much profit they were making.
2. Whole market surveys. Unless the market was exclusively for dry coconuts, whole market surveys were conducted at each market to generate context for the dry coconut market and identify where it fitted into the whole market structure. This survey identified the total number and diversity of vendors, the types of produce being sold and the returns made. At larger markets just a subset of vendors from the whole market were surveyed with a tally recorded of those not included.

Details of dates of data collection and vendor numbers are included in Tables 5.4 and 5.5.

Table 5.4 Large markets - Whole Market and Coconut vendor surveys

Market location	Date of survey	Day of survey	Total no. vendors at market	No. vendors included in whole market survey	No. coconut vendors surveyed
ENB					
Kerevat (urban)	3-Nov-15	Tuesday			3
	26-Nov-15	Thursday	132	50	
Kokopo (urban)	7-Nov-15	Saturday	1399	389	12
Rabaul (urban)	5-Nov-15	Thursday	600[3]	339	7
Warangoi Sawmill	4-Nov-15	Wednesday	52	52	1
Milne Bay					
Alotau (urban)	02-Sep-16	Friday			22
	05-Sep-16	Monday	352	115	11
Hagita Oil Palm Estate	01-Sep-16	Thursday	49	30	9
Waigani Oil Palm Estate	01-Sep-16	Thursday	17	17	5
WNB					
Kimbe (urban)	14-Nov-15	Saturday	555	222	4
Buluma	13-Nov-15	Friday	106	53	3
Poinini	15-Nov-15	Sunday	48	25	2

Table 5.5 Small markets - Whole Market and Coconut vendor surveys

Market location	Date of survey	Day of survey	Total no. vendors at market	No. vendors included in whole market survey	No. coconut vendors surveyed
ENB					
Bitavavar	3-Nov-15	Tuesday	4		4
	6-Nov-15	Friday	4		4
Malakuna	4-Nov-15	Wednesday	26	20	11
Laup	4-Nov-15	Wednesday	1		1
Milne Bay					
Boiou Roadside	29-Aug-16	Monday	6	4	2

[3] Average number of vendors attending the Rabaul Market accounting for those occupying multiple spaces. From market authority data.

WNB					
Klin Wara	12-Nov-15	Thursday	9	9	6
Kulungi	12-Nov-15	Thursday	16	16	10
Mai	13-Nov-15	Friday	42	42	14

The surveys provided a single day snapshot of each market. The size of the markets in terms of the number of vendors and buyers varies with some days larger than others. Market size is also influenced by season.

6 Achievements against activities and outputs/milestones

Objective 1: To assess the status of food security among cocoa and oil palm households

no.	activity	outputs/ milestones	completion date	comments
1.1	1. Conduct 360 baseline HH surveys among LSS & VOP oil palm growers in WNB & Popondetta. 2. Conduct 330 baseline HH surveys among cocoa growers at 3 sites in ENB and 4 sites in ARB & Milne Bay. 3. Analyse survey data.	Improved understanding of the impacts of CPB on cocoa growers, and the effects of land & population pressures on oil palm smallholders in regard to HH food security. Knowledge of the main demographic & socio-economic factors and HH characteristics affecting HH food & livelihood insecurity & the capacity of farming HHs to adapt to shocks & stresses.	Yr 1, m10 Yr 1, m10	Activity 1 & 2 achieved – reported in 2015 annual review. Activity 3 achieved. Reported in 2016-2017 annual review. Summary reports completed for all sites. Reports outlines main socio-economic factors, HH characteristics & access to food gardens for HH consumption & income. Good knowledge of the impacts of CPB on cocoa growers and land & population pressures on oil palm smallholders regarding HH food & income security. New knowledge gained on the capacity of cocoa and oil palm households to adapt to environmental shocks and stresses.
1.2	1. Conduct surveys of food gardens belonging to 70 LSS & VOP HHs in WNB & Popondetta. 2. Conduct surveys of food gardens belonging to 90 HHs at 3 sites in ENB, 3 sites in ARB & 1 site in Milne Bay. 3. Analyse data.	Documentation of the area, planting age, main staples, food gardening practices & intercropping of HH oil palm/cocoa holdings. Impacts of CPB on cocoa holdings recorded. Improved knowledge of the status of food security through measuring size of gardens, range of crops, levels of intensification of cropping, soil management techniques, & land tenure & ownership.	Y2, m6 Y2, m6	Food garden surveys and analysis completed for all sites Survey data reports completed for each of the cocoa and oil palm sites. Technical working papers outlining results completed for both oil palm and cocoa sectors (see Section 9.2).

1.3	1. For each of the HHs selected in Activity 1.2, weekly visits will be made over a 4 week period to collect data on dietary intake & weekly income & expenditure. 2. Analyse data.	Knowledge of diet quality and diversity, from where food is derived, food access, the status of HH food & livelihood security. Indication of sources of HH income, total weekly income & expenditure on food & other HH costs. Indication of the ability of HHs to purchase food.	Y2, m10	Dietary data analysis (of main food groups eaten and sources of food) of cocoa HHs in ENB & ARB and oil palm HHs in WNB completed, and reported in 2016-2017 annual report. Draft report outlining Household Dietary Diversity (HDD) and Food Consumption Scores (FCS) for cocoa and oil palm households completed. The draft report provides an indication of the reliance of households on access to land to grow food and income to purchase protein. There is strong evidence to show the important role household gardens played in maintaining food security among cocoa households whose capacity to purchase food has been undermined by CPB. Overall the quality of diets is reasonable at all sites.

PC = partner country, A = Australia Assess the status of food security among cocoa and oil palm households

Objective 2: To determine the key factors that enhance or constrain the capacity of cocoa and oil palm households to adapt and respond to food insecurity

no.	activity	outputs/ milestones	completion date	comments
2.1	1. HHs selected in Activity 1.3 will be interviewed during visits on a range of food & income security topics. 2. Combine HH interview data with survey data results from activities 1.1, 1.2. & 1.3 for analysis.	Knowledge of a HH's capacity to respond to livelihood threats & the ways farmers have modified farming & livelihood practices. Indication of what combination of farm management & livelihood strategies is most likely to support viable cocoa & oil palm farming systems that maintain food & livelihood security. Improved understanding of why some households are able to maintain food and income security and others are not. Typology of the main responses HHs have adopted in their subsistence & commodity crop farming systems to cope with economic & demographic pressures.	Y2, m10 Y2, m10 Y2, m12	Household interviews and analysis at all sites completed and reported in earlier annual reports. Some working papers for oil palm and cocoa sectors are now complete (Section 9.2). The development of a typology of the main HH responses to livelihood pressures completed by early 2019. To assist land-short oil palm farmers, a fuel-efficient stove was trialled in September 2017 among 10 women for assessment. The stove is to help alleviate the scarcity in wood fuel and the work burdens of women collecting and chopping firewood. The stove has proven very popular and is now being sold by the milling companies for smallholders to purchase. The stove is promoted during field days by the OPRA researchers. See social impact Section 8.3.2.

2.2	1. Combine HH interview data with survey data results from activities 1.1, 1.2. & 1.3 for analysis. 2. Conduct workshops with extension officers in WNB, Popondetta & ENB, ARB & Milne Bay. 3. Present findings from objectives 1 & 2 at CCIL & PNGOPRA research seminars.	Identification of the key HH & socio-economic factors that enhance or constrain the capacity of smallholders to adapt and respond to food & livelihood insecurity. A set of indicators to delineate levels of HH food security & to distinguish vulnerable and viable smallholder HHs. Guidelines for extension organisations & industry to assist vulnerable HHs to improve the viability of their farming systems. Report to industry on the findings from objectives 1 & 2.	Y2, m12 Y3, m8 Y3, m10 Y4, m12	Combining HH interview data with survey data results from activities 1.1, 1.2. & 1.3. for cocoa HHs in ENB and ARB and for oil palm HHs in WNB is complete, and reported in working papers and published in academic journals (see section 9.2) Identification of the key HH & socio-economic factors affecting food and livelihood insecurity completed and presented at industry seminars in PNG and outlined in working papers (see Section 8.4 and 9.2) A set of indicators to delineate levels of HH food security has been distributed to industry to refine the indicators. Industry working papers have been developed for both the cocoa and oil palm industries.

PC = partner country, A = Australia

Objective 3: To Assess and implement a range of strategies to improve the capacity of smallholders to produce and purchase food

no.	activity	outputs/ milestones	completion date	comments
3.1	1. Three trials in WNB & Popondetta of intercropping oil palm with food crops on smallholder blocks. 2. Four trials in ENB on cocoa blocks under rotational replanting and intercropping cocoa with food crops. 3. Monitor farmers' perceptions of the benefits of the replant & intercropping trials. 4. Conduct farmer field day awareness regarding the trials. 5. Present findings of trial at CCIL & PNGOPRA research seminars.	An understanding of the potential of alternative spacing & replanting arrangements for cocoa & oil palm to facilitate intercropping of food crops. Knowledge of the growth/yields of intercropped oil palm & cocoa. Knowledge of food crop tolerance to shade & yields of food crops & food garden-oil palm/cocoa interactions. An understanding of the suitability of intercropping of cocoa/oil palm with food crops from the perspective of smallholders. Report on the trials.	Y4, m10 (trials will start in Yr1, m2) Y4, m10 (trials will start in Yr1, m2) Y4, m6 (monitoring will start in Yr1, m1) Y4, m10 (field days will start in Yr2, m1)	A 1 hectare smallholder replant trial which intercrops oil palm with food crops began in June 2015 at Bialla in partnership with Hargy Oil Palm Ltd. Seven smallholder blocks were in the trial. The blocks were monitored quarterly to record the range of food crops, farm management practices, debt recovery on purchased seedlings and farmers' perceptions of the 1 ha replant option in comparison with the industry standard 2 ha replant practice. Some data collection is ongoing by OPRA. Hargy has adopted the 1 ha replant option as standard practice and it is anticipated that NBPOL will also adopt the strategy. A draft report for industry has been completed. From June 2015 data were collected from two smallholder blocks, with a replant section intercropped with food crops. Two main sets of data were regularly collected: i) transect surveys which measured soil water and recorded food crops planted; and 2) oil palm canopy and leaf area measurements. The data provided information on the capture of light and water by food crops and oil palm in the replant section. The aim was to determine the time course of light and water use from the time oil palm is planted to the time food gardening ceased, and the relationship between food crops grown and the oil palm development during this time. The latter has not been examined by the industry, yet replants are a major site for food gardens and critical to maintaining food security among farmers. Monitoring of cocoa holdings intercropped with food crops is now complete and the data are currently being analysed.

3.2	Assess efforts to promote income diversification measures for smallholders. 1. Work with OPIC, NGIP-Agmark & other extension providers to assess their income diversification strategies. 2. Facilitate the training of farmers in financial literacy & small business management by linking training providers with OPIC, PNGOPRA, CCIL & NGIP-Agmark.	Preliminary findings will be released to farmers & other relevant stakeholders through informal meetings. Report identifying the reasons the success (or failure) of the income diversification measures implemented by OPIC & NGIP-Agmark & other extension providers. Smallholders trained on financial literacy & small business management.	Y2 onwards Y4, m6 (will start in Y1, m6)	As outlined in the 2016 annual report, and agreed to at the project's mid-term review, component 1 of Objective 3.2 was dropped. As outlined in the 2016 annual report financial training was completed in the oil palm study sites. It was reported in the 2017 annual report that many farmers were accessing financial training through a large World Bank funded project (PPAP) which is operating in many cocoa growing areas in ENB and ARoB
3.3	Investigate the potential to expand the local marketing of dry coconuts in ENB, WNB, ARB & Milne Bay. 60 farm surveys among a subset of HH in Activity 1.1 in WNB, ENB, ARB & Milne Bay.	A section of the report under activity 3.2 will document the contribution of dry coconut sales to HH income & indicate new trends in the marketing of dry coconuts, transport & marketing issues.	Yr4, m6	

PC = partner country, A = Australia

Objective 4: To increase the capacity of smallholder households and extension providers to address food and livelihood security through improved access to training, information and ICT innovations

no.	activity	outputs/ milestones	completion date	comments
4.1.	Assist the oil palm & cocoa industries to link farmers with banking & micro-finance institutions & provide information to smallholders to improve savings. 1. Assessment of the services offered to farmers to encourage savings. 2. Attend OPIC, & NGIP-Agmark field days & farmer meetings to promote a savings culture amongst growers.	Report (& workshop) on the range of banking services & the potential of mobile phone banking to assist farmers. Report will contain guidelines for OPIC, PNGOPRA, CCIL & NGIP-Agmark to promote savings amongst growers.	Y3, m10 (start in Yr1)	Nasfund (superannuation scheme) has been rolled out for oil palm farmers in Bialla and Hoskins. The number of growers joining Nasfund continues to grow in Bialla, with both men and women joining the scheme. By June 2018 almost 1,400 growers at Bialla had signed up for superannuation/saving deductions. The scheme was introduced into Hoskins in the second half of 2016, however, the growth remains slow due to the difficulties the milling company at Hoskins face with incorporating savings deductions into their smallholder payment system. Mobile Phone banking has proven not to be be sustainable or popular among cocoa farmers. Although it was introduced by NGIP-Agmark to smallholders early in the project, by June 2018 only a few farmers were still using Mobile Phone banking. Most prefer to receive cash payments for their cocoa so that they can make store purchases immediately after selling their cocoa. Also, the high withdrawal fees by the banks, together with the inconvenience and cost of travelling to town to access their cash has been a disincentive to the adoption of mobile phone banking.
4.2.	Assess the potential of advances in ICT for improving extension delivery.	A report (&workshops) on the potential of ICTs to advance extension methods & the uptake of training messages by smallholders. This will: 1) Identify the potential of mobile/ smart phones, Facebook, DVDs & other ICTs to improve the effectiveness & efficiency of disseminating information to smallholders.	Yr4, 6 (start in Y1)	A draft ICT report will be completed in late 2019.

4.3.	Develop the capacity of the oil palm & cocoa sectors to design & expand extension programs to improve food & livelihood security. 1. Train OPIC, PNGOPRA, CCIL & NGIP-Agmark staff in the production of extension videos and the use of smart-phone technology for delivery of extension innformation. 2. Work with OPIC & NGIP-Agmark to establish links with community & NGO groups to facilitate their participation in extension field days & other activities.	OPIC, PNGOPRA, CCIL & NGIP-Agmark staff trained in the production of extension videos and the use of smart-phone technology for delivery of extension information. Increased involvement of community groups & NGOs in extension field days from working closely with OPIC & NGIP-Agmark during extension field days & other activities. Review report of adoption of training skills by OPIC, PNGOPRA, CCIL & NGIP-Agmark staff in the production of extension videos.	Yr3, m2 (start in Yr2) Yr4, m6 (start in Yr2) Yr 4, m1	The video training of OPRA and CCI staff was successful and short extension videos have been produced. OPRA has expanded the use of ICTs since the training in 2017 and is currently developing a website for the organisation which can be accessed by smallholders. OPRA has been regularly running field days at Hoskins and Bialla in collaboration with OPIC and the Milling companies. Income diversification, savings, food security, land tenure and education are among some of the topics discussed with growers. In cocoa, the number of extension field days held by CCI and NGIP-Agmark has dropped since 2015. This is due to other work commitments by the two organisations related to a large World Bank Project (PPAP) and other ACIAR-funded projects in ENB and ARoB (TADEP) which are drawing heavily on staff time. The merger of CCI with the Cocoa Board has also been disruptive to extension activities.

PC = partner country, A = Australia

7 Key results and discussion

Key findings

Objective 1. Assess the status of food security among cocoa and oil palm households.

The research findings derived from both the qualitative and quantitative data indicate that the status of food security among oil palm and cocoa smallholders was reasonably good. This is despite the pressures on households and their gardening systems due to land pressures and reduced incomes at our cocoa sites. Generally people have sufficient access to food – both from their own gardens and purchased. Food from people's own gardens overwhelmingly dominate diets and garden foods are supplemented with the purchase of protein and energy rich foods.

However, it cannot be concluded that households within these communities will not experience food insecurity into the future. What is clear is the capacity of farming households to adapt to changing circumstances and respond to demographic and economic pressures and environmental shocks (see below). The general situation in our study sites is one of cocoa and oil palm smallholders actively seeking solutions and finding new ways to maintain food security and household well-being. Smallholders are very resilient and will respond positively to new opportunities that come their way to improve household food and income security.

We base this conclusion on three key indicators used to assess the status of food security among smallholder households, which included:

- Access to garden land and food availability
- Access to a regular income
- Access and availability of good quality diets.

There are other minor variables we have used to assess the status of household food security, but these three were considered the most important, based on previous food security and nutritional studies in PNG.

As shown in Box 1, virtually all households at all the study sites maintain food gardens and most claim their gardens meet their family food needs. Food gardens play a significant role in maintaining household food security in cocoa and oil palm growing households and food gardening remains an important daily livelihood activity for both men and women, especially women who spend more time than men in subsistence food production. Historically, food gardening was the major livelihood activity of rural villagers for generations before the introduction of cocoa and oil palm into local agricultural systems.

Food gardens not only provide a buffer against fluctuating commodity export prices but also provide a regular income from selling fresh food produce at local markets. This income together with the income from either oil palm or cocoa enables households to supplement garden foods with store purchased nutritious food. A regular income source acts to strengthen local agricultural and livelihood systems by providing smallholders with money to purchase protein and energy dense foods (which is lacking in traditional diets). It also takes pressure off land where populations are increasing and most importantly enables access to cash to buy food when subsistence crops fail due to drought, floods and other environmental perturbations, and when export crop prices plummet (Allen & Bourke 2000, Mueller *et al*. 2001a, 2001b).

Box 1. Maintaining food security among cocoa and oil palm farmers

90% or more of households maintain food gardens.

80% or more of households with gardens claim their gardens meet their family food needs,

Between 80 and 90% of all meals consumed in the previous evening meal contained ingredients sourced from the household's own garden (staple root crops).

Between 29-70% of all households at all sites had purchased store foods as part of the previous evening meal (mostly rice & tinned fish).

Most households had regular access to two main income sources (with the exception of Misima)

Most households had access to a nutritional and diverse diet. None of the households had Food Consumption Scores that were in the 'poor' category. The vast majority had 'acceptable' food consumption scores (see below).

The following section discusses the role of gardens and diets in maintaining food security among cocoa and oil palm smallholders.

THE IMPORTANCE OF FOOD GARDENS

This section covers the importance of food gardens among oil palm and cocoa smallholders in maintaining food and income security. At the heart of smallholders everyday life is subsistence food production. Garden cultivation in PNG dates back to between 5,000 and 9,000 years (Golson 1982), and food gardening is a primary livelihood activity of virtually all oil palm and cocoa smallholders (particularly women) and provides a vital safety net for communities relying on export cash crops for their main household income. As noted below, the overwhelming majority of food eaten on a daily basis comes from food gardens. Thus, garden cultivation is the main determinant of household food security. Given its central part in maintaining food security, this section provides an overview of role gardens in meeting household food and income needs.

Oil palm smallholders

Garden cultivation

The following discussion will focus on the oil palm smallholders residing on the land settlement schemes (LSS) in Hoskins and Bialla, WNB where population and resource pressures are high. Since the LSS were first established almost 50 years ago, access to gardening land has declined. When settlers moved onto the LSS block, each family was allocated a leased land holding of 6-6.5 ha, with a lease condition that specified approximately 4 ha be planted to oil palm. The remaining reserve land (termed *wasblok* by settlers) was reserved for food gardens (Benjamin 1977; Hulme 1984; Landell Mills Ltd. 1991).

Since 1975 the average population per LSS block at Hoskins has almost tripled to a mean of 20 persons per LSS block at the time of the study. Today, LSS blocks at Bialla and Hoskins have a mean of 3.75 households per block spanning three generations as the offspring of original settlers marry and raise their own families on their parents' leasehold block. Now several households rely on the resources and oil palm income earned from the block. As a result land use has also changed on the LSS blocks and from the early 1990s, households began extending their oil palm plantings into the 'reserve' (*wasblok*) for food gardens.

Yet, despite rising population pressure and severe constraints on land acquisition found among oil palm smallholders, virtually all continue to grow sufficient food for their families, regularly sell surplus garden foods at local markets and consume nutritionally rich foods. Households at Bialla looked after more gardens (2 or 3) than those on the Hoskins scheme (1 or 2). The food garden

surveys revealed that Bialla households had almost twice as much land available for food gardening as Hoskins households. A possible reason for this difference may be due to fewer Hoskins households replanting their old oil palm. Households without gardens tend to be those where the household head is too old or suffering from a long-term illness or the household has insufficient land. These households rely on other family members to provide them with access to food.

For households maintaining gardens, data were collected on the farming systems and the main features of food gardens, including the main crops grown. Most gardens were dominated by mixed cropping systems with two or more sub-dominant staple crops and a variety of greens and vegetables (Table 7.1). Less than 10% of gardens were mono-cropped.

Table 7.1. Typical crops grown in household gardens on the LSS blocks.

STAPLE CROPS	
Banana *(Musa cvs)*	Taro *(Colocasia esculenta)*
Sweet potato *(Ipomoea batatas)*	Yam *(Dioscorea esculenta & alata)*
Chinese taro *(Xanthosoma sagittifolium)*	Cassava *(Manihot esculenta)*
VEGETABLES	
Aibika *(Hibiscus manihot)*	Garden cress *(Lepidium sativum)*
Aupa *(Amaranthus spp.)*	Ginger *(Zingiber officinale)*
Bean *(Psophocarpus & Vigna spp.)*	Karakap *(Solanum nodiflorum)*
Cabbage head *(Brassica oleracea)*	Kumu mosong *(Ficus copiosa)*
Capsicum *(Capsicum annuum)*	Pitpit *(Saccharum edule)*
Chilli *(Capsicum frutescens)*	Pumpkin tips *(Cucurbita moschata)*
Chinese cabbage *(Brassica chinensis)*	Spring onion *(Allium cepa)*
Corn *(Zea mays)*	Tomato *(Solanum lycopersicum)*
Cucumber *(Cucumis sativus)*	Tulip *(Gnetum spp.)*
NUTS	
Peanut *(Arachis hypogaea)*	Marita *(Pandanus conoideus)*
Galip *(Canarium indicum)*	Okari *(Terminalia spp.)*
Coconut *(Cocos nucifera)*	
FRUITS	
Ripe banana *(Musa spp.)*	Pineapple *(Ananas comosus)*
Kudiwai	Watermelon *(Citrullus lanatus)*
Mango *(Mangifera indica)*	Sugarcane *(Saccharum officinarum)*
Pawpaw *(Carica papaya)*	
STIMULANTS	
Betel nut *(Areca catechu)*	
Betel pepper *(Piper betel)*	
Tobacco *(Nicotiana tabacum)*	
OTHER	
Sago *(Metroxylon sagu)*	

More than 70% of households cultivated staples crops, and vegetables were widely grown as were fruits, nuts and sugarcane (Table 7.2).

Figure 7.2, shows the most widely grown staple crops in smallholder gardens. The top four are

banana, Chinese taro, sweet potato and cassava. Less important crops included yam *(Dioscorea alata)* and mami (*Dioscorea esculenta*), taro (*Colocasia esculenta)* and an assortment of other vegetables including corn (*Zea mays*), beans (*Phaseolus vulgaris* and *Vigna unguiculata*), choko (*Sechium edule*), capsicum (*Capsicum annuum*), cucumber *(Cucumis sativus)*, *pitpit* (*Saccharum edule*), tomato (*Lycopersicon esculentum*) and green-leaf vegetables such as aibika (*Abelmoschus manihot*), aupa (*Amaranthus* spp.), pumpkin tips (*Curcurbita moschata*) and Chinese cabbage (*Brassica chinensis*). Peanuts (*Arachis hypogaea*) and pineapples (*Ananas comosus*) were also popular cash crops.

Table 7.2. Per cent of households growing each crop type

LSS BIALLA	LSS HOSKINS
STAPLES	*STAPLES*
Banana *(100%)*	Banana *(100%)*
Sweet potato *(100%)*	Sweet potato *(90%)*
Chinese taro *(85%)*	Chinese taro *(95%)*
Colocasia taro *(65%)*	*Colocasia* taro *(80%)*
Cassava *(95%)*	Cassava *(100%)*
Yam *(70%)*	Yam *(65%)*
OTHER	*OTHER*
Peanuts *(35%)*	Peanuts *(40%)*
Vegetables *(95%)*	Vegetables *(100%)*
Fruits *(85%)*	Fruits *(80%)*
Other nuts *(11%)*	Other nuts *(24%)*
Sugar cane *(75%)*	Sugar cane *(65%)*

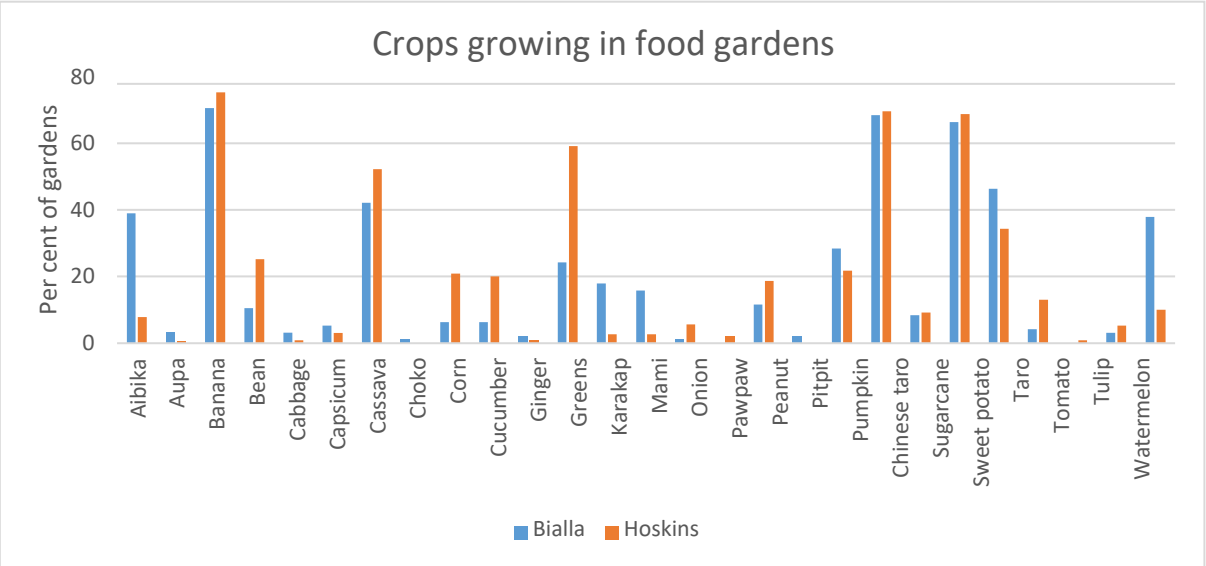

Figure 7.2: Percentages of gardens with different crop types.

