Maintaining Household Food and Income Security amongst Oil Palm Smallholders: the One Hectare Replant Trial, Bialla, West New Britain Province, Papua New Guinea

BIALLA OIL PALM PROJECT,
WEST NEW BRITAIN,
PAPUA NEW GUINEA

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Cover photo: Source: Steven Nake

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Abbreviations and Acronyms

CRP	Customary Rights Purchase
FFB	Fresh Fruit Bunch
HOPL	Hargy Oil Palms Ltd
LSS	Land Settlement Scheme
NBPOL	New Britain Palm Oil Ltd
OPIC	Oil Palm Industry Corporation
OPRA	Oil Palm Research Association
PNG	Papua New Guinea
RSPO	Roundtable on Sustainable Palm Oil
SAC	Scientific Advisory Committee (OPRA)
VOP	Village Oil Palm
WNBP	West New Britain Province

EXECUTIVE SUMMARY

Rapid population growth is undermining food security amongst oil palm smallholders in two key ways. First, diminishing per capita incomes are reducing people's capacity to purchase store foods; and secondly, the area of land per person available for food gardening is also declining. Declining access to land has been exacerbated by smallholders increasing their oil palm plantings from 4 ha to 6 ha on 6.07 ha (15 acres) Land Settlement Scheme (LSS) blocks. The old strategy of maintaining 2.07 ha of land for food gardening (*wasblok* – reserve area) has been largely abandoned as smallholders began planting 6 ha of oil palm. In response to the reduction in the area of land available for food gardening, smallholders adopted the practice of intercropping newly replanted oil palm with food crops to provide food for their families and supplementary income from sales of surplus garden foods at local markets.

Nearly all LSS blocks have 6 ha of oil palm leaving for food gardening only the 0.07 ha *wasblok* and areas where oil palm has recently been replanted. The standard industry practice of replanting 2 ha of oil palm at a time has enabled access to an additional 2 ha of gardening land for 2-3 years when the replanted oil palms are immature and there is sufficient light reaching the ground for food crops. However, as the oil palm production cycle is approximately 22-25 years, three 2 ha replants on a 6 ha block means that gardening land is available for just 6-9 years out of 22-25 years. To address this shortfall of gardening land, smallholders have developed a system of reciprocal exchange of land through social and kinship networks to secure access to gardening land now and into the future.

Replanting 2 ha of oil palm at a time creates a double disadvantage for smallholders, particularly when there are multiple families co-residing on a block. Smallholders are required to go into debt (replanting loan) at the same time as their capacity to service loans is reduced through the loss of income from 2 ha of poisoned palms, or one-third of their palms. This means that the maximum ratio of palms in production to repay each seedling is 2:1. Furthermore, with loan repayments deducted at rates of 30% and 50% of gross income at Bialla and Hoskins respectively, net income is reduced drastically for growers. Thus, the severe financial pressure on growers resulting from this double disadvantage is a major disincentive to replanting and is the reason for most growers postponing replanting for as long as possible. Moreover, this reluctance to replant results in oil palm stands being

very old with a high proportion of palms being too tall to harvest or prune fronds. Consequently, under-harvesting and the presence of unpruned fronds creates an environment conducive to pests such as sexava. This results in smallholder oil palm production being significantly lower than would be achieved with timely replanting. Also, much smallholder labour, especially the labour of women and older men, is underutilised on blocks dominated by stands of old and tall palms because only the younger men are able to harvest tall palms.

A new innovation developed by the project in association with Hargy Oil Palms and OPIC-Bialla is the 1 ha, or 120 palm replant option. This has multiple advantages over the conventional 2 ha (or 240 palm) replant practice for smallholders in terms of loan servicing, access to gardening land and environmental sustainability. First, the costs of replanting are staggered, making loan servicing less onerous for farmers and replanting much more financially rewarding for them. 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. Also, as timely replanting becomes standard practice, there will be six stands of palm at different ages or development stages. This will enable greater utilisation of labour with women and older men able to harvest younger and shorter oil palm stands.

Also, food security is addressed not only by increased income from rising oil palm production and more work opportunities for women and older block residents, but it is greatly enhanced through the doubling of the period that residents can cultivate food crops on their own blocks. Instead of replant areas being available for intercropping on the block for 6-9 years in a 25 year oil palm cropping cycle under the 2 ha replant strategy, residents will have replant areas on their own block for 12-18 years of each 25 year replanting cycle. Increased gardening on-block also takes pressure off 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.

1. INTRODUCTION

Background

This report presents the results of a trial of a new replanting initiative among oil palm smallholders, known as the "120 replant" (1 ha) option. The trial was conducted from January 2016 to October 2017 amongst smallholders residing on 6.07 ha blocks in the Wilelo subdivision of the Bialla Land Settlement Scheme (LSS), West New Britain Province (WNBP) (Figure 1.1).

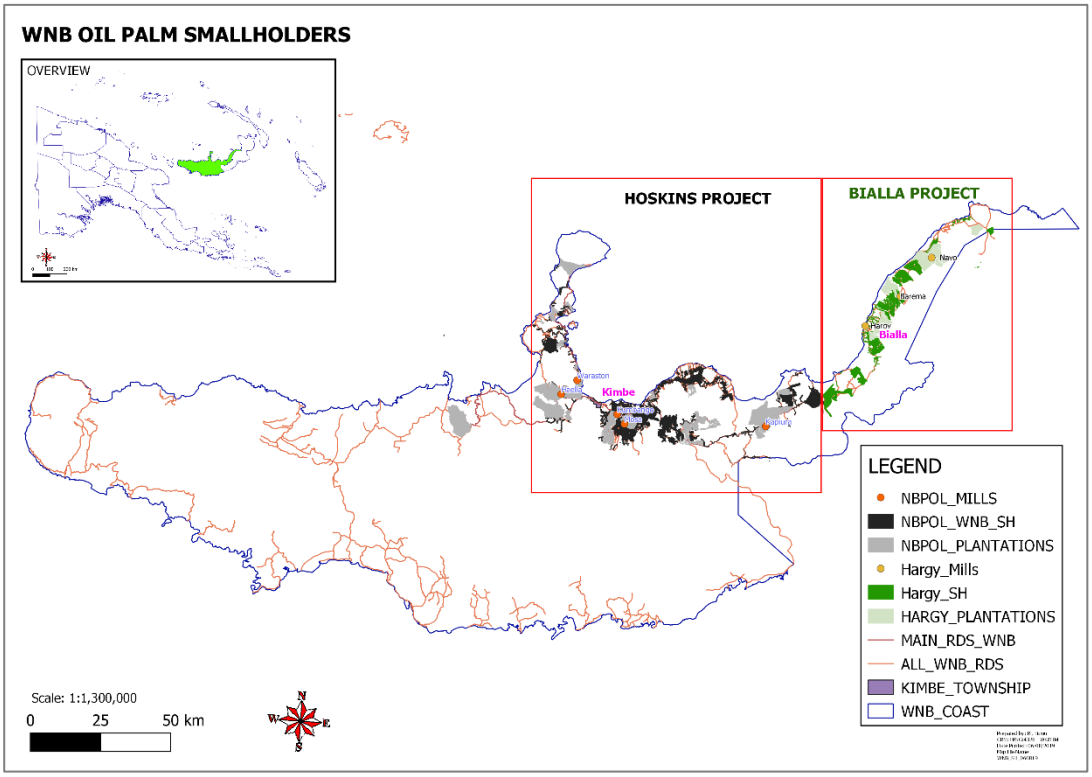

Figure 1.1. West New Britain Province and Kimbe Bay
(Source: Mr. Richard Tiamu, PNG OPRS)

The replant trial formed part of a larger socio-economic assessment of household food security amongst smallholder cocoa and oil palm households in Papua New Guinea (PNG) (ACIAR project ASEM/2012/072). The food security assessment collected data on three key aspects: i) the 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. An aim of the project was to investigate strategies that would help improve and maintain food security amongst smallholder households.

Industry concerns have been raised about growing population pressures and the diminishing access to land for food gardens amongst smallholders residing on the land settlement schemes (LSSs) at Hoskins and Bialla (see Koczberski et al. 2001). In recent decades, smallholders have increased their oil palm plantings from 4 ha 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 amongst 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 replant trial was initiated with the goal of strengthening smallholder food and income security and to provide smallholders with a replanting option that better suits 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[1]. 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. 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 when 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 1 ha 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 replanting.

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

[1] After about 22-25 years the productive capacity of oil palm trees begins to decline. Productive capacity declines mainly because the palms become too tall to harvest.

ha) of which 4 ha (480 palms) were planted to oil palm with the remaining 2.07 ha reserved for food gardens (Jonas 1972; Benjamin 1977; Hulme 1984; Landell Mills 1991; 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; Koczberski et al. 2018). 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; Koczberski et al. 2019). 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. 2012). 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 1.2).

Smallholders explained this expansion of oil palm into the original reserve garden area by the rising demand for cash from a rapidly growing population on their blocks. They also cited poor food crop yields in the 2.07 ha reserve garden area – perhaps from continuous food cropping – and the relatively high oil palm prices from the mid to late 2000s as other inducements for planting an additional 2 ha of oil palm (Koczberski et al. 2012). By about 2007, over 90% of LSS blocks at Hoskins had 6 ha planted to oil palm (Dewhurst 2007; Curry et al. 2007); today, the figure is almost 100% of blocks, while at Bialla, 96% of blocks have 6 ha of oil palm. Thus, the effective area of gardening land has contracted significantly over the past two decades.

At Hoskins, the cultivated garden area per block required to meet the needs of residents was 0.4 ha in 1975 which was easily met by the 2.07 ha reserve area at that time (see Benjamin 1977). By 2010, despite agricultural intensification and a reduction in the garden area per person, the garden area required had increased to 0.6 ha which exceeded the area available on blocks with 6 ha of mature oil palm (Koczberski et al. 2012). Thus, for most smallholders there is now insufficient land on their own block to meet the food gardening needs of the growing number of block residents.

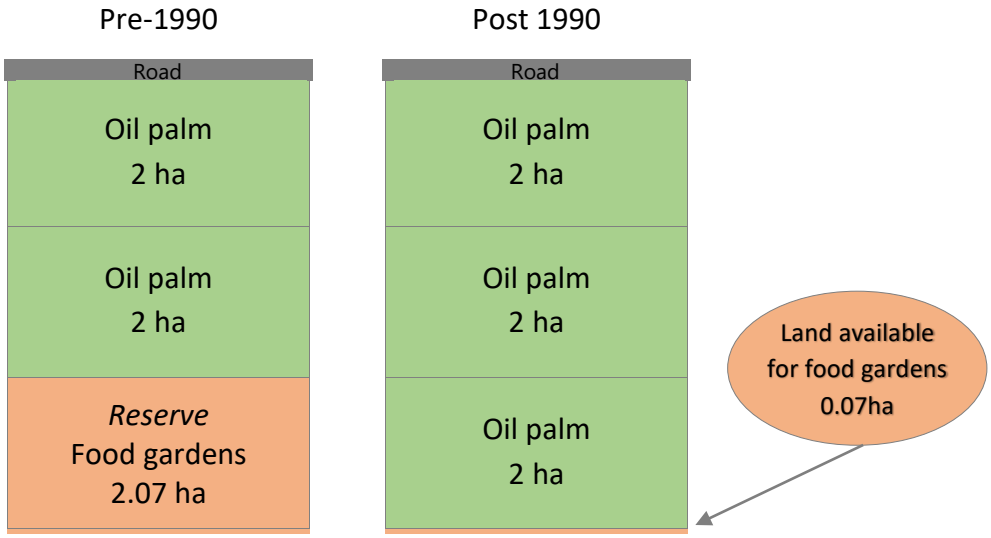

Figure 1.2. Planting arrangements on LSS blocks before and after the early 1990s

Importance of Food Gardens

At the heart of smallholders' everyday life is subsistence food production. Garden cultivation in PNG dates back 10,000 years (Golson et al. 2017), and food gardening is a primary livelihood activity. For women, the cultivation of food crops remains a core daily activity, and they allocate more time to food gardening than to oil palm production (Curry et al. 2019). As noted in Table 1.1, the overwhelming majority of food eaten on a daily basis comes from food gardens. Thus, garden cultivation is a key determinant of household food and nutritional security.

Despite less land being available for food gardening on the LSS block since growers expanded their oil palm plantings to 6 ha, the cultivation of food gardens remains critical for not only meeting household food consumption needs but as an important source of supplementary income, especially for women and secondary families on the block who do not have regular access to oil palm income (Table 1.1). Women rely heavily on the sale of food crops to earn income to meet everyday household needs and to purchase food for the family. When conducting household surveys interviewees were asked if any household members had sold garden food in the previous seven days. This is an indication of the regularity of market income. On the LSS at Bialla over one quarter of female heads of households had sold garden foods in the preceding seven days. 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 (18% of women) (Table 1.1).

Women tend to have more control over the income they earn from marketing food crops than from oil palm.

Table 1.1. The importance of food gardens to household livelihoods at Bialla in 2014

Gardening and household livelihoods	
Garden cultivation	90% of households maintain food gardens. 89% of households with food gardens claim they meet most of the food needs of their families (nearly every household supplements garden foods with store purchased food).
Garden & oil palm labour	67% of women rank working in food gardens as their main livelihood activity. 85% of men rank oil palm production as their main livelihood activity.
Income source	50% of women rank income from garden sales as their most important income after oil palm. 18% of women ranked the sale of garden foods as their main income source.
Dietary food intake	24 hour dietary recall: 80% of all meals consumed contained some meal ingredients sourced from smallholders' own gardens.

Adapted from Koczberski et al. 2018a

Food gardening on the Bialla LSS plays an insurance role in sustaining livelihoods. When oil palm prices are low, smallholders increase their reliance on garden foods as purchases of store foods decline (Koczberski et al. 2012), and food gardens improve a family's capacity to cope with decreased oil palm income during replanting (Curry et al. 2015). In other oil palm producing countries, food gardening has also been found to be an important safeguard and buffer against fluctuating oil palm prices (Orewa 1984; Cheyns and Rafflegeau 2005) and the income from food gardens helps families meet other financial needs such as education for children (Orewa 2008; Nchanji et al. 2016).

Most smallholder gardens on the Bialla LSS are dominated by mixed cropping systems with two or more sub-dominant staple crops and a variety of greens and vegetables. Banana, sweet potato, cassava and Chinese taro are the most commonly grown staples in smallholder gardens (Table 1.2). 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, and grown mainly as cash crops.

Table 1.2. Percentages of Bialla LSS smallholder households growing each crop type

LSS BIALLA	
STAPLES	**OTHER**
Banana *(100%)*	Peanuts *(35%)*
Sweet potato *(100%)*	Green leaf vegetables *(95%)*
Chinese taro *(85%)*	Fruits *(85%)*
Colocasia taro *(65%)*	Other nuts *(11%)*
Cassava *(95%)*	Sugar cane *(75%)*
Yam *(70%)*	

The continued importance of food gardens in the daily lives of LSS smallholder households demonstrates the capacity of smallholders to respond to rising population pressures and shortages of gardening land. They have responded to these pressures in several ways including:

- Intensifying garden production (shorter fallows, longer cultivation periods, quicker maturing and higher yielding crops and use of fertiliser)
- Intercropping immature oil palm with food crops
- Diversifying income sources
- Increasing the proportion of store foods in daily diets
- Resettling family members on nearby customary land
- Locating gardens on land beyond their own leasehold block
- Developing exchange relationships with other growers to increase the supply of land available for food gardening

- Delaying replanting of senile 2 ha oil palm stands to maintain some cash income.

