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Final report

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2 Executive summary

Cocoa production in PNG, dominated by smallholders, declined from a high of 50,000 tonne in 2010 to an average of about 36,000 tonne/annum by 2015 as a result of poor management of tall, overgrown, overshaded and highly variable hybrid seedling trees. The neglected farms were vulnerable to Phytophthora Pod Rot, and Cocoa Pod Borer following its incursion from Indonesia in 2006, leading to pod losses above 80%. Smoke tainting of cocoa dried with poorly maintained wood-fired kiln driers caused the International Cocoa Organisation to downgrade the quality profile of PNG cocoa in 2019. Poorly funded government research and extension services failed to address these problems. The project sought to foster production of smallholder cocoa in East Sepik, Madang, New Ireland and Simbu Provinces by developing self-supporting village farmer-extension workers (here called Cocoa Model Farmer-Trainers – CMFTs) linked to government research and extension services, and by promoting farmer-centred research, and cocoa farming and related activities as family businesses (Objective 1).

- The project trained CMFTs (mainly husband/wife teams) in 81 villages (22 in New Ireland, 25 in Madang, 27 in Sepik, 7 in Simbu). They were supported to work with farmers to establish budwood gardens of superior cocoa clones developed at the PNG Cocoa Coconut Institute (CCI) and train farmers in bud grafting to propagate clones, thus making them widely available. Training in sustainable farming livelihoods, including gender equity, health and financial literacy, was provided by the University of Natural Resources and Environment (UNRE) and through a collaboration with ASEM/2014/095 (Improving opportunities for economic development for women smallholders in rural Papua New Guinea) that provided Family Farm Team training, with a senior CCI officer becoming an accredited trainer. Twelve thousand copies of two farmer handbooks, one in Tok Pisin, covering all aspects of cocoa production were written and distributed to guide on-going farmer-education in villages.
- The strategy was enthusiastically adopted by most CMFT groups and by many self-funded satellite groups or nearby villages linked to CMFTs (107 in East Sepik, 137 in Madang, 40 in New Ireland, 28 in Simbu). A man who attended training in New Ireland extended the project to his home area in West Sepik using his own resources to develop 40 farmer groups. The strategy was also adopted by a New Ireland Provincial Government Cocoa Project and by an FAO/EU development project in the Sepik.
- Participation by women and youth was high as the benefits from a renewed effort in cocoa farming (better management, planting of superior clones instead of variable seedlings) were seen and income from cocoa contributed to family welfare. The main local cocoa buying and exporting company, NGIP-Agmark, reported greater enthusiasm for cocoa and greater production in 2021 than in previous years. Nearly all CMFTs surveyed considered that they will be able to continue their mentoring role, supported by their improved cocoa production, sale of planting material, fermentary businesses, or fee-for-service.

Objective 2 was to introduce and evaluate, with farmer participation led by CMFTs, new cocoa cultivars and cocoa selection, propagation, production and postharvest methods.

- Nearly 100 budwood gardens with the 18 superior CCI clones were established by CMFTs across the four provinces. Many farmers became skilled budders, giving them access to the clones previously available only from research stations and allowing local assessment of the clones in different environments. Farmers were encouraged to propagate the best clones from the budwood gardens and to produce clones from the best seedling trees on their farms.
- Cocoa has generally been considered to have an upper altitude limit of about 600 masl, but the test planting in 2008 by CCI of hybrid seedling cocoa at 1200 masl in Karimui Valley produced some impressive trees with many large pods. The project trained farmers in cocoa management and clonal propagation that enabled them to select and test trees from the original highly variable test planting as well as from budwood gardens of CCI clones stablished during the project. Fermentaries and solar driers were built, and export of dry cocoa beans from the district increased from 1 tonne in

2015 to 25 tonne in 2019. As a farmer, Miriam, said – “Cocoa has changed our lives.” Women commented that cocoa can give an income every 2 weeks compared with only every 6 months for coffee. A woman farmer, Bomagai Wei, established a large project extension using her own resources in Gumine District, adjacent to Karimui. The selection and testing of cocoa types adapted to the highlands is continuing with farmer participation. Project staff promoted cocoa growing and test plantings in other highland provinces with potential for cocoa.