The dominant staple crop (by area) on the LSS was banana (*Musa* cvs) (Figure 7.3). The subdominant crops were Chinese taro *(Xanthosoma sagittifolium),* sweet potato *(Ipomoea batatas)* and cassava (*Manihot esculenta*). Chinese taro and sweet potato take up a similar area on the LSS at Bialla although at Hoskins about half the area of Chinese taro is grown to that of sweet potato. Cassava has been increasing on the LSS blocks and in oil palm villages around Hoskins. It is very adaptable, particularly in adverse conditions, can tolerate poor soils, and does not have any threats from pest and disease (Bourke 2001). Cassava was being grown by more than 90 per cent of households on all subdivisions. However, it is not grown over very large areas with the exception of the village (VOP) blocks where it accounted for 40% of garden area. When grown, it is commonly planted as a boundary crop. Yam, once grown widely by those of Sepik ethnicity, is now an insignificant crop as supported by Bue's research (2013).

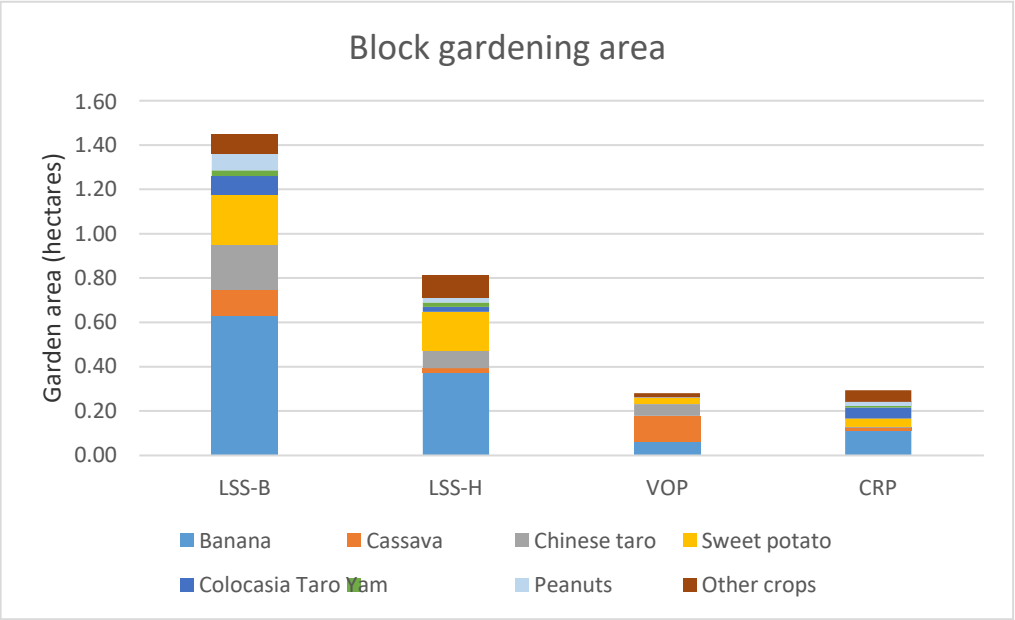

Figure 7.3. Block gardening area and the proportion occupied by crops (ha).

Garden labour input

Household survey and interview data with oil palm smallholders at Bialla and Hoskins indicate that gardening remains a significant daily activity, particularly for women. Women claimed they allocate more labour to food gardening than to oil palm production (Figure 7.4). When the husband and wife were asked to rank in importance the daily livelihood activities where they spent most of their time and labour, 60% of women ranked gardening as their primary activity. Men also commit time to food gardening but ranked gardening as secondary to oil palm. The most common top activity for men is oil palm (Figure 7.4). Males take responsibility for most of the harvesting of oil palm, a very labour intensive task. The availability of women's labour, therefore, to grow food for their families is very important in maintaining household food security.

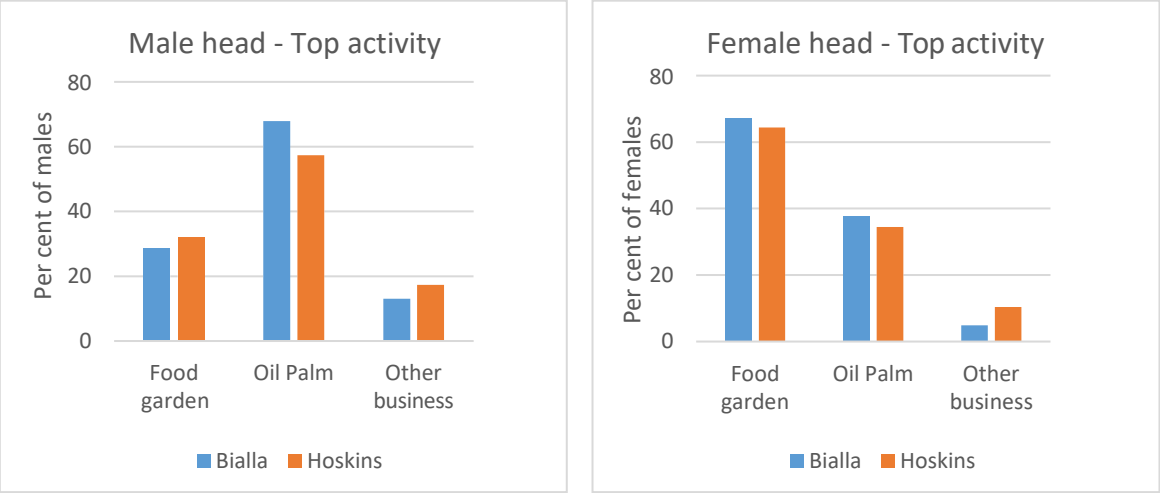

Figure 7.4. The most dominant activities in terms of total labour allocations for male and female household heads on the LSS schemes at Bialla and Hoskins.

The amount of time men and women spend in food gardening varies, and depends on the price of oil palm. When oil palm prices fall and people have less income, they tend to rely more on their food gardens for their daily meals. When prices are high growers take advantage of the increased income from oil palm to purchase more store foods (such as tinned fish and rice) (Koczberski *et al*. 2012a). Previously when smallholders were being paid monthly by the milling company and when oil palm prices were low, their consumption of store foods (especially protein) was concentrated in the first few days of receiving the monthly oil palm payment. After this period most food consumed came from their own food gardens. Thus, food gardens are very important in helping to reduce smallholders' vulnerability to fluctuating oil palm prices.

Gardens as a source of income

Food gardens play an important role in household income security. Women in particular rely heavily on the sale of food crops to earn income to meet everyday household needs and to purchase food for the family. For most women the sale of marketed crops was the second most common primary income source. Some women ranked the sale of garden foods as their primary income source (25% and 18% of women at Hoskins and Bialla respectively). Women tend to have more control over the income they earn from marketing food crops than from oil palm.

When conducting the household surveys interviewees were asked if any household members had sold garden food in the previous 7 days. This is an indication of the regularity of market income. Figure 7.5 shows the proportions of households that sold food in the past week. On the LSS at Bialla over a quarter of households had sold garden foods whereas at Hoskins almost half of households (46%) had sold garden foods in the preceding 7 days. Even among Village Oil Palm (VOP) households and CRP blocks, many households had sold garden foods in the previous week.

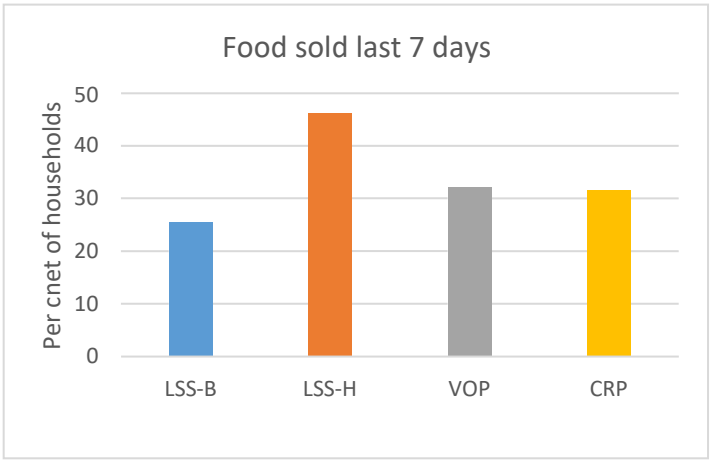

Figure 7.5. Per cent of households selling garden foods in the previous 7 days.

When smallholders were asked about their gardens and marketing food crops, the majority said they were cultivated for the mixed purpose of firstly, providing food for family consumption and secondly, for providing income from the sale of surplus food production at local markets (Figure 7.6). Only around 15% of households at Hoskins and Bialla cultivated gardens solely for home consumption and very few were purely for marketing. At Bialla and Hoskins, around 80% of gardens were for both family consumption and marketing.

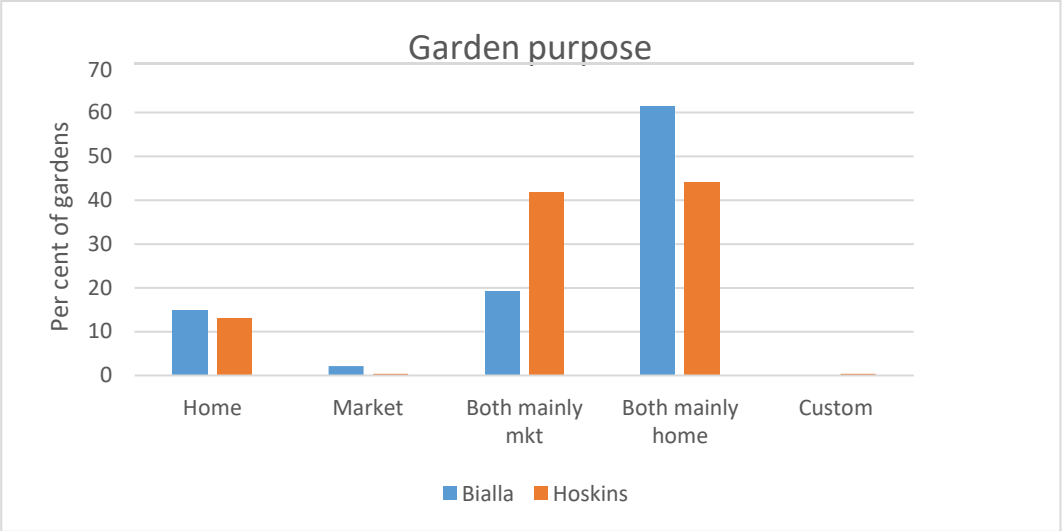

Figure 7.6. The primary purposes of food gardens.

The proportion of gardens primarily for marketing at Hoskins was more than twice that at Bialla. More families at Hoskins were planting food crops for commercial sale than at Bialla. The reasons for this may be because at Hoskins population pressure is greater and opportunities for marketing food crops are better than at Bialla. The most commonly marketed food crops sold by smallholders at Bialla and Hoskins are listed in Table 7.3. They include most of the traditional staples consumed in PNG, such as banana, sweet potato, Chinese taro and greens. Banana is a high priority crop on the LSSs at both Bialla and Hoskins. The crops sold by LSS and Customary Rights Purchase (CRP) smallholders at Hoskins differ from those sold by smallholder women in the surrounding villages where cassava is the most commonly sold crop.

Table 7.3. Most commonly sold food crops irrespective of rank from most common to 4th most common (% HH).

	Bialla	Hoskins		
Priority	LSS	LSS	VOP	CRP
Most common	Banana (70%)	Sweet potato (51%)	Cassava (59%)	Sweet potato (45%)
2nd most common	Sweet potato (58%)	Banana & Greens (49%)	Greens & Banana (47%)	Banana (37%)
3rd most common	Chinese taro (38%)			Greens (34%)
4th most common	Greens (34%)	Chinese taro (44%)	Chinese taro (39%)	Peanut (18%)
No marketing of food crops	19%	26%	32%	45%

The additional cash earned by women increases their purchasing power to buy food (especially protein). This is especially important when oil palm income is short and when prices fall. There are three main reasons explaining why a large number of householders, especially women at Hoskins, claimed market sales to be an important income source. These are:

1. Income pressures on the heavily populated blocks mean that some households such as secondary households and female-headed households have less regular access to oil palm income. The involvement of these households in local food markets is more "business oriented" with food production mainly for sale at local markets. Other co-resident households (e.g. primary households controlling oil palm production) sell only surplus garden produce, and market income plays a less important role in household income security.

2. Some women claimed that market income was their primary income source. These women often did not have primary access rights to the oil palm income and/or they did not work in oil palm because their husbands did not share fairly the oil palm income with them.

3. Good market access.

The findings on the marketing of food crops support earlier research on local marketing among LSS women. Research findings from an earlier ACIAR project and a 2008 student research study at Hoskins found that women from the LSS comprised the major group selling produce at the main town market in Kimbe (Koczberski *et al*. 2001; Ryan 2009). Almost 80% of the root crops and vegetables on sale at Kimbe market in 2000 were from the LSS. In the follow up survey in 2008 the figure was 70%.

Cocoa smallholders

The importance of food gardens

While cocoa was by far the dominant source of household cash income prior to the CPB incursion, farmers spent very little time in their cocoa plots and pursued a range of livelihoods in addition to cocoa (Omuru *et al*. 2001; Curry *et al*. 2007; Nelson *et al*. 2011). Only during the main cocoa flush periods, or when cocoa prices were exceptionally high would they increase their labour inputs in cocoa. Occasionally smallholders engaged in more intensive harvesting to meet large expenses like school fees, indigenous exchange obligations like bride prices and mortuary payments or church fund-raising events (Curry *et al*. 2015). Instead households devoted much time to food crop production and most households sold garden food crops at local markets as well as a range of fruits, nuts and dry coconuts.

Following the collapse of household cocoa income due to CPB, the primary strategy pursued by farmers was to scale-up garden food production, both for household consumption and sale at local markets (see Curry *et al*. 2015). Food gardening was the preferred initial response because it was an activity people were familiar with, and marketing of fresh food has long been an important livelihood strategy for rural households in ENBP. Following the arrival of CPB, sales of garden foods at local markets became the major source of income for most cocoa-growing households. Although, income from local markets became the top ranked income source for both men and women, household income has remained low and uncertain, and according to smallholders, lower than had been earned previously from cocoa in the pre-CPB environment. Thus, food gardens have played a critical role and provided a buffer against falling household incomes by continuing to provide food and other income generating alternatives.

Garden cultivation

Almost all households in the cocoa growing communities looked after food gardens with the number most commonly being 2 to 3 in ENB and ARoB and 3 to 5 in Milne Bay. Very few gardens were intercropped with cocoa or coconut but instead were typically stand-alone mixed or monocrop gardening systems. More than half of the gardens in ARoB were monocrop gardens planted mostly with sweet potato. In ENB and Milne Bay mixed gardens were the primary garden type. Mixed gardening systems were typically planted with two or more dominant or subdominant staple crops and a variety of greens and vegetables.

More than 60 % households at each site were cultivating the staple crops banana, cassava, Chinese taro and sweet potato in their food gardens. The main staple crops grown in ARoB, ENB and Milne Bay have traditionally been recognised as sweet potato (after the decline of *Colocasia* taro during WW11), banana and yam respectively (Packard 1975; Risimeri, 2001; Bourke *et al*. 2002). This was supported by the fact that these three crops were most commonly ranked as the most important crop grown in gardens in each of the three relevant provinces (Table 7.4). In ENB although banana was the most common, similarly important were sweet potato, peanut and taro.

Table 7.4. Most important crops grown in food gardens (per cent of gardens).

ARoB	ENBP	MBP
Sweet potato (53%)	Banana (21%)	Yam (48%)
Banana (23%)	Sweet potato & Peanut (17%)	Banana (23%)
Taro (7%)	Taro (16%)	Taro (12%)

Evidence for the significance of individual staple crops in each location can be identified in Figure 7.7 which shows the area occupied by each crop. Although there was a wide distribution of staple crops across many smallholder gardens at each site sweet potato by far occupied the most area in ARoB as did yams in the more traditional agricultural systems of Milne Bay.

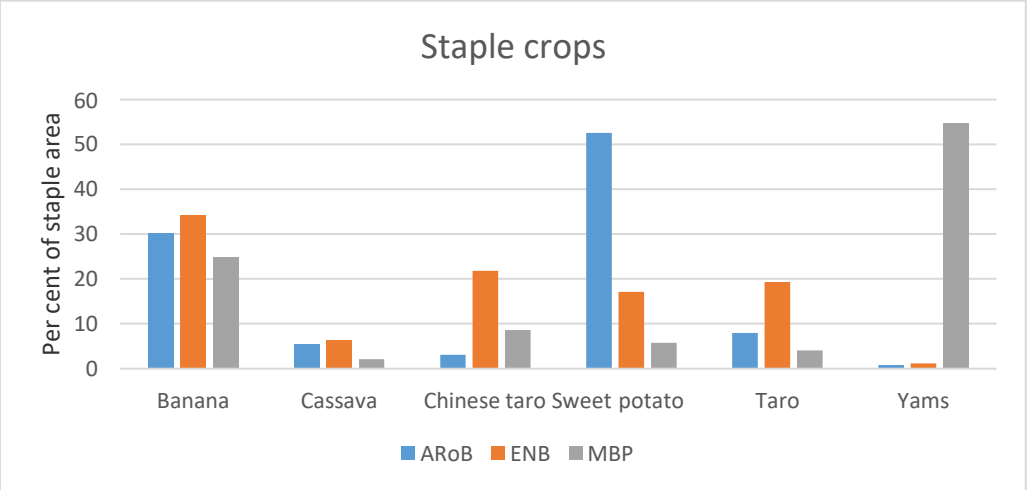

Figure 7.7. Per cent of total staple garden area occupied by staple crops.

Despite the large areas dedicated to staple crops, particularly in ARoB and MBP, smallholders were also growing a range of other fruit and vegetable crops the most important of which are shown in Figure 7.8. By household others widely grown included crops such as bean, corn, greens, peanut, pumpkin tips and sugarcane.

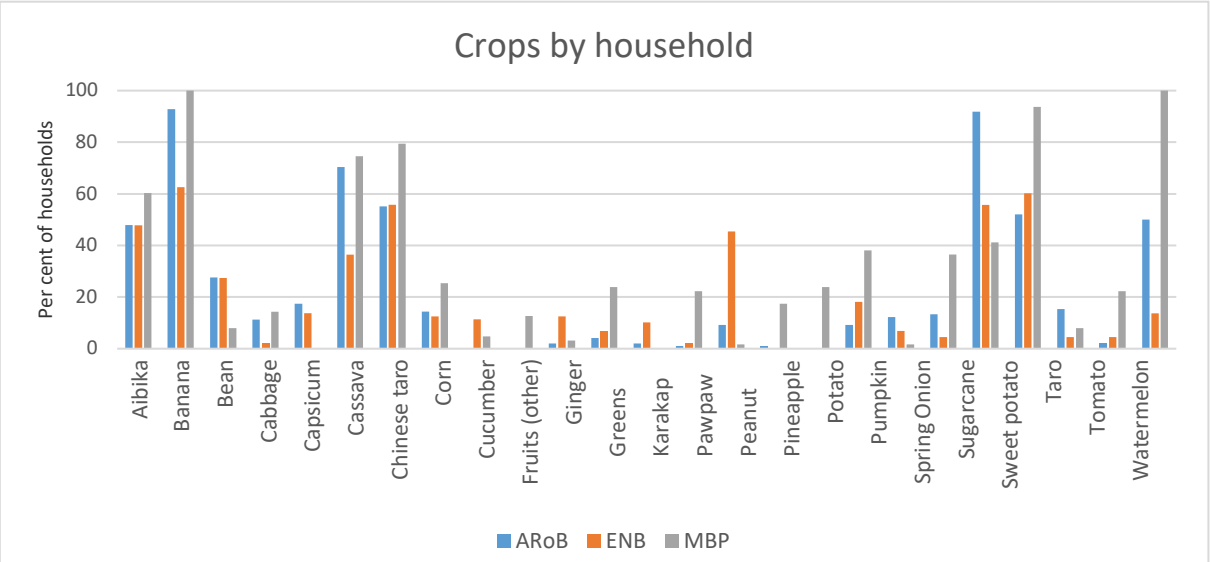

Figure 7.8. The main crops grown by households in their food gardens.

All crops identified in household food gardens whilst undertaking the garden surveys are shown in Table 7.5. A diversity of crops were being grown the greatest of which was in ENB. In all three provinces traditional staples, fruits and vegetables were being grown alongside more modern crops such as cabbage, capsicum, eggplant and tomatoes.

Table 7.5. Crops growing in smallholder food gardens in cocoa growing communities in ARoB, ENB and MBP.

STAPLE CROPS	
Banana *(Musa cvs)*	Sweet potato *(Ipomoea batatas)*
Cassava *(Manihot esculenta)*	Taro *(Colocasia esculenta)*
Chinese taro *(Xanthosoma sagittifolium)*	Yam *(Dioscorea esculenta & alata)*
VEGETABLES	
Aibika *(Hibiscus manihot)*	Ginger *(Zingiber officinale)*
Aupa *(Amaranthus spp.)*	Karakap *(Solanum nodiflorum)*
Bean *(Psophocarpus & Vigna spp.)*	Kumu mosong *(Ficus copiosa)*
Cabbage *(Brassica* sp.*)*	Peanut *(Arachis hypogaea)*
Capsicum *(Capsicum annuum)*	Pitpit *(Saccharum edule)*
Chilli *(Capsicum frutescens)*	Potato *(Solanum tuberosum)*
Chinese cabbage *(Brassica chinensis)*	Pumpkin tips *(Cucurbita moschata)*
Choko (Sechium edule)	Spring onion *(Allium cepa)*
Corn *(Zea mays)*	Tomato *(Solanum lycopersicum)*
Cucumber *(Cucumis sativus)*	Tulip *(Gnetum spp.)*
Eggplant *(Solanum melongena)*	
FRUITS	
Ripe banana *(Musa spp.)*	Pawpaw *(Carica papaya)*
Breadfruit *(Artocarpus altilis)*	Pineapple *(Ananas comosus)*
Orange/mandarin *(Citrus)*	Watermelon *(Citrullus lanatus)*
Mango *(Mangifera indica)*	Sugarcane *(Saccharum officinarum)*
STIMULANTS	
Betel nut *(Areca catechu)*	Tobacco *(Nicotiana tabacum)*

Garden labour input

Although households were engaged in cash cropping of cocoa food gardening remained an important livelihood activity. The allocation of family time and labour is always an important consideration when cultivating cash crops as well as keeping food gardens. Data collected from the female and male heads of household on their top ranked livelihood activities illustrated that there was a clear division of tasks in ARoB. While some time was spent working in food gardens and in other business activities men devoted most of their time to cash cropping cocoa with more than 60% men ranking this as their number one activity (Figure 7.9). Women on the other hand spent very little time engaged in cocoa with more than 85% claiming that their top activity was food gardening.

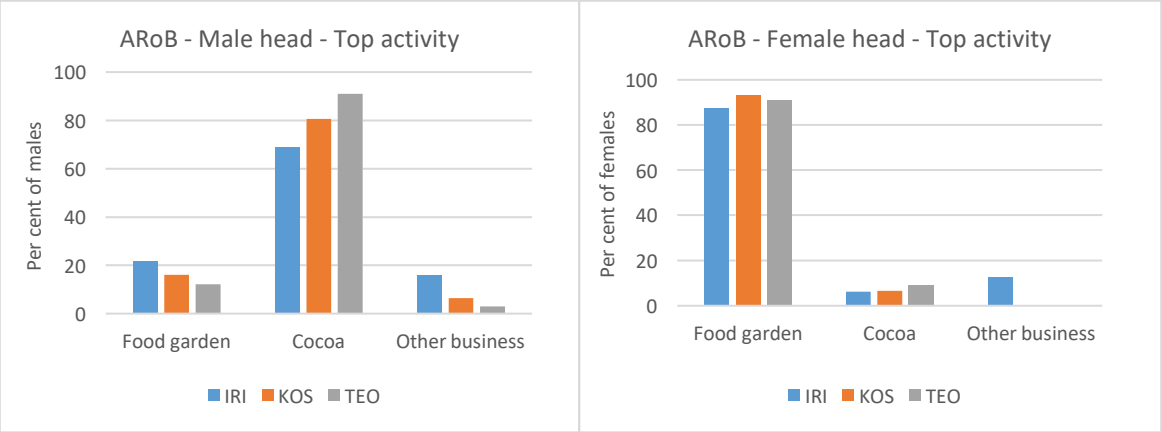

Figure 7.9. The top activity for men and women in ARoB.

In Milne Bay the top activity for men was quite different to those in ARoB supporting the fact that cash cropping cocoa is not a priority in this province. More than 70% of men ranked the food garden as their number one activity (Figure 7.10). The food garden, as for ARoB, was the main priority for women with more than 90% ranking this as their number one activity.