Evidence of the use of these strategies was supported by data collected from household and garden surveys and household interviews (for further information see Koczberski et al. 2012; 2018a; 2018b; 2018c).

Over the past 10 to 15 years intercropping newly replanted oil palm with food crops has become common practice enabling households to produce food for their families and supplement incomes with the sale of surplus garden foods (Plates 1.1 and 1.2). When smallholder households do not have a replant section on their own block and insufficient land of their own for food gardens, they typically seek access to garden land on replant sections from neighbours, friends and relatives living in the same subdivision. Thus, seizing opportunities to utilise additional garden land made available during oil palm replanting has become a significant strategy for maintaining household food security.

Chapters 3 and 5 will discuss in more detail the importance of replanting, intercropping immature oil palm with food crops and social networks for maintaining household food security.

Plate 1.1. Corn, cucumber and banana planted between newly planted and poisoned oil palm in Wilelo LSS (Source: S. Nake)

Plate 1.2. Capsicum, corn, yam, sweet potato, banana and aibika in a 1 ha replant section of oil palm
(Source: S. Nake)

2. REPLANTING OIL PALM

Disadvantages of the 2 ha replanting system for smallholders

There is a reluctance on the part of many smallholders to poison and replant their senile oil palm. This is despite declining production and the availability of interest-free credit from the milling companies to do so. 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 Bialla, loan repayments are at 30% of gross income. This means that block income drops to 47% of the level prior to replanting. At Hoskins, where loan repayments are 50% of gross income, net income after loan deductions is reduced to 31% of the level prior to replanting. Thus, 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; only the younger and physically stronger men are able to harvest the tall palms. Women and older men lack the strength to manage heavy harvesting poles.

LSS smallholders who experience the most financial stress during replanting are those living on densely populated blocks where several co-resident households share the oil palm income. Blocks practising either the *skelim hecta* or *makim mun* production strategies are particularly vulnerable (see Koczberski et al. 2013). Under the *skelim hecta* production strategy each of

the three, 2 ha phases (total 6 ha) is allocated to a separate household on the block. Each household takes responsibility for its own 2 ha phase and controls harvesting, block maintenance and fertiliser applications (Koczberski et al. 2013).[2] Replanting under the *skelim hecta* management arrangement results in one family losing all of its oil palm income for 2-3 years, with loan repayments met by the remaining two phases managed by other people, usually brothers. Thus, they are reluctant for one brother to take out a replanting package, realising that they will have to cover the cost. These pressures, and the reluctance to replant, are intensified when there are three or more households residing on the block.

For those practising *makim mun* a rotational harvesting system operates whereby one month's income for the whole block (6 ha) is allocated to an individual person or household (there is often a different arrangement for loose fruit production and income). Taking 2 ha of oil palm out of production during replanting will seriously affect households receiving only a few payments each year (e.g. each household in a four-household block will receive only three payments per year). Thus the conventional 2 ha replanting system was appropriate when block populations were considerably smaller than today and smallholders had over 2 ha of 'reserve' land available for food gardening which provided households with an alternative income source during replanting. The 2 ha replanting system does not suit the contemporary demographic situation of multiple household blocks, increased consumption of store foods and the increased cash demands of most growers.

Two other groups who experience financial stress during replanting are VOP and CRP growers. With only 2 ha of oil palm, these growers, like those practising the *skelim hecta* production strategy on the LSS blocks, lose all of their oil palm income for 2-3 years with no ability to service their debt until their new palms come into production. While some VOP growers have access to customary land and can therefore pursue alternative incomes, the situation of the CRP growers is much more difficult as they are unlikely to have access to livelihood opportunities on land off-block. Some VOP growers, especially around Hoskins, are now experiencing similar land pressures to CRP growers.

Although delayed replanting may defer the onset of the burden of the "double-disadvantage" on smallholders, it creates a significant burden for the milling company. Lower productivity and yields result from a high proportion

[2] In 2014, 40% of smallholder LSS blocks at Bialla practised *skelim hecta* (Koczberski et al. 2013).

of smallholder oil palms being too tall to harvest and from pest and disease hot spots occurring in old neglected palms. Planning for milling and transport, seedling production and fertiliser recommendations are all made more difficult when there is uncertainty about the timing of replanting (Bonneau 2017).

Given these constraints on production arising from delayed replanting, there is a need to innovate in a way that provides incentives to smallholders to replant in a timely manner by reducing the double disadvantage of replanting.

What is the solution?

There are two main strategies for changing replanting practices to encourage timelier replanting. They are, underplanting senile palms with oil palm seedlings and reducing the area of palms to be replanted at the one time (from 2 ha to 1 ha). Each is discussed below.

Underplanting

Underplanting involves establishing seedlings under old palms and then gradually thinning the senile palms as the new seedlings develop. In this way, smallholders are able to harvest fruit from the old palms until their new palms come into production, at which point all remaining senile palms are poisoned. This strategy has been tried at both Bialla (1999/2000 – Koczberski and Curry 2003: 73-74) and at Hoskins in the late 2000s with limited success. However, underplanting relies on careful management of shade levels by thinning the senile palms at the appropriate time. If this is not done correctly in a timely fashion, shade levels can remain too high resulting in a high mortality rate of new seedlings and long and spindly growth of seedlings. In the smallholder sector where management input levels are generally well below plantation levels, this is a high risk strategy.

Most smallholders, especially women, are not keen on underplanting because the high shade levels deny them opportunities to intercrop their oil palm with food crops. When smallholders replant their oil palm, they intercrop with food crops for home consumption and sale at local markets. In this way, they compensate partially for the loss of oil palm income from the poisoned oil palm stand. Underplanting is not an attractive option for most smallholders, particularly for growers from densely populated and multiple household blocks.

The 1 ha replant option

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 staggered replanting strategy which can be grouped under two categories: smallholder benefits and milling company benefits (Figure 2.1):

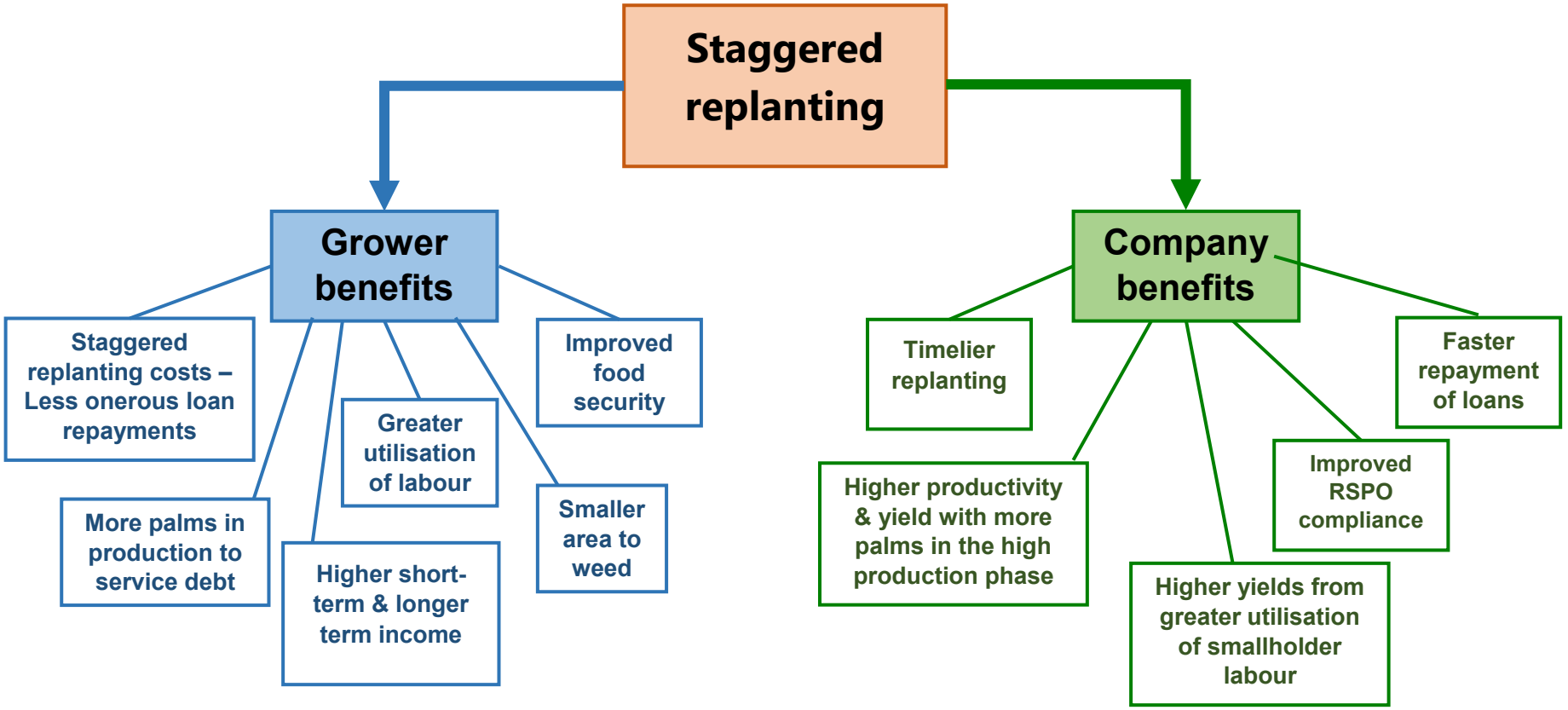

Figure 2.1. The advantages to growers and the oil palm milling companies of staggered replanting under the 1 ha replant strategy

Grower 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. Half of the replant debt for 2 ha is incurred in Year 1 of replant, while the second half of the debt is incurred in Year 2 or 3. 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, 15 t/ha at a price of K227/tonne (average price 2017-2018), the 1 ha replant option provides additional gross income of K3405 per annum over the conventional 2 ha replant practice. Thus loan servicing is much less onerous for farmers and the debt can be paid off more quickly. Replanting becomes much more financially attractive to farmers (Table 2.1).

Households on LSS blocks practising *makim mun* and *skelim hecta* harvesting arrangements and on 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 K3405 rather than no oil palm income as under the conventional 2 ha replant practice.

Table 2.1. Income available to service loans for 1 ha and 2 ha replants

Project area & loan repayment rate	Replant area (ha)	Yield / ha (t)*	Price / t (Kina)	Income / ha (Kina)	Hectares in production	Gross fortnightly Income (Kina)	Fortnightly loan deduction (Kina)	Net fortnightly Income after loan repayment	Replant debt (Kina)	Number of weeks to repay loan	Drop in net income during loan repayment (%)
Bialla (30%)	0	15	227	3405	6	786	0	786	0	-	0
	1				5	655	196	458	1200	12.2	42
	2				4	524	157	367	2400	30.5	53
Hoskins (50%)	0	15	227	3405	6	786	0	786	0	-	0
	1				5	655	327	327	1200	7.3	58
	2				4	524	262	262	2400	18.3	67

* Yield per ha at Hoskins is slightly higher at 16 t/ha. We use 15 t/ha to enable comparisons of repayment rates with Bialla growers.

❖ More palms in production to service debt

Servicing the replanting debt is made easier for smallholders as there is a higher ratio of palms in production to seedlings. 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 (Figure 2.2). Thus smallholders have the capacity to repay their loans faster and maintain a higher income stream than under the 2 ha replanting option.

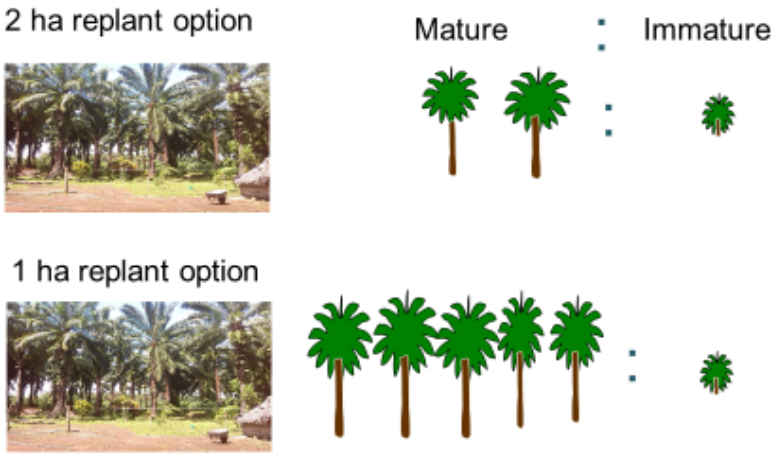

Figure 2.2. Ratio of palms in production to replanted seedlings

❖ Higher short-term and longer-term income

With the 1 ha replant option, smallholders' income stream would be more stable and higher in both the short and long-term. In the short-term, incomes are higher during the debt recovery stage as more palms are in production to service the loan and provide income to purchase food and other household needs. Also, income is more stable and higher over the long-term as there will be more incentive for smallholders to undertake timelier replanting before palms become too tall to harvest and yields drop off due to palm senility. With more palm stands in the high production phase, harvesting rates are likely to improve.

❖ Greater utilisation of labour

An additional benefit to growers of the 1 ha replant is that the incentives to delay replanting beyond 22-25 years would be greatly diminished 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 become less common (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 replant area to maintain

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 demands on labour for weeding are greatly reduced.

❖ Improved food security

A 1 ha replant option would provide 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 would provide growers with on-block land for gardening for 12-18 of 25 years, instead of 6-9 of 25 years under the current 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 food gardening effectively doubles. Given the importance of garden foods in household food consumption (Table 1.1), the 1 ha replant 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 smallholder blocks will reduce the burden of walking to and from distant gardens. A more detailed discussion of the 1 ha replant option in relation to food security is provided in the next chapter.

Company benefits

❖ Timelier 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 yields on smallholder blocks. This means more fresh fruit bunches would be delivered to the mill and fewer tall and difficult to harvest senile palms. With timelier replanting, the latest varieties of palms could 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 restricted to those capable of harvesting 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. In addition, with women spending less time walking to distant food gardens they will have more time to assist with oil palm harvesting and maintenance tasks.

❖ 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[3] 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 (240 palms) 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.

The 1 ha replant option provides benefits to both the smallholder and the milling company in terms of oil palm 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 as smallholder families are better able to meet their livelihood needs.

[3] Interest free 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, chemicals and transport. In 2018 this equated to approximately K2400 for a 2 ha replanting package (Hargy Oil Palms Ltd). A separate package for fertiliser is available when the new palms come into production.

3. OIL PALM REPLANTS AND INTERCROPPING

Intercropping food crops and oil palm

Historically, oil palm companies in many countries discouraged or prohibited smallholders from intercropping their oil palm with food crops. Intercropping was condemned for its perceived negative impacts on oil palm growth and yields. It was thought there would be competition for nutrients, water and sunlight and that additional crops would attract more pests and diseases and provide a refuge for them. It was also believed food cropping would divert smallholders' labour and time away from oil palm management. It was assumed that the complexity of an oil palm-food intercropping system would create greater vulnerability to environmental stresses (Nchanji et al. 2016).

However, smallholder intercropping of oil palm with food crops has been found to increase access to land, use land more efficiently and stabilise incomes. Farmers intercrop their oil palm to mitigate the costs of replanting. By providing groundcover, food crops can reduce the amount of weeding required when maintaining new oil palm plantings, thus increasing returns to labour. Intercrops can also aid in weed control by usurping resources such as nutrients and sunlight from weeds or suppressing their growth by allelopathy[4] (Liebman and Dyck 1993).