- Forty plastic covered solar driers were built by CMFTs and others for testing and demonstration. They are a fraction of the cost of a conventional kiln drier, the essential materials (a roll of UV-resistant plastic film) are easier to transport to isolated areas, and they eliminate smoke tainting of beans and the need for firewood collection and stoking of fires. Women reported that they require less labour and are cleaner. A handbook on construction and operation of the driers was prepared. Farmers were enthusiastic about the driers and modified the basic design, for example by substituting bamboo slats and shade cloth for expensive wire mesh drying beds. The project demonstrated that cheap methods of solar drying are effective and available to smallholders to allow them to realise the full value of their production by selling dry beans. Some cocoa buyers are paying a premium of 10% for solar dried cocoa.
- Preliminary results of trials conducted in East Sepik in collaboration with SMCN/2014/048 (Optimising soil management and health in PNG integrated cocoa farming systems) showed that deep ploughing and ripping of the kunai grassland soils have potential to allow establishment of shade trees and cocoa on the vast Sepik Plains and a CMFT group in Bogia District, Madang, established cocoa on grassland.
- Most CMFTs reported reduced damage by Cocoa Pod Borer with improved management methods, especially heavy pruning of cocoa and shade used to rehabilitate cocoa plantings abandoned because of the pest. The effect of planting of new clones and possible biological control on the pest are yet to be assessed.

Objective 3 was to introduce and evaluate, with farmer participation led by CMFTs, options for developing cocoa farming systems integrating food crops, livestock and high-value shade and other crops.

- Farmers routinely integrated food crops with cocoa, especially during the early stages of establishing a new planting such as a budwood garden when shade levels are low. Trials on wider spacing of cocoa to allow more food crop integration, and possibly reduce pest/disease problems in cocoa, are required.
- High prices encouraged the planting of vanilla as an adjunct to cocoa, with vanilla vines being grown on the shade trees. This diversified household incomes and encouraged family members to spend more time on block maintenance to the benefit of both crops.
- In collaboration with the UNRE, three successful goat colonies were established by CMFTs, creating great interest from farmers and showing the potential for goat husbandry to be integrated with cocoa farming. Goats thrived on weeds and prunings from the *Gliricidia* shade trees (an animal fodder tree), encouraging the pruning required for good cocoa management. Goat manure collected from under raised goat houses contributed to compost production and manuring of cocoa. There was high demand for goats by farmers and it was evident that they could become an important part of smallholder farming systems in PNG as they are in Indonesia.

The great innovative potential of village farmers was evident during the project. They changed from conventional raising of plants in polybags in large central nurseries introduced at the start of the project to use of small field nurseries or field planting of seed and field budding, obviating the need for costly nurseries and the arduous task of transporting plants in polybags. Farmers enthusiastically adopted the idea of endogenous village extension training, forming many groups in addition to project CMFT groups. They also took up and adapted a range of low-cost and beneficial technologies including various designs of solar driers, cheap budding knives, plastic film substitutes for expensive budding tape, chupon budding with new clones to renovate old trees, farmer selection of good trees, new methods of clonal propagation of trees, and the integration of vanilla with cocoa.

3 Background and project development

Cocoa is an important export commodity and driver of village development that has not reached its full potential to improve farmers' livelihoods in PNG

Cocoa exports now average about 36,000 t dry bean annually, valued at US$88 million in 2019, with village farmers contributing more than 90% of production (https://www.statista.com/statistics/497885/production-of-cocoa-beans-in-papua-new-guinea/). Over 150,000 families in 14 provinces rely on cocoa for cash income required to pay school fees, purchase high protein food, and pay for medical treatment among other things. It was the largest source of income in East New Britain before 2006 and accounted for the province's prosperity (Curry *et al.* 2009). It was also the major source of village income in Bougainville before the crisis of 1988-98. Widespread planting by smallholders of hybrid seedling cocoa from 1980 to 2000 boosted production to a peak of about 50,000 t in 2010 but production has declined since then as a result of the incursion of Cocoa Pod Borer and lack of research and extension effort to address the general management and pest and disease problems faced by smallholder village farmers.