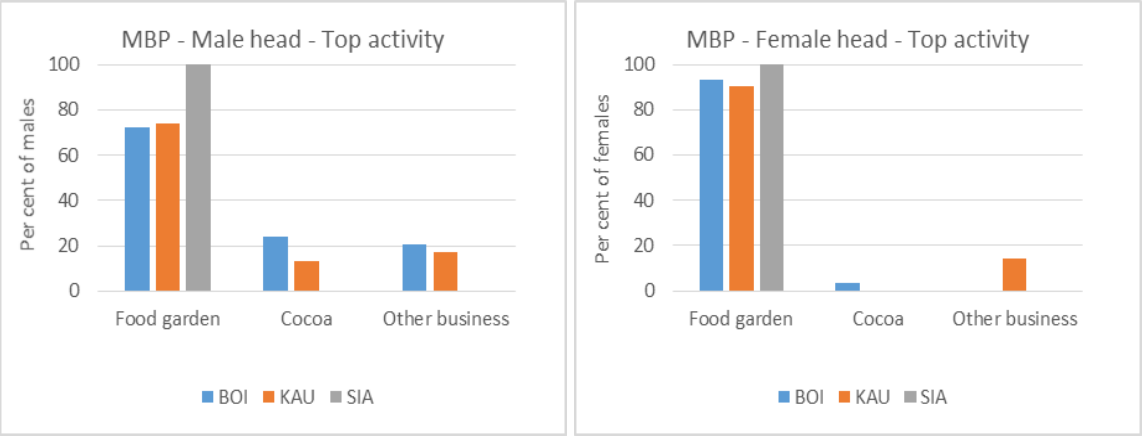

Figure 7.10. The top activity for men and women in MBP.

The purpose of food gardens

Household food gardens can have varied functions. Some are specifically for home consumption, some are purely for marketing; others are for both. In some instances they may have been planted explicitly for a cultural event. In ARoB despite the study sites being closer to markets the function of food gardens was primarily for home consumption with over 50% used for this purpose (Figure 7.11).

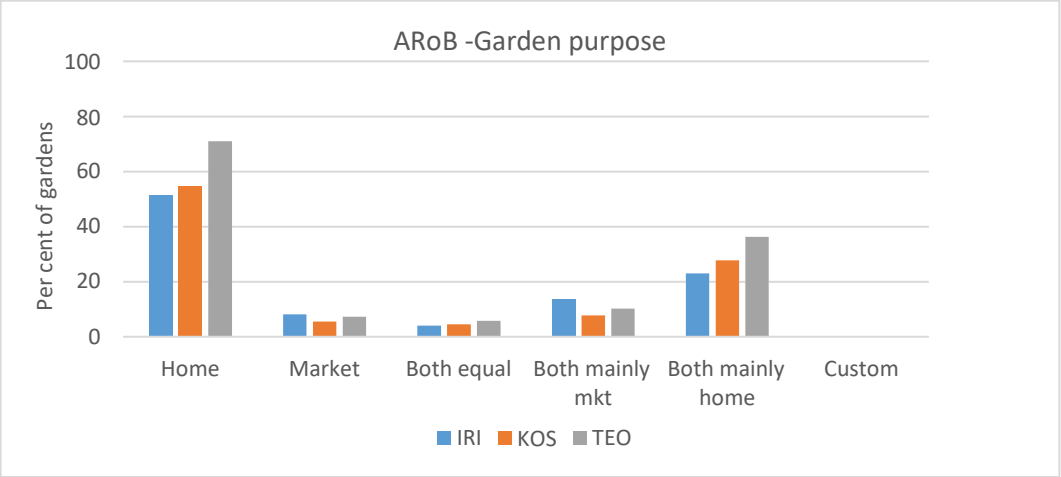

Figure 7.11. The purpose of food gardens in ARoB.

In ENB there was more of an emphasis on marketing as food from the majority of gardens in Lamarainam and Rabagi was mainly for home consumption but it was also used for marketing (Figure 7.12). On the Land Settlement Scheme at Tavilo the majority of gardens were specifically for home consumption, however, most others were for a combination of both home use and marketing.

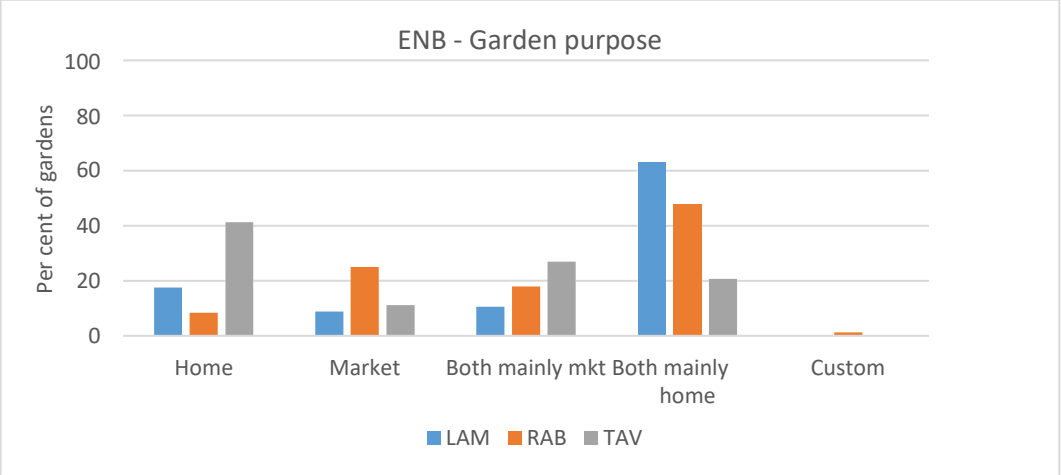

Figure 7.12. The purpose of food gardens in ENB.

In a society where cash cropping is less significant, land is allocated to food gardens for the purpose of marketing. In Milne Bay a higher proportion of gardens were cultivated for marketing than in the other two provinces (Figure 7.13). Very few gardens in any of the three provinces were specifically for customary purposes as it tends to be more common for smallholders to use produce from their general food gardens when such events arise.

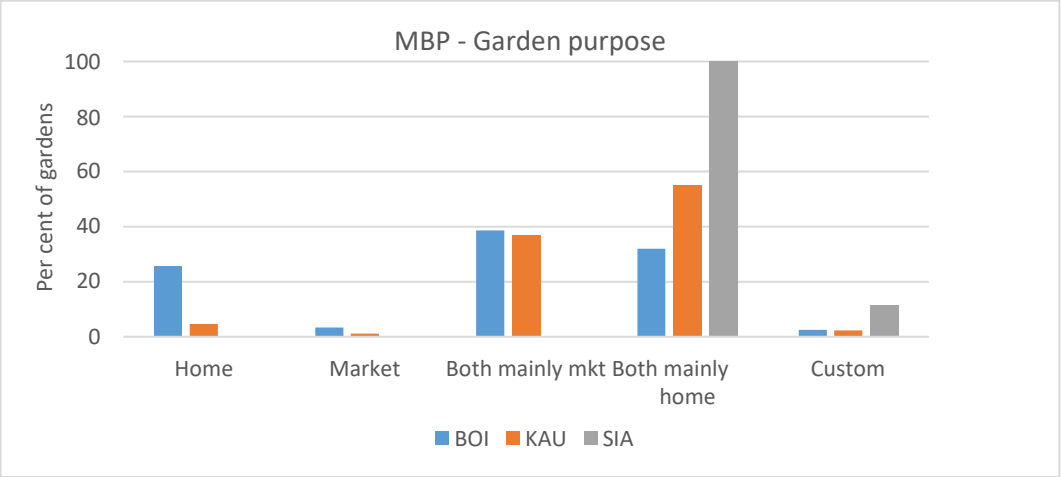

Figure 7.13. The purpose of food gardens in Milne Bay Province.

Food gardens as a source of income

In cocoa growing areas the sale of garden food is a source of supplementary income for households or in some cases a primary income source. Many households in all three provinces had sold produce from their food gardens in the seven days prior to the household survey (Figure 7.14). In Milne Bay more than a third of households at each site had sold garden foods.

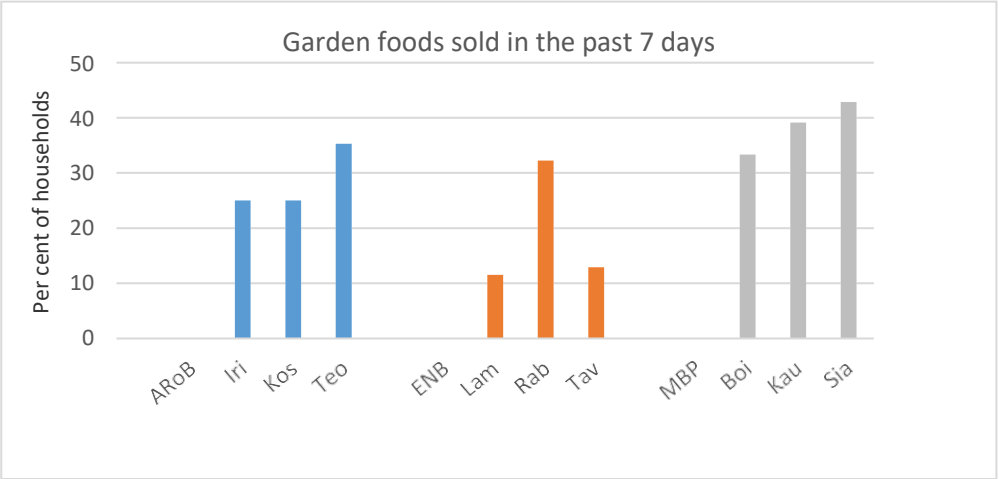

Figure 7.14 Per cent of households selling garden foods in the previous seven days.

CPB impacted cocoa farmers significantly particularly when their primary source of cash income was cocoa, as in ARoB and ENB. This was the situation for both men and women and it was at this time that the importance of food gardens became evident. Marketing of garden foods became the most common top ranked income source for women just after the arrival of CPB (Table 7.6). Although they cannot generate near the same income earned from cocoa, food gardens provide a safety net for smallholders when there is an upheaval in household income earning capacity. This reliance on garden foods for income reflected the lack of alternative income sources available to smallholders. By 2014 it could be seen that cocoa was starting to make a comeback as farmers, including women, learned to manage CPB. However, even though cocoa production was being maintained through the CPB infestation period, income earned from it was much lower than in pre-CPB times.

Table 7.6 The most common primary income sources for women just after the incidence of CPB and in 2014 (per cent of women).

Period in relation to incidence of CPB	AROB			ENB		
	IRI	KOS	TEO	LAM	RAB	TAV
Just after	Marketing garden food crops (25%)	Marketing garden food crops (30%)	Marketing garden food crops (44%)	Marketing garden food crops (56%)	Marketing garden food crops (52%)	Cocoa (39%)
Now (2014)	Cocoa (53%)	Cocoa (53%)	Cocoa (59%)	Cocoa (52%)	Marketing garden food crops (66%)	Cocoa (61%)

The importance of food gardens in Milne Bay was also evident in Boiou where CPB had impacted cocoa production the most. Although cocoa was only the primary source of income for around 40% of men and women before CPB, after its initial impact by far the most common primary source of income for both men and women became the marketing of garden food crops.

All household income sources

When householders identified all of their income sources it was apparent that cocoa and copra were both common in AROB (Table 7.7). In ENB and MBP the sale of garden foods at local markets was the most common method of earning income for households. Other popular income sources included the sale of food in the village, by the house or roadside, the sale of cooked or processed foods, and the sale of betel nut.

Table 7.7 Household income sources (per cent of households).

	ARB			ENB			MBP		
	IRI	KOS	TEO	LAM	RAB	TAV	BOI	KAU	SIA
Most common	Cocoa (88%)	Cocoa (97%)	Copra (88%)	Food sales local mkts (58%)	Food sales local mkts (81%)	Cocoa (74%)	Food sales local mkts (82%)	Food sales local mkts (96%)	Food sales local mkts, Betel nut & Cooked proc foods mkts/ roadside (71%)
2nd most common	Copra (72%)	Food sales house/ vill/road (72%)	Cocoa (85%)	Cocoa (50%)	Copra (71%)	Food sales local mkts (71%)	Betel nut (73%)	Cocoa (91%)	
3rd most common	Betel nut (63%)	Cooked/ proc foods mkts/rd & Copra (69%)	Food sales local mkts (74%)	Cooked/ proc foods mkts (35%)	Betel nut (68%)	Cooked/ proc foods mkts (68%)	Food sales house/ village/ roadside & Cocoa (61%)	Betel nut (83%)	
4th most common	Food sales local mkts (59%)		Betel nut (62%)	Betel nut (31%)	Cocoa (58%)	Betel nut (61%)		Live-stock (39%)	Cocoa (57%)

Sale of Garden Food

As shown in Table 7.7 above many households source income from the sale of garden food crops. Banana and sweet potato were the most commonly sold crops in both ARoB and ENB (Table 7.8). Being a society which places great cultural significance on yam growing for prestige and status, yam and banana were the most commonly sold crops in Milne Bay. Also being culturally significanttaro was a crop that was widely sold by smallholders across all three provinces. Peanuts and aibika were other crops sold extensively at markets.

Table 7.8. Most commonly sold food crops from 1st to 4th most common (per cent of households).

	ARB			ENB			MBP		
	IRI	KOS	TEO	LAM	RAB	TAV	BOI	KAU	SIA
1st	Sweet potato (53%)	Banana (66%)	Banana (74%)	Banana (54%)	Banana (84%)	Sweet potato (39%)	Yam (64%)	Banana & Yam (70%)	Banana, Taro & Yam (57%)
2nd	Banana (50%)	Sweet potato (63%)	Sweet potato (56%)	Aibika (35%)	Peanut & Chinese Taro (55%)	Banana (35%)	Banana (58%)		
3rd	Aibika (44%)	Taro (34%)	Aibika (26%)	Peanut & Taro (31%)		Peanut (32%)	Taro (48%)	Chinese Taro (39%)	
4th	Peanut (22%)	Aibika (31%)	Taro (24%)		Sweet potato (35%)	Taro & Bean (23%)	Sweet potato (30%)	Aibika & Taro (30%)	Cabbage & Sweet potato (29%)

Although many smallholders grow some of their own food in their food gardens they also use cash income to purchase other foods such as those from the store or local markets. The main sources of cash income used for food purchases in ARoB and ENB were cocoa and the marketing of garden produce. Marketing was the main source of income in Milne Bay, however, many smallholders also used income they earned from alluvial mining to purchase food items.

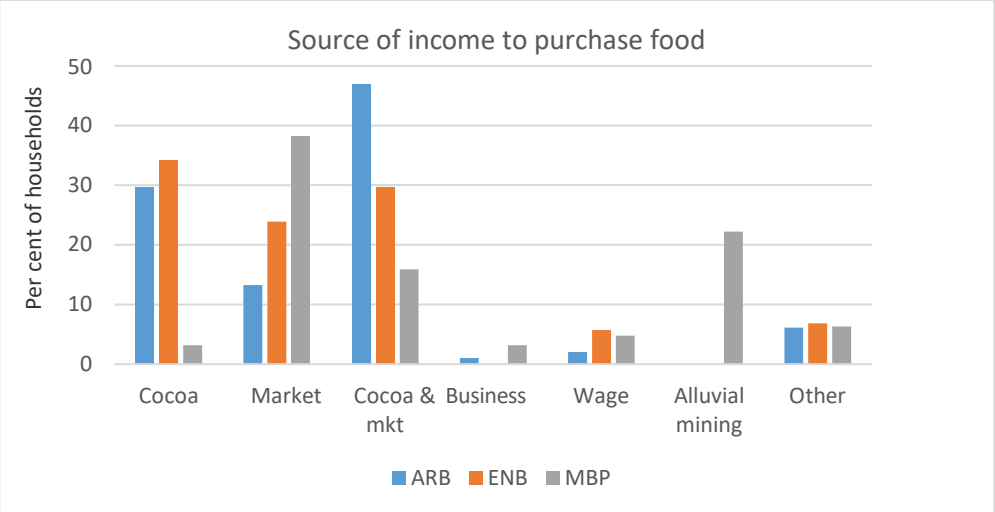

Figure 7.15. The main source of income used to purchase food.

Conclusion

As illustrated above, food gardens in the oil palm and cocoa growing areas are of considerable importance in maintaining food security. Not only do they provide an extensive diversity of foods for smallholders but also an important source of income with which they can purchase foods. The main functions of gardens in the agricultural systems of smallholders include:

- Provision of food for daily meals and cultural events
- Buffering household incomes during periods of low commodity prices or outbreaks of pest and diseases
- Providing income to households constrained by population pressures
- Providing supplementary income for women, or even a primary source of income for women, who may otherwise not have access to the income from cash crops. Smallholders engaged in cash cropping have the capacity to divert their labour to food gardening activities when household demands cannot be met by income from cash crops.

ACCESS AND AVAILABILITY OF GOOD QUALITY DIETS

According to the FAO, "Food security exists when all people, at all times, have physical and economic access to sufficient safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life" (FAO, 2008). Currently more attention is being given to the interrelationships between food security and nutrition. Hence increasingly the term food and nutritional security is becoming a commonly used term. In 2018 the FAO defined food insecurity as:

> A situation that exists when people lack secure access to sufficient amounts of safe and nutritious food for normal growth and development and an active and healthy life. It may be caused by unavailability of food, insufficient purchasing power, inappropriate distribution or inadequate use of food at the household level. Food insecurity, poor conditions of health and sanitation and inappropriate care and feeding practices are the major causes of poor nutritional status. Food insecurity may be chronic, seasonal or transitory (FAO *et al*. 2018, 159)

As outlined in the methods section 5, above, the study recorded the meal ingredients eaten by household members as part of their main meal. Dietary data were collected at two levels: a one-off 24 hour food intake recall question among 634 cocoa & oil palm smallholder households and a 24 hour food intake recall survey for 7 consecutive days among 101 cocoa and oil palm smallholder households. These data helped determine if smallholders had regular access to nutritious and sufficient quality food to meet their daily dietary needs. Information collected on the main sources of meal ingredients enabled the study to assess the importance of household food gardens in daily food consumption and to evaluate the capacity of households to purchase food.

Further, by conducting food intake surveys over seven consecutive days, the study was able to use two proxy food security indicators: the household dietary diversity score (HDDS) and the food consumption score (FCS). The HDDS is a measure of access to a variety of foods (FAO, 2013) and it is a widely used proxy indicator of food access. The FCSs are used by the FAO as a standard measurement for assessing household food security. The scores are a good measure of diet quality and, to a lesser extent quantity. Knowing the different food groups individuals are consuming allows an assessment of the quality of diets. Studies show that more diverse diets (people eating foods across a wide range of food groups e.g. vegetables, fruit, meat, dairy products, etc), are more nutritious. Conversely eating food from only one or two food groups, such as root crops and sago is less nutritious, especially when the food groups high in protein like meat or chicken, are absent from the diet. Thus assessing dietary diversity not only tells us about the variety of foods a household can access but it is also a proxy for the nutrient adequacy/quality of diets.

In PNG, nutritional studies have shown that it is the quality of the diet rather than the quantity of

food consumed that is the major factor contributing to poor nutrition and poor child growth in the country (e.g. Harvey & Heywood 1983; Gibson *et al*.1991; Mueller *et al*. 2001a, 2001b). The majority of the population generally have good access to food, but diet quality, especially protein levels, is inadequate in many rural areas. This is due to the prevalence of bulky root crops in traditional rural diets which consist largely of low protein tubers such as sweet potato, yams and taro, and these low protein diets are associated with undernutrition in PNG. For young children, the bulkiness of the root crops, of which up to 80% of the total dietary energy is derived, may make it difficult to consume sufficient volume for energy, protein or other nutrient requirements to be satisfied (Mueller *et al*. 2001a, 2001b).

The following discussion draws on the one-off previous meal dietary recall and the seven day dietary recall survey.

Dietary recall of previous night's meal

Figures 7.16 and 7.17 show the foods most widely eaten by households in all of our study sites in Bougainville, ENB, Milne Bay, Oro, and WNB. The most dominant ingredients/ foods consumed in the previous night's meal were:

- Coconut milk. This was dominant across all sites, especially in Milne Bay and Bougainville where 80% of the meals consumed in the last 24 hours contained coconut milk.
- Green vegetables in meals was almost universal.
- Green leaf vegetables. Aibika, aupa, ferns, pumpkin tips, etc., were common across all sites.
- Traditional staples such as bananas and tubers. Taro, sweet potato and yams remain important (40% of all meals), and it is common for at least one or two staples to be part of a meal. With the exception of the VOP villages in WNB, 30% or more of the meals consumed contained bananas. Banana was an important staple consumed in Oro and Milne Bay meals.
- Mami/yams remain the major staple in Milne Bay. Just over 70% of meals in the previous 24 hours contained mami. Mami/yams are not only a very significant part of the diet, but culturally very important. At Milne Bay there does not appear to be the shift away from their traditional root crops of mami/yams that was witnessed in Bougainville and ENB where the cultivation of traditional taro is declining. Similarly, in the oil palm study villages in WNB, taro was once a significant crop in the gardening systems but it is now declining, and people are planting more banana, sweet potato (as in Bougainville) and cassava. These dietary shifts are discussed further below.
- Purchased food from the store and local fresh food markets. At some sites, such as Hoskins, WNB and Tavilo ENB, 70% or more of the meals consumed in the previous evening contained some store purchased foods. The most common store foods consumed were rice and tinned fish. At all sites, rice was consumed by more than 25% of households in the previous evening's meal, with over half of the previous meal on the Bialla and Hoskins LSSs containing rice.

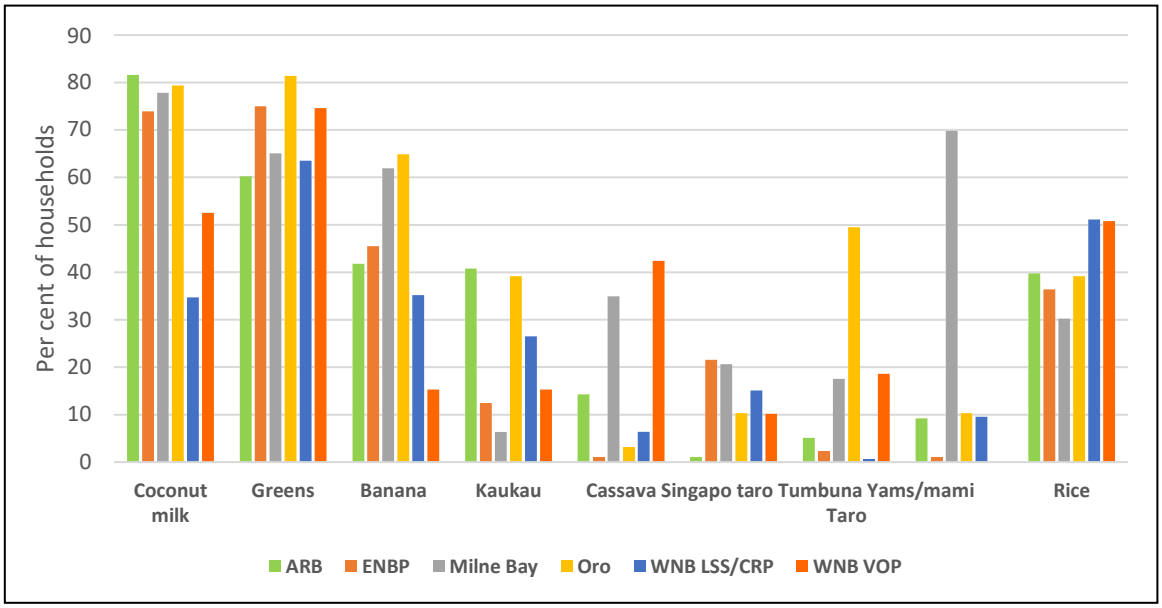

Figure 7.16 Proportion of households' foods consumed in the previous night's meal.

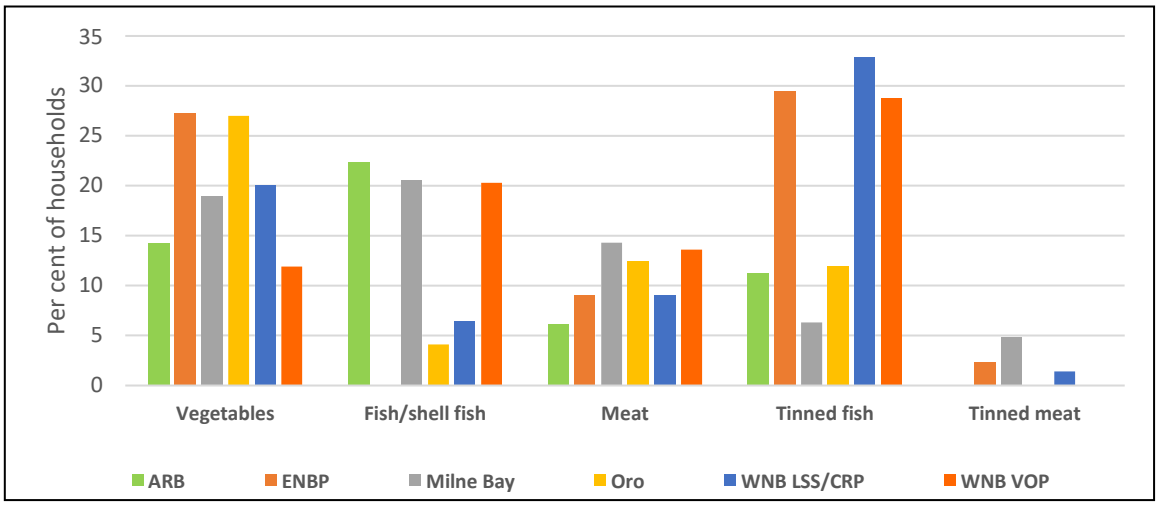

Figure 7.17 Proportion of householeds consuming individual food groups.

The consumption of tinned fish is very important nutritionally in PNG because, as mentioned above, the traditional staples that dominate the diet are low in protein and energy. Thus, having access to income to purchase high nutrient density store foods to supplement the traditional diet has a beneficial effect on diets and nutrition. Studies in the 1980s and 1990s demonstrated that in PNG where cash crops such as coffee, copra and cocoa were introduced there was an associated improvement in the nutritional status of the population especially among children. The Institute of Medical Research in PNG has shown that consumption of rice, tinned fish/meat, fresh fish and legumes, which are much higher in protein, zinc and energy than local staples, is significantly correlated with improved child growth (in length and/or weight) (Mueller *et al*. 2001a, 2001b).