By far, the biggest gain for oil palm production from intercropping with food crops during replanting arises from the incentives created for smallholders to weed their food gardens which also benefits the oil palm. Weed control in newly planted oil palm is a large task which is made easier when the owners of the oil palm or their nearby relatives and friends establish food gardens in the replant area.

There are two categories of intercropping. First, the intercrop may be a monocrop where the farmer is primarily concerned with the yield of one crop with a few minor supplementary crops. Within this category different monocrops may be rotated, for example, a legume may be rotated with non-legumes. Alternatively, farmers may prefer the second category which is that of a mixed intercropping system. In this case, a mixture of crops is grown.

[4] Allelopathy is where growth of one plant is influenced by the release of biochemicals into the environment by another.

Although the yield of individual crops may be suppressed by competition from other crops, the overall yield per unit area of land may be higher than that of a monocrop intercrop. This may be achieved by manipulating the spatial arrangements of crop types and engaging in nonsynchronous planting (Liebman and Dyck 1993).

Brooker et al. (2015) suggest that with the appropriate selection of crops, intercropping can in fact enhance productivity through complementarity effects such as using leguminous crops like peanuts to fix nitrogen. Traits from different crops can be combined to overcome resource limitations. In West Africa, intercropping of oil palm with food crops in the early years of establishment had no depressive effect on the growth of the oil palm; it actually improved it (Fabunmi et al. 2004; Okyere et al. 2014). Putra et al. (2012) advocate that the right food crop selection will not interfere with oil palm growth but on the contrary accelerate its growth. Examples of suitable crops included soybeans and peanuts. Also, as mentioned above, the increased attention to weeding of food cops is also beneficial to oil palm.

As part of the broader food security assessment conducted as part of this study, preliminary work was done on oil palm replants on two LSS blocks in Hoskins, WNBP. The purpose was to determine whether food crops and oil palm complemented or competed with each other. At quarterly intervals up until the oil palm canopy closed, the food crops being grown, food crop canopy cover, oil palm canopy and leaf area and soil water content were recorded. An analysis of the soil in the replant area was compared to that where mature palms were growing. Results indicated that exploitation of the replant area was moderate in terms of canopy area and there appeared to be adequate light, water and nutrients available to the growing oil palms in the presence of food crops (Nelson and Nake, 2018; Koczberski et al. 2019).

An important, environmentally favourable implication of intercropping is that it increases biodiversity. This is important for certification as there is concern worldwide over the environmental consequences of oil palm monocultures. Osei et al. (2016) advocate mixed cropping over monocropping because it can be an effective control strategy for pests and diseases as long as the mixture of crops differ in their susceptibility to pests and pathogens. Wahbi et al. (2016) found that cropping systems based on carefully designed species mixtures can produce advantages in terms of productivity, pest and disease control and soil microbe functionality. Recent research conducted on monocultures and intercropped oil palm in Indonesia concluded that

intercropping with food crops improved land productivity and associated environmental systems (Stomph 2017).

Intercropping may also have beneficial effects on the physiology of oil palm. It has been observed that when superior selections of oil palm, as are used in PNG, are planted in favourable growing conditions, male inflorescence production is close to zero in the first year or two of flowering thus jeopardizing fruit production (Adam et al. 2011). In West Africa, Nuertey (1999) found that oil palm that was intercropped produced more male inflorescences than those that were monocropped.

Land pressures and intercropping amongst Bialla smallholders

When first settling their smallholder blocks in the late 1960s and early 1970s, farmers had to adapt their agricultural production systems to produce sufficient food to meet their family's needs from a fixed area of land – the 2.07 ha '*wasblok*' remaining after planting 4 ha of oil palm. Initially, there was sufficient land in the *wasblok* to permit a fallowing period of 6-9 years (Benjamin 1977). However, the rapidly growing population and the establishment of a third, 2 ha plot of oil palm necessitated agricultural intensification. This was achieved mainly through the use of inorganic fertilisers and pesticides, rotations with leguminous crops, the shortening of fallow periods, the extension of cultivation periods, the adoption of quicker maturing varieties of traditional crops and new crop introductions that were tolerant of less fertile soils (Koczberski et al. 2012; 2018a).

By the time oil palm replanting commenced in the 1990s, most smallholders had expanded their oil palm plantings and had three, 2 ha plots of oil palm. This left only 0.07 ha of the old 2.07 ha *wasblok* for food gardening. As land pressures grew and limits to intensification emerged, smallholders developed a range of strategies to bring additional land into production for food gardens on-block and bordering the block. Four main strategies were pursued:

1) Utilising previously unused land on the block for food gardening (e.g. around house sites, along edge rows of palms, in gullies and on steep slopes).

2) Appropriating and incorporating small areas of land bordering the block.

3) Seeking temporary access to gardening land off-block which was either under customary ownership or governed by state leases; and

4) Utilising immature oil palm replant areas on their own and other people's blocks (Koczberski et al. 2018a).

The utilisation of oil palm replant areas for food gardening was a crucial strategy for maintaining household food security. At Bialla, at the time of fieldwork, large-scale replanting of oil palm was in progress, and 75% of the total area of smallholders' food gardens were on-block, mostly in replant sections (Figure 3.1). Fifty-three per cent (53%) of household food gardens by area were located in oil palm replant sections; in the subsample survey where individual garden plots were assessed, the proportion of total gardening area in oil palm replant areas at Bialla was 55% (0.79 ha) of garden area.

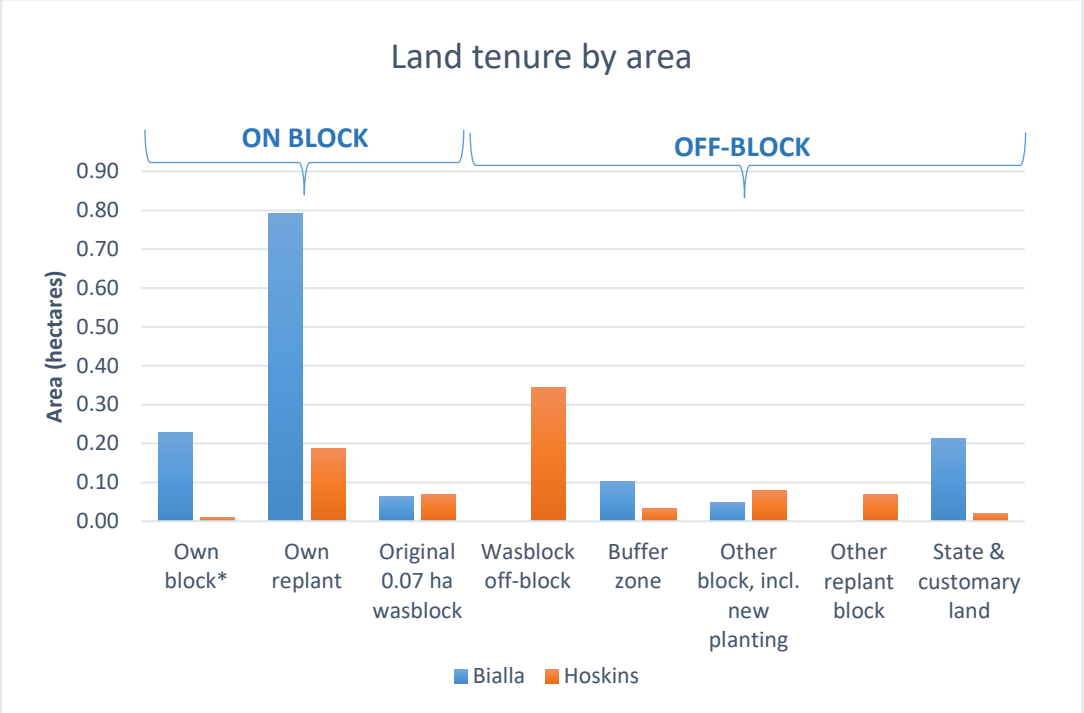

Figure 3.1. Area of garden land per block in each land tenure category on the LSS

*Includes land next to houses, along edge rows of palms and land unsuitable for oil palm.

When a 2 ha replant area of land becomes available for food cropping, intercropping of oil palm with food crops can be carried out for two to three years or until the oil palm canopy closes. During this time three to four cropping cycles can take place, sometimes with a very short fallow between planting rounds. Typically, preparations for food gardens commence as soon

as the old palm fronds collapse around the trunk of the palm and sunlight reaches the ground. Gardening inputs, particularly labour, decline as the oil palm canopy begins to close at 2-3 years. Chapter 5 provides a more detailed discussion of food gardens in oil palm replant areas.

Developing exchange relationships for access to gardening land

Despite smallholders intercropping their 2 ha oil palm replants there are still about 16-19 years within the 25 year oil palm cycle in which there is only 0.07 ha of land available for food gardening. To address the diminishing per capita supply of land for food gardens, smallholders, through their own innovation and drawing on their social networks, have developed a system of reciprocal access to land in the replant areas with neighbouring blocks. This is modelled on the reciprocal access to land arrangements that are common on customary land in village settings. Growers invite neighbours, relatives, members of their church and/or *wantoks* (those related by a common language or ethnicity) to intercrop gardens on their replant area in an informal arrangement in an effort to secure gardening land for themselves into the future.

The unwritten, but implicit, agreement in this informal system of accessing land is that gardeners will reciprocate and invite the leaseholder's family to garden on their land when they themselves are replanting. This is a mechanism by which smallholders invest in social relationships to reduce risk and uncertainty and reflects their adaptive capacity to withstand stressors on their livelihoods. The risks associated with having numerous gardeners on one's block are those of theft, social conflict and damage to oil palm seedlings. Despite these risks, which did not seem to be a major problem, there are numerous benefits arising from these reciprocal exchange relationships, both for host and guest gardeners (Figure 3.2).

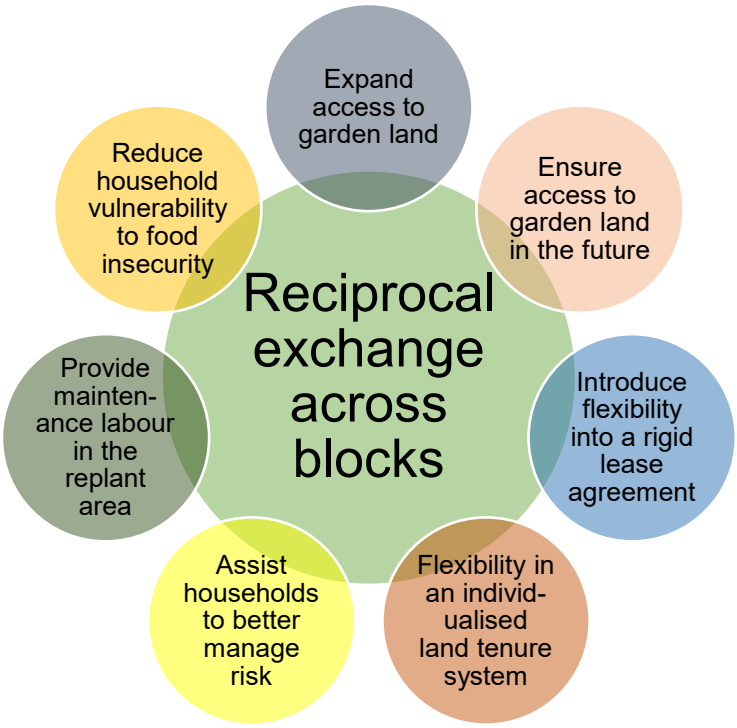

Figure 3.2. The benefits of reciprocal exchange relationships

By developing these reciprocal relationships, smallholders expand their short and long-term access to gardening land. Having ongoing access to sufficient land for food gardening enhances food security through increased food production for consumption and marketing and through food sharing in the gift economy of cultural obligations.

The terms of the individual lease agreements on the LSS blocks are somewhat rigid and govern most facets of oil palm production. The LSSs were established on the basis of individual lease titles over fixed areas of land and a set of land tenure regulations that specified the cash crop to be cultivated (oil palm) and the area of land reserved for food production (2.07 ha). Effectively, there was little flexibility in the location of food gardens on the leasehold block, and smallholders were discouraged from intercropping juvenile oil palm with food crops. This puts some limitations on how smallholders can use their land. Thus, the adoption of reciprocal land access arrangements has 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. Social innovation has thereby led to the diffusion of risk both spatially and socially from the individual farm household to the broader community and by doing so enhanced both individual and community resilience.

Being able to access additional land for food gardening also reduces the risks associated with crop failure or the incidence of pests or diseases. Gardeners can assist the owner of the replant by providing labour to maintain the replant area, mainly by weeding. This weeding for food gardens improves maintenance thereby creating a healthier environment for oil palm seedlings to develop.

In essence, reciprocal gardening relationships are a means of reducing vulnerability to food insecurity. Food can be grown directly for the household or sold to provide income that can be saved until needed to purchase store foods. A constant supply of food for the household can therefore be maintained, especially during the financially difficult time of oil palm replanting.

Food security and the 1 ha 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 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 3.1).

Table 3.1. 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 that land is available for gardening				6-9

When a 2 ha plot of oil palm is replanted in two, 1 ha phases 2-3 years apart, the period in which growers can garden on-block is doubled. With 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 3.2). Although the gardening area available during replanting is halved, the period in which garden land can be accessed is doubled. 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 3.2. Block planted with 6 ha of oil palm using the 1 ha replanting strategy

	Phase 1 (2 ha)		Phase 2 (2 ha)		Phase 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 of 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 3.3). 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 3.4). This is a simpler model for securing garden land into the future.