Reasons for decline and stagnation of cocoa production

The precocious hybrid seedling cocoa and the recommended shade tree, *Gliricidia sepium (https://en.wikipedia.org/wiki/Gliricidia_sepium)*, developed under the influence of expatriate plantations prior to independence, eventually proved to be inappropriate for village farmers: the fast-growing cocoa and shade trees required regular heavy pruning to prevent over-shading and maintain production, the hybrid cocoa seedlings were highly variable (with most of the production occurring on a small proportion of trees, with unproductive trees occupying scarce land for no return), and the early high yield of the hybrids began to decline after a few years. The heavy work needed for pruning, the high proportion of 'passenger' trees and the yield decline caused farmers to neglect their cocoa plantings, which became tall and over-shaded, resulting in low yields, under-harvesting and heavy losses to Phytophthora Pod Rot (Black Pod) (Curry *et al.* 2007). The Cocoa Pod Borer moth (*Conopomorpha cramerella,* CPB) incursion from Indonesia in 2006 was favoured by the neglected state of the farms and pod losses from Black Pod and CPB together increased to over 80%, leading to widespread abandonment of cocoa and undermining the livelihoods of smallholders and the goal of the Cocoa Industry Strategic Plan 2016-2025 (Cocoa Board of PNG 2016) to increase cocoa production to 90,000 t per annum by 2025. PNG has had a reputation for some of the world's highest quality cocoa, based on its fine-and-flavour Trinitario component derived from original German introductions, but this reputation has been lost in recent years due to smoke tainting of beans during drying with poorly maintained wood-fired kiln driers that have been recommended since the 1960s, again under the influence of plantation practice. The International Cocoa Organisation downgraded the fine-and-flavour rating of PNG's cocoa from 90 to 70% in 2019 because this problem was not being addressed by the PNG Cocoa Board.

Research supported by ACIAR and AusAID has addressed many problems in cocoa production

Research supported over many years by AusAID and ACIAR at the PNG Cocoa Coconut Institute (CCI), Tavilo, East New Britain Province, has produced sound knowledge of how to grow cocoa well in the face of pest and disease problems (see PNG Cocoa Extension Manual, CCI, 2017, and PNG Cocoa Farmer's Handbook, CCI, 2017). Clones have been selected from the best of the hybrid seedlings to give more uniformly productive and smaller trees more suitable for smallholders. Methods of growing cocoa as a smaller tree with more regular pruning of cocoa and shade trees and frequent sanitary removal and disposal of CPB and Phytophthora infested pods were developed under ASEM/2003/015 (summarised in Konam *et al.* 2011) (see References for project titles). Small-scale cocoa fermenting and drying methods were developed under the AusAID Cocoa Quality Improvement Project (1992-96) and PHT/1995/136. A fundamental strategy for increasing the productivity of cocoa is to transition from tall, labour-intensive plantings to smaller, more manageable trees that can be integrated better into traditional village farming and food crop systems, be resilient if neglected when prices are low or labour is short, and require less labour for harvesting and regular, 'light-touch' management. Research under ASEM/2006/127 has shown that this transition can free up time for other activities and facilitate the involvement of women in managing cocoa alongside food crops.

Poor uptake of research recommendations on farms due to a failure of conventional extension and inappropriate research approaches
Adoption of the above knowledge on farms has been poor, as evident in the stagnation of PNG's cocoa production despite a doubling of global demand since 2000 and an effective marketing system within PNG involving several competing buyers and exporters of dry bean. Extension services have been ineffective, very poorly resourced, and fragmented and uncoordinated over four levels of government (National, Provincial, District and Local Level Government) (Sitapai 2012). Many cocoa buying companies and development agencies have conducted training programs to address this deficiency. However, the training programs, like the government services, were usually based on intermittent 'training and visiting' extension methods that have proved to be expensive to run and ineffective for village agriculture in PNG because they fail to engage farmers in ways meaningful to their lives. Geared to a high-input, male-dominated plantation outlook, cocoa development and extension in villages often failed to address the reality of the lives of village farmers, including their diverse livelihood strategies based on self-sufficiency through food crop production, low-input farming methods, high value and time placed on socio-cultural activities, and the important role of women in all farming activities. Based on detailed field studies (ASEM/2006/127, ASEM/2012/072), Curry and Koczberski (2009) concluded that smallholder cocoa production and livelihoods were limited by farmers' inadequate knowledge of the new technologies developed at Tavilo, their lack of access to the new suite of hybrid clones developed at Tavilo, and their lack of access to effective and regular advice about how these could be incorporated into village life. It was shown that more intensive training of cocoa farmers under a program run since 2008/9 by the cocoa buying company NGIP-Agmark Ltd. in East New Britain greatly improved farm management and encouraged farmers to resume working cocoa blocks abandoned after the CPB incursion. It was noted that, despite the dramatic impact of CPB, farmers still had trust in cocoa to provide a regular source of income and recognised that improved management could restore production.