Among cocoa farming households, banana, coconut milk and rice were commonly consumed by more than 20% of households in all three provinces. In ARoB, sweet potato was a common ingredient, and in Milne Bay yam and cassava were consumed by more than 20% of households. On the oil palm LSSs, rice, green leafy vegetables, banana and tinned fish were included in more than 20% of meals at both Bialla and Hoskins. Coconut milk and sweet potato were also common ingredients at Hoskins. Greens, rice, tin fish, coconut milk, sweet potato and banana, were eaten by more than 20% CRP households in the previous evening's meal. Popondetta was the only site where rice did not appear in more than 20% of meals.

Dietary micronutrient content

Another way to assess household food security is to investigate the consumption of key food groups characterised according to their micronutrient content. The FAO (2013) recognises vitamin A and iron as being especially important. A deficiency in Vitamin A is related to preventable blindness in children and the risk of maternal mortality, while iron deficiency is related to anaemia, ill-health and preventable death (FAO *et al*., 2018). Other important food groups include protein rich meats and oils/fats. Protein plays an important part in growth and is correlated with child stunting. The consumption of oils and fats improves energy density and absorption of some fat-soluble vitamins (FAO, 2013). Thus, the study examined the intake of Vitamin A and iron rich foods, and oil and fats. In general, the majority of households on cocoa blocks consumed foods rich in vitamin A and oils and fats whilst a minority (between 36% and 40%) consumed foods rich in iron (Table 7.9).

On the oil palm blocks, there is significant variation between the sites of Hoskins and Bialla regarding consumption of vitamin A and oils and fats (Table 7.10). A majority of households in Hoskins consumed food rich in each of the micronutrient categories vitamin A, iron and oils and fats but only a minority of households consume iron and oils and fats in Bialla.

The general findings from both the cocoa and oil palm blocks are perhaps to be expected. Vitamin A rich vegetables and tubers are readily consumed as are coconuts, which provide oils/fats. Less consumed in some rural diets are iron rich foods such as meat.

Table 7.9 Proportion of cocoa households consuming foods rich in vitamin A, iron and oils and fats according to location (previous night's meal data).

	Bougainville *(n=98)*	ENBP *(n=88)*	Milne Bay *(n=63)*
Vitamin A	81	77	67
Iron	36	40	40
Oil and fats	87	84	78

Table 7.10 Proportion of oil palm households consuming foods rich in vitamin A, iron and oils and fats according to location (previous night's meal data).

	WNBP *(n=276)*	
	Bialla *(n=89)*	Hoskins *(n=187)*
Vitamin A	60	88
Iron	42	53
Oil and fats	11	54

Source of food items

People have several ways of meeting their daily food needs. Overwhelmingly, people's own food gardens are providing the food they consume on a daily basis (Figure 7.18 and Figure 7.19). Oil palm smallholders in WNB rely heavily on their own garden foods for food access and between 60% and 70% purchased some food from the store; at Hoskins almost 40% of households bought ingredients from the market.

Cocoa farmers are also heavily reliant on their own gardens for food. More than 80% households at the ENB sites indicated that they sourced ingredients from their own food gardens for the previous evening's meal (Figure 7.19). In Tavilo more than 70% of households included store foods; these were included in 46% and 48% of meals respectively at Lamarainam and Rabagi. At Lamarainam 42% used ingredients purchased from the market. In Rabagi and Tavilo the bush or sago grove were also important sources of ingredients.

The significant contribution of garden food to daily diets of smallholders reflects the importance of gardening in the livelihood system of smallholders.

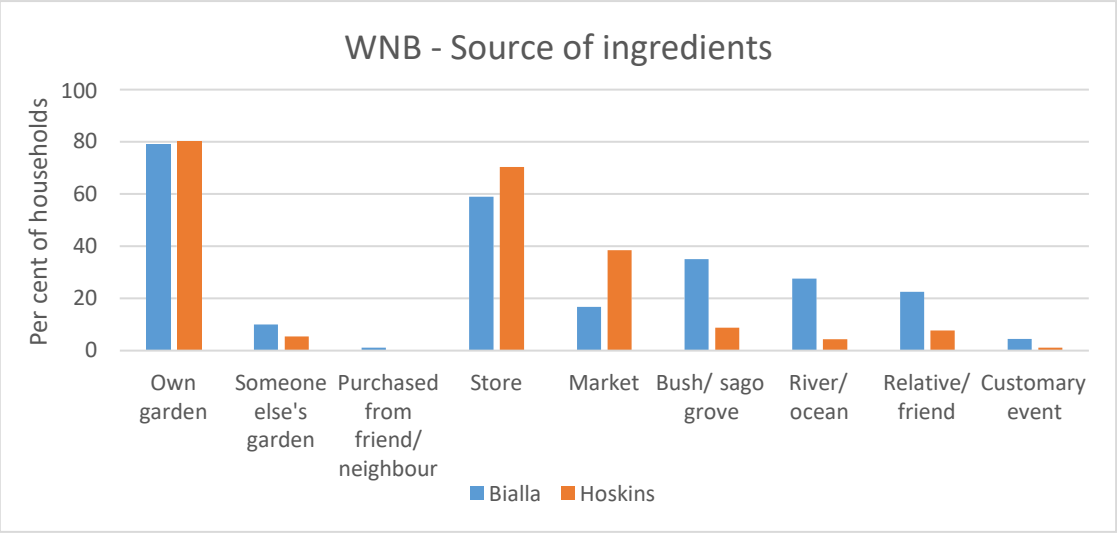

Figure 7.18. Source of food items/ingredients in the previous evening's meal on the LSS at Bialla and Hoskins.

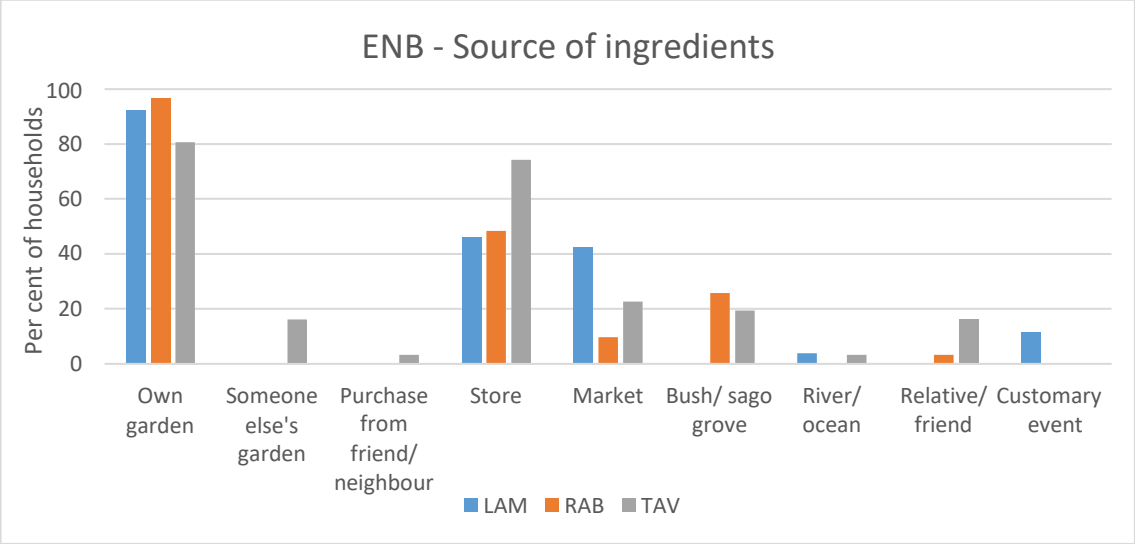

Figure 7.19. Source of food items/ingredients in the previous evening's meal in ENB.

However, a significant portion of food items also come from stores, being typically the second most common origin of food. Within the cocoa sites, there is some variation in the portion of food coming from different locations. For example, East New Britain smallholders rely more heavily on store bought food than smallholders from other Provinces. At all sites, rice was regularly purchased and consumed by households. Rice is becoming a main staple on the LSSs and a secondary staple at other sites such as Bougainville and ENB. At these sites, rice is no longer a luxury food item as is still the case in many rural areas of PNG. Instead, it has become a normal part of the diet and people, especially younger members of the family, expect to consume rice several times a week. This increased consumption of rice is presumably matched by a reduction in the consumption of traditional staples.

Seven-day dietary recall

This section will discuss the HDDS and FCS results. The seven day survey data has allowed for a more detailed assessment of smallholders access to a variety of foods and the quality of diets.

Household dietary diversity scores

Overall a high proportion of households have medium and high HDDS, although within each location there is significant variation among households. Thus, some households have far more diverse diets than others. The FAO (2013) recommends grouping HDDS data into three categories: low, medium and high dietary diversity. Other authors, such as Vaitla *et al*. (2017) suggest the categories of severely food insecure, moderately food insecure and food secure, using the same cut-off points. Tables 7.11 and 7.12 show the oil palm and cocoa household data classified according to the FAO cut-off scores.

According to these categories, the majority of households in both Bialla and Hoskins have medium to high dietary diversity: 83% of households in Bialla and 80% in Hoskins (Table 7.11). As the HDDS measures household access to food variety, it may be assumed that the majority of households have a medium to high access to a variety of foods. Although, it should be noted that there are a number of difficulties when interpreting these scores. As discussed by several authors (Ruel, 2002; Savy *et al*. 2005; Vaitla *et al*. 2017), cut-off points need to be defined in context of where they are used. It is possible that the categories used are unsuitable for PNG or even for this specific area within PNG. There are also other complications such as variations in the number of people within the household between days. For example, in one household in Hoskins a female household head was absent during the reference period, thereby, possibly decreasing the overall household score. Such variations as these have a larger impact when the sample size is small, as is the case with this study. The FAO (2013) guidelines suggest looking at population level samples, in which case, such variations would not make much difference.

In the cocoa growing areas, the majority of households in Bougainville and Milne Bay have medium to low dietary diversity (56% of households in Bougainville and 70% in Milne Bay) (Table 7.12) whilst 100% of households in ENB have medium to high dietary diversity. Care needs to be taken when interpreting these scores. A combination of low count numbers and the use of non-context specific cut-off points may mean the results overstate the proportion of households in the low and medium categories. However, like the oil palm data, there is significant variation within provinces and it does seem that certain households on particular days have diets with low diversity.

Table 7.11 Proportion of oil palm households grouped according to HDDS categories*

	Low (0-3 food groups)	Medium (4-5 food groups)	High (6-12 food groups)
Bialla *(n=12)*	17	50	33
Hoskins *(n=30)*	20	37	43

* Standard categories as specified by the FAO (2013).

Table 7.12 Proportion of cocoa households grouped according to HDDS categories*

	Low (0-3 food groups)	Medium (4-5 food groups)	High (6-12 food groups)
Bougainville *(n=29)*	28	28	45
ENB Province *(n=29)*	0	41	59
Milne Bay *(n=30)*	23	47	30

* Standard categories as specified by the FAO (2013).

Food Consumption Scores (FCS)

As mentioned above, FCSs are a good measure of diet quality and quantity. Table 7.13 shows cocoa and oil palm smallholder household food consumption scores according to ward/subdivision. There is significant variation in household scores in each of the locations. In the cocoa growing areas, households in Tavilo have the highest FCSs followed by those in Iris. Next, households in Teobuin and Rabagi have approximately the same scores followed by those in Lamarainam. Households in Boiou and Kaubwaga have the lowest FCSs overall. For the oil palm growing areas in WNB, Gaungo and Gavaiva have the highest average FCS (approximately 55) followed by Sarakolok and Tiauru (50.5 and 45.8). Valoka has the lowest overall score of food group consumption at the household level (44.5). It is difficult to assess any difference between LSS and village growers when examining the mean scores. However, the village growers have far less variation in scores, as reflected in the range of scores and relatively small standard deviations.

Table 7.13. Cocoa and oil palm block food consumption scores according to ward/subdivision

Location	Ward/Subdivision	Mean	Standard deviation	Range
Bougainville	Iris *(n=12)*	52.1	7.0	40-60
	Teobuin *(n=14)*	48.3	9.9	33-65
East New Britain	Lamarainam *(n=6)*	45.0	7.0	37-55
	Tavilo *(n=9)*	53.9	7.7	45.5-71.5
	Rabagi *(n=11)*	48.4	14.8	33-84
Milne Bay	Boiou *(n=15)*	43.0	9.0	27.5-58.5
	Kaubwaga *(n=15*)	44.4	12.1	25-64
Bialla	Tiauru *(n=12)*	45.8	12.6	29.5-66.5
Hoskins	Gaungo *(n=10)*	54.8	12.0	43.5-79
	Gavaiva *(n=3)*	54.7	3.5	51-58
	Sarakolok *(n=13)*	50.5	10.4	35-70
	Valoka *(n=3)*	44.5	4.4	39.5-47.5

To make sense of the magnitude of scores, the FCS scores are grouped into three categories poor, borderline and acceptable. The cut-off points are based on standard categories as specified by the FAO *et al*. (2008). The rationale behind the cut-off points is as follows: a poor score, less than or equal to 21 means a household is not expected to eat at minimum, staples and vegetables on a daily

basis. The categories 'borderline' and 'acceptable' reflect improvements on the minimum score through household consumption of food groups, particularly those with larger weights. The score a household is given, is calculated by analysing the frequency of consumption by household members over a 7 day period of 8 main food groups – each group is given a different weighted score.

At all studysites, none of the households had FCSs that were in the poor category (Table 7.14). The vast majority had 'acceptable' food consumption scores – indicating relatively good quality diets for most households. However, at 6 of our 12 study sites, there were 14% or more households that were in the 'borderline' category (25% Tiauru, 15.4% Sarakolok, 14.3% Teobuin, 18.2% Rabagi, 15.4% Boiou and 33.3% at Kaubwaga). At Kaubwaga, on Misima, 33.3% of households had 'borderline' FCSs. The households in the 'borderline' FCS category are potentially at risk of falling into the Poor category and being vulnerable to food and nutritional insecurity– this could happen if households were not earning sufficient income to purchase high quality food – especially protein.

Table 7.14. Proportion of cocoa households according to FCS cut-off points.

	Subdivision	**Poor (<=21)**	**Borderline (21.5-35)**	**Acceptable (>35)**
Oil Palm	Tiauru *(n=12)*	0	25	75
Oil Palm WNB Hoskins	Gaungo/Gavaiva *(n=13)*	0	0	100
	Sarakolok *(n=13)*	0	15.4	84.6
	Valoka** *(n=3)*	0	0	100
Cocoa Bougainville	Iris *(n=12)*	0	0	100
	Teobuin (*n=14)*	0	14.3	85.7
Cocoa East New Britain	Lamarainam *(n=6)*	0	0	100
	Rabagi *(n=11)*	0	18.2	81.8
	Tavilo *(n=9)*	0	0	100
Cocoa Milne Bay	Boiou *(n=15)*	0	15.4	86.7
	Kaubwaga *(n=15)*	0	33.3	66.7

Analysis of the frequency of food group consumption, as measured by the FCSs (Tables 7.13 and 7.14) indicates that the majority of oil palm and cocoa households have acceptable levels of food consumption whilst a relatively small portion of households have FCSs classified as borderline in certain locations. These results differ somewhat from the HDDS data (Tables 7.11 and 7.12), as the HDDS data contains a higher distribution of households in the medium and low categories (the equivalent of borderline and poor when looking at the FCSs). There are a number of reasons why this might be the case. Firstly, the HDDS and FCS measure different aspects of food security. The HDDS only examines dietary quality while FCSs are a proxy measure of dietary quality and quantity. Secondly, the two scores have different reference periods. The HDDS is calculated from data collected over a 24 hour reference period while the FCS uses 7 days of data. As the data set is relatively small, it is likely that variations, such as household members being absent, are disproportionately affecting the HDDSs. Therefore, the FCS is perhaps the more reliable indicator due to the larger time reference period.

Correlation Coefficients for Bivariate Data

The association between food security indicators and a number of variables were investigated to ascertain whether any relationships between certain variables exist. The relationship between these variables are summarised in Table 7.15. The Table shows correlations between two variables to

determine whether change in the independent variable would 'cause' change in the dependant (food security) variable.

In general, the correlation coefficients between the examined variables were very small ($r \leq 0.1$), meaning the relationships between the food security indicators (HDDS and FCS) and other variables are weak.

Table 7.15 Summary of correlations between HDDS/FCS and key variables for oil palm and cocoa households.

Independent variable	Dependant variable	Count	Correlation coefficient (Spearman's rho)
Garden area			
Garden area	HDDS	114	0.144
Garden area	FCS	108	0.067
Education			
Male household head education level	HDDS	122	-0.123
Male household head education level	FCS	116	-0.027
Female household head education level	HDDS	121	-0.103
Female household head education level	FCS	115	-0.106
Household/living Index			
Household index	HDDS	130	0.126
Household index	FCS	124	0.247
Living condition index	HDDS	130	0.123
Living condition index	FCS	124	0.137
Population			
Block population	HDDS	123	0.150
Block population	FCS	117	0.009
No. of households on block	HDDS	124	0.059
No. of households on block	FCS	118	-0.078
No. of children (≤10) on bock	HDDS	82	-0.219
No. of children (≤10) on bock	FCS	76	-0.120

Conclusion

This study has examined food consumption data according to several indices and descriptive statistics in an attempt to provide a relatively broad assessment of food security among oil palm and cocoa smallholders, given the available data. Such an analysis is complex, due partly to measurement issues, ambiguity in classifying scores and the multidimensional nature of food security. However, it is concluded that overall food security levels on the oil palm and cocoa blocks appear reasonable. This conclusion is based on the FCS data in which no households were categorised as poor. The FCS is perhaps the more robust indicator (compared to the HDDS) due in part to the 7 day recall period

(utilising a larger data set) and the weighting of nutritious foods. Therefore, more clout has been given to the FCS over the HDDS results.

Despite the overall food security being reasonable, it is possible that certain households on certain days are food insecure (or certain people within households are less food secure than others). Evidence of this is the very low diversity in diets of some households, shown in the HDDS data. Perhaps also of concern, is the low consumption of iron rich foods in certain areas, such as Bialla and Milne Bay. Low count numbers have limited how 'deep' some of this data can be explored and they have also limited some of the conclusions that can be drawn.

Objective 2: **Determine the key factors that enhance or constrain the capacity of cocoa and oil palm households to adapt and respond to food insecurity.**

As outlined above, the dietary assessments indicate that the status of food and nutritional security at all our field sites is relatively good. Most people claim that their gardens are meeting their food needs and most are able to supplement garden foods with the purchase of protein and energy rich foods. To some extent the findings were unanticipated, especially given the large fall in incomes among cocoa growers and especially in the oil palm growing areas where there are intense land pressures.

There is little doubt that access to customary land amongst CPB growers provided a safety net. When cocoa incomes collapsed communal land tenure enabled smallholders to expand food production for home consumption and local markets. Fortuitously, the expansion of food production coincided with depreciation of the Kina making local market foods cheaper relative to imported store foods. Formal sector workers and the urban population increased their consumption of locally produced foods.

The case in oil palm reflects the adaptive capacity of Papua New Guinean smallholders. Technical innovation in the form of agricultural intensification through use of inorganic fertilisers and pesticides; rotation with leguminous crops; adopting quick maturing and high yielding staple crops; and intercropping newly replanted oil palm with food crops was very effective in increasing food production to match population growth. This combined with social innovation by cooperating with other farmers to share access to each other's oil palm replant areas for intercropping with food crops led to a dramatic increase in the supply of land for food production.

What explains the current status of food security among households? Based on the study findings, we have identified several interacting factors that help explain the status of food security among cocoa and oil palm smallholders and how they have managed to maintain food and income security. The study suggests that although smallholders have faced both short-term shocks and long-term demographic stressors on their agricultural systems, generally they have successfully responded to protect their households from food insecurity. As shown in Figure 7.20 there are several wide-ranging factors contributing favourably to the availability of and access to a stable supply of nutritious food. For the study households these various elements provide the foundations to shield most against food insecurity.

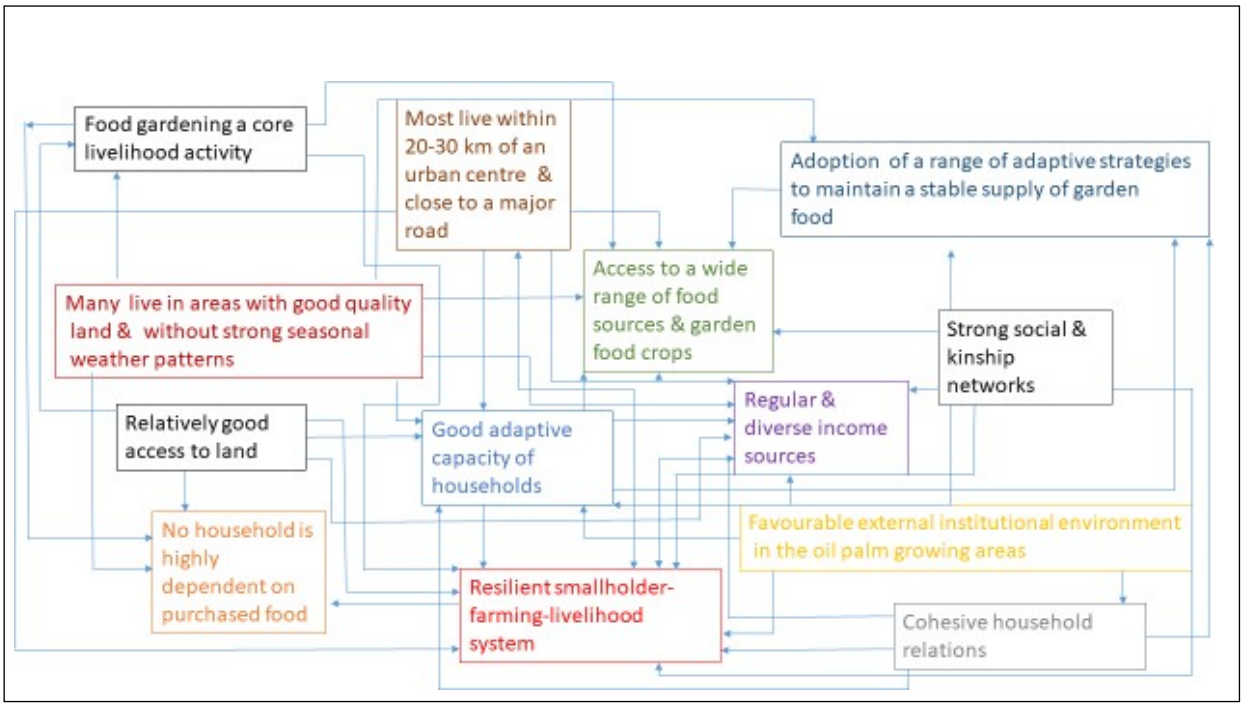

Figure 7.20 Factors contributing to status of household food security among cocoa and oil palm smallholders.

Importantly these various elements inter-dependently maintain household food security. So for example, cohesive household relations which allow for all household members to work together cooperatively and cohesively, in turn act to support a resilient smallholder-livelihood system and fosters the capacity of a household to adapt to pressures. Cohesive household relations are also important in explaining why some households have good and regular income sources. Similarly living close to an urban centre and to a major road strengthens food security as it means smallholders have access to town and markets to earn income and to purchase store foods that add to the nutritional quality of the diets.

These overlapping factors can be grouped into four main categories

- Smallholder livelihood-farming system
- Household adaptive capacity
- Location/biophysical environment
- External institutional environment.

Each are discussed below and outlined in Figure 7.21.

Figure 7.21 Household Food Security

Smallholder Livelihood- farming System	Household Adaptive Capacity	Location/ Bio-physical Environment	External Institutional Environment
Land access Flexible, integrated & resilient farming system Stable and varied food supply Regular & diverse income sources High cultural value placed on subsistence production Low dependence on store foods	Willingness to innovate and adapt Adoption of a range of adaptive strategies Strong Kinship & social networks Cultural/social institutions & norms Intra-household relations	Close to town/markets Close to a main road Good quality land Good terrain for agriculture No strong seasonal variations Proximity to government services	Access to extension training and support Access to private sector support Access to credit Access to services Access to information

SMALLHOLDER LIVELIHOOD AND FARMING SYSTEM

A fundamental component that helps maintain relatively good food security among most households in the study sites is the farming-livelihood system of smallholders in which access to food and income are embedded (Figure 7.22). A key feature of this farming-livelihood system is that it is a highly flexible, dynamic and adaptive system made up of diverse livelihoods, and is grounded in and governed by a set of social structures (largely kinship and social network) & institutions (e.g. belief systems, societal rules and clan groupings). In terms of sustaining household food security, these networks, social institutions and norms, and belief systems are important because they:

i) enhance household access to resources (land, labour and food) that are vital to maintaining food security;

ii) work to obligate and facilitate resource sharing and reciprocity across households which helps sustain food security during times of adversity (e.g. pest outbreaks, drought, etc.);

iii) reduce people's reliance on purchased food;

iv) aid households and communities to better respond to changing circumstances.

This is very important in supporting household *adaptive capacity* and enabling households to better manage and alleviate risk/uncertainty and to maintain a level of resilience in the farming system. One of the principal functions of the livelihood system is to ensure household well-being through reducing vulnerability to food insecurity as well as economic and social insecurity. This livelihood system is based on labour flexibility across a range of activities that allow smallholders to engage in a diverse range of livelihood and social activities that are important for maintaining food security and the economic and social well-being of families, extended kinship groups and village communities.

The smallholder livelihood-farming system is made up of several components (Figure 7.22), including:

1. Subsistence food production

2. Export tree crop production
3. Non-export cash income activities
4. Cultural and community activities
5. Household and domestic activities

All these activities are central to everyday life and together they contribute to household well-being by reducing vulnerability to food insecurity as well as reducing exposure to economic and social risks.