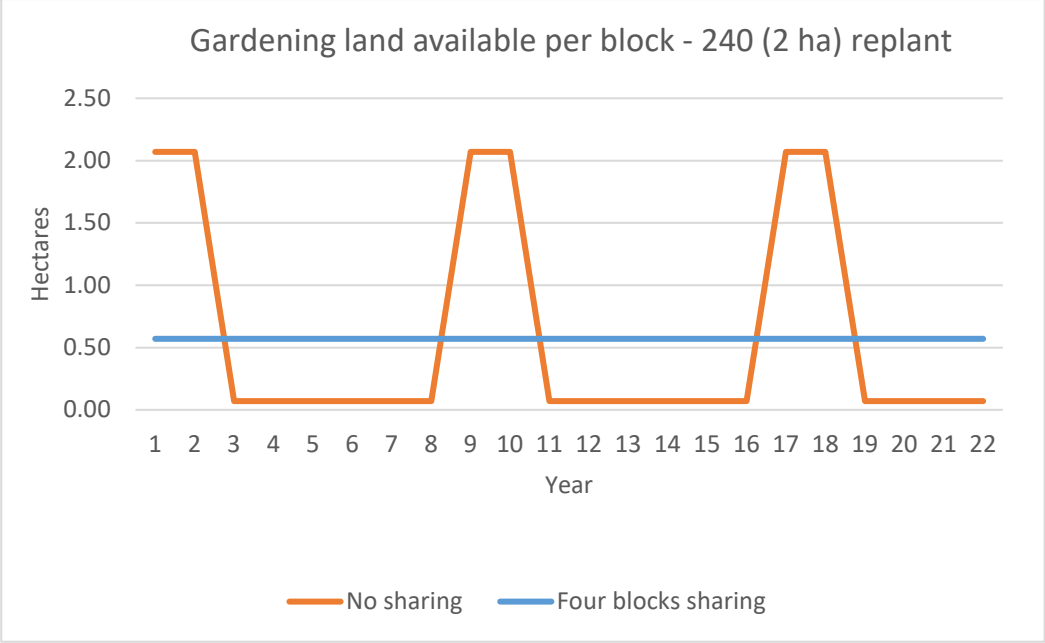

Figure 3.3. Land available for food gardening when there is no reciprocal access across blocks and when four blocks coordinate replanting and share access to each other's 2 ha replant area
(Assumes 2 years of food gardening in replant area)

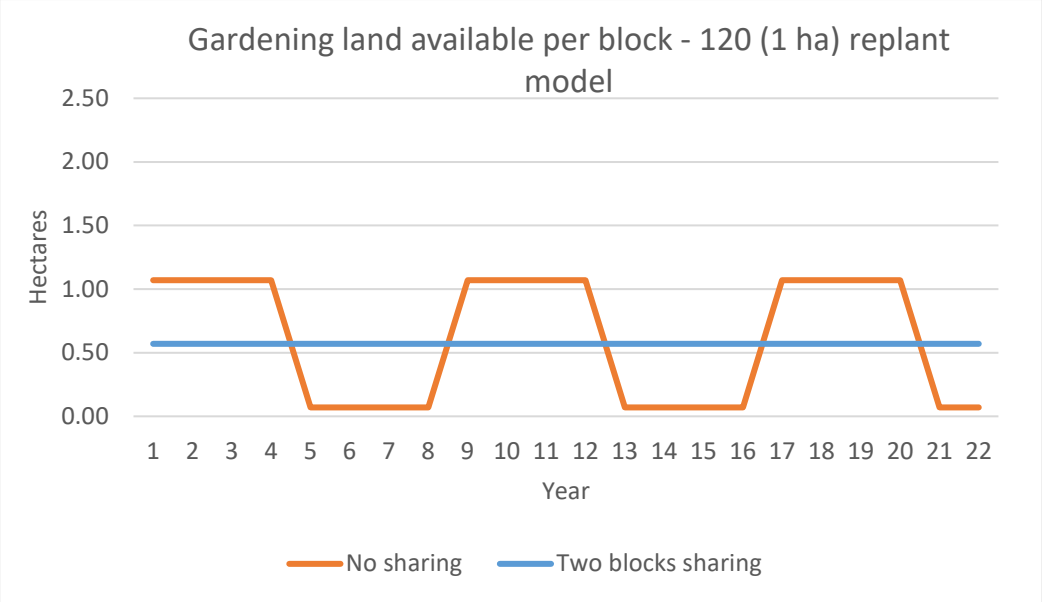

Figure 3.4. Land available for food gardening when there is no reciprocal access across blocks and when two blocks coordinate replanting and share access to each other's 1 ha replant area
(Assumes 2 years of food gardening in replant area)

If the oil palm companies institute the 1 ha replanting strategy it is anticipated that the release of land for food gardening would alleviate much of the land 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 minimising 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. Planned surpluses of food crops are typically sold at local markets, and are often high value crops such as sweet potato and peanuts. Crops primarily intended for sale are often planted during the early stage of the replant cycle. The market income helps offset the financial double disadvantage associated with replanting – reduced income while servicing loans.

4. METHODS: THE 1 ha REPLANT TRIAL

The 120 replant trial was undertaken on seven blocks in the Wilelo LSS subdivision at Bialla from January 2016 to October 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 they were reluctant to replant. The trial was done in collaboration with Hargy Oil Palms Ltd (HOPL) with the aim of assessing the advantages and disadvantages for smallholders and the company of switching to a 1 ha (120 palm) replant option and to evaluate its potential to improve the long-term status of household food and income security amongst smallholders. Given there were no previous studies on intercropping oil palm with food crops in PNG, detailed food garden assessments were conducted as part of the trial. Due to time and financial constraints, a scientific analysis of the effects of food cropping on 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 for light, nutrients and water (Nelson and Nake 2018).

Awareness

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 (Plate 4.1). Several presentations to smallholders during field days explained how the 1 ha option would operate and its potential benefits for smallholders, especially in terms of food gardening (clear benefits for women) and income and loan repayments (benefits for both men and women). Pamphlets in Melanesian Pidgin explaining the 1 ha option were distributed to smallholders present at these field days (Appendix 1). The awareness programs and pamphlets gave the opportunity to promote the trial amongst smallholders and recruit interested farmers to participate in the trial.

Plate 4.1. OPRA awareness for the replant trial at Bola, Tamambu Bialla field day
(Source: S. Nake)

Selection of trial participants

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

- 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.
- The block was 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.
- The production strategy was either *skelim hecta* or *makim mun*.

All seven blocks selected had two or more co-resident households. Of the seven blocks, four practised the 1 ha (120 palm) replant strategy and three used the conventional 2 ha (240 palm) strategy. All four, 1 ha replant trial blocks, practised either *makim mun* or *skelim hecta* harvesting strategies.

Prior to the trial's commencement, trial farmers signed an agreement to allow researchers on their blocks during the trial.

Data collection

Data collection incorporated both quantitative and qualitative techniques, namely:

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

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 leaseholder and the gardening arrangement each gardener had with the leaseholder. The current pest and disease status was also noted.

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 1 ha replant would provide for the family (e.g. smaller loan repayments, less labour burden, etc.). Smallholders were also asked questions concerning their current debt levels with the company.

Household garden monitoring surveys

At quarterly 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. Leaseholder-gardener relationship (e.g. relative, 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 occupied by the most dominant crops

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 leaseholder; and Part B for each garden in the replant. In Part A the leaseholder provided information on the date the oil palm seedlings were planted, the number of people who 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 (Plate 4.2). The crops grown and the proportions of each garden area occupied by the most dominant crops were also documented.

Plate 4.2. Garden monitoring at Wilelo subdivision
(Source: S. Nake)

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 2). Across all seven replants, the maximum number of gardens surveyed during a field visit was 69 in April 2017. Details of dates of surveys and garden plot surveys are listed in Table 4.1. A map of the Wilelo subdivision showing the locations of study plots is shown in Figure 4.1.

The garden monitoring surveys were used to establish:

- Who gardens on the replants
- The proportions of gardeners residing on and off-block
- Off-block gardeners' relationships to the host leaseholder
- 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

Table 4.1. Blocks surveyed detailing the timeframe of the survey and the numbers of garden plots being cultivated at the time of each visit

	1 ha – 120 Replant				2 ha - 240 Replant		
Block visit	Block No.	Months from oil palm planting	No. gardens	Block visit	Block No.	Months from oil palm planting	No. gardens
Nov-16		5	7	Jul-16		-3	10
Jan-17		7	7	Jan-17		3	10
Apr-17	719	10	7	Apr-17	717	6	11
Jul-17		13	7	Jul-17		9	11
Oct-17		16	7	Oct-17		12	8
Sep-16		17	13	Jan-17		1	13
Jan-17		21	13	Apr-17		4	13
Apr-17	723	24	14	Jul-17	802	7	13
Jul-17		27	13	Oct-17		10	13
Oct-17		30	1	-		-	-
Aug-16		-4	6	Sep-16		5	13
Jan-17		1	6	Jan-17		9	13
Apr-17	744	4	6	Apr-17	1106	12	13
Jul-17		7	6	Jul-17		15	13
Oct-17		10	6	Oct-17		18	8
Jul-16		3	4				
Jan-17		9	5				
Apr-17	745	12	5				
Jul-17		15	5				
Oct-17		18	4				

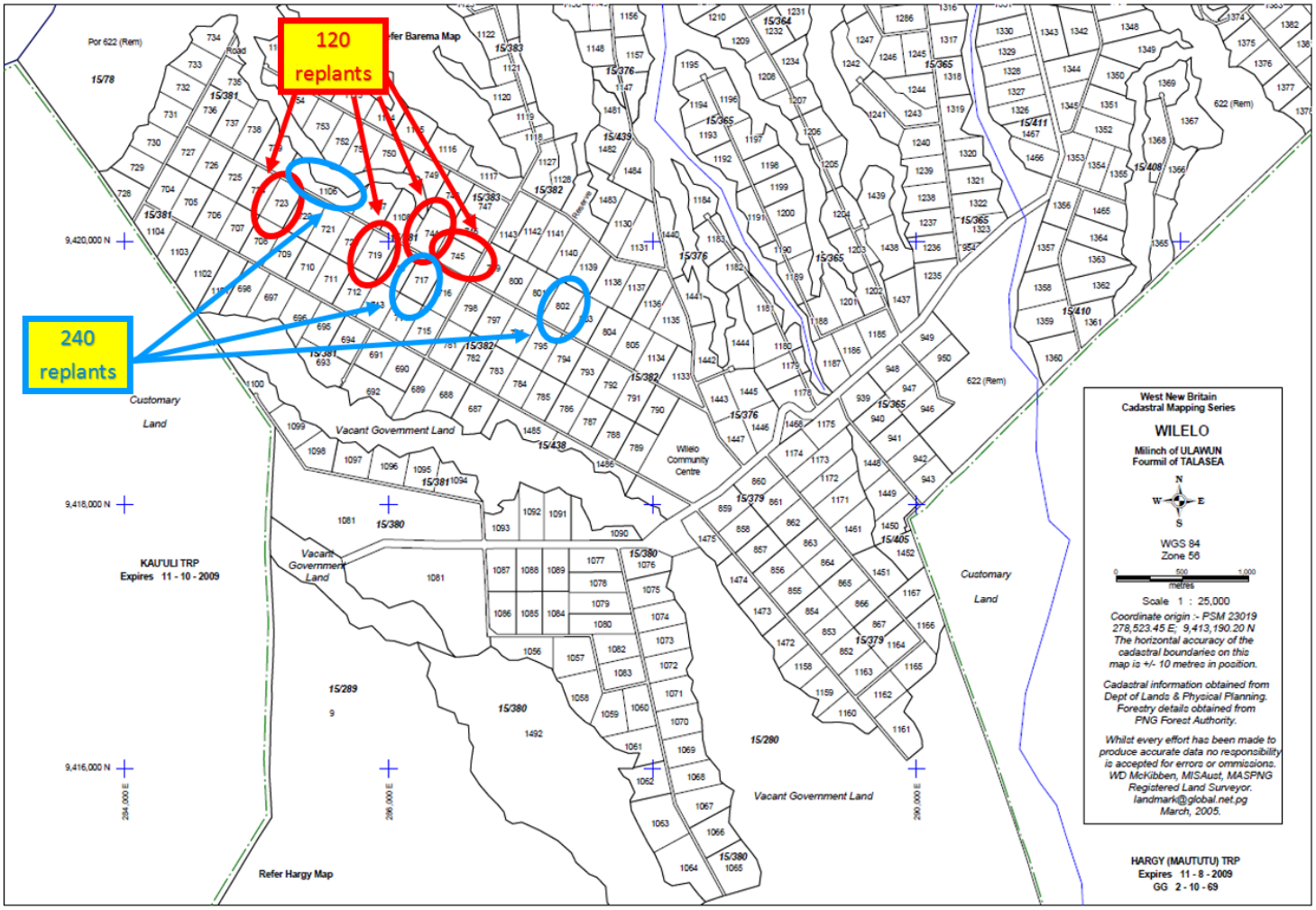

Figure 4.1. Wilelo subdivision, Bialla, showing locations of 1 ha and 2 ha replant trial blocks

Description of the replant blocks

Before oil palm replanting begins the old senile palms are poisoned. The trunk is injected with 30 mls of Glyphosate and within three months the fronds collapse around the palm trunk and fall, leaving a naked trunk (Plate 4.3). The trunks are then left to decompose where they stand[5]. This has the benefit of producing a concentration of nutrients around the base of the trunk, and because the fronds are no longer present there is adequate light for the newly planted oil palm seedlings and food crops.

Plate 4.3. Poisoned oil palm after fronds have collapsed
(Source: G. Curry)

New oil palm seedlings are planted in the existing palm rows adjacent to the poisoned palms at a planting density of 120 palms per hectare. Fertiliser is not applied to the newly planted oil palm seedlings. The fertiliser programme starts when the palms produce fruit at 18-36 months old[6] (Plate 4.4).

[5] Felling and windrowing of palm trunks is done in the plantations, but would be a very costly procedure for smallholders.

[6] Fertiliser is no longer included in the replanting package and is now recommended when the new palms come into production. Urea costs K69 per 45 kg bag and is applied at a rate of 1.5 kg per palm (180 kg per ha) costing K276 per hectare.

Plate 4.4. Three-year old oil palm almost ready to harvest for the first time
(Source: G. Tilden)

After the new oil palm seedlings have been planted, or, in some instances beforehand, food gardens are established amongst the palms taking advantage of available light and soil resources (Plate 4.5). Often families will allow a short grass fallow (<6 months) to establish before gardens are prepared. Smallholders believe that a short fallow 'loosens' the soil ready for garden production. Intercropped food gardens benefit from residual fertiliser in the soil remaining from years of application on the previous stand of oil palm. The soil in the old frond rows where pruned fronds from the previous oil palm stand were stacked are particularly valued for their high organic content and friable, nutrient-rich soils. The oil palm seedlings profit from being weeded regularly promoting better establishment and potentially earlier fruiting.

Plate 4.5. Newly planted food crops in an oil palm replant – banana and peanuts between rows and the old palms providing support for yams
(Source: G. Curry)

The data collected over the two years of the trial were used to assess the advantages and disadvantages of the 1 ha replant option relative to the conventional 2 ha replant. The assessments identified strategies used to incorporate food gardens into the replant areas both for the block households as well as for those from off-block. A comparison was made between the arrangements and practices used on 1 ha replants with those used on 2 ha replants. The trial results are presented in the next chapter.

5. TRIAL RESULTS

The trial results are grouped into four sections:

1. Improved access to land for food gardening
2. Crops and cultivation cycles in oil palm replant areas
3. Crop diversity
4. Socio-economic outcomes

Land access is crucial for those on highly populated blocks, and households utilise a range of strategies to secure access to land for current and future gardening purposes. The types of crops grown on both the 1 ha and 2 ha oil palm replants are compared along with the diversity of individual staple crops. The socio-economic consequences of the two replant options are then discussed in terms of current and future land access and food and income security.

Improved land access for food gardening

Invited gardeners

Smallholders utilise their garden plots in replant sections very efficiently. Leaseholders of all seven blocks in the trial invited people from other blocks to garden on their replant area in either a block maintenance and/or reciprocal gardening arrangement. The impetus behind these arrangements was therefore twofold:

1. In the short-term it was a means of sourcing labour to assist in maintaining the replant area, primarily weeding
2. In the long-term it provided a mechanism to secure future access to gardening land through reciprocal access to land (for further detail, see Koczberski et al. 2018a).

On a typical replant area, food cropping activities were undertaken by the leaseholder's family, other co-resident households and invited households from other blocks. Most off-block gardeners were from blocks located nearby (Figure 5.1).