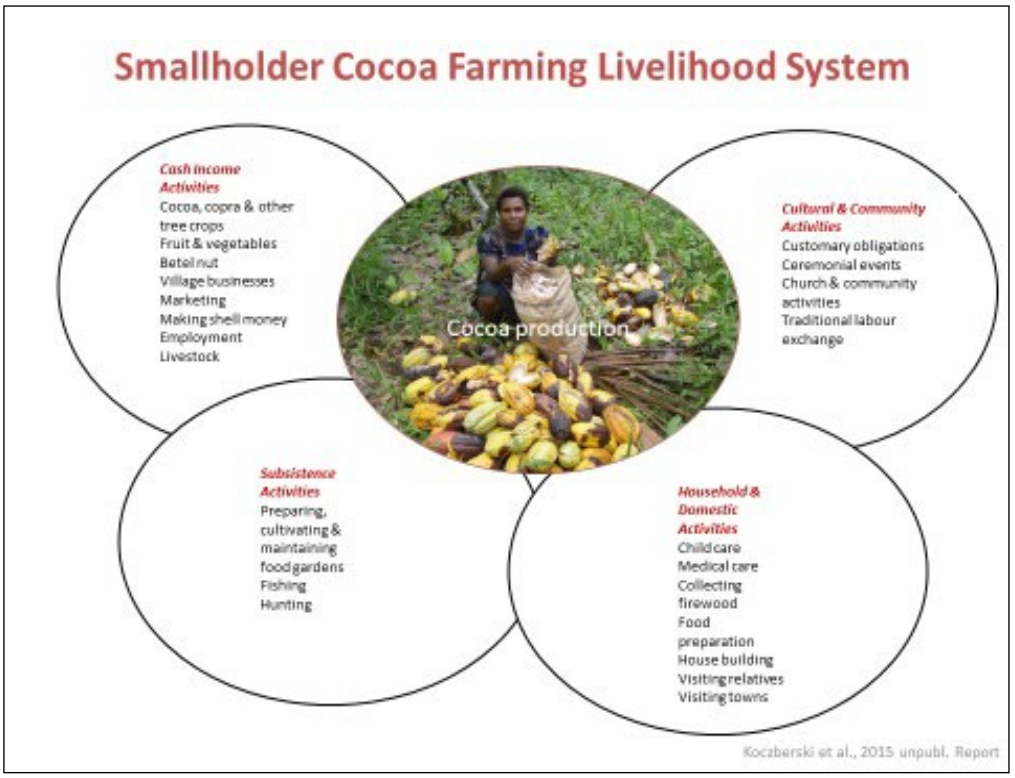

Figure 7.22 Smallholder cocoa farming livelihood system.

The livelihood system provides:

- Good access to land
- A stable and varied food supply
- Regular and diverse income sources
- Cultural meaning to people's lives
- Low dependence on store foods

As outlined in Objective 1 above, garden food production plays a very important role in household food security and subsistence activities remain a significant activity within this farming livelihood system, especially for women. This indicates that most smallholders have access to land for short-term gardening. Food garden survey results found that the mean garden area per person varied across the study sites. In WNB, the CRP households at Hoskins have the lowest mean garden area per person and the VOP households the highest, given their greater access to land. The gardening area per person on the Bialla LSS blocks is twice that at Hoskins and this is largely explained by the large number of LSS blocks at Bialla undergoing replanting in 2015 at the time of the garden surveys. Replant sections have become vital in maintaining household food security on the land short LSS blocks where most have now planted their full 6 ha leasehold block to oil palm. Intercropping of oil palm with food crops in the replant sections of blocks, greatly increases the land available for food gardening.

Because the various components of the livelihood system are closely linked, what happens in one part of the system will have an impact on other parts of the system. Thus, when the price of oil palm falls significantly, smallholders will reduce their store purchases and rely more heavily on their food gardens and similarly if there is an extended period of high prices for oil palm smallholders will take advantage of the price and reduce their labour inputs into their food gardens and enjoy more store foods. And they may also increase time in customary activities because of the increased amount of cash in the community. CPB is another example - In our CPB sites, the primary response of cocoa growers after the infestation of CPB and the loss of cocoa income was to turn to gardening. Gardens became the main source of income for families and with less cash to purchase food there was an increased reliance on garden foods as part of the daily diet. Cocoa growers also got through the initial shock of CPB infestation by being able to rely on relatives living elsewhere to send money back to the family or to send family members to live with them to take pressure off the family. This support was essential in getting families through the initial impact of CPB.

Table 7.16. Garden area (ha) by household and per person

	WNB				ARoB	ENB	MBP
	Bialla	Hoskins					
Smallholder category	LSS	LSS	VOP	CRP			
Number of gardens	47	46	17	18	62	64	77
Number of households	20	20	8	9	29	30	30
Mean garden area (ha) per household	0.42	0.24	0.50	0.15	0.15	0.20	0.16
Mean garden area (ha) per person	0.08	0.04	0.13	0.03	0.03	0.03	0.03

Despite the resilient and flexible/adaptive farming livelihood system, it cannot be assumed that there are no households vulnerable to food insecurity in the near or distant future. It is very likely that some households and certain people within some households may fall into categories which leave them vulnerable to food and nutritional insecurity. For example, as outlined above, almost half of our field sites had families whose FCSs fell in the borderline category. With all our cocoa and oil palm farmers being heavily dependent on land and natural resources more generally to maintain food and income security, then many potentially face an uncertain future as their farming and livelihood become exposed to further population and social pressures and the impact of increased climate variability

HOUSEHOLD ADAPTIVE CAPACITY

The extent to which the cocoa/oil palm farming livelihood system remains flexible and can respond to pressures, is in part dependent on household adaptive capacity. Household Adaptive Capacity can be defined as the capacity/ability of a household to respond and adjust to change and potential threats/pressures that may undermine the smallholder's livelihood-farming system. Adaptive capacity enables a household to evolve and adapt their livelihood system to cope and accommodate the shocks and the stressors on their system.

Despite the long-term and short-term stressors placed on the farming systems of cocoa and oil palm growers, many smallholder households have successfully modified their agricultural and livelihood systems to cope with these pressures. Households have employed an array of skills and strategies to reduce risks in the farming system. This section examines the main ways cocoa and oil palm growers have adapted their livelihood-farming systems and sought solutions to maintain food security and household well-being. There is now a growing body of work based on research in other parts of the developing world that provides insights into how farmers are adapting their agricultural and

livelihoods systems and employing diverse strategies to reduce their vulnerability to food and income security. In this expanding literature, several studies indicate that despite population and land pressures, ecological challenges and predictions of disasters and environmental degradation, some smallholder and pastoral households have successfully adapted their agricultural and livelihood systems (Curry *et al*.2015).

Cocoa smallholders

Most cocoa growers in the ENB and ARoB study sites still experience the damaging effect of CPB on their cocoa production. In ARoB more than 68% (Figure 7.23) and ENB more than 58% (Figure 7.24) cocoa blocks were infested with CPB.

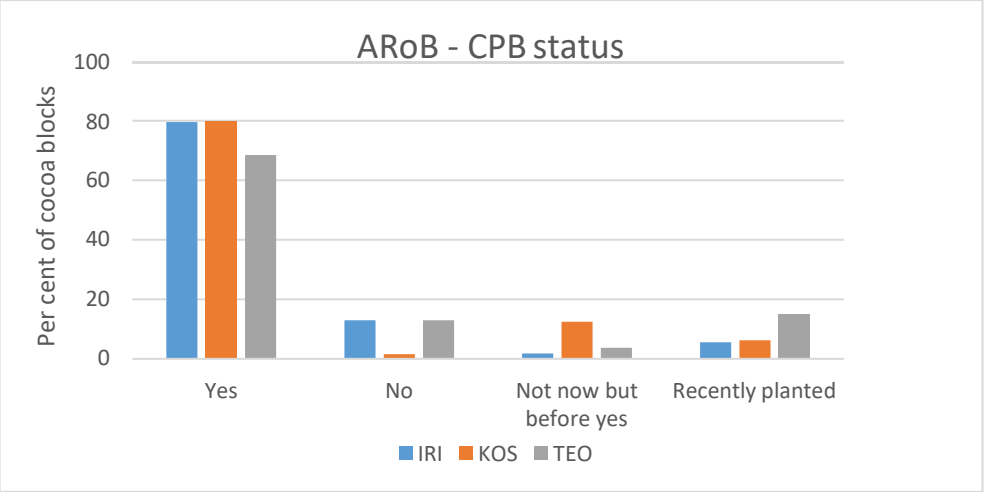

Figure 7.23. CPB infestation of cocoa blocks on ARoB.

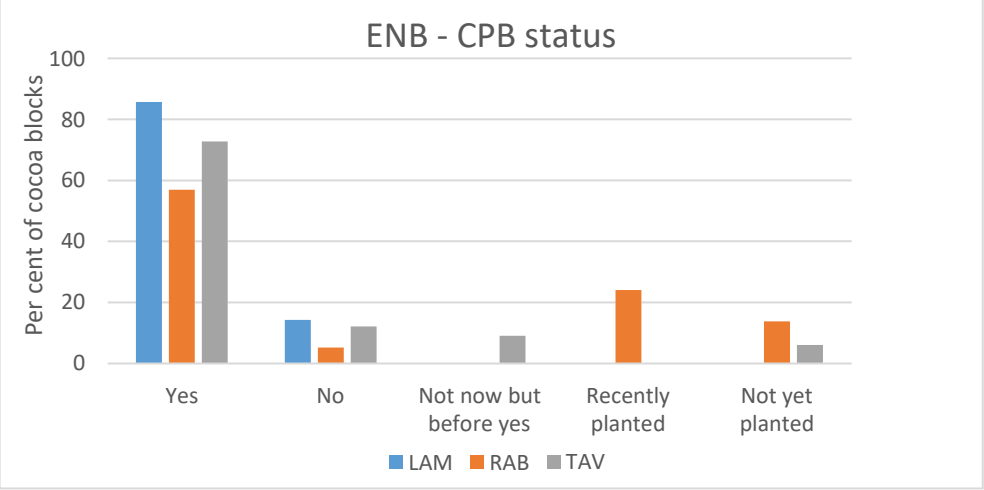

Figure 7.24. CPB infestation of cocoa blocks in ENB.

As expected cocoa yield for most cocoa blocks has been reduced at all locations where CPB is present (Figure 7.25). Yield reductions have occurred on over 75% blocks on ARoB and over 65% in ENB. In MBP, at Boiou where CPB is present cocoa yield reduction has been experienced on 87% blocks. In Kaubwaga, where CPB infestations have been less prevalent, yield reductions have occurred on 20% of blocks. In some instances at ARoB and ENB yields are no longer being reduced but were previously.

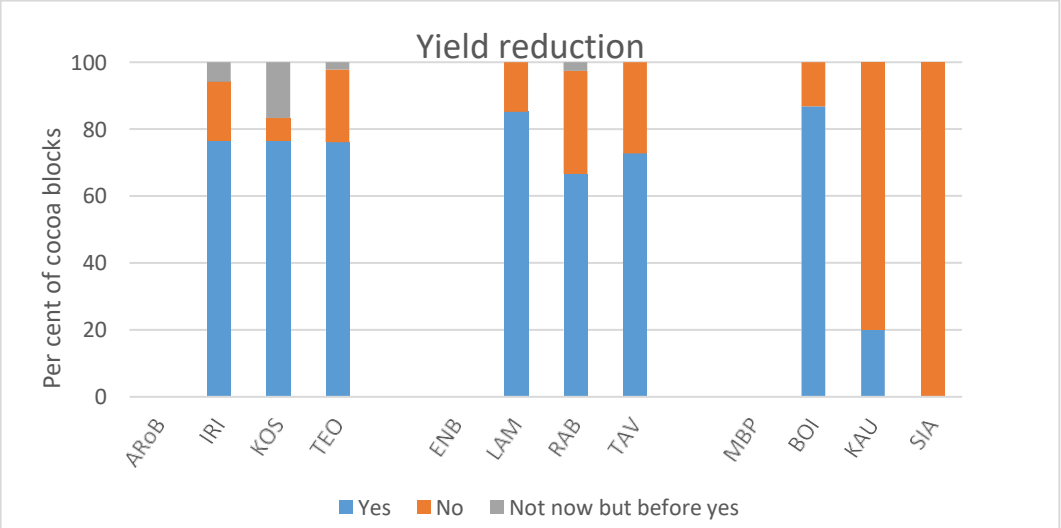

Figure 7.25. Yield reduction as a result of CPB.

With a dramatic loss of cocoa income, smallholders have adopted an array of livelihood options which have varied in importance since 2007 when the impact of CPB began to be felt. Table 7.17 outlines the range of livelihood responses pursued by cocoa farmers both in the immediate period following CPB until now. Whilst farming and livelihood systems are still in a process of adaptation and change, livelihood adaptation responses by farmers can be grouped into six main categories where significant changes have occurred. They include:

1. Cocoa farm management practices
2. Household expenditure
3. Land-use change
4. Economic livelihoods
5. Kinship and community networks, and
6. Skills development.

Table 7.17. Farmers' responses in ENB to CPB

CATEGORY	COPING/ADAPTIVE LIVELIHOOD RESPONSES
COCOA FARM MANAGEMENT PRACTICES	Abandoned or partially abandoned cocoa blocks Switched to wet-bean sales (no processing) Reduced area under cocoa Rehabilitation of cocoa holdings *Establish farmer groups* Adoption of more intensive cocoa management practices and new technologies Replanting of old cocoa with new high yielding hybrid clones
HOUSEHOLD EXPENDITURE PATTERNS	Reduction in purchases of store foods, especially protein (greater consumption of household garden foods) Decreased consumption of store-bought alcohol by men Greater reliance on credit to purchase store foods and other goods Drawing down of household savings Reduced expenditure on health care, education and travel Reduced financial support to kin
LAND-USE CHANGE	Expansion of food gardens Diversification of food garden crops for marketing. Partial replacement of cocoa with other cash crops (e.g. Balsa, coffee & oil palm) and garden foods

INCOME ACTIVITIES	Sales of garden foods have become the main source of household income Diversification of income activities Greater reliance on the sale of coconut products, such as copra and green and dry coconuts Smaller and more affordable quantities of store goods sold in village tradestores Increase in road-side marketing of store goods and fresh and cooked garden foods More formal employment Increased labour migration
SOCIAL AND KINSHIP NETWORKS	Greater reliance on remittances from relatives Harvesting of cocoa belonging to relatives residing in non-CPB affected areas Formation of village farmer groups/co-operatives (wok bung) Mobilisation at the ward level for collective action
SKILLS DEVELOPMENT	Training on CPB management practices Training and awareness on alternative income opportunities

Initially following the incursion of CPB, the most widespread response by farmers was to reassess the labour input into cocoa production (Curry *et al*. 2015). With their cocoa trees heavily infested with CPB and little or no crop to be harvested, the initial response by most farmers was to either abandon or partially abandon cocoa production.

As CBP persisted, smallholders began modifying their livelihood strategies. This involved scaling-up some existing livelihood activities, establishing new ones, and/or cutting back livelihood activities that became unviable. Two immediate and most noticeable responses made by farmers were to reduce household expenditure, especially the purchase of store foods and to expand production of garden crops for home consumption and sale at local markets. The expansion of food gardens as the favoured response is largely because people are very familiar with food gardening and gardening has always been a central part of the everyday economic and social life of villagers in PNG. Thus in the unpredictable environment of CPB, food production provided a safe and rapid way to secure immediate household needs and to respond to the income squeeze experienced by households. For many women, income from the sale of food gardens became their main income source following the incursion of CPB (Curry *et al*. 2015). Presently, 12 years on since the arrival of CPB, cocoa income has returned to being the main income source for most women (Table 7.18). The reliance on selling garden foods as the main source of household income, indicates the few viable alternative income opportunities available to cocoa growers and the overall poor government and extension support farmers have received.

Table 7.18. Primary income sources for women “Before” & “Just after” CPB, and “Now” (Per cent of females).

Period in relation to incidence of CPB	ARB			ENB			MBP		
	IRI	KOS	TEO	LAM	RAB	TAV	BOI	KAU	SIA
Before	Cocoa (72%)	Cocoa (80%)	Cocoa (78%)	Cocoa (52%)	Cocoa (55%)	Cocoa (71%)	Cocoa & Mkt garden food crops (39%)	N/A	N/A
Just after	Mkt garden food crops (22%)	Mkt garden food crops (30%)	Mkt garden food crops (41%)	Mkt garden food crops (48%)	Mkt garden food crops (38%)	Cocoa (39%)	Mkt garden food crops (58%)	N/A	N/A
Now	Cocoa (53%)	Cocoa (53%)	Cocoa (59%)	Cocoa (52%)	Mkt garden food crops (55%)	Cocoa (61%)	Mkt garden food crops (61%)	N/A	N/A

As discussed above food gardens continue to provide the bulk of daily meals and the income earned from cocoa and other sources of income. Many farmers have gradually returned to cocoa, although it is still only a small proportion of growers who have returned to cocoa as their main income source. However, the return to cocoa production has required farmers to adopt more labour intensive CPB management regimes that require weekly harvesting of all mature cocoa pods, removal and burial of all diseased and CPB-affected pods, regular pruning and shade control, weed control and insecticide spraying. For many, the decision to adopt modern cocoa farming methods and engage more strongly with the market economy was seen to conflict with traditional socio-cultural values and practices (Curry *et al*. 2015). Presently, cocoa production is still in a downward decline nationally, but in ENB (and in Bougainville) there has been a bit of a turnaround in 2018 with Agmark reporting that their fermentary at Kokopo is at full capacity with the highest production since 2008. In part this has been due to a drop in CPB levels as a result of the El Nino. However, growers cannot be complacent because the conditions are now ripe for CPB to make a comeback with the wetter conditions and the large amount of crop on the trees. CPB remains a key threat to food security for cocoa growers throughout the lowlands.

Oil Palm Smallholders

As outlined above, population and land pressures are major threats to food security in the oil palm growing areas of WNB, especially in the Hoskins area. Over the past 40 years population densities have doubled and smallholders are extending oil palm onto land that was once reserved/used for food gardens. Yet most households in our study have managed to maintain garden food production to sustain an ever-growing population. Our results indicate that smallholders are adapting and responding to shortages of garden land through incorporating a range of adaptive strategies into their gardening systems to maintain food security. These include both technical innovation in the form of agricultural intensification, crop substitution, accessing additional land, new land and social innovation through cooperative arrangements of reciprocal access to land:

1. Agricultural intensification. That is, the intensification of garden food production through increasing the crop yields/productivity from a fixed area of land. Intensification has ensured that smallholders continue to feed themselves. The main drivers of agricultural intensification are population and market opportunities (such as commodity export production) With less land available for food gardens, smallholders have increased the productivity of their food gardens to ensure their food gardens continue to meet household food needs.
2. Multi-purpose cropping – Multi-purpose cropping is associated with the diversification of agricultural production and especially cropping for both home consumption and income. In the LSS gardens, there is now an increase in the cultivation of high value crops which can be sold at local markets. Whilst women have always sold garden crops as a source of income, initially only surplus food or a small amount of additional crops were planted to earn an income. Now more crops are purposely planted for sale, especially when smallholders are replanting and temporarily have less oil palm income.
3. Expanding the supply of land for food gardening. With virtually all the 6 ha block now planted to oil palm smallholders have expanded the supply of land for food gardening both on their own block and through gardening off block.
4. Introduction of new farming and social innovations – especially the reciprocal exchange of gardening land on replant sections.
5. Introduction of new farming and social innovations – especially the reciprocal exchange of gardening land on replant sections.

The most common and most important of these strategies has been the intensification of food production. Smallholders have gradually intensified their food gardening systems in several ways, namely:

- Introduction of high yielding and quick maturing varieties of staple crops.
- Intercropping
- Use of inorganic fertilisers and pesticides. Although this is not widespread, studies on oil palm smallholder gardens in 2000-2001 did not observe farmers using pesticides or inorganic fertilisers in their food gardens (Koczberski *et al*. 2001). There was minor use of pesticides on approximately 40% of gardens. Bue (2013) found that at Hoskins in 2010, 29% of gardens surveyed had crops where pesticides had been applied.
- Rotation with leguminous crops. With more continual cultivation soil fertility must be restored.
- Shorter fallows. Progressive reduction in fallows.

None of these practices was observed by Benjamin (1977) who conducted a detailed study on smallholder food gardens in the mid-1970s. Thus these practices have been gradually introduced over the years to maintain food output and a stable food supply. Agricultural intensification is also occurring at all our cocoa sites in ENB and Bougainville.

Smallholders have intensified food production by favouring staple food crop types that are more tolerant of poorer soils, fast maturing and less prone to pest attack. Table 7.19 compares this study's WNB garden survey results with those of (Benjamin 1977) when the most common staple crops were sweet potato, Chinese taro, taro and yam.

Table 7.19 Four most common staple crops grown in household gardens by area.

1975 Hoskins LSS	2015 Hoskins LSS	2015 Bialla LSS
1. Sweet potato	1. Banana (Kiaukiau, Mosbi, Tukuru & Highlands)	1. Banana (Kiaukiau, Mosbi, Tukuru & Highlands)
2. Chinese taro	2. Chinese taro	2. Sweet Potato (Crisis & Whaghi besta)
3. Taro	3. Sweet potato (1 mun & 3 mun)	3. Chinese Taro
4. Yam	4. Cassava (white, yellow & 1 mun)	4. Taro 5. Cassava (white, yellow & rice)

Benjamin 1977 (40 gardens at Kapore, Tamba, Sarakolok, Buvussi, Gallia, Kavui and Kavagara subdivisions
Hoskins LSS, 230 gardens at Buvussi, Kapore, Sarakalok, Tamba (91 households)
Bialla LSS, Tiaru and Wilelo, 90 Houshoelds

Compared to 1975, smallholders are planting less sweet potato, taro and yams and relying more on bananas, Chinese taro and cassava: crops which can tolerate less fertile soils (although this pattern varies somewhat amongst different ethnic groups). Thirty years ago, cassava was an insignificant crop and Benjamin (1977) hardly made a mention of bananas throughout her report, except in relation to bananas being planted around the house by the Tolais of ENB. Smallholders are also planting less yams and *Colocasia* taro. Yams require fertile soil and are typically grown as a first crop in new gardens cleared from grass or shrub fallows. Similarly, taro is prone to pest attack when planted in secondary gardens with lengthy cultivation cycles. Bananas, Chinese taro and cassava are also less labour intensive than traditional crops such as *Colocasia* taro and yams/mami. Thus, they are not only land saving but labour saving which is very important when we consider women's heavy workloads. It is why many of these new cultivars are being favoured over other crops such as

tumbuna taro and yams and mami. Moreover, these more productive cultivars of existing staple crops can provide a continuous food supply year round: such as *Kiaukiau*, *Mosbi* & *Tukuru* banana and *crisis* and *3 mun* sweet potato. The short maturity and potential yields of food crops is now a major determinant of crop choice among smallholders. It is for these reasons why in all the taro growing sites in this study (WNB, ENB and Bougainville) we see the decline of *tumbuna (Colocasia)* taro and an increase in sweet potato and cassava, especially in the oil palm growing villages around Hoskins. Finally, legumes such as peanuts are being incorporated into crop rotations.

The shift in crop choice and the introductions of faster maturing and more productive cultivars of existing staple crops have been critical in ensuring an adequate food supply as they have significantly increased productivity per unit area of land. Whilst smallholders have been good at raising productivity by intensifying garden food production, research elsewhere suggests that a farming system solely undergoing continual intensification will remain vulnerable without the introduction of additional farm innovations.

Social Innovation

Reciprocal access amongst oil palm blockholders to each other's oil palm replant areas is a recent social innovation that has led to more flexible land access arrangements in what has been hitherto a rigid land tenure system under leasehold title. Together, intercropping and flexible land access arrangements have expanded the supply of land for food gardening (Figure 7.26). As land available for food gardening has contracted on the LSSs, smallholders have become more dependent on off-block access to gardening land belonging to other people (see above). As the 2 ha replant sections have assumed more importance for household food security, leaseholders have begun allocating plots of gardening land within their own replant section to residents of other blocks. In 2014, 33% and 21% of Bialla and Hoskins households, respectively, had someone else gardening on their block. With the need to acquire access to gardening land off-block, social and kinship networks were increasingly being utilised to secure land for food production, both in the short-term and over the long-term. Most often, smallholders drew on their relatives, friends, neighbours, church members and those from their own language/ethnic group (*wantoks*) to access gardening land where oil palm replanting was occurring.

The effect is reduced vulnerability to food insecurity for the individual farm household by expanding the supply of garden land and introducing flexibility into a rigid land tenure system and redistributing risk through the broader smallholder community. Thus social innovation has led to the diffusion of risk both spatially and socially from the individual farm household to the broader community, thereby enhancing both individual and community resilience.

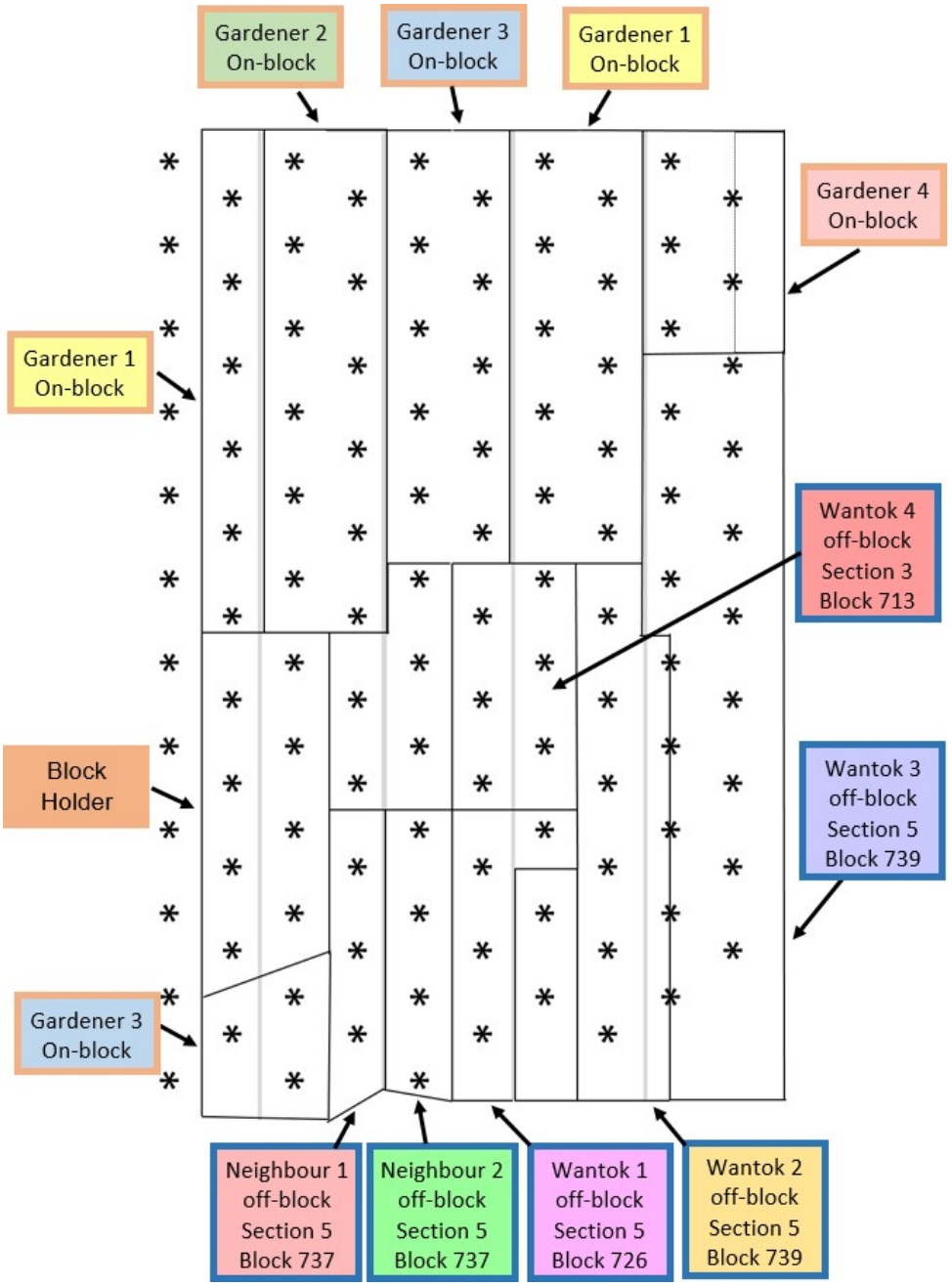

Figure 7.26. Garden plots in Round 1 of gardening after palm poisoning (the block numbers of gardeners from off-block and their relationships to host blockholder) (1 ha replant).

LOCATION AND PHYSICAL ENVIRONMENT

Another very important component explaining the relatively good status of food security among smallholders is that most of the study population live in favourable locations with good biophysical environments. Most smallholders live in areas:

- Close to town
- Close to a main road
- With good quality land and terrain for agricultural production
- With no strong seasonal influence on food production (with the exception of Misima).

Most villagers live within 20-30 km of a town/urban area and are close to a major road. By livingin a favourable location most of the smallholders are free of the disadvantages of remoteness many rural villagers in PNG endure, such as poor access to services, training, health care etc. Indeed WNB (and Bougainville) has pockets of both the highest and lowest income earners in PNG, and this inequality in income levels within the province is largely explained by accessibility to roads and markets. Access to a town and a good road means that smallholders have good access to buyers and markets, and can access stores to purchase protein. Importantly, they have a great opportunity to earn regular and diverse incomes.

The opportunity to have a regular source of income in many of our study sites, is enhanced because many of the households live in areas where land quality is good and without strong seasonal weather patterns. Land quality is determined by inundation risk, slope, and soil type (See Allen *et al*. 2005). Hence, by good land quality we are referring largely to the generally fertile soils and good terrain for agriculture at most of our study sites.

It would be very difficult to maintain long-term food security and the high population densities in the oil palm growing areas, and in ENB and Bougainville, if smallholders lived on poor quality land. Good soils have allowed intensive commodity crop production and adequate food production.

A very important component of food security is people's access to income. Oil palm and cocoa smallholders' access to both regular and diverse income sources further explains why their food security status is relatively good. Most smallholders, both men and women, have regular access to income, with the two main income sources being through the sale of commodity export crops and fresh produce. Most families have also diversified their incomes over the years and many have a range of other supplementary income sources e.g. poultry, small retail, selling cooked food, etc. (Table 7.20).

Table 7.20 Average number of income sources, other than oil palm or cocoa for smallholders.

Oil Palm Households		**Cocoa Households**	
West New Britain Bialla	5.0	East New Britain	4.4
West New Britain Hoskins	5.5	Bougainville	5.5
Popondetta	4.0	Milne Bay	5.4

The average number of income sources per smallholder household (excluding oil palm or cocoa) is 5.5 and 5 for Hoskins and Bialla respectively. Whilst many of these may not be a regular income source, they are important in providing some additional cash to households to allow small purchases or there may be a temporary cash activity to save money for a particular goal – like a church trip or customary obligation. However, it is the main income sources that tend to be used to buy store foods. Figure 7.27 shows the results of a question we asked smallholders at Hoskins and Bialla regarding what was the main source of income used to purchase food. Most used a mixture of oil palm income and market income, although just over 50% of households at Bialla claimed that money from oil palm alone was the main income used to purchase food.

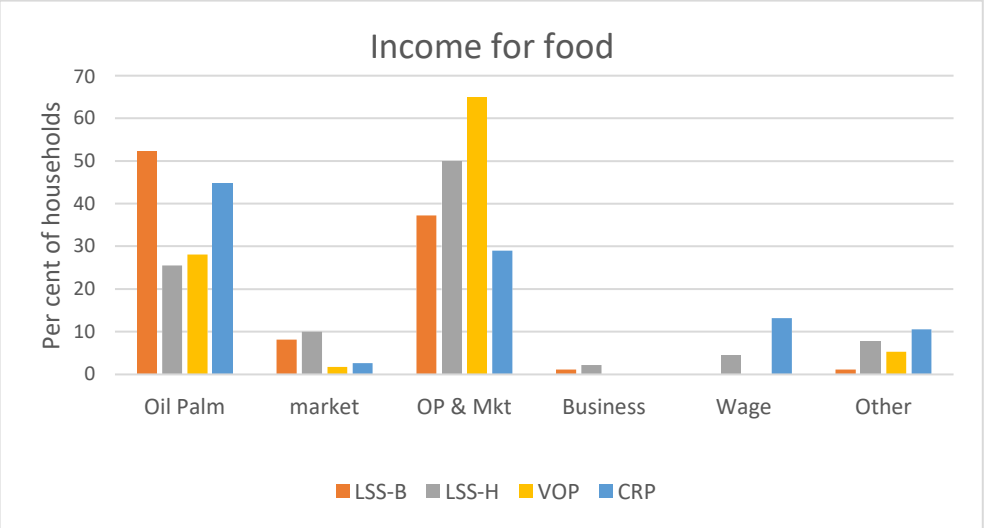

Figure 7.27 The main income source used to purchase food on the LSS at Bialla and the LSS, VOP and CRP at Hoskins.

Access to a regular income is closely linked to improved food security. As the FAO note:

> "Household food security is a function not only of availability of food but also of the purchasing power available to each household (FAO, 1994)".

Purchasing power is the ability of households to purchase food and it is one of the main determinants of food access. Some researchers suggest that access to markets and income may be moreimportant for nutrition than increasing food production diversity (Sibhartu 2018).

The purchasing power of households to buy protein/energy rich food is very important in PNG. As noted above past nutritional studies in PNG show that it is the quality of the diet rather than the quantity of food which is the major factor contributing to poor nutrition and poor child growth in PNG. In PNG, protein-energy malnutrition is the most significant form of malnutrition and greater access to imported foods such as tinned fish and meat has been associated with improved energy-protein nutrition among children. Traditional staple root crops and bananas have low bulk density and therefore provide barely enough energy and protein for the needs of infants and young children. Thus, most people have good access to food, but quality especially protein levels in diets is often deficient in rural PNG. Thus having the purchasing power to buy protein and energy rich food is important, and evidence has shown that in areas where villages can regularly consume store foods, such as tinned meat, rice etc., that the nutritional status of adults and children has improved (see Bourke 2000).

Access to a regular and diverse set of income sources not only improves purchasing power to supplement traditional staple crops, but has a range of other benefits which act to improve food security among smallholders.

- Regular and diverse income sources improves a household's capacity to cope with increases in prices of store foods.
- An insurance against loss of food crops during environmental shocks.
- Helps with more consistent supply of food in study sites that experience seasonal variations in food supply such as Milne Bay.
- Security against fluctuating commodity prices.
- Improves capacity of households to save.
- Increases the purchasing power of families to buy protein-rich nutritious foods.

- Takes pressure off the land and resources and therefore reduces land degradation and soil fertility decline.
- Takes pressure off women's labour. Purchasing food is labour efficient.

Whilst purchasing power is important it should be noted that our dietary intake surveys show that no household is highly dependent on purchased food. At this point in time it is not apparent if farming households are becoming more dependent on purchased food: it may be a necessity because of land and labour shortages or poor soils, or reflects people's greater preference to consume store food (taste better, young people and children prefer rice to traditional staples, less need to work in gardens and easy to prepare for meals, less firewood for cooking). Whilst the expansion of export cash crops and food crops for commercial sale removes land for subsistence food production, there are currently no significant signs that this has been deleterious to household food and nutritional security or has reduced significantly food production for household consumption.

EXTERNAL INSTITUTIONAL ENVIRONMENT

Local/national public and private sector institutions & organisations or international funding organisations all play a vital role in supporting or undermining household food and income security and well-being. For example, the oil palm milling companies by providing interest free credit for seedlings allows smallholders the opportunity to timely replant their old palms which helps families to maintain a steady income source which is important to enable a stable supply of purchased protein by smallholder households.

The external institutional environment has had a major influence on the extent of the impact of CPB in our study sites. The impact of CPB and the difficulties farmers have faced in adapting their cocoa cropping systems have been exacerbated by the lack of access to quality training and support programmes, both the PNG government. This has hindered the implementation of a long-term, well-coordinated government-led CPB programme for the province. When CPB was first detected in ENBP, the province had six government cocoa extension officers: an extension officer to grower ratio of 1:3,833 (Curry *et al*. 2015). The provincial Department of Primary Industry (DPI) had allocated their own extension officers to train farmers on CPB management, although the capacity and resources of the government extension services remained inadequate to maintain the necessary levels of extension programmes to ensure sufficient numbers of farmers received training and follow-up support. Thus, a lack of funding and governance issues have undermined the ability of government institutions to equip smallholders with the necessary training, information and other resources to develop their capacity to control CPB.

More recently the institutional support and donor funded programs (especially the World Bank) to address CPB in Bougainville have been more widespread and readily available to growers than what was available to growers in ENB. This largely explains why Bougainville cocoa production has been able to bounce back more rapidly than in ENB.

Will household food security among oil palm and cocoa smallholders be sustainable for the foreseeable future?

The findings suggest, that oil palm and cocoa smallholders are actively seeking solutions and finding new ways to maintain food security and household well-being. The majority of smallholders are very resilient and have shown they will respond very positively to new opportunities that come their way to improve household food and income security.

However, can we assume that household food security status will be sustainable for the foreseeable future?

Despite the fact that the overall food security is reasonable at all our field sites, it is possible that more households and certain people within some households will fall into categories which leave them vulnerable to food and nutritional insecurity.

There are three main reasons to suggest this:

1. Although nearly 80% of households claim their gardens meet most of their food needs, 20% do not. We were unable to examine in detail the reasons why these families feel food insecure but lack of access to gardening land was a major area of concern among smallholders.
2. At all the field sites, there were families whose FCSs fell in the 'borderline' category, therefore they are potentially at risk of falling into the Poor Category and being vulnerable to food insecurity in the future.
3. Finally, with all our cocoa and oil palm farmers being heavily dependent on land, and natural resources more generally, to maintain food and income security into the future, then many could face an uncertain future as their farming and livelihood become exposed to further population and social pressures and the impact of increased climate variability.

Whilst there are many protective factors operating to maintain the reliability of food availability and access, there are also a number of threats that may act to undermine both short- and long-term food security. The study found that some of the main challenges and emerging risks to food security into the future, for both cocoa and oil palm smallholders, include:

- Rising land and population pressures
- Declining soil fertility in some study sites
- Weakening of household adaptive capacity
- Intra-household and gender relations
- Declining per capita income among oil palm growers
- Growing unequal access to resources among oil palm growers
- Low educational status among household heads
- Climate Change
- External and institutional support
- Law and order

These points identified are very general and some are more relevant to particular cocoa or oil palm sites than others. Although very few smallholders mentioned climate change as a potential threat to their long-term food security, it is included in the list because the projected increase in the frequency and intensity of severe weather events to come will leave smallholders vulnerable to both short-term and long-term uncertainty in food supply. Indeed, during our study, PNG experienced a very bad drought during 2015-16.

The biggest threat to food security into the future is land pressure. Land pressures are emerging due to the rapid population growth at all our cocoa and oil palm sites. Population and land pressures were the most common topic people were keen to discuss during fieldwork. Although people are successfully intensifying and adapting their agricultural systems in response to growing land pressures and adopting some novel social and agricultural innovations, continuing pressures on land have the potential to undermine food security for some households in other direct and indirect ways through, mainly:

- Increasing reliance on cultivating gardens on land belonging to others.
- Increasing frequency of land disputes and tenure insecurity
- Tightening constraints on income diversification
- Reduced fallow periods
- More exclusive forms of land tenure system

A growing trend observed in this study in WNB and ENB where land pressures are most intense was the reliance on cultivating gardens on land belonging to others. Because of land shortages, more households are gardening on land belonging to other clans, friends and neighbours. At Rabagi in ENB, just over a third of food gardens were cultivated on other peoples' customary land – most were on a temporary access basis and some on 'purchased' customary land. Similarly, in WNB, just over 30% of smallholder gardens were on land belonging to others. On CRP blocks, 80% of smallholder gardens are off –block. Relying on another's land can be a high risk strategy over the long-term because tenure rights can be challenged by members of the landowning group, especially when land pressures increase.

Land and population pressures invariably lead to higher rates of land disputes and tenure insecurity, and disputed land can be locked out of production for extended periods – reducing a family's access to land for income purposes. There are many oil palm and cocoa blocks that are abandoned due to land and inheritance disputes. Similarly land pressures can lead to tightening constraints on income diversification. Given that most cash income activities as well as garden food production rely on access to land, then less land available will mean families will need to make trade-offs in land utilisation. This may reduce the livelihood options available to households in the future and constrain income diversification.

Another challenge that may act to undermine food security in the future is the weakening of household adaptive capacity. It is possible that in some of our study sites, as land and economic pressures continue to build through time, household adaptive capacity may weaken as strains are placed on family and social relationships. During this study and in previous studies it has not been uncommon to come across

- Intergenerational & gender conflicts (especially between fathers & sons as young men reject traditional generational relationships).
- Tensions within and across clans and sub-clans (mostly land disputes)
- Weakening of kinship and social networks and institutions
- Decline in obligatory sharing and reciprocity (especially labour, ENB).
- Declining per capita cash incomes

These features are not purely an outcome of economic pressures but also the result of general social change and growing western values influencing people's decisions – however, they all have the potential to effect long-term adaptive capacity.

A further long-term threat to long-term food security is the low educational status of cocoa and oil palm smallholders (see Ryan *et al*. 2016). The highest average number of years of education for men and women aged 25 years and older was in ENB - for men it was 7.8 years and for female smallholders it was slightly less at 7.4 (Table 7.28).

Table 7.28. Average years of schooling for cocoa and oil palm smallholders aged 25 years and older.

ARoB *n=290 (m=157; f=133)*		ENB *n=310 (m=160; f=150)*		MBP *n=204 (m=100; f=104)*		WNB *n=765 (m=400; f=365)*		ORO *n=311 (m=172; f=139)*	
male	female	male	female	male	female	male	female	male	female
7.6	7.0	7.8	7.4	6.5	5.3	7.2	6.3	7.1	6.7

To put these results into perspective, in PNG at the national level, the average years of schooling received by people aged 25 years and older is just 3.9 years. So whilst the educational status of cocoa and oil palm smallholders in our study are higher than the national average, it is disappointingly low

given that most smallholders are still not finishing primary school. It is well established that education is a key component of rural development and there is a positive correlation between people's education levels and their technical efficiency as producers with educated farmers having a greater ability to adopt new agricultural practices and technologies.

Objective 3: Assess and implement a range of strategies to improve the capacity of smallholders to produce and purchase food.

This section reports the results of the trial of the 1 ha oil palm replant option among oil palm smallholders. The trial was conducted from June 2016 to January 2018 among smallholders residing on LSS blocks in the Wilelo subdivision of the Bialla Land Settlement Scheme (LSS), West New Britain Province (WNBP). Our earlier research had indicated growing population pressures and the diminishing access to land for gardens among smallholders residing on the LSSs at Hoskins and Bialla. More recently, industry stakeholders became aware of these issues. In recent decades, smallholders have increased their oil palm plantings from 4 to 6 ha which has significantly reduced the area of land on-block for food gardening. At the same time, rapid population growth has led to declining per capita income from oil palm among LSS smallholders, thereby reducing people's capacity to purchase store foods to compensate for reduced access to land for food gardening. These trends have the potential to undermine household food security and they pose a threat to the long-term sustainability of smallholder oil palm in WNBP. The 1 ha (120 palm replant) trial was initiated with the goal of strengthening smallholder food and income security and to provide smallholders with a replanting option that better suited their situation and the socio-economic realities on smallholder blocks.

Since replanting of oil palm began in the early 1990s, the industry practice has been for smallholders to undertake rotational replanting of 2 ha stands of oil palm (240 palms) every 22 to 25 years. This conventional 2 ha (240 replant) replanting strategy was appropriate when block population densities and the number of households residing on-block were considerably lower than today, and when there was more land available for food gardening. In the contemporary situation, the 2 ha replant is no longer suitable for LSS smallholders given the diminishing per capita incomes and declining access to gardening land resulting from rapid population growth. Although rotational replanting of both 1 ha and 2 ha stands opens up the same total area of land (6 ha) over a 22-25 year period, rotational replanting using the 1 ha replant option doubles the period that there is an oil palm replant area on-block available for food gardening. Also, the 1 ha replant option increases by 2.5 times the capacity of growers to service their replanting loans from oil palm income leading to quicker loan repayments and higher incomes for growers during the replanting phase. Under the 120 palm replant option, smallholders replant a 2 ha plot of oil palm in two, 1 ha stages, with the second 1 ha delayed until the first 1 ha replant comes into production, approximately three years after planting.

Population growth and food and income security

The smallholder LSSs at Hoskins and Bialla were established in 1968 and 1972 respectively. The LSSs were based on a standard block size of 15 acres (6.07 ha) of which 4 ha (480 palms) were planted to oil palm with the remaining 2.07 ha reserved for food gardens (Hulme 1984; Koczberski *et al*. 2001). Since 1975 the average population per LSS block at Hoskins has almost tripled from 7.2 persons per block to a mean of 19.3 persons per LSS block in 2015 (Ploeg 1972). Similarly, at Bialla the mean number of persons per LSS block has increased from 11.1 in 2002 to 18 persons per block in 2015 (Koczberski and Curry 2005: 327). Today, LSS blocks at Bialla and Hoskins have a mean of 3.75 households per block spanning three generations as the offspring of the original settlers marry and raise their own families on their parents' leasehold block. Now several households rely on the resources and oil palm income earned from the block.

Increasing population densities on the LSS blocks have inevitably resulted in land use change over time. By the early 1990s, some leaseholders were beginning to extend their oil palm plantings into the 2.07 ha 'reserve' for food gardens (Koczberski *et al*. 2012b). Now, nearly all LSS blocks have a

third, 2 ha, phase of oil palm leaving only 0.07 ha for food production when all three 2 ha oil palm plots are in production (Figure 7.29).

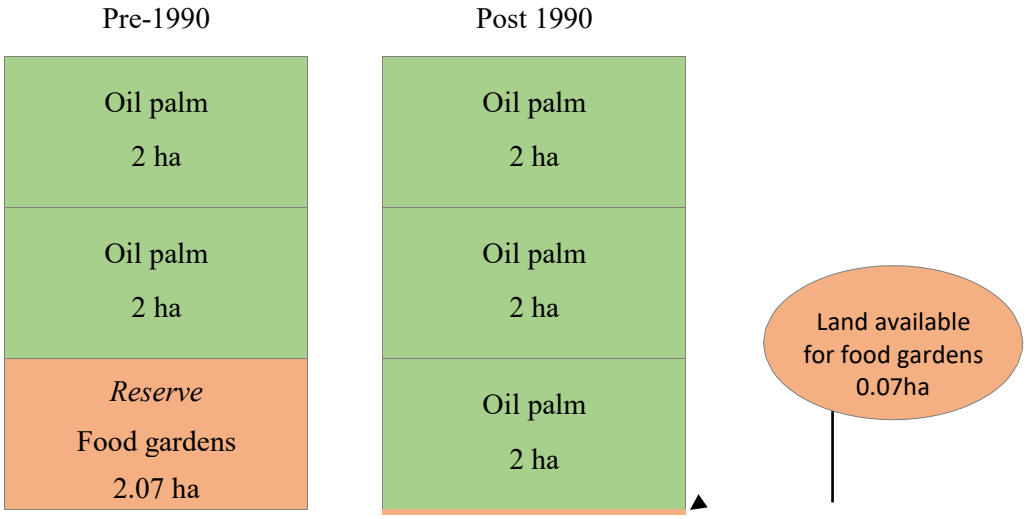

Figure 7.29 Planting arrangements on LSS blocks before and after the early 1990s.

Why is the 2 ha replanting system no longer appropriate for smallholders?

There is a reluctance on the part of many smallholders to poison and replant their senile oil palm, despite declining production and the availability of interest-free credit from the milling companies. There are several interrelated reasons for this reluctance to replant. One main factor is that replanting 2 ha of senile palms presents growers with a 'double-disadvantage':

1. Debt liability. Taking out a loan to purchase an oil palm replanting package.
2. Loss of income. Reduced capacity to service the loan because oil palm income falls by one-third.

Smallholders are averse to taking on debt, particularly if there is a large resident population on the block and/or oil palm prices are low. Income from 240 palms (2 ha) is foregone for up to three years, the time required for the new palms to come into production. At Hoskins, where loan repayments are 50% of gross income, net income after loan deductions is reduced by two-thirds of the level prior to replanting. So, depending on oil palm prices, the income from the remaining 4 ha of productive palms after loan repayments may be insufficient to cover basic household needs and other expenses such as education, medical costs and customary obligations.

Also, as palms age, growers harvest an ever declining proportion of them as they become too tall to harvest and access to the fruit becomes more difficult. Eventually, the reluctance of growers to replant can lead to all three, 2 ha plots being old and tall, meaning that only the younger and physically stronger men on the block are able to harvest the tall palms. This leaves the labour of other block residents like women and older men under-utilised as they lack the strength to manage heavy harvesting poles.

A proposed solution to the problem of taking 2 ha (240 palms) of oil palm out of production is to offer growers the option of staggered replanting of a 2 ha plot of senile palms with 1 ha (120 palms) plots replanted at a time. One ha of old palms is poisoned and replanted, with the second ha poisoned and replanted when the first one comes into production after two to three years. There are several advantages associated with the 1 ha replant strategy which can be grouped under two categories: smallholder benefits and milling company benefits.

Staggered cost of replanting

Staggering the replanting of 2 ha in two, 1 ha phases two to three years apart will encourage timely replanting. When the new seedlings come into production at two to three years, the second 1 ha of palms is poisoned and new seedlings planted. Half of the replant debt is incurred in Year 1 of replant, while the second half of the debt is incurred in Year 2 or 3. Instead of a ratio of two palms in production to repay the loan for each seedling as under the conventional 2 ha replant practice, the ratio is 5 palms in production for each seedling under the 1 ha replant option. With a smaller loan required to replant 120 palms together with more palms in production to service the debt, the 1 ha option reduces the double disadvantage which growers experience under the 2 ha replant practice. Assuming, 20 t/ha at a price of K250/tonne, the 1 ha replant option provides additional gross income of K5000/annum over the conventional 2 ha replant practice. Thus loan servicing is much less onerous and replanting becomes much more financially attractive to farmers.

Densely populated LSS blocks and 2 ha VOP and CRP blocks would find replanting much less of a financial burden as they would continue to have an income stream from oil palm during the replanting. If the grower has only 2 ha of oil palm just 1 ha is taken out of production at a time. Using the same assumptions above, 1 ha of oil palm in production during replanting would provide a gross income from oil palm of K2500 rather than no oil palm income under the conventional 2 ha replant practice. Of course, timely replanting would be encouraged if the companies were to suspend loan repayments until the full 2 ha were replanted. Failing this, the repayment rates should be lowered considerably (say 10%) until 2 ha are back in production.

Greater utilisation of labour

An additional benefit to growers of the 1 ha replant is that the reluctance of growers to replant at 22-25 years would be greatly reduced leading to timelier replanting of oil palms thereby reducing the proportion of very tall, difficult to harvest oil palm stands. Thus the practice of growers harvesting an ever declining proportion of their palms as they become too tall to harvest would be discouraged (it was observed at some blocks at Wilelo that growers were harvesting less than half their tall palms and remained reluctant to replant). Also, as timely replanting becomes standard practice, there will be six stands of palms at different stages of development. This will enable greater utilisation of the available labour on the block with women and older men able to harvest younger and shorter palms, leaving younger men to harvest the remaining taller, older palms as they transition to more highly productive blocks. The harvesting work carried out by other family members on shorter palms would strengthen their claim on the oil palm income, leading to a more equitable distribution of oil palm income, and of course greater social stability which is more conducive to oil palm production.

Smaller area to weed

Weeds can become a significant problem in newly replanted oil palm as more light reaches the ground. Weeds compete with oil palm seedlings for sunlight, nutrients and water, and they can harbour pests (Nchanji *et al*. 2016). To reduce competition for resources and provide favourable growing conditions for the new oil palm seedlings these areas must be kept weed free, which is a labour intensive task. Replanting just 1 ha of oil palm instead of 2 ha means that the labour demands for this task are greatly reduced.