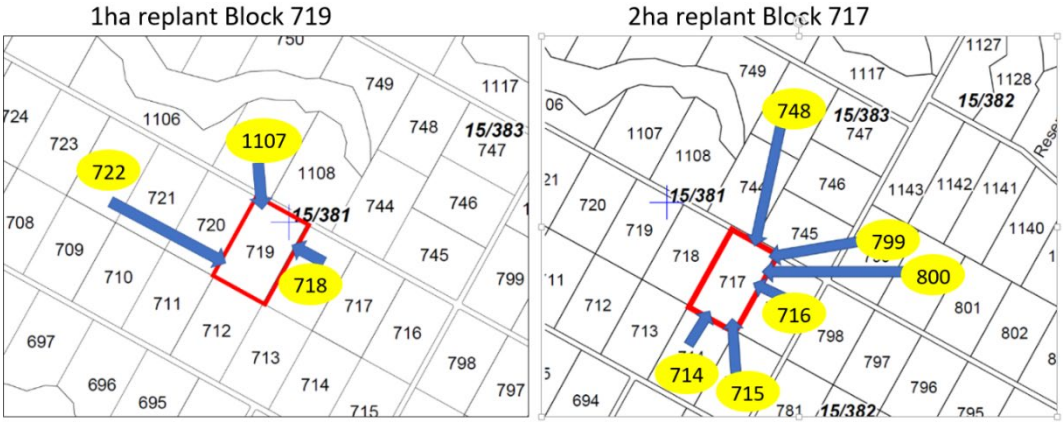

Figure 5.1. 1 ha (Block 719) and 2 ha (Block 717) replant blocks and the home blocks of off-block gardeners

Social and kinship networks were key to securing land for food production, both in the short and long-term. Smallholders drew on networks with neighbours, those from their own language/ethnic group (*wantoks*) and relatives to access gardening land where oil palm replanting was occurring (Figure 5.2). Intermarriage across ethnic groups amongst second and third generation settlers has meant that the pool of people that can be drawn upon for access to gardening land has expanded markedly since initial settlement (Koczberski et al. 2018a).

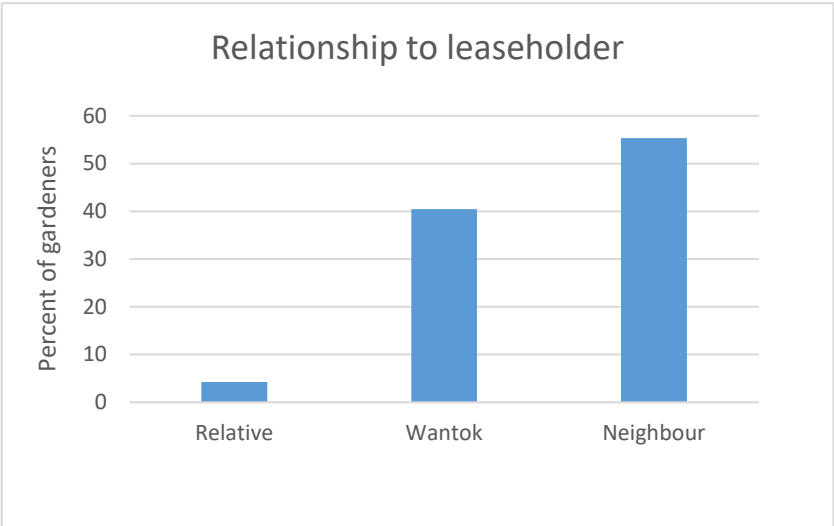

Figure 5.2. Relationship of invited gardeners to the leaseholder of the block

On 1 ha replants, 60% of garden plots belonged to off-block residents while the corresponding figure for 2 ha replants was 80%. This is to be expected given that on a 2 ha replant there is much more gardening land available after meeting the needs of resident households. A typical 1 ha replant area with

food gardens cultivated by on- and off-block gardeners is shown in Figure 5.3.

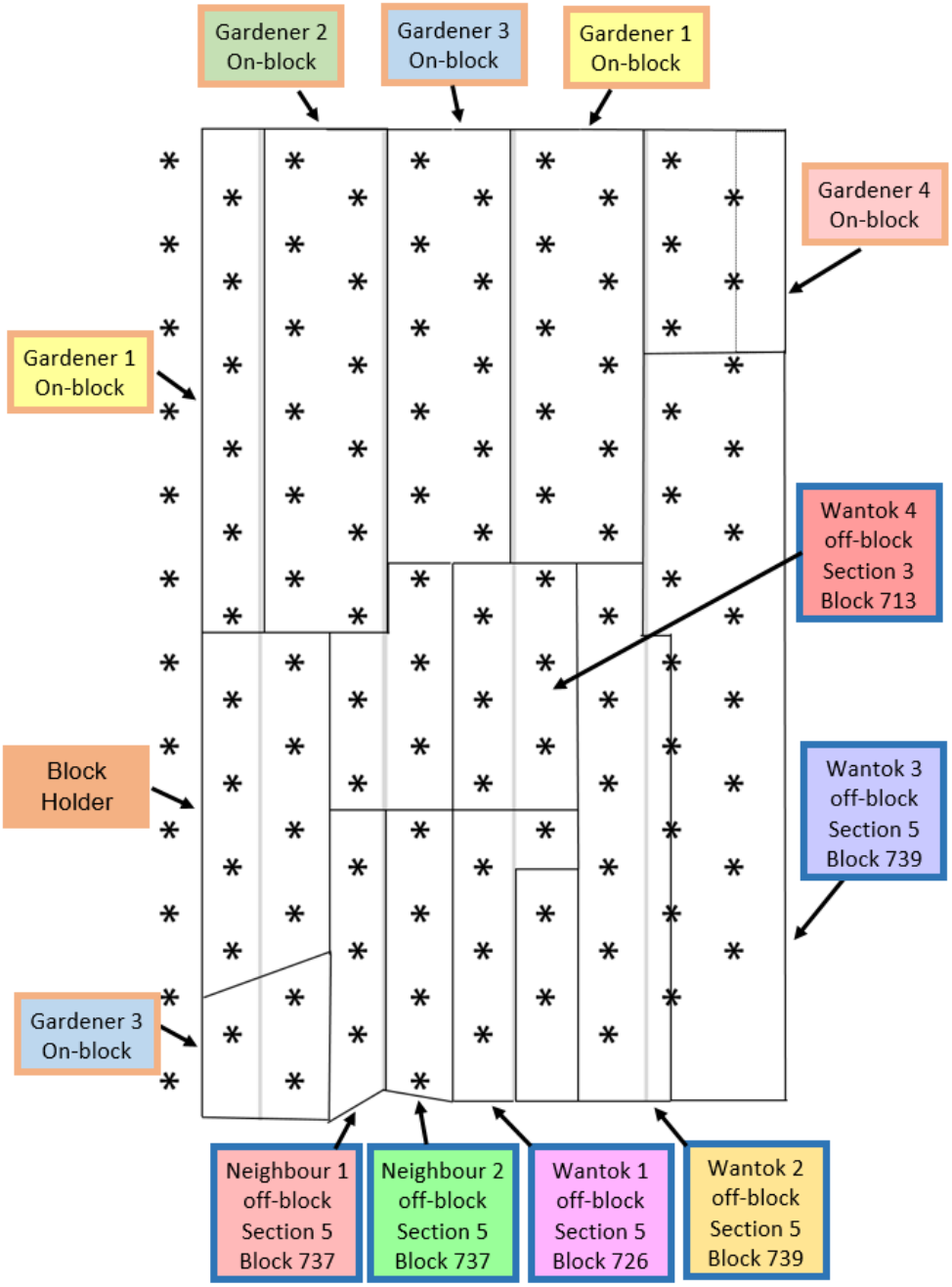

Figure 5.3. Garden plots in Round 1 of gardening after palm poisoning
(The block numbers of gardeners from off-block and their relationships to host leaseholder provided) (1 ha replant Block 723, October, 2016).

Plate 5.1. Garden plot boundaries marked with sticks
(Source: G. Curry)

Garden Plots

The number of garden plots being cultivated in the early stages of the replants in 2016 was on average around eight in the 1 ha replants and 12 in the 2 ha replants (Figure 5.4). At this time, most gardeners were in their first round of gardening. Some had two plots but most had a single plot. The total number of plots increased a little as time progressed but then began to decline by July 2017. Most gardeners by this stage were up to their third round of gardening. As there was a lot of replanting being undertaken in Bialla in 2016-17 gardeners were using the opportunity to take up plots in newer replants. Here they could take advantage of the low shade levels in the first gardening round, and possibly access larger areas of land. It was not necessarily the off-block gardeners who ceased gardening on the replant blocks as shown in Figure 5.4. On the 1 ha replants the proportions of off-block gardeners did not decline as markedly as the decline in the number of garden plots. Our sample size was small, but a general observation on 2 ha replants was that the number of garden plots declined as the cultivation period lengthened.

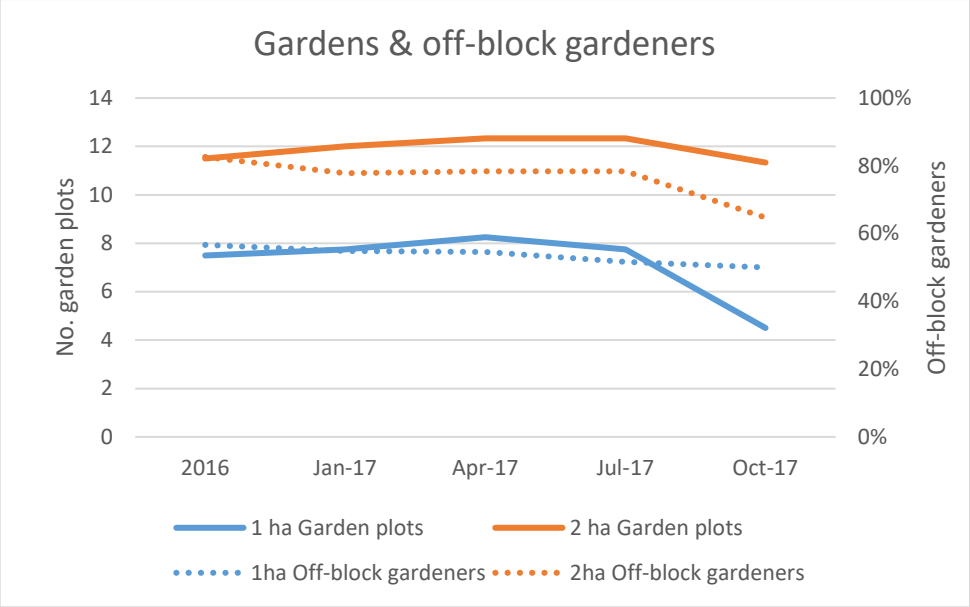

Figure 5.4. Mean number of garden plots and the proportions of off-block gardeners at each visit on the 1 ha (n=4) and 2 ha (n=3) replant blocks

During the period of maximum garden areas in replants on the trial blocks in April 2017 approximately half of the replant area on the 1 ha replants was being cultivated by off-block gardeners, while on 2 ha replants they were cultivating 70% of the total garden area (Table 5.1). There were twice as many off-block gardeners on the 2 ha replants as there were on the 1 ha replants.

Table 5.1. Garden plots and gardeners on replant blocks during the period of maximum garden area in April 2017, Wilelo, Bialla

Replant area (ha)	Mean no. garden plots	Mean no. gardeners	Mean no. gardeners from off-block	Proportion of garden area used by off-block gardeners	Mean size of on-block gardeners' plots (ha)	Mean size of off-block gardeners' plots (ha)
1 (n=4)	8	7.5	4.5	48%	0.119	0.097
2 (n=3)	12	12	9	71%	0.287	0.164

On most blocks there were small changes in the size of some garden plots over the survey period (Figure 5.5). Some gardeners took over adjacent plots abandoned by neighbouring gardeners, and others acquired non-contiguous additional plots within the replant area. By October 2017, most replant gardens had been abandoned to fallow as off-block gardeners had moved on to replants on other blocks leaving just small areas where some on-block residents were still cultivating crops. The key point is that food gardening had largely ceased by 30 months.

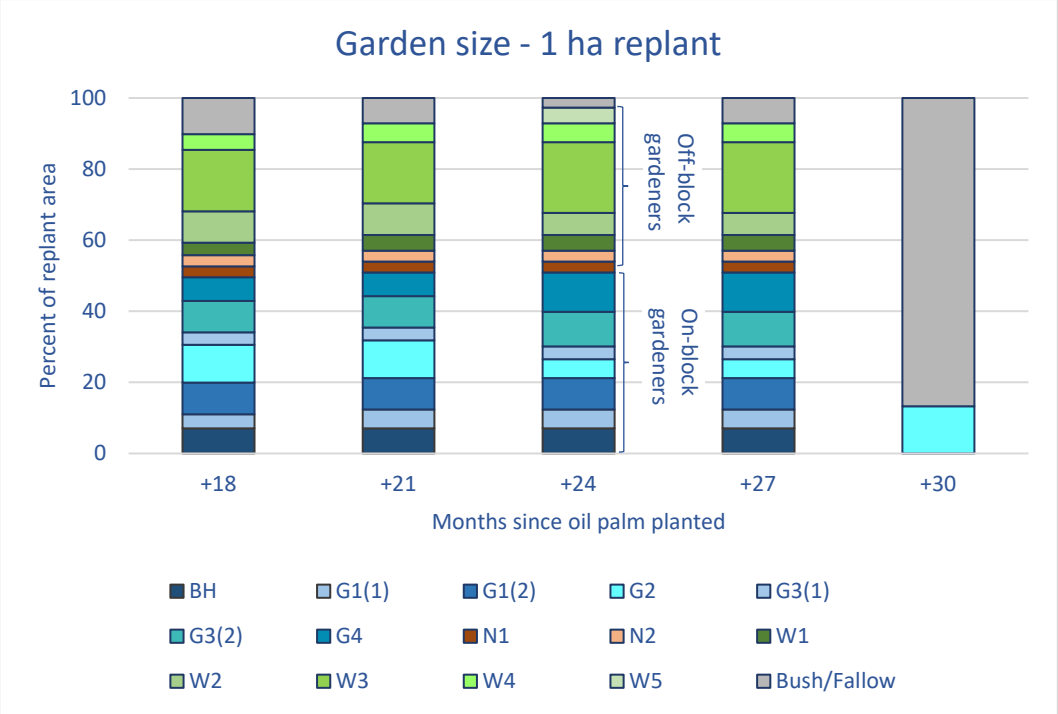

Figure 5.5. Change in the size of garden plots over time as a percentage of replant area from 18 months post-planting of oil palm to 30 months post-planting (1 ha Block 723)

BH=Block holder; G=On-block Gardener (garden no.); N=Neighbour; W=*Wantok*

Blue gardens = On-block gardeners; Orange & Green gardens = Off-block gardeners

Crops and cultivation cycles in oil palm replant areas

The types of food crops grown in oil palm replant areas are influenced by several factors (see Putra et al. 2012: 170). A key factor determining which type of food crop is planted is a crop variety's tolerance to shading by the developing oil palm canopy. Food crops can be grown in a multi-strata system in amongst the primary crop, in this case oil palm. Bananas are planted in the first round and under these are planted short duration crops. Early in the first round there is little competition for space, light, nutrients or water (Molina and Valmayor 1998). Understorey crops are usually planted in such a way that when short duration crops like greens have been harvested, longer maturing crops such as bananas will grow in size and fill the remaining spaces. Orewa (2008) also found that price is a key factor influencing a farmer's decision to plant a particular crop. Consequently, the cropping patterns adopted by smallholders are determined by social, economic and environmental, factors.

The first cropping round in the replant is the most important to those cultivating gardens and typically has a high diversity of crops. The best harvests, in terms of yield and quality, are achieved from this round. This may not reflect declining soil nutrient levels, although gardeners claimed that soil fertility was highest during the first planting round and declined by the third gardening round. Perhaps rising shade levels from the newly planted oil palm made production of certain crop varieties less viable.

Soil structure and nutritional status and light levels are not spatially uniform throughout the replant area, and gardeners take these factors into account when choosing where to plant particular crop varieties. Patches of ash where vegetation has been heaped and burned are planted to crops like beans, aibika and yams (*D. esculenta*) (Plate 5.2). The remnant frond rows where pruned palm fronds from the previous oil palm stand were stacked between every second row of palms and where fertiliser was applied, are particularly important as they are rich in nutrients and organic matter, and have soft friable soils. They are the premium sites for planting crops such as taro, aibika (*Abelmoschus manihot*), yams, karakap (*Solanum nodiflorum*), aupa (*Amaranthus* sp.) and pumpkin tips (*Cucurbita* sp.) as well as diploid bananas such as Tukuru and Highlands' banana (Plate 5.3).

Plate 5.2. Aibika and pumpkin growing in an ash bed
(Source: G Curry)

The least preferred planting sites, initially, are the old wheelbarrow tracks along which harvested fruit from the previous oil palm planting was carted to the roadside collection point. Although the soil has been compacted, it can be 'loosened' by planting sweet potato (*Ipomoea batatas*), cassava (*Manihot esculenta*) and peanuts along these tracks. The roots of these crops and the tilling of soil to form mounds for sweet potato cuttings are thought to make the soil more friable.

Plate 5.3. Tobacco and pumpkin growing in the old frond row
(Source: G. Curry)

Typically, the most dominant crops cultivated in the first round of gardening on the replants were peanut and banana (Figures 5.6 and 5.7; Table 5.2). Although farmers may not be aware that a legume such as peanut improves the structure and nitrogen content of the soil through its nitrogen fixing capabilities, they do recognise that growing peanut improves the fertility of the soil for the benefit of crops grown in the following rounds. In addition, as peanuts are a high value crop they can be marketed thus providing an additional source of income that can partly compensate for the loss of oil palm income during the replanting phase. Other high value, fast maturing crops such as greens (aibika, karakap, pumpkin tips and aupa) and corn (*Zea mays*) as well as sweet potato and Chinese taro (*Xanthosoma sagittifolium*) were also commonly grown in the first round over relatively large areas.

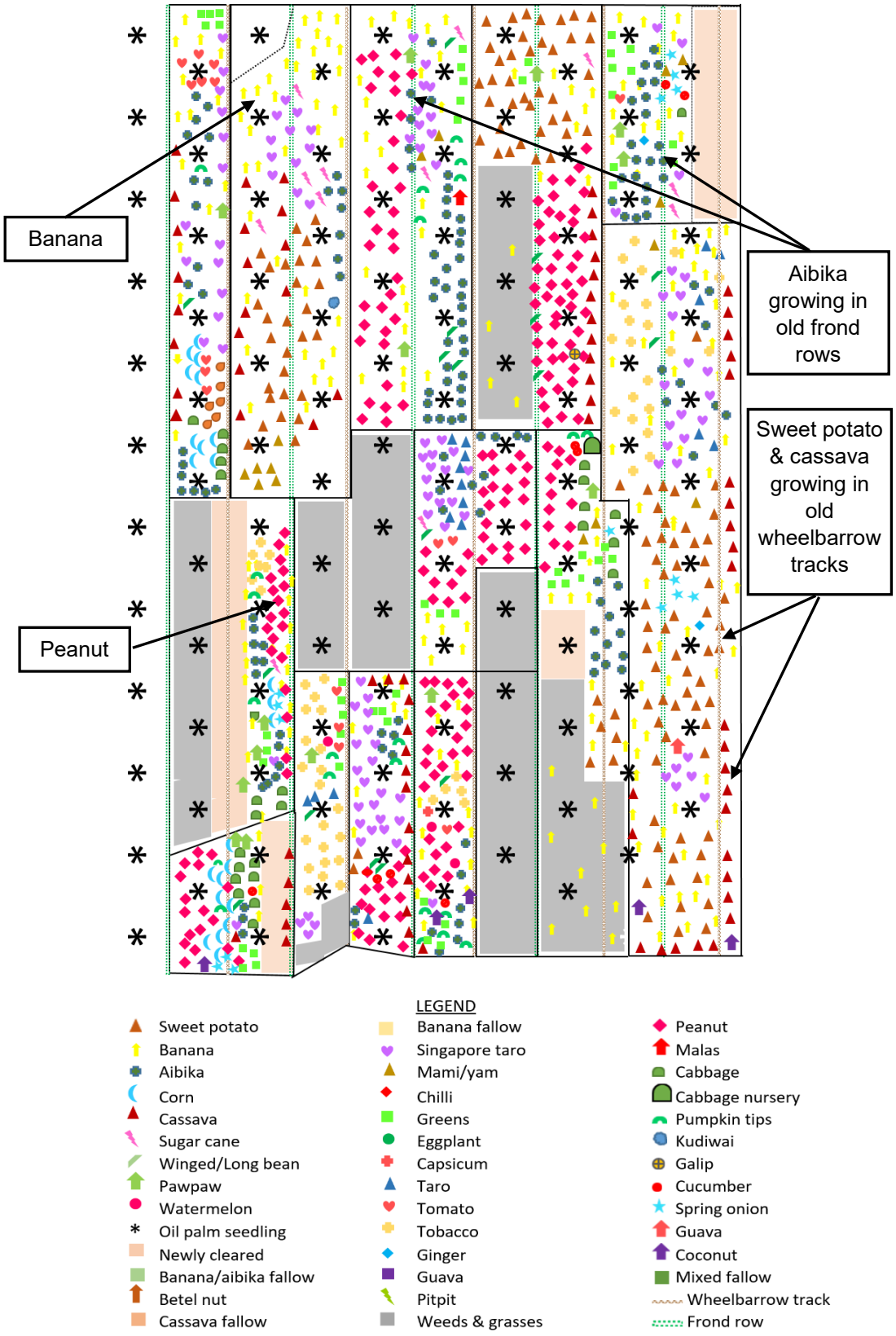

Figure 5.6. Typical planting layout of food crops in **Round 1** of food gardening in a newly replanted oil palm plot
(Bialla: 1 ha replant, Block 723, oil palm 12 months old)

Smaller areas were dedicated to other valuable crops such as bean (*Vigna & Psophocarpus spp*), capsicum (*Capsicum annuum*), cucumber (*Cucumis sativus*), spring onion (*Allium* sp.) and tomato (*Solanum lycopersicum*).

Table 5.2. The main crops, by area, grown in each gardening round on the replants

Gardening round	Most dominant crops	Other common crops
1	Peanut & banana	Aibika, sweet potato, corn, karakap, Chinese taro , aupa
2	Banana & Sweet potato	Peanut, aibika, Chinese taro, corn, karakap, pumpkin tips, yam
3	Banana & sweet potato	Chinese taro, aibika, yam, cassava, corn
Fallow	Banana	Cassava, sweet potato

Plate 5.4. Peanuts planted amongst newly planted oil palm seedlings in the first round of food gardening
(Source: G. Curry)

Plate 5.5. Bananas growing on the edge of the old frond row
(Source: G. Curry)

Like a newly cultivated garden in a swidden system cut from a secondary forest fallow, labour inputs are high in the initial stages of clearance, firing of dry vegetation and establishment of crops. Initially, the gardens are cultivated intensively and as the oil palm canopy increases, the diversity and planting density of food crops declines. In the second round of gardening, for example, crop diversity declines a little and there is a preference for more robust crops. Banana continues to be grown and expands from 23% of total garden area at 17 months to 65% by 27 months, just before fallowing begins (Figure 5.7). As the cultivation period lengthens, a larger proportion of the garden plot is planted to root crops, particularly sweet potato, Chinese taro, cassava and yam (*Dioscorea* spp) (Figure 5.7). Peanuts are often planted again but over a reduced area as are other high value crops. Although areas of green vegetables are reduced, aibika continues to be grown widely, often over a larger area than in the first round.

By the third round as the oil palm shade canopy begins to close, crop diversity declines even further. Many gardeners from off-block begin to wind-up their cropping activities (Figures 5.5, 5.7 and 5.8). By this stage the majority of the garden area is planted to banana and root crops although other high value crops such as bean, tomato and capsicum may continue to be grown where

there are gaps in the shade cover, but over very small areas, and typically by on-block residents.

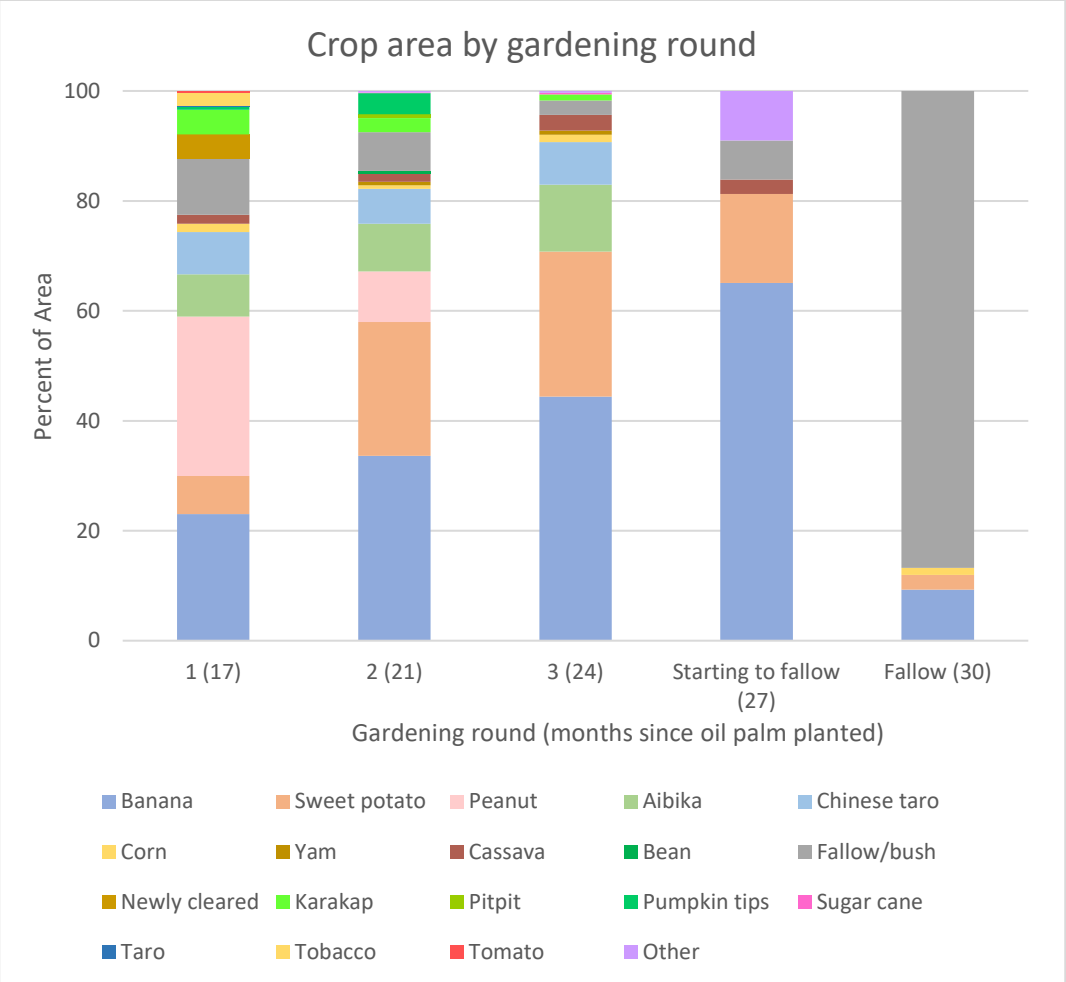

Figure 5.7. Area of crops planted in each gardening round on an oil palm replant

Other = small areas of multiple crops

(Bialla: 1 ha replant, Block 723)

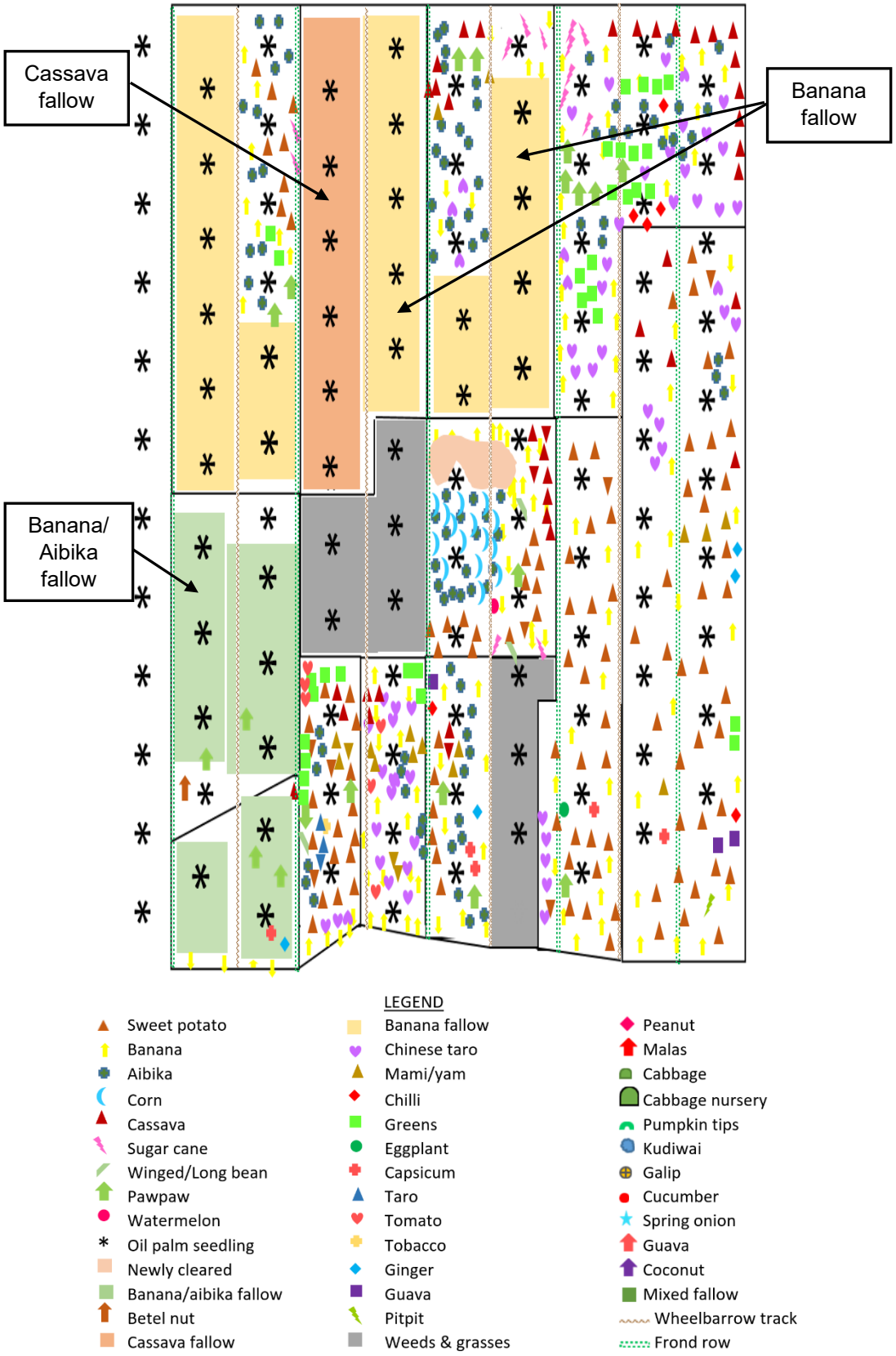

Figure 5.8. Typical spatial arrangement of crops in **Round 3** of food gardening in a replanted oil palm plot

Note presence of banana fallows (Bialla: 1 ha replant, Block 723, oil palm 2 years old)

Beyond the third gardening round, few crops are planted and consequently the fallow area increases with fallow crops dominated by cassava, sweet potato and bananas (Figure 5.9). Block residents may continue gardening in