Improved food security

The 1 ha replant option provides growers with more regular access to gardening land on their own block. With most smallholder blocks now planted with 6 ha of oil palm, many households are heavily reliant on replant sections, either on their own or someone else's block, for food gardens. As noted above, just over half of the total area of food gardens of Bialla smallholders was in oil palm replant areas. On a 6 ha block fully planted to oil palm, the 1 ha staggered replant option provides growers with on-block land for gardening for 12-18 of 25 years, instead of 6-9 of 25 years under the standard 2 ha replant package. Whilst the area of land available for gardening over a 25 year period remains the same (6 ha), the period of time when an area of land is available on-block for gardening effectively doubles. Given the importance of garden food crops in daily household food consumption the 1 ha option has the potential to improve food security dramatically. In addition, for women, who take the main responsibility for food gardening, more regular access to land on their own blocks will

reduce the burden of walking to and from distant gardens. Improvements to food security are discussed further below.

Company benefits

More timely replanting

With the financial burden of replanting reduced, growers are more likely to replant in a timely manner. Thus replanting will become more predictable and easier to plan for in terms of palm poisoning, seedling production and delivery.

Higher productivity & yields with more palms in the high production phase

A greater proportion of palms in the high production phase means higher productivity and yield on smallholder blocks. As grower's replant in a more timely manner a higher proportion of palms will be in their most productive age range. There will be fewer old, tall and therefore difficult to harvest senile palms producing low yielding fresh fruit bunches. With timelier replanting, the latest varieties of palms can be introduced earlier to smallholders as they become available.

Greater utilisation of smallholder labour

Improved utilisation of labour will contribute to higher production and yields from the smallholder sector. Harvesting will not be limited only to those capable of accessing fruit bunches on very tall, older palms. As pointed out above, with six stands of oil palm at different stages of development, women and older men will be able to harvest shorter palms.

Improved RSPO compliance

With a higher proportion of food gardens on-block, there will be less need for gardens off-block. Thus, there will be less food gardening on insecure customary land, company and state forestry land and in environmentally sensitive areas like buffer and riparian zones.

Faster repayment of loans

A smaller size company loan to smallholders[4] for a 1 ha (120 palms) replant will enable the company to recoup their interest-free loans much more quickly than under the conventional loan for a 2 ha replant. With a ratio of 5 palms in production to repay one seedling under the 1 ha replant, instead of two palms repaying each seedling, loan amortisation is much quicker.

For oil palm production the 1 ha replant option provides benefits to both the smallholder and the milling company in terms of production and improved financial security. This combination should produce an outcome of increased productivity and yield from the smallholder oil palm sector as well as contribute to greater social stability in the smallholder sector as smallholder families are better able to meet their livelihood needs.

Food Security and the 120 replant option

The 1 ha replant model described earlier not only raises smallholder oil palm production and enables easier loan servicing, but also enhances food security by doubling the period that food gardens can be cultivated on-block. If we begin with the conventional 2 ha replant and assume replanting is staggered, each 2 ha planting phase would provide access to 2 ha of gardening land for 2-3 years, totalling 6-9 years (2 years being the minimum time taken for the oil palm canopy to close after new

[4] Credit by the milling company is made available to smallholders for purchasing replanting packages that cover the cost of poisoning the old palms, new seedlings, fertiliser, chemicals and transport. In 2018 this equated to approximately K4000 for a 2 ha replanting package (Hargy Oil Palm Ltd).

seedlings are planted). With an oil palm replanting cycle of 25 years, there would be 16-19 years when gardening on-block would be limited to the 0.07 ha *wasblok.* (Table 7.21).

Table 7.21. Block planted with 6 ha of oil palm using the conventional 2 ha replanting strategy.

	Phase 1 (2 ha)	Phase 2 (2 ha)	Phase 3 (2 ha)	No. years garden land is available
Phase 1 replant	2 ha			2-3
Phase 2 replant		2 ha		2-3
Phase 3 replant			2 ha	2-3
No. years in 25 year period land is available for gardening				6-9

When a 2 ha plot of oil palm is replanted in two, 1 ha phases, the period in which growers can garden on-block is doubled. When a 2 ha phase is replanted as two, 1 ha replants, each 1 ha replant provides 1 ha of gardening land for 2-3 years, totalling 4-6 years over the 25 year cycle (Table 7.22). Although the gardening area is halved, the period in which garden land can be accessed is doubled to 12-18 years. Assuming 2.5 years of garden cultivation in a replant, land for gardening would be available for 60% of the oil palm cycle compared with 30% for the conventional 2 ha replant strategy.

Table 7.22. Block planted with 6 ha of oil palm using the 120 (1 ha) replanting strategy.

	Plot 1 (2 ha)		Plot 2 (2 ha)		Plot 3 (2 ha)		No. years garden land is available
Phase 1 replant	1 ha	1 ha					4-6
Phase 2 replant			1 ha	1 ha			4-6
Phase 3 replant					1 ha	1 ha	4-6
No. years in 25 year period land is available for gardening							12-18

Where smallholders share access to their replant areas with growers from other blocks, access arrangements for food gardening are simpler for the 1 ha replant model than the 2 ha replant. Under the conventional 2 ha replant strategy, four blocks would need to coordinate their replanting to enable each block to have ongoing access to 0.5 ha on gardening land in replant areas. When the *wasblok* of 0.07 ha is added, each block would have ongoing access to gardening land of 0.57 ha (Figure 7.29). In contrast, under the 1 ha replant option, only two blocks need to coordinate replanting and share access to each other's replant areas to have access to 0.57 ha of gardening land on an ongoing basis (Figure 7.30). This is a simpler model for securing garden land into the future.

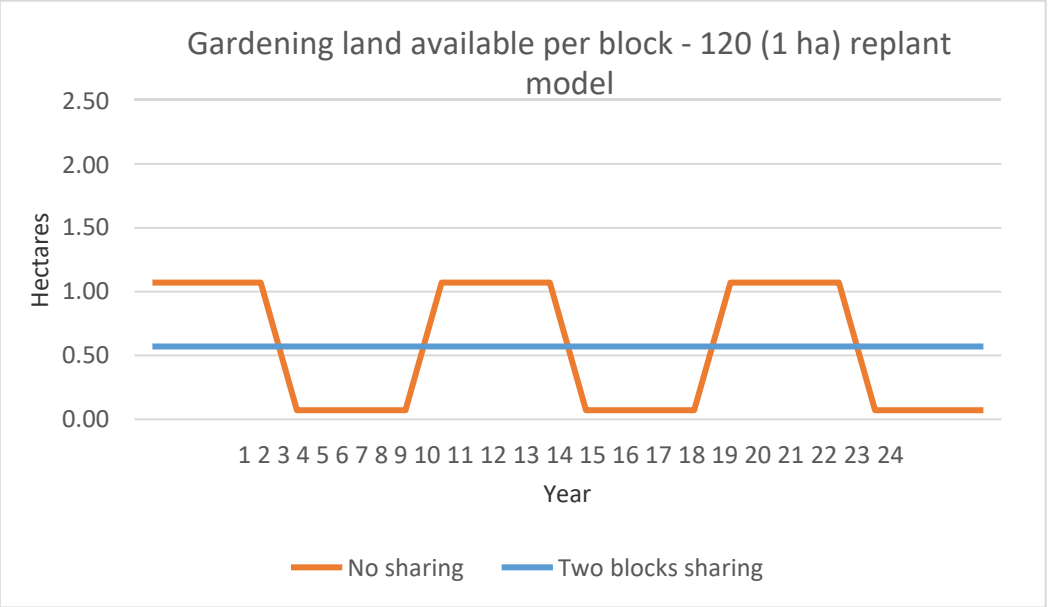

Figure 7.30. Land available for food gardening when there is no reciprocal access and when two blocks coordinate replanting and share access to each other's 1 ha replant area (assumes 2 years of food gardening in replant area).

The introduction of the 1 ha replant option at Bialla will alleviate much of the pressures on gardening land. Not only will there be less financial burden on smallholders but they will also be able to grow food crops over a longer period on their own blocks thus reducing their dependence on store foods, particularly during the financially stressful time of replanting oil palm. Food gardening also provides the opportunity to earn supplementary income from surplus produce harvested from their gardens. The 1 ha replant is improving food security on the highly populated oil palm subdivisions both now and into the future.

Competition for light and water by oil palm and food crops during the immature phase of a replanted smallholder oil palm block

There were 9-10 gardeners cultivating food crops in the 1 ha replant section of Block 372 in 2015. They were all family or friends of the block owner, both male and female. Each gardener had an area approximately two palm rows wide and 2-7 palms long. They had no payment obligations or planting restrictions for use of the land. In total, 53 types of food crop were planted. Vegetables were present in all plots at all times, and cooking bananas were present in most plots at most times.

Over the course of monitoring, the sum of areas covered by food crops was 20-120% of the replant area (Figure 7.31). Food crop coverage was greatest at 23 months after planting in Block 372 and 2 months in Block 260. Sweet potato was the most important crop in terms of canopy area. The transect method underestimated oil palm canopy coverage compared to more detailed measurements of the oil palm canopy. Total leaf area grew at a greater rates than horizontal extent of the canopy (Figure 7.32).

Soil resources were not significantly depleted by the food crops. Soil water content was higher on average in the mature section than the replant section. There was no relationship between soil water content and distance to palm (Figure 3). Soil total N content and exchangeable K and Mg content were higher in the replant than the mature section (Table 7.23).

Exploitation of the replant area was moderate in terms of canopy area, and appeared to have little or no impact on the light, water and nutrients available to the growing oil palms. The results indicate that intercropping food crops and oil palm in the manner carried out by smallholders in West New Britain is a productive use of the land. Concerns have been raised that food cropping may negatively impact on oil palm production, but such an effect could not be tested in this work. Further work is

warranted to determine the effect of crop type, planting intensity and management on oil palm production.

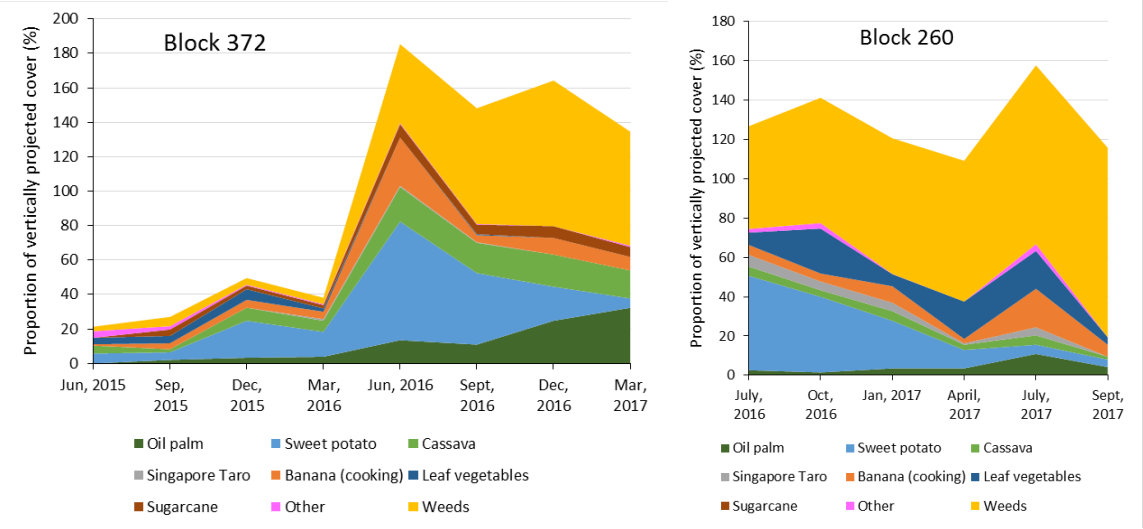

Figure 7.31. Vertically projected proportion of replant area taken up by various crop types.

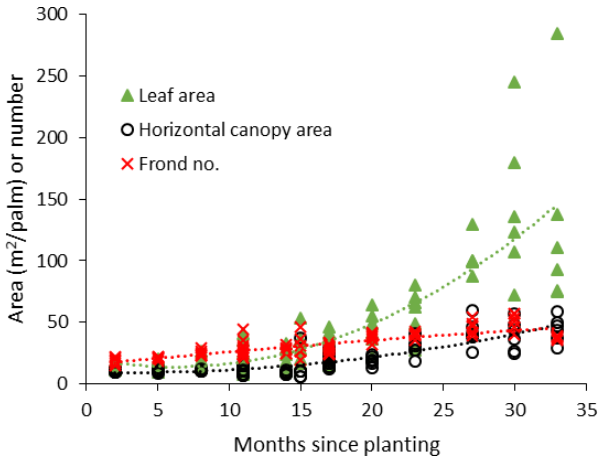

Figure 7.32. Oil palm canopy development in the replant section (data from both blocks).

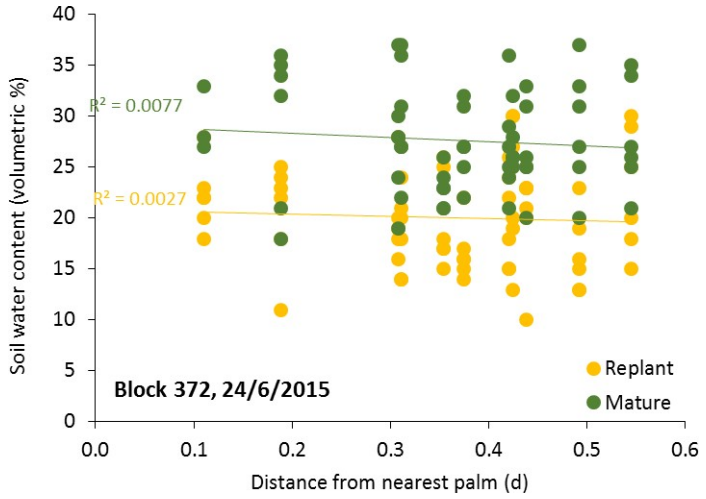

Figure 7.33. Soil water content as a function of distance from the nearest palm (expressed as d, a proportion of palm spacing)

Table 7.23. Mean soil chemical properties in the mature and replant section of each block, and significance of the effect of block and crop stage (p values).

Variable	Means				p values			
	Block 260		Block 372					
	Mature	Replant	Mature	Replant	Block	Crop	Block*Crop	Crop effect
pH	6.34	6.19	6.17	6.53	0.015	0.003	0.000	Opposite in two blocks
Olsen P (mg/kg)	7.13	6.81	7.58	12.40	0.000	0.004	0.001	Opposite in two blocks
Pot. avail. N (kg/ha)	89.9	83.2	115.8	103.8	0.002	0.212	0.721	
Total C (%)	4.43	4.64	4.69	5.30	0.061	0.093	0.415	
Total N (%)	0.42	0.46	0.47	0.53	0.003	0.012	0.518	Increased in both
Exch. K (cmol+/kg)	0.24	0.55	0.24	0.60	0.584	0.000	0.498	Increased in both
Exch. Ca (cmol+/kg)	9.12	5.90	8.96	11.47	0.001	0.658	0.000	Opposite in two blocks
Exch. Mg (cmol+/kg)	0.54	0.76	0.60	1.17	0.004	0.000	0.032	Increased in both
CEC (cmol+/kg)	16.2	14.5	19.2	18.9	0.000	0.247	0.411	
Base sat. (%)	59.0	48.1	50.7	68.9	0.002	0.071	0.000	Opposite in two blocks

Assessment of the relationship between food production on cocoa plots (intercropping) and management of the cocoa crop.

In the prime production cocoa plots, plot owners identified the shade crop and cocoa growth as having influence on whether or not they planned to continue planting food crops after the current round. Three plot owners said they had or would continue to grow food crops until the shade trees fully shaded the block, at which time food crops would become less viable, and six said that they would plant food crops until the cocoa shaded over, or was in production stage, at which time they would focus efforts on cocoa only. Four cocoa plot owners said that planting food crops would compete for nutrients with the cocoa trees, and five plot owners identified that the cocoa plantation company did not recommend intercropping cocoa with food crops because they would compete for nutrients.

Two prime production cocoa plot owners identified food security as a reason to continue growing food crops on their plot. One said he must continue growing food crops as he and his family depended on it, and another said that he would continue growing bananas for home consumption. Three plot owners claimed that they would continue planting bananas on their block even if not growing food crops. One plot owner was not growing food crops as he had another area of land devoted to food crops.

The majority of owners of senile production plots identified the growth of cocoa plants to influence their food crops. Eleven plot owners said they did not or would not plant any more food crops due to overshading or crowding out by cocoa trees and eight said that soil fertility had declined due to the cocoa growth and food crops were no longer viable.

Two owners of senile production plots identified food security influences, saying that they would continue food gardening because they depended on food crops for food or marketing.

Among newly planted cocoa plots, food security and weed control were identified as influences for growing garden crops. Eleven plot owners said they would continue to grow food crops once cocoa seedlings had been planted for food security and to assist with weed control, and eight identified home consumption or sale alone as their reason for growing food crops.

One farmer identified that the food crops would help identify his land boundary.

Of those not planting food crops, or intending to stop planting in future, two plot owners planned to stop growing food crops so that the cocoa would grow better, two planned to stop once the plot shaded over, two plot owners said they had other available land for food crops and one said that pigs were causing problems for food crops.

Garden species diversity and intensity

The newly planted cocoa plots with food crops showed the highest level of diversity of food crop species (Figure 7.34). This may be due to factors such as the shade crop being still young and not yet fully shading the plot, and plot owners utilising garden space not yet planted in cocoa, even if they intend to stop gardening once the cocoa is planted.

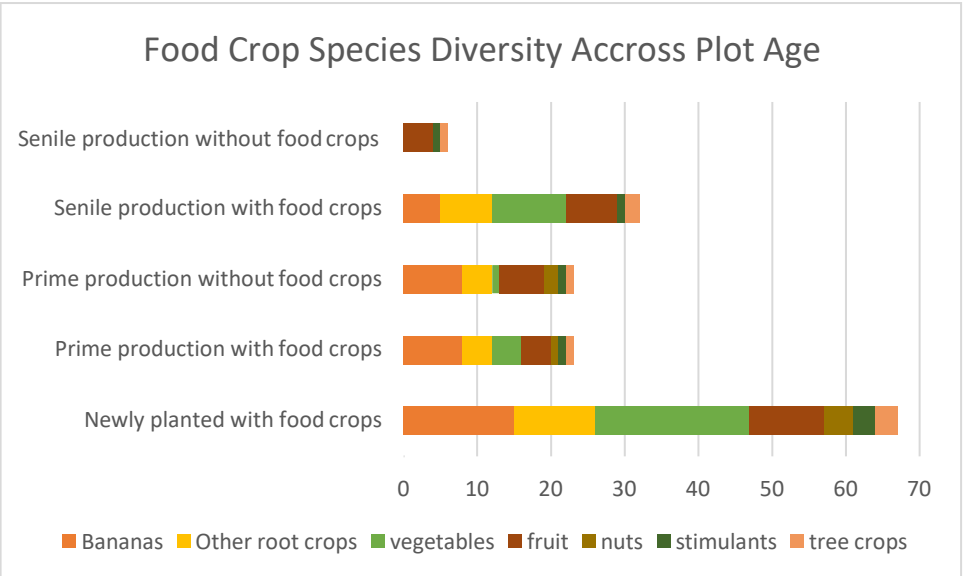

Figure 7.34. Number of food crop species identified in different categories of cocoa block.

The Prime production cocoa plots with food crops and Prime production plots without food crops showed comparable diversity in most food crop categories. Exceptions included the fruit category, where the prime production without food crops showed higher diversity, and the vegetables category, where prime production with food crops showed higher diversity. This may reflect the decision to

use the presence of vegetable species as the method used to identify cocoa plots with or without food intercropping for the study.

Crop management practices

For both the prime production cocoa plots and the senile production cocoa plots, the cocoa plot post-harvest assessment did not reveal any significant differences between plots with food crops and without food crops for presence of unharvested pods, unripe pods, black pods, dry pods or pods showing evidence of cocoa pod borer as shown by T test comparisons between the recorded data for plots in each category. It should be noted that only six plots in the prime production category were old enough to have had at least one harvest.

For the prime production plots and senile production plots, values given for crop care (Harvest Practices, Weed control, Pruning, Shade Control, Sanitation and Pest Control) did not differ significantly between plots where the gardeners were growing food crops and plots where the gardeners were not growing food crops, as shown by T test comparisons between the recorded data for plots in each category.

Interviews and visits to the prime production plots were taken shortly after a long dry season, and the interviewers noted in several plots that this meant that weeding practices had not been undertaken as regularly as is usual, likely because weeds had grown slowly over the dry period.

The interviewers identified that cocoa pod borer control methods were better in one case where the plot owner employed three boys to help and were not very good in one case where the plot owner was the only person working on the plot.

Interviewers identified four plots sprayed weekly with pesticides to control cocoa pod borer, two that were monitored regularly for pests and diseases and three that were too young to show evidence of pests and diseases.

Interviewer comments did not indicate whether the presence or absence of food crops had effect on crop management practices in the prime production plots.

Interviewers identified seven senile production plots that were managed well in terms of weed and pest control. Ten plots were identified that required more extensive pest management practices in the form of insecticide spraying or improved cocoa pod borer management practices and three plots as needing increased weed management. Three blocks were identified as having low production levels and requiring replanting of the cocoa and one plot was identified as being neglected by the owner as he had acquired other income. Interviewers did not identify any differences in management practices due to the presence or absence of food crops.

Food crops were cultivated in all cocoa plots visited, whether or not the owner identified them as having food crops present. The species diversity data indicated that a majority of the cocoa plots in this study were planted with vegetable crops and banana crops in some capacity and all were planted with fruit and stimulant crops. Fruit and stimulant crops often require owner visits for harvesting and sometimes crop care, so the presence of these crops may also have a significant influence on the care of the cocoa crop.

There was very little data obtained about the contribution of the plot gardens to the food security of the plot owner. The presence or absence of garden species could only show the diversity of gardens. Additional descriptive information about which crops tend to be used within households or traded and what their uses are to the gardener may have provided a more rounded picture of the garden contribution to the food security of plot owners. Written comments provided in the questionnaire as part of the questionnaires themselves and added in the margins provided a limited narrative around food security.

It was clear that intercropping was important for food security of cocoa farming households. However, it was not possible to detect any effects of intercropping on management of the cocoa.

8 Impacts

8.1 Scientific impacts – now and in 5 years

This project has filled a gap in the knowledge and understanding of the status of food security among oil palm and cocoa smallholders in PNG. Prior to this project no comprehensive study of oil palm and cocoa smallholders and household food security had been undertaken. Indeed few studies in PNG and the South Pacific have examined adaptation strategies and the adoption of new farming innovations and adaptive strategies in response to more environmental, social and economic change.

Some of the key findings and new knowledge produced include:

1. Knowledge of the status of household food and livelihood security and the factors that enhance or constrain the capacity of smallholders to cope with food and livelihood insecurity.

2. The relatively good status of household food security across the study sites is largely the result of the farming-livelihood system of smallholders in which access to food and income are embedded.

3. Socio-cultural factors play a fundamental role in influencing household adaptive capacity and resilience. The study showed that despite the pressures on smallholders food gardening systems, many households have displayed an ability to explore new livelihood options to maintain household food security.

4. The primary elements influencing successful agricultural change and household food security relate to how adaptable and willing smallholders are to initiate new or modified ways of managing and organising labour, land and other resources in response to changing conditions.

5. The capacity of the smallholder farming system to sustain food security lies not so much in the incremental adaptive changes smallholders have made to their farming systems to intensify production, but in the more transformative social innovations that they have adopted.

6. Garden cultivation is the main determinant of household food security.

7. Where land pressures are intense, the role of social networks is vital for enabling them to access to additional land for food production, both in the short and long term.

8. The incorporation of cash earning activities into local farming systems and access to a regular and stable income source has helped support a nutritious diet and strengthen food security in the study sites.

9. Suitable indicators to delineate levels of household food security and which identify vulnerable and resilient smallholder households.

Industry impacts

The project has generated much interest in both the cocoa and oil palm industries. In the oil palm industry there is now a greater appreciation that food security is an important smallholder livelihood issue and is closely linked to smallholder oil palm productivity. Prior to, and at the start of the project, some stakeholders did not see the value of the industry research body allocating time and resources to examining the status of food security among oil palm growers. Through several meetings with stakeholders where the preliminary results of the project were presented, it has been shown how

food gardening and commodity crop production are linked and fit into a broader livelihood system which we refer to as the "smallholder oil palm farming livelihood system". When there are stressors or upheavals in food production and gardening, then it is likely there will be an impact on oil palm production and productivity and *vice versa*. This link is now better recognised in the industry. Similarly, although the majority of the palm oil exported from PNG is certified by the Round Table on Sustainable Palm Oil, to date, there has been little recognition by the industry of the important role of food gardens in the long-term sustainability of smallholder oil palm farming systems. This project has helped the industry to change its perception of smallholder oil palm farming to encapsulate a broader livelihood system that includes both oil palm production and food production for home consumption and as an income, especially for women. This change in mindset also recognises that an oil palm farming livelihood system that can provide stable access to nutritious food and produce heathy well-nourished smallholders is an indication, to an extent, of the long-term sustainability of the system.

This new knowledge and shift in thinking about smallholder food security issues is indicated by Hargy Oil Palm's willingness to trial a new 1 hectare replanting option with smallholders. The new planting option has the potential to improve food security through creating greater access to land for gardening close to smallholders' residence. Similarly, the Director of Research at OPRA (Dr Luc Bonneau) has taken steps to promote the 1 hectare replanting option. He presented an overview of the replanting option at the industry's annual Scientific Advisory Committee Meeting on 9 November, 2016. New Britain Palm Oil Ltd, the major milling company in WNB, is also interested in introducing the 1 hectare replant initiative at the Hoskins oil palm project.