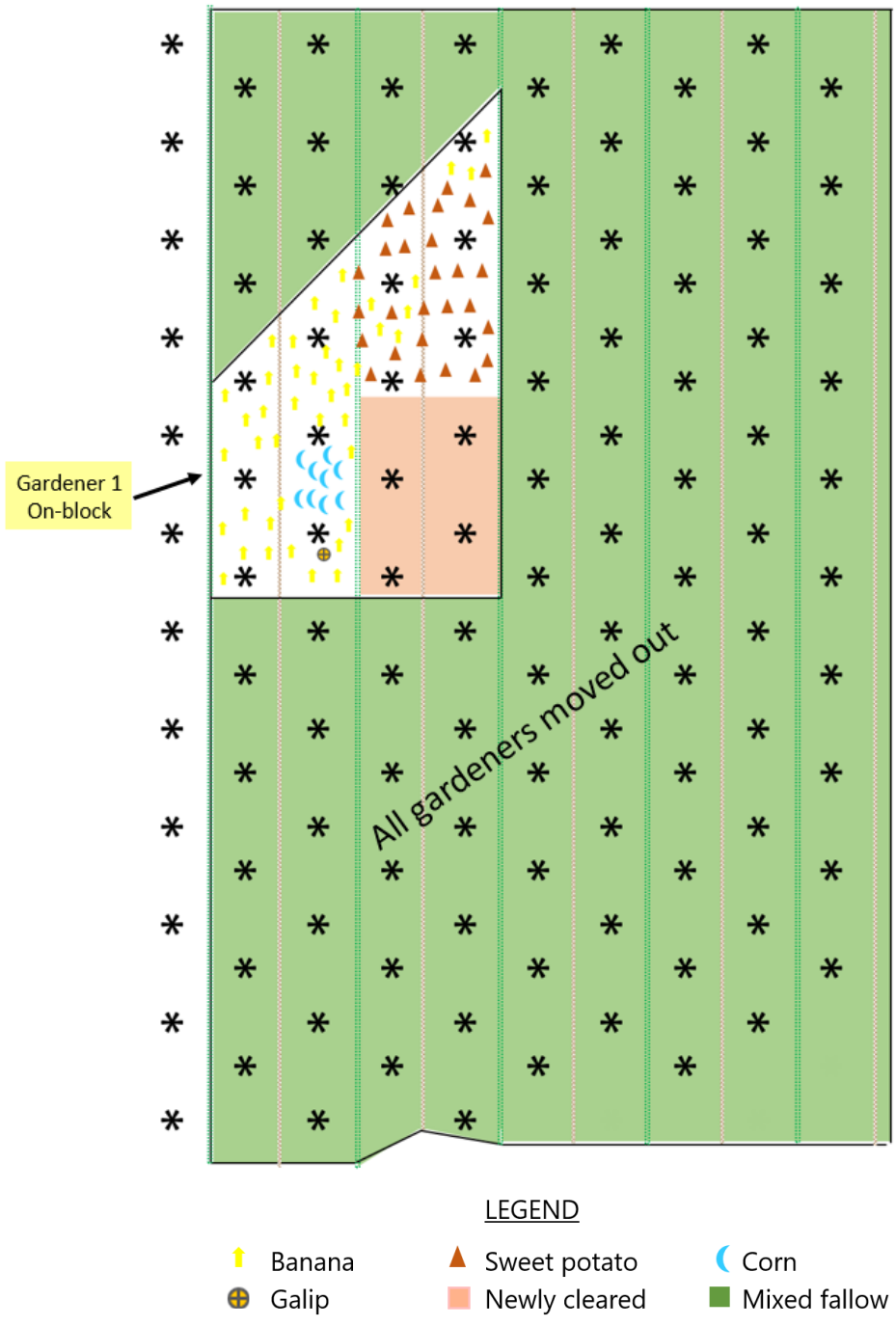

Figure 5.9. The replant area after the third round of gardening dominated by areas of fallow with residual crops of banana, sweet potato and cassava
(Bialla: 1 ha replant, Block 723, oil palm 2.5 years old)

some areas of the replant until the oil palm canopy fully closes, but the range of crops that they can cultivate narrows considerably. Labour inputs gradually fall with the emergence of an oil palm 'fallow' and labour is limited to the harvesting of residual crops. By 30 months banana occupies just 9% of the former garden area. As shade levels continue to rise, food cultivation is gradually abandoned and gardeners move on to a new oil palm replant area, if available.

As discussed above, bananas occupy a large proportion of replant gardens in every round, and increase proportionately each gardening round until they become, along with cassava, the typical final crops before being shaded out by oil palm. Cassava is valuable in times of food shortages, and can become a reserve food supply. Bananas, as Molina and Valmayor (1998) suggest, provide many benefits. Fruiting is non-seasonal so they provide a year-round supply of food. Production surplus to household consumption requirements can be marketed. They are early maturing but have an extended productive life and their overall productivity is high.

Crops grown in 1 ha vs. 2 ha replants

There was little difference between 1 and 2 ha replants in terms of the range of crops grown (Figure 5.10). When comparing crop types grown in gardening rounds 1 and 2, bananas and yams were grown in slightly higher percentages of gardens on the 2 ha replants but the occurrence of other staples and peanuts was relatively similar.

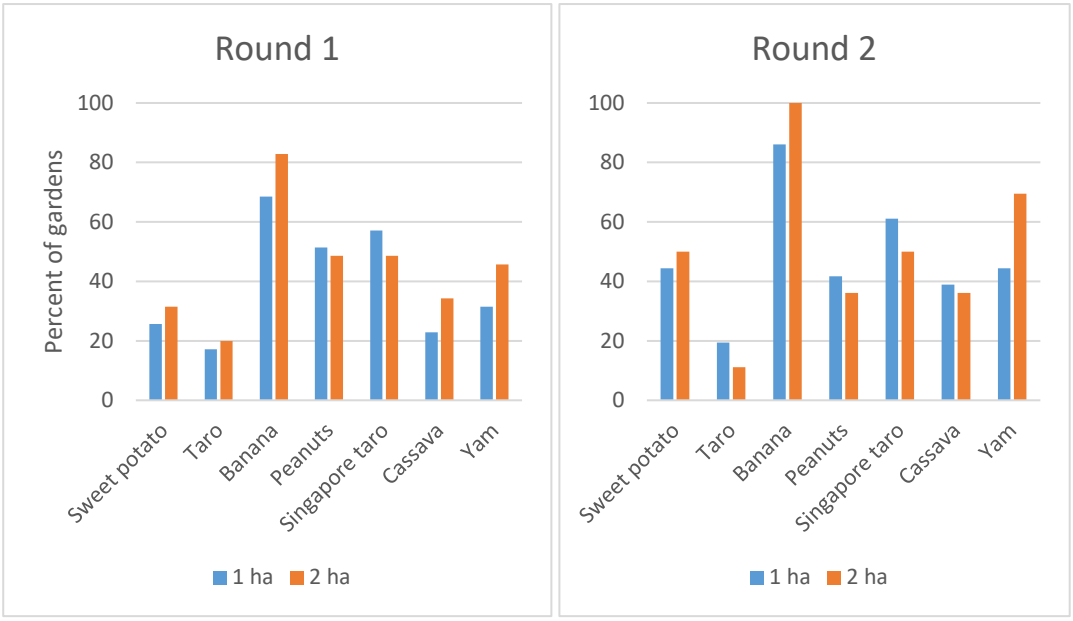

Figure 5.10. Per cent of gardens growing staple crops and peanuts in gardening rounds 1 and 2 on 1 ha and 2 ha replants

Green vegetables were grown in similar proportions of gardens on both 1 ha and 2 ha replants and included aibika, karakap and pumpkin tops (Figure 5.11). Long beans were more common in the 1 ha replants in both the first and second gardening rounds where they were grown in more than 50% of gardens.

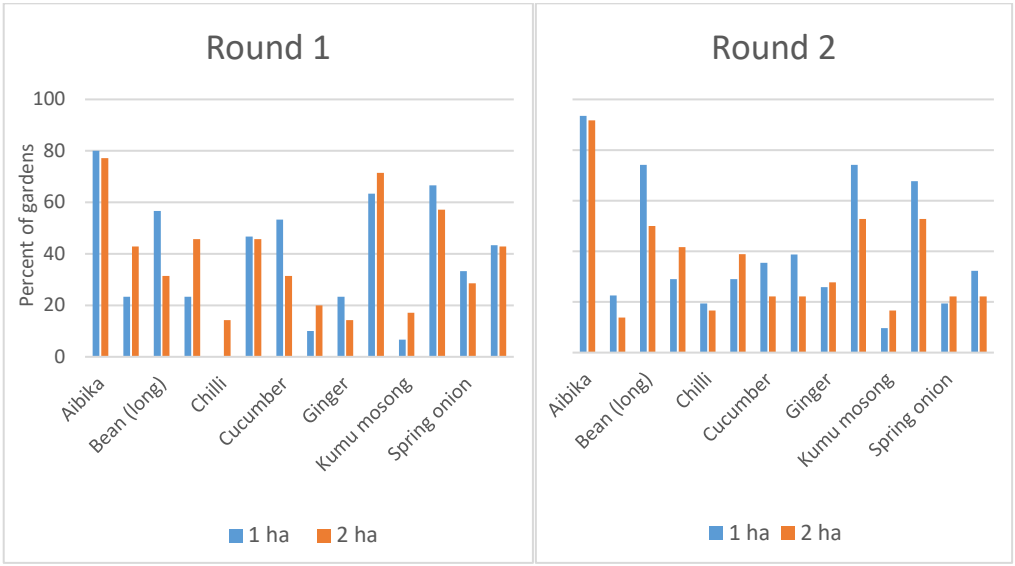

Figure 5.11. Vegetables grown in gardening rounds 1 and 2 on both 1 ha and 2 ha replants

Crop diversity

Staple crops

The varieties of each of the staple crops grown were similar in all replants (Table 5.3). Both diploid and triploid bananas were grown, with the most popular diploid being Tukuru and triploids, Kiaukiau, Highlands and Papua/Mosbi bananas. Triploid bananas give a greater yield than diploids and will produce for a longer period (Bourke, 2001). In addition to yield, cultivation of different banana varieties is based on such factors as their capacity to adapt to different conditions as well as their varied uses and tastes (Bakry et al. 2009). *One mun* was the most common variety of sweet potato grown, with this variety recognised as fast maturing and high yielding. *Crisis, three mun* and *wahgi besta* were also quick maturing, and commonly planted varieties. Both the white and red varieties of Chinese taro (*Xanthosoma sagittifolium*) were the only varieties grown and were similarly popular. The white variety of cassava was much more common than other varieties.

Table 5.3. Staple crop varieties being grown in oil palm replants in descending order of occurrence by number of gardens

BANANA (*Musa* cvs.)	**SWEET POTATO** (*Ipomoea batatas*)	**CHINESE TARO** (*Xanthosoma sagittifolium*)
Kiaukiau (triploid)	One mun	White
Highlands/Hagen (diploid)	Crisis	Red
Papua/Mosbi (triploid)	Three mun	
Tukuru (diploid)	Wahgi besta	
Popondetta (diploid)	Ox & palm	
Nakanai		
Katkattur (diploid)	**CASSAVA** (*Manihot esculenta*)	**TARO** (*Colocasia esculenta*)
Five minute		
Yawa (triploid)	White	Yellow
Four wheel (triploid)	Yellow	Ox & palm
Semis	One mun	Purple mix
Markham	Tapiok rice	Bakovi
Talasea/Kandrian (diploid)	Red	Nari
Daru (diploid)	Tapiok Buka	White
Manki		Purple
Three finger	**YAM** (*Dioscorea* spp)	Doli
Komo (triploid)		
Sepik	African yam (*D. rotundata*)	
Marau	Mami (*D. esculenta*)	
Red	Yam (*D. alata*)	
Tilak		

Other crops

Other crops in addition to staples are listed in Table 5.4. Fruits were grown widely but not over large areas. Sole perennial fruit trees could be found growing in amongst other crops with by far the most common being pawpaw which was present in more than 50% of gardens by Round 3 of gardening.[7] Aibika was the primary green leafy vegetable and was grown in all replants. In addition to being simple to grow and a popular vegetable, it is an important dietary component as it is very high in folate compared with other green vegetables such as cabbage and aupa (Devi et al. 2008; Rubiang-Yalambing et al. 2016). Watermelon was grown in a small number of gardens. Liebman and Dyck (1993) suggest that intercropping with watermelon is an effective labour saving strategy as it reduces the incidence of weeds due to its sprawling, prostrate habit. Stimulants were grown in a a small percentage of gardens with the most common being tobacco, followed by betel nut. The latter is typically planted around house sites or in gardens at the edges of the block.

[7] Pawpaw is a popular crop for sale at local markets.

Table 5.4. Other crops grown in replants in descending order of occurrence (by garden number) for each crop type

VEGETABLES	
Aibika (*Abelmoschus manihot*)	Ginger (*Zingiber officinale*)
Karakap (*Solanum nodiflorum*)	Spring onion (*Allium cepa*)
Pumpkin tips (*Cucurbita moschata*)	Kumu mosong (*Ficus copiosa*)
Long bean (*Vigna* sp.)	Chilli (*Capsicum frutescens*)
Capsicum (*Capsicum annuum*)	Pitpit (*Saccharum edule*)
Corn (*Zea mays*)	Winged bean (*Psophocarpus* sp.)
Tomato (*Solanum lycopersicum*)	Chinese cabbage (*Brassica chinensis*)
Cucumber (*Cucumis sativus*)	Cabbage head (*Brassica oleracea*)
Eggplant (*Solanum melongena*)	Garlic (*Allium sativum*)
Aupa (*Amaranthus* spp)	
NUTS	
Peanut (*Arachis hypogaea*)	Coconut (*Cocos nucifera*)
Galip (*Canarium indicum*)	
FRUITS & SUGARCANE	
Pawpaw (*Carica papaya*)	Ripe banana (*Musa* spp)
Sugarcane (*Saccharum officinarum*)	Pineapple (*Ananas comosus*)
Watermelon (*Citrullus lanatus*)	Mango (*Mangifera indica*)
Guava (*Psidium guajava*)	
STIMULANTS	
Tobacco (*Nicotiana tabacum*)	Betel pepper (*Piper betle*)
Betel nut (*Areca catechu*)	

In general, the crop types and varieties grown in replant gardens were similar on the 1 ha and 2 ha replants. There was also no evidence to suggest that gardeners residing on the block or those living off-block grew different types of crops. As part of the Food Security project, surveys were conducted on all food gardens belonging to a subset of LSS households. Garden tenure ranged from oil palm replants to the *wasblok*, buffer zones, company, state or customary land. Similar crop types and varieties were recorded repeatedly across all tenure types as were cultural practices. Therefore, despite tenure type, residence of the gardener or whether gardens were on a 1 ha or 2 ha replant, food gardening practices tended to be the same. It is for this reason that the adoption of the 1 ha replant strategy is seemingly quite a simple and straightforward innovation.

Socio-economic outcomes

Garden purpose

Crops were grown for household consumption, for marketing, or for both reasons. The purpose of cultivating gardens was beyond the scope of the in-depth surveys conducted on the seven replant blocks for this study. However, households interviewed for the baseline household surveys in 2014 were asked to identify the main purpose of their food gardens. For those who had gardens on replants, by far the majority were growing them for home consumption with some surplus produce sold at local markets.

Trials comparing 1 ha and 2 ha replants revealed gardening practices on both replant types to be very similar. Arrangements of reciprocal land access to replant areas across blocks were almost identical but with fewer gardens in the 1 ha replants than in the 2 ha replants, as would be expected. There were proportionately fewer off-block gardeners on the 1 ha replants compared with the 2 ha replants. Garden plots were similar in size with the same crops cultivated across staples, greens and other high value crops.

Smallholders at Bialla quickly identified the many advantages of the 1 ha replant and the relative ease of adaptation to their existing production systems (see Chapter 2 on income, food gardening and oil palm maintenance benefits). This strategy also generates significant benefits for the oil palm company in terms of increased production and reduced costs (Chapter 2). Recognising these potential benefits for the company and for smallholders, HOPL instituted the 1 ha replant as standard practice for replanting from the beginning of 2017.

With increasing population pressures on smallholder oil palm blocks and diminishing access to land for food gardening, the implementation of the 1 ha replant strategy has the potential to be a major contributor to long-term food security for smallholder families living on oil palm blocks throughout PNG. The long-term sustainability of the 1 ha replant strategy would require ongoing support from the oil palm companies, including continued monitoring and evaluation and regular consultation with smallholders to ensure the scheme is meeting their needs.

6. ADOPTION OF THE 1 ha REPLANT STRATEGY

The preceding chapters of this report outlined the problems associated with rising population pressure and risks to food and income security on smallholder oil palm blocks in WNBP. Per capita incomes are falling as a result of population growth which is exacerbated by the double disadvantage of repayment of replanting loans while gross income has been reduced by the poisoning of one-third of one's palms for replanting. Population pressure, loan repayments and reduced gross income during replanting have induced growers to postpone replanting for as long as possible. Furthermore, with the whole block planted to oil palm, food gardening options have become more constrained and have imposed limitations on access to land for food production. Until now, the combination of agricultural intensification and intercropping of replanted oil palm have been sufficient to sustain an acceptable level of food and income security. The 1 ha replant has strengthened this capacity to sustain food security into the future through higher incomes and improved access to gardening land.

Like any innovation, the 1 ha replant option has both advantages and disadvantages. Smallholders have been quick to highlight the advantages of the 1 ha replant option over the conventional 2 ha option, and have strongly endorsed the company's rollout of this initiative which has been a relatively smooth process. The numerous advantages of the 1 ha replant option were described in Chapters 2, 3 and 5. In this chapter, we consider potential disadvantages for smallholders and the company that may reduce the potential benefits of this new initiative.

Summary discussion

Smallholders

The disadvantages of replanting in general have been discussed previously with the primary disadvantage for smallholders being the acquisition of debt liability and reduced capacity to service loans through the loss of income from 2 ha of poisoned oil palm. However, the financial burdens of replanting are significantly reduced under the 1 ha replant strategy. It is important to note that to date no disadvantages have yet been reported to our research team by smallholders and the company and, overall, the advantages of the 1 ha

replant option vastly outweigh any disadvantages. However, potential disadvantages that may emerge for smallholders include extended periods of debt on the block; and fewer opportunities for socialising and building exchange relationships through gardening. Each is discussed briefly below.

Extended period of debt on the block because of staggered replanting. It is possible that some leaseholders will be reluctant to carry debt for an extended period because of the staggered replanting associated with the 1 ha replant. However, with five palms in production for every oil palm seedling instead of two, as in the conventional 2 ha replant strategy, loan repayment will be much faster. In other words, the switch to the 1 ha replant will be less than double the debt period of the 2 ha replant. They will also have higher net incomes during replanting. As timely replanting becomes more common, a higher proportion of palms will be in production and in the high production phase to service loan repayments. Anecdotal evidence suggests that loan repayments are much quicker under the 1 ha replant option.

Fewer opportunities for socialising and building exchange relationships through gardening. The social and kinship networks that are strengthened through engaging in reciprocal access rights to the oil palm replant areas across blocks provides a form of insurance relating to land access through time. On 2 ha replants the leaseholder has about double the number of off-block gardeners that he can call on for future access to gardening land when they replant their oil palm. However, this overlooks the point that the gardening period is doubled under the 1 ha replant strategy and we cannot assume that off-block gardeners will be the same people from the first 1 ha replant who will take-up garden plots when the second 1 ha replant is replanted. If an expansion of these networks is important for long-term food security it is likely that smallholders will cultivate these networks by entering into arrangements that increase the numbers of blocks that they can obtain access to in the future. This means that a gardener may not move to the second 1 ha replant after completing a garden cycle on the first 1 ha garden replant and will instead seek out a garden plot on another block.

The Company

There are possibly higher administrative and logistical costs associated with the 1 ha replant option. Palm poisoning is done in two stages rather than one; seedlings that were delivered to a block in a batch of 240 seedlings are now delivered in two batches of 120 seedlings a few years apart; and in the smallholder office, the number of replanting loan packages to be processed

and monitored is doubled. These are quite significant additional costs, but the productivity gains in terms of increased oil palm production are likely to be significant and should more than offset these additional costs.

Furthermore, the high total outstanding debt that smallholders have with the company is likely to be reduced significantly and rapidly. These interest-free loans are a major cost to the company. Smallholders found the debts associated with the 2 ha replanting package pernicious and very difficult to manage. Consequently, a high proportion of them sought to reduce the impact of loan repayments on their net income by shifting some or all of their FFB to neighbouring debt-free blocks. Such perverse incentives to avoid debt repayments are less likely to be a problem with the 1 ha replant because the financial pressures on smallholder families decline significantly as a result of lower overall debt levels, higher incomes and increased capacity to repay loans.

Concluding comments

It is apparent that if the benefits of a potential innovation are clearly visible to smallholders and adoption is relatively easy with little cost, uptake is much more likely to occur. Smallholders are not resistant to change, but nor are they passive acceptors of innovation and new technologies. They are highly discriminating in their approach to adoption. Adoption is much less likely to occur if initiatives are incompatible with livelihood strategies or if there is no opportunity to augment their livelihoods. The resounding success of the *Mama Lus Frut Scheme* introduced in 1997 was attributable to its ease of participation and the significant benefits generated for women and their families, including men. A need and desire for such a payment system was identified; there were few cost barriers to participation and it was incorporated into existing food crop and oil palm production strategies relatively easily (Koczberski et al. 2001; Koczberski 2007).

Likewise, the 1 ha replant appears to be on a similar adoption trajectory as the *Mama Lus Frut Scheme*. With the institutional support of the companies, it could become standard practice of replanting for all smallholder oil palm subdivisions in PNG. Smallholders have quickly identified the considerable benefits of the system both financially and in terms of accessing land for food gardening. There are few cost or structural barriers to adoption, and smallholders have recognised that it can be easily and smoothly incorporated into their food and oil palm production systems. Similarly, for the oil palm

companies few modifications are required to be made to their replanting or accounting procedures.

Table 6.1 summarises the key components accounting for the successful introduction and adoption of the 1 ha replant option amongst smallholders at Bialla. The list of components draws on a similar analysis of the *Mama Lus Frut Scheme* undertaken in 2001 (Koczberski et al. 2001). Table 6.1 lists each of these components and explains how each component is addressed by the 1 ha replant option. In essence, the fact that all issues relating to household labour, income, land tenure and economic and social well-being can be addressed by the 1 ha replant innovation presents a strong argument as to why this replanting strategy would be a success elsewhere.

Table 6.1. Key components for successful short- and long-term adoption of the 1 ha replant option

Timeframe	Key component*	How component is addressed by the 120 replant strategy
Short-term	Increases net income and well-being	Income is earned from 600 palms instead of 480 Debt levels are lower and repaid much more quickly
	Promotes more sustainable livelihoods	Increases household choices and food and income security More efficient use of household labour if replanting is done in a more timely fashion Fewer senile, low-producing tall palms Increased access to gardening land on-block
	Strengthens people's capacities to meet their basic needs	Continuity of food supply and income to meet health, education and socio-cultural obligations Women's economic empowerment through improved access to garden land and oil palm production
	Contributes to a stable social environment	Strengthened social networks through reciprocal land access arrangements enhance household and community resilience Reduced conflict and enhanced social cohesion Greater gender equity in income and access to oil palm income
	Facilitates the distribution of income within and between households	Improved access to income from food gardening for all co-resident households. On subdivided blocks (e.g. *skelim hecta*), a household replanting will continue to have access to income

		from the 120 palms still in production.
Long-term	Enhanced access to gardening land into the future	Reciprocal access rights to gardening land across blocks strengthens long-term food security.
	Compatible with existing household livelihood strategies aimed at maintaining economic and social well-being	Gardening practices used in 1 ha replant are the same as those used in a 2 ha replant so can be easily adapted to the standard oil palm production system.
	Higher incomes/revenue for families and the company	On typical 6 ha block there will be palms in 6 stages of development. Women and elderly men can harvest shorter palms, leaving younger men to harvest the taller palms.

*Key components adapted from Koczberski et al (2001: 212)

7. RECOMMENDATIONS

Given the importance of food gardens for the sustainability of the smallholder oil palm industry in PNG, we make the following recommendations:

1. To maximise the availability of gardening land in oil palm replant areas a staggered replanting schedule for each subdivision should be developed to maximise the period that land is available for food gardening. It makes little sense to have a large-scale replanting programme in one subdivision over a short period so that there are long periods in the future when land for food gardening in oil palm replant areas is in short supply.

   In a 300 block subdivision, assuming a 24 year production cycle for oil palm, there would need to be seventy five, 120 replants completed annually, equating to 9000 seedlings.

2. Preliminary studies conducted on intercropping in oil palm replants at Kapore as part of the Food Security project have shown no detrimental effects on the growth of oil palm (Nelson and Nake 2018). Further investigation could include the effect of intercropping on the rate of maturity of new oil palm seedlings and the ratio of male and female inflorescences. The purpose of this would be to determine whether young oil palms come into production earlier than when planted as a monocrop.

3. Related to Point 2, there is anecdotal evidence that juvenile oil palm comes into production earlier in 1 ha replants than in 2 ha replants. If this is correct, it may be because 1 ha replants are better maintained than 2 ha replants because of the lower labour demands for block maintenance (e.g. weeding). This should be investigated.

4. Although smallholders prefer to maintain their conventional production systems, there may be quality and yield benefits from alternative planting arrangements. Selected crop species and alternative planting geometries and temporal patterns could be trialled to maximise the utilisation of solar energy and resources in the soil stratum, including water and nutrients.

5. With ever-increasing populations on smallholder blocks, there is a need to investigate the modification of oil palm planting designs to

allow permanent intercropping with food crops. This could involve wider avenue spacing of oil palm on a section of the block to allow permanent intercropping. Maximisation of yield for the oil palm companies is dependent on a smallholder sector that is food secure.

6. On 2 ha VOP and CRP blocks where financial pressures are greater during replanting, consideration should be given to suspending loan repayments while only 1 ha of palm is in production. Once 2 ha are in production the standard repayment rate should be imposed. This would encourage 2 ha blocks to replant their oil palm in a timelier manner. If suspension of repayments is not possible, repayment rates could be lowered considerably (to say 10%) until 2 ha of oil palm are back in production.

7. It would be useful to ascertain the value of food crops produced in the three-year period following replanting of oil palm. This would provide an understanding of the true value of production (oil palm and food crops) from smallholder oil palm blocks.

8. Awareness programmes for farmers of the potential benefits of the 1 ha replant option should be instigated widely. The awareness programme should be incorporated into the training of OPIC extension officers with training materials provided by OPRA.

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Appendix 1. 1 ha replant pamphlet

Niupela opsen bilong 1 hecta riplent i ken helpim yu long gutpela sindaun insait long wel pam

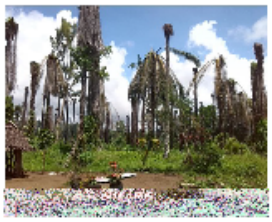
SAPOS YU INTERES LONG WOKIM 1 HECTA RIPLENT INSAIT LONG WEL PAM BLOK BILONG YU, LONG KISIM MOA TOKSAVE O HELPIM LUKIM;

PNG OPRA
Bialla Sub-Station o
Dami Researc Station.

Hargy Oil Palm Limited
na
Oil Palm Industry Cooperation
(OPIC)
Bialla

SIPEF

1 HECTA (120)
RIPLENT OPSEN



Kilim 120
wel pam diwai

Planim 120 Sidlings

Appendix 1. 1 ha replant pamphlet (cont'd)

Wonem samting em 120 pam riplent opsen?

Dispela em i wanpela nupela rot bilong wokim riplent insait long blok wel pam bilong yu. Bipo yumi save posinim 240 wel pam diwai na planim 240 nupela sidlings, tasol nau yumi gat nupela rot em long posinim 120 wel pam diwai na planim niupela. Taim yu planim niupela wel pam na em i karim gut kaikai bihain long tupela (2) yia bai yumi posinim narapela 120 wel pam diwai i sanap yet na planim niupela.

Wonem ol gutpela samting bai kamap sapos yu bihainim long 120 pam riplent opsen?

1. Nogat bikpela dinau.

Em i isi pela rot lo bekim dinau bilong replent. Taim yu posinim na planim 120 sidlings bai yu bekim dinau bilong 120 sidlings tasol igo long kampani, ino 240. Na tu narapela 120 wel pams i stap yet long prodaksen bai helpim yu long bekim dinau bilong nupela sidling. Taim u stat havest long nambawan 120 yanpela wel palm, yu ken posinim narapela 120 na planim nupela. Moni yu kisim long yanpela wel pam wantaim wel palm long narapela 4 pela hecta is sanap yet i ken helpim yu long bekim dinau long kampani na tu lukautim family.

RESIO BILONG WEL PAM I BEKIM DINAU BILONG SIDLING INSAIT LONG 2 NA 1 HECTA REPLENT.

2 Hecta replent opsen Long Prodaksen : Sidling

1 Hecta replent opsen

2. Nogat hatwok

Em i isi long lukautim, klinim na tromoi fetelaisa long ol dispel nupela 120 sidling. Wantaim gutpela lukaut wel pam bai grow strong na stat karim kaikai hariap. na tu bai gat plenti taim bilong u long lukautim ol narapela wel pam i sanap yet insait long blok.

3. Igat graun bilong wokim gaden long wel pam blok.

Posinim na planim 120 wel pam tasol bai givim inap graun bilong wokim gaden na planim kaikai insait long wel pam blok bilong yu.

Dispela i soim hamas yias bai u wokim gaden insait

	Yia 1-2	Yia 3-4	Yia 5-6	No. Bilong yia long wokim gaden
Phase1	2 ha Riplent			2
Phase 2		2 ha Riplent		2
Phase 3			2 hecta Riplent	2
Hamas yia's bai yu wok gaden				6

Dispela i soim hamas yias bai u wokim gaden insait long 1 hecta replent

	Yia 1-4	Yia 5-8	Yia 9-12	No. blong yia long wokim garden
Phase1	1ha 1ha			4
Phase 2		1ha 1h		4
Phase 3			1ha 1ha	4
Hamas yia's bai yu wok gaden				12

Dispela bai helpim yusat?

1. Ol growas we i gat bikpela populeson na ol i painim hat long bekim dinau.
2. Ol growas i save usim *Skelim hecta na makim mun* insait long blok.
3. Ol lapun growas na ol meri yusat is save painim hat long havestim longpela pam.
4. Ol bloks we nogat hap graun bilong wokim gaden (e.g. ol blok i stap namel).
5. Ol meri yusat i ken havestim sotpela pam na ol i ken wokim gaden long insait long blok longpela taim.

Appendix 2. Field sketch of a 1 ha replant