Likewise, in the cocoa research in East New Britain and Bougainville, there is now greater awareness among cocoa exporters and public servants of the impact of CPB on household food security. It is anticipated that this new awareness will translate into shaping future research activities of the Enabling Environment section at CCI. Furthermore, there is now a noted shift in the industry's attitude. Since the CPB incursion, cocoa smallholders have increased their reliance on food gardens to meet their food and income needs. Thus food gardens have been a key to assisting cocoa farmers cope with the devastating impacts of CPB. Previously, there had been a tendency to discourage intercropping of cocoa with food crops, but the impact of CPB on incomes and people's ability to purchase food (together with growing land pressures) has highlighted the need to reassess attitudes towards intercropping in the industry.

8.2 Capacity impacts – now and in 5 years

Almost 600 smallholder households have participated in the project and this has required research staff to spend intensive periods working at the village/community level. This strong community engagement has greatly enhanced the knowledge among the researchers of the complexity surrounding food security and improved their understanding of how economic, demographic, social and institutional factors combine to influence the status of food security at the household level and how households respond to risks and stressors.

Several of the research techniques employed to assess food security in this project are new for the PNG partner researchers. Hence there was an ongoing element of capacity building as team members learnt new skills in socio-economic work, and in particular skills to investigate the status of food security at the household level. The new skills and knowledge set included:

- how to assess household food security using the four key elements of: food availability; food access; food utilisation; and stability of food supply.

- New data collection methods used for assessing household food consumption using 24 hour recall surveys.
- Improved skills in GPS mapping and food garden survey techniques.
- Improved database management and analysis skills. The project has incorporated a mixed methods approach to data collection and has required research staff to learn skills in managing a range of large and different data sets. This is an important skill when working on large collaborative projects.
- Collaborative team work skills. This project has improved the skills of the researchers to work in large multidisciplinary research projects. Regular face-to-face meetings and email correspondence among the teams has required staff to participate in discussions to solve problems, make suggestions on methodology and fieldwork, present ideas and communicate findings. This has helped build trust, collegiality and highlighted how multidisciplinary teams can be successful through each individual bringing their own particular skills and ideas to a project.

Most PNG research members also improved their writing skills through co-authoring reports and papers resulting from the research (see Section 9.2). Also some of the key researchers at OPRA and CCI had the opportunity to improve their confidence in presenting research at an international conference in Cairns in 2016. In PNG, where conference funding is scarce, the opportunity for researchers to attend an international conference is rare, especially for Early Career Researchers.

In 2016 Gina Koczberski, George Curry and Geraldine Tilden conducted a four-day research workshop (4-7 April) with seven project team researchers from OPRA and CCI. The workshop focused on the preliminary findings emerging from ASEM/2012/072. The first two days of the workshop provided advanced training on Excel database management and analysis and GPS mapping for garden survey investigations. The remaining two days were spent by participants in small groups working on interpreting project data. Also, many of the PNG researchers do not have tertiary training in social science and/or are junior researchers, and therefore the workshop provided an opportunity to develop their skills further in social science research methods. These more advanced skills will lead to better use and interrogation of the project data.

A four-day video training program in May 2017 was organised for OPRA, OPIC and CCI. Video-mediated learning has not been used in extension training in the main commodity export cash crops in PNG. The training provided the first opportunity in the cocoa, oil palm and coffee industries to build skills among staff in media and video production techniques. The aim of the training, as outlined in the project proposal, is "to increase the use of visual-support tools in communicating with famers to improve the effectiveness of extension communication and extension outcomes". Two officers from CCIL, one from OPRA and one from OPIC attended the training in Port Moresby. One officer from the Coffee Industry Corporation also attended. The training was a basic introduction to media and video production. The first 2 days focussed on basic camera work, DSLR camera use and functions, camera angles in still shots and video recording. The third day touched on editing footages, using SONY Vegas 13 software as an editing tool, how to import files from camera/ recording devices to laptops for editing, and basic briefing on chroma studio (post production phase). The final day was used for trainees to produce a short documentary. The documentaries were presented in the evening at the Crown Plaza Hotel.

An informal evaluation of the training was conducted which indicated that everyone completed the training with a set of new skills that could be used to either begin or improve video production. All participants have shown an interest in further training. For OPIC, OPRA and CCIL, the training has triggered further interest in the potential of ICTs and videos as a means of improving extension delivery and increasing the flow of information to farmers and other industry stakeholders. Since the training in May, OPRA has made additional investments in video production equipment (such as a tripod and a laptop) to further establish video production as an integral part of the organisation's

efforts to improve the effectiveness of information flows to smallholders (especially youth) and other industry stakeholders. Later this year, OPRA planned to develop a Facebook page and the new skills in video production will assist the organisations to post regular interesting videos and photos on their Facebook page that will be relevant to smallholders.

Scholarships/fellowships

Emmanuel Germis (OPRA), was awarded a John Allwright scholarship to begin his Masters by Research degree in June 2016. His thesis examined the informal land markets operating in the oil palm growing areas and their impact on smallholders land tenure security and livelihood options.

Joachim Lummani (CCI), was awarded a John Allwright scholarship and began his PhD at Curtin in 2014. He examined the impacts of Cocoa Pod Borer on household labour in smallholder cocoa production and other economic livelihoods in Bougainville. The thesis is currently under examination.

Veronica Bue was awarded a John Dillon scholarship to travel to Australia for leadership training earlier this year. While in Australia she visited Curtin University for a week to work on a co-authored paper on food security in West New Britain with Gina Koczberski, George Curry and Steven Nake.

8.3 Community impacts – now and in 5 years

Replant and intercropping trial

The impacts on the smallholder oil palm growers in Bialla, WNB, have been dramatic. All replanting is now on the 1 ha basis which is of tremendous benefit to the smallholder families in terms of improved food security which has been addressed on two key fronts:

1) higher incomes for farm families during replanting enabling them to purchase market and store foods; Six stands of palm at different growth stages enabling women and older men to earn income from harvesting short palms;

2) increased period in which women can grow food on-block for household consumption and local market income.

Misima Community resource

Since the closure of the mine on the Island, the flow of cash in the communities has dropped and there is a renewed interest to increase cocoa production. In particular farmers expressed the need for cocoa seedlings to rehabilitate and/or expand their cocoa holding and training in budding and cocoa block management. Many farmers were also interested in diversifying their farm incomes. Farmers in the study were provided with:

1. Training in cocoa clonal budding.
2. Training and assistance in establishing a central cocoa hybrid nursery
3. Training in the cultivation of new high-value vegetable production for marketing.

Project staff worked with the community and trained them in the construction and establishment of a cocoa nursery. During the visit, the construction of nursery beds and a shade cloth shelter was completed and 2,024 polybags with hybrid cocoa seeds were filled by farmers and stacked in the new nursery. The seedlings will be raised in three central nurseries then distributed to contact farmers in the three ward locations. Vegetable seedlings, such as corn, buk choi, Chinese cabbage, capsicum, tomato, watermelon and cucumber were distributed to farmers. Access to good vegetable seedlings is very limited on the island. Farmers also received training in vegetable plot management and nursery establishment.

8.3.1 Economic impacts

Replanting and intercropping trial

The 1 ha replant option is proving very popular among smallholders as there is a significant reduction in the debt burden among families. By replanting only 1 ha at a time rather than the standard 2 ha replanting unit, the cost of replanting is halved. A 1 hectare replant package costs K1,000 rather than K2,000 for a 2 ha replant. Also, the financial pressure on smallholders to repay the loan is less because five palms remain in production to repay the loan on each replanted seedling compared with only two palms in production for each seedling under the standard 2 ha replanting package. This makes loan recovery much quicker for the companies and significantly eases the financial pressure on families as they have higher net incomes as a result of having more palms in production during replanting. It has been observed among the trial families that repayment of loans has been more timely than among families repaying replanting loans for 2 ha replants. The incentives for timely replanting of oil palm are greatly enhanced and thus generating significant gains in production for smallholders and the milling companies. Also, with timelier replanting, palms are in the high production phase and the proportions of over-tall senile palms is reduced to zero.

The 1 ha replant makes much more efficient use of land because growers are more likely to replant in a timely manner. The previous situation with a high proportion of over-aged palms made inefficient use of land both in terms of oil palm and food cropping.

Nasfund and savings

Despite regular income from the sale of oil palm, saving levels among growers are typically very low. When growers are paid oil palm income into their bank accounts, most withdraw a significant proportion of that income, leaving only a small amount in the account to keep the account open. In part this is due to the very high demands on the income by the immediate and extended family and the high withdrawal bank fees per transaction. One way to limit the amount of income distributed to family and kin is to have a small percentage deducted and transferred to another savings account. In effect the automatic deduction circumvents the competing claims on the income and makes it easier for the grower to 'quarantine' some of the income before it is deposited into the main bank account and withdrawn as cash.

As a means to improve savings the research team worked in collaboration with Hargy Oil Palm Ltd, the Bialla Growers Association and Bialla OPIC Extension to link up oil palm growers with Nasfund, the national PNG Superannuation Fund. By the end of June 2018, almost 1,400 oil palm growers at Bialla had opened an Eda Supa Savings account, with a percentage of the oil palm income earned being transferred to their savings account. Just over 20% of these growers are women. The deduction has been set up on the Milling Company's smallholder payment system to assist with the savings scheme.

Due to the interest of growers, NASFUND opened a Service Centre in Bialla in late 2016. Since 2015 when we first linked farmers to NasFund, smallholder members have contributed approximately $700,000 to the scheme. This is a remarkable achievement given the very low rates of savings among smallholder farmers in PNG. Many growers anticipate using the savings scheme for improved housing and their retirement savings. With over 4,000 smallholder households with a Papa and Mama card in the Bialla region, the impact on savings and improved living standards is potentially enormous. The long-term economic and social impact of the savings initiative is likely to be significant. The number of growers opening accounts is expected to continue to rise as other farmers see the advantages of this savings initiative.

8.3.2 Social impacts

Replanting and Intercropping trial

The 1 ha replant trial is proving to greatly benefit women and households. Specifically the social impacts of the replant and intercropping trial include:

- More access to land for gardening. Given women are primarily responsible for food gardening and providing food to their families on a daily basis, the 1 ha option will enable women to spend more of the time gardening on land belonging to the household rather than relying on other households for land access.
- Doubling the period on block that land is available for food gardening enables women to grow high value commercial crops for local markets. Commercial crops grown on-block are at less risk of theft.
- Reduced vulnerability to food insecurity. A more secure and stable food supply will result and the 1 ha option increases the total number of years land is available on-block for food gardening from 6 years (2ha replant) to 12 years (1 ha replant) in a 22 year period.
- As timely replanting becomes standard practice under the 1 ha replant option, there will be six stands of palms at different stages of development. This will enable greater utilisation of the available labour on the block with women and older men able to harvest younger and shorter palms, leaving younger men to harvest the remaining taller, older palms as they transition to more highly productive blocks. The harvesting work carried out by other family members on shorter palms would strengthen their claim on the oil palm income, leading to a more equitable distribution of oil palm income, and of course greater social stability which is more conducive to oil palm production.

Ecozoom stoves benefitting women

In September 2017 the project trialled 10 Ecozoom fuel-efficient stoves among women for assessment. The fuel-efficient stoves were introduced following concern about fuelwood shortages among women on the land settlement schemes. Virtually all household meals are cooked on an open fire by women. Shortages of firewood act to undermine household food and security in three main ways: First, it increases the work burden of women by collecting and carrying fuelwood from further afield. Second, the labour and time to collect fuelwood diverts women's labour away from other productive livelihood activities. Third, there is some evidence to suggest that women are giving preference to preparing meals which are quicker to cook (e.g. noodles), but low in nutritional value.

The assessment found:

- The stove uses much less firewood than cooking on open fire. It is estimated at less than half of the firewood used on an open fire.
- A mix of fuels can be used including coconut fronds, stems of the betel nut and oil palm loose fruit.
- Women spent less time collecting firewood.
- Preparing meals during wet periods is easier as the stove uses less fuelwood.
- The stove produces less smoke than cooking on an open fire
- The stove's portability is very handy and can be shared among the extended family living nearby or taken to local markets to prepare and sell cooked food.
- Heat is confined so makes cooking easier and faster.

The stove has proven very popular. The team collaborated with the two milling companies in West New Britain to purchase the stoves to sell in their stores. Each company has ordered stoves and at

the end of 2018 over 3,000 stoves have been sold to smallholders. The stoves will lead to a major reduction in the workloads of women and take pressure off their already heavy workloads.

8.3.3 Environmental impacts

Replanting and Intercropping trial

The one-hectare replant trial and the intercropping of cocoa with food crops will result in more intensive and efficient use of scarce land for food gardening with the potential to take food gardening pressure off environmentally sensitive areas such as 'buffer' zones.

Under the 1 ha replant option, a higher proportion of food gardens will be on-block, and therefore there will be less need for gardens off-block. Thus, there will be less food gardening on insecure customary land, company and state forestry land and in environmentally sensitive areas like buffer and riparian zones.

Ecozoom stoves

The eco-zoom stove will result in less pressure on environmentally sensitive 'buffer zones' and riparian zones which are often used by women to collect firewood.

8.4 Communication and dissemination activities

Throughout the project, the PNG partners attended regular meetings with the key stakeholders and extension agents in their relevant industries. In cocoa, the CCIL socio-economic researchers were in ongoing dialogue with Agmark Ltd. At the request of Agmark, the team also regularly report project findings to the manager to support his work with smallholders.

In oil palm there was regular communication by the OPRA researchers with the milling companies, smallholders and extension officers. This engagement is largely through presenting the research and trial data at field days and industry meetings. Steven Nake at OPRA is also on the OPIC Local Planning Committee which has members from the main stakeholder groups in in the industry. The committee meets monthly and project progress reports are presented at the meetings and feedback received. Visits to schools were also been conducted by the OPRA researchers.

Industry technical papers

The following industry technical papers were distributed to the relevant industries:

Cocoa

Koczberski, G., Curry, G., Nailina, R., Peter, E., Natera, K & Tilden, G. (2017). Food Security in Cocoa Growing Areas in Papua New Guinea. *The Social-Coconomics Technical Note*, Volume 1, Issue 1. Enabling Environment, CCI, ENB.

Nailina, R., Koczberski, G., Peter, E., Curry, G., Natera, K & Curry, G. N., & Tilden, G. (2017). The Impact of Cocoa Pod Borer on Food and Income Security Among Smallholders. *The Social-Coconomics Technical Note*, Volume 1, Issue 2. Enabling Environment, CCI, ENB.

Peter, E., Koczberski, G., Curry, G., Nailina, R., Natera, K., & Tilden, G. (2017). Farmers Livelihood Responses to Cocoa Pod Borer. *The Social-Coconomics Technical Note*, Volume 1, Issue 3. Enabling Environment, CCI, ENB.

Oil Palm

Koczberski, G., Curry, G.N., Nake, S., Germis, E., Bue, V. & Tilden, G (2017). Food Security in Papua New Guinea. *The OPRAtive Word Technical* Note 1. OPRA, Hoskins, WNB.

Nake, S., Koczberski, G., Curry, G.N., Germis, E., Bue, V. & Tilden, G. (2017). The Role Of Smallholder Gardens In Maintaining Food Security On The Land Settlement Schemes. *The OPRAtive Word Technical* Note 2. OPRA, Hoskins, WNB.

Germis, E., Koczberski, G., Curry, G.N., Nake, S., Germis, E., Bue, V. & Tilden, G. (2017). Changing food production systems among smallholders. *The OPRAtive Word Technical Note* 3. OPRA, Hoskins, WNB.

Koczberski, G., Curry, G.N., Nake, S., Germis, E., Bue, V. & Tilden, G. (2017). Smallholder Food Consumption and Food Security. *The OPRAtive Word Technical Note* 4. OPRA, Hoskins, WNB.

Seminars/Conferences

2015-2016

In oil palm, the following are some of the research presentations communicated to industry stakeholders on the progress of the project and preliminary findings.

- 27 August 2015, meeting with OPIC Extension Divisional Managers. . Gina Koczberski, Steven Nake and Emmanuel Germis presentation on ICTs in extension in African and Pacific Island nations and feedback sought on a draft ICT report.
- 2nd February, 2016. OPRA Research Seminar. Emmanuel Germis. Finding from the household and garden surveys presented.
- 23rd May 2016. George Curry, Gina Koczberski & Linus Pileng presentation to Hargy Community Affairs Section on 1 hectare replant trial.
- 31st May. Steven Nake and Emmanuel Germis presentation to Hargy Community Affairs Section on the findings from the Bialla Household and garden survey findings.
- 10th June 2016. Emmanuel Germis and Steven Nake presented 8 short seminars to OPIC extension officers, Hoskins on the research results from the WNB household food security data.
- 30th June, 2016. Steven Nake, presented to the OPIC Local Planning Committee at New Britain Palm Oil Limited, Hoskins, a summary of the 1 hectare replant trial at Bialla.

Research findings were presented at the Australian Association for Pacific Studies Conference hosted by the Cairns Institute and the College of Arts, Society & Education at James Cook University, Cairns, 1-3 April, 2016. The theme of the conference was “Tides of Transformation: Pacific Pasts, Pacific Futures” The following conference presentations based on the research findings were given by the research team:

1. G. Curry & G. Koczberski (Curtin University), E. Peters, R. Nailina, R. and K. Natera (PNG Cocoa & Coconut Institute). *Defining successful adaptation & resilience: how do we reconcile indigenous & market values in an agricultural system under stress?* Presented by E. Peters.
2. G. Koczberski & G. Curry (Curtin University), E. Germis (PNGOPRA), V. Bue (Unitech, PNG), S. Nake (PNGOPRA), P. Nelson (JCU). *Land pressures & social networks of exchange: securing gardening land in the oil palm belt of West New Britain Province, PNG.* Presented by E. Germis.
3. C. Docherty (JCU), Paul Nelson (JCU), Steven Nake (PNGOPRA), Lisa Law (JCU). *Strengths and adaptation of soil knowledge and management in a subsistence-cash production system in PNG undergoing rapid change.* Presented by C. Docherty

4. Joachim Lummani (John Allwright Fellow), currently enrolled in a PhD at Curtin University, also presented a paper titled "*From one crisis to another: Bougainville household responses to threats to their cocoa-based livelihoods*". His PhD thesis is linked to ASEM/2012/072.

2016-2017

- Steven Nake and Emmanuel Germis (September 2016). A summary of the 1 hectare replant trial at Bialla and project update. Presented to the OPIC Local Planning Committee, Hoskins. Industry stakeholders present.
- Luc Bonneau (November 2016). Smallholder one hectare replant option. Presented at the Annual PNGOPRA Scientific Advisory Committee Meeting. Hoskins, WNB. Industry stakeholders present.
- Steven Nake (November 2016). Food security status on the land settlement blocks in WNB. Presented at the Annual PNGOPRA Scientific Advisory Committee Meeting. Hoskins, WNB.
- Sean Ryan, Gina Koczberski and George Curry (July 2016). Migration, economic development and education levels in PNG: a case study from West New Britain. Paper presented at the Institute of Australian Geographers conference, July, Adelaide.
- Gina Koczberski, George Curry, Joachim Lummani, Esley Peters, Robert Nailina and Kathleen Natera (2017). Livelihoods in Transition: farmers' responses to environmental shocks in rural Papua New Guinea. International Symposium on Society and Resource Management (ISSRM), June 19-22, Umeå, Sweden.
- Gina Koczberski, George N. Curry, Veronica Bue Emmanuel Germis, Steven Nake and Paul Nelson. (2017). Transformative versus incremental adaptations to land shortages: a case study from Papua New Guinea. European Society for Oceanists Conference, Ludwig-Maximilians-Universität Munich, Germany, 29 June 2017 – 02 July 2017.

2017-2018

In June 2018, a one-day seminar on the main findings of the project was held in Kimbe. Over 50 stakeholders from the oil palm and cocoa industry attended. The presentations included:

1. Background and overview of project
2. Data collection and methods
3. The status of food and nutritional security amongst smallholders
4. Socio-economic factors explaining food security status amongst smallholders
5. Maintaining household food security in oil palm areas under land pressure: the importance of replant areas
6. Food crops in the oil palm replant: complementarity or competition?
7. Maintaining food security in Cocoa Pod Borer affected areas
8. What are the potential threats to long-term food security amongst smallholders?
9. Capacity and community impacts

G. Koczberski (2017). Food Security in Papua New Guinea. Geography Association of Western Australia, September, 2017, Perth.

G. Koczberski, G. N. Curry, E. Peters, E. Germis, and S. Ryan. (2018). Food Security and vulnerability among smallholder farmers in Papua New Guinea. Geography Seminar Series, Curtin University, May 2018, Perth.

International Conference

G. Koczberski, G. N. Curry, V. Bue, E. Germis, S. Nake and P. Nelson. (2017). Transformative versus incremental adaptations to land shortages: a case study from Papua New Guinea. European Society for Oceanists Conference, Ludwig-Maximilians-Universität Munich, Germany, 29 June 2017 – 02 July 2017.

9 Conclusions and recommendations

9.1 Conclusions

Food security amongst smallholder cocoa and oil palm growers in PNG is being undermined. Following the arrival of CPB in East New Britain in 2007, the pest spread rapidly throughout the province and soon to other cocoa-growing provinces. CPB has since decimated the production and incomes of cocoa growers. Among oil palm growers, especially in WNB, population and land pressures on the oil palm LSSs have contributed to declining per capita incomes and land shortages for food gardening amongst oil palm growers.

The research findings derived from both the qualitative and quantitative data indicate that the status of food security among oil palm and cocoa smallholders was reasonably good. The project found that despite the pressure on the livelihoods of cocoa smallholders from the Cocoa Pod Borer (CPB) incursion and the land shortages for food gardens amongst oil palm growers, both groups of smallholders are pursuing a range of adaptive strategies to enable them to maintain household food and income security. The study examined two very different scenarios: first, people's adaptation responses to a sudden environmental shock (CPB) which wiped out the primary livelihood activity of large numbers of cocoa farmers in the PNG lowlands; and second, a slow fuse threat of rising population pressure over a relatively long time period in smallholder oil palm communities. In both cases, our results indicate farmers have shown remarkable capacity to adapt to these threats. In cocoa, understandably, adaptation took some time as farmers initially abandoned their cocoa blocks and redirected their efforts to increasing food production and the pursuit of new livelihood activities. Some farmers have successfully managed the transition to high input farming necessary for living with CPB; others are now beginning to modify their production strategies to respond to CPB. However, a large proportion of farmers have not made the transition to high input farming, and continue to live with income levels much lower than in the pre-CPB period. CPB remains a threat to household food and nutritional security for cocoa growers throughout the lowlands.

In oil palm, research results reveal that many families have demonstrated considerable adaptive capacity to respond to the effects of population pressures and land shortages on food production (Koczberski *et al*. 2019). Despite rising land scarcity for food gardens, virtually all smallholder families continue to grow sufficient food to meet their daily nutritional needs. In addition, local marketing of garden foods continues to be women's most important income source after oil palm, and food gardens remain an important buffer against the vagaries of fluctuating oil palm prices.The diverse strategies households have developed to maintain food security include: the intensification of food garden production; income diversification; increased reliance on purchased food; intercropping of oil palm; gardening in areas not previously used; and importantly new farm and social innovations that have introduced more flexible land access arrangements to a rigid land tenure system. Whilst these strategies appear to be effective in maintaining household food security, the long-term sustainability of the farming systems remains uncertain and there is increasing recognition by industry stakeholders (e.g. PNGOPRA, OPIC and the milling companies) that solutions must be found to ensure the future viability of smallholder production on the LSSs.

9.2 Recommendations

The overall aims of the recommendations below are to increase the resilience of households and their livelihood systems to reduce their vulnerability to food insecurity into the future.

Oil palm smallholders

Follow-up research and support activities

1. Research into nutrient cycling in replant/immature phase of oil palm.

2. Detailed research on oil palm-food crop relationship during the replant phase.
3. More research is needed to clearly identify techniques used in maintaining soil fertility such as mulching, legume rotations, composting, soil retention barriers (particularly for crops being grown on hillsides) and planting of leguminous trees along garden boundaries. Place major emphasis on the advantages of adopting these techniques in maintaining the fertility of soils on limited land areas.
4. Further research into sustainable integrated farming systems in cocoa, coffee and oil palm growing areas where intense land and economic pressures exist. In particular the examination of new and suitable conservation farming methods for permanent agriculture. There is a need for smallholders to better manage soil nutrients.
5. Establishment of central seed garden for distribution of high yielding and early maturing staple crop varieties and fruit and nut trees. Nursery should also have access to seedlings for selected vegetables that have a good economic return, such as cabbages.
6. Train women belonging to women's groups to set up nurseries for the sale of seedlings at local markets.
7. The project receive an unfunded extension to do further monitoring of the 1 ha replant, particularly the financial benefits for smallholders and the companies.
8. Extend the 1 ha replant option to other oil palm growing areas of PNG, such as the various NBPOL sites at Hoskins Popendetta and Morobe.
9. The 1 ha replant option has potential for other oil land settlement schemes in other countries in our region, particularly Indonesia and Malaysia. With modes funding, the project teams could investigate opportunities for introducing this option in other countries.

Stakeholder activities

10. More collaboration with external stakeholders (NARI, Provincial DAL, financial institutions, fisheries).
11. Improve current market access to improve income opportunities for small poultry enterprises managed by women.
12. Promote education among smallholder households and in particular for young girls.
13. More awareness during farmer field days on farm management, food security, family planning, education and income diversification.
14. Further training videos should be produced by OPRA in collaboration with OPIC and milling companies on topics closely linked to household food and income security, such as improved food production techniques, population control, etc.
15. Provide training in post-harvest techniques to facilitate longer term storage of garden foods.

Cocoa smallholders

Follow-up research and support activities

1. Further research, in collaboration with NARI, to assess new food crop varieties that are capable of higher yields, more pest, disease and drought resistant and suitable for the land-poor cocoa growing sites in PNG.
2. Continue to monitor rotational replanting of cocoa so that no cocoa trees in a block are more than 10 years old (remain in high production stage). Collaborate with NARI and FPDA to research and develop a farming system for rotational replanting of cocoa where newly replanted cocoa is intercropped with food crops and other cash-crops.

3. Work in collaboration with cocoa exporters to promote nutritional knowledge among smallholders.
4. Conduct awareness on the importance of maintaining soil fertility under permanent cultivation.

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11 Appendixes

11.1 Appendix 1:

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