Development of a new extension model to be rolled out and tested in the project
The Agmark program trained lead farmers, selected for showing good community engagement and leadership, who in turn trained other farmers and remained as a permanent source of advice and support in villages. This approach was applied in the project in four provinces, East Sepik, Madang, New Ireland and Simbu (Karimui District), to provide a more coordinated extension system reaching to villages by training lead farmer-trainers (here called Cocoa Model Farmer-Trainers, CMFTs) and linking them to government extension staff.

The lack of female extension officers and the neglect of female farmers in extension activities have been identified as serious impediments to effective village development by Curry and Koczberski and their students (e.g. Hamago 2019; 2021), and on a global scale by FAO (2019) and the World Bank (2014). An attempt was made to address this in the project.

Particular research questions that were intended to be addressed in the project through involvement of CCI research staff with the participation of farmers
While the development of a permanent, village-based extension system was the main objective, particular studies involving the participation of farmers led by CMFTs were planned as follows –

1. Testing of solar cocoa driers to overcome the problem of smoke tainting of beans, especially to test a type of drier that had been developed by Trevor Clarke and John Konam in an AusAID project in the Solomon Islands. It was known that most cocoa, including the global standard cocoa from Ghana, and all cocoa in Sulawesi, Indonesia under similar climatic conditions to PNG, is sun dried using cheap and simple methods readily available to smallholder farmers. The hot-air kiln driers promoted in PNG since the 1960s are expensive to build and maintain and are therefore not readily available to smallholder farmers.
2. Assessing the extent to which incidence of CPB is being reduced by the build-up of natural predators and parasites, as observed previously in Sulawesi.
3. Further testing the 18 latest CCI ‘hybrid clones’ in a wide range of environments, especially for their degree of resistance to pests and diseases such as CPB, Phytophthora Pod Rot and Stem Canker, and Vascular Streak Dieback. The senior plant breeder at CCI, Dr Peter Epaina, considers that the clones require further testing.
4. Assessing methods of maintaining soil fertility in cocoa plantings, especially by composting and use of cocoa wastes. This aspect was planned in collaboration with SMCN/2014/048 (Optimising soil management and health in PNG integrated cocoa farming systems).
5. Incorporation of goat husbandry into cocoa farming as commonly seen in Indonesia, as a source of income and high protein food, as an incentive to prune the widely used leguminous shade tree, *Gliricidia sepium,* a known fodder tree, to feed the goats, and as a source of manure to assist composting of cocoa waste.

4 Objectives

Aim: To foster enterprise-driven transformation and increased production and profitability of smallholder cocoa in East Sepik, Madang, New Ireland and Simbu Provinces of Papua New Guinea, working with families through village extension workers

This overall aim will be achieved through the following three working objectives.

Objective 1: To foster the development of profitable, self-supporting, village-based cocoa extension and other services as micro-enterprises supported by financial institutions, commercial cocoa buying and supply companies, and existing research and extension services

Activities led by Project Leader and Project Manager and Provincial Project Coordinators:

1. Inception meeting of all stakeholders
2. Hold planning meetings with all stakeholders in each Province
3. Visit selected villages in each province and in awareness meetings discuss the project with LLGs, Ward Committees, village leaders and farming families, and recruit Village Extension Workers (VEWs, here called Cocoa Model Farmer Trainers, CMFTs)
4. Work with financial institutions to support small businesses based on cocoa advisory, production, postharvest processing and buying, leading to on-going education of the institutions about cocoa businesses
5. Train Village Extension Workers/Cocoa Model Farmer-Trainers (VEWs or CMFTs)
6. Introduce and support CMFTs as self-sustaining advisory businesses in villages
7. Establish other small cocoa businesses in villages (nurseries, cocoa fermenting and drying)
8. Using digital survey methods (CommCare), monitor changes in uptake of new cocoa varieties and planting methods, farm health, farm productivity and farmer family livelihoods, and assess development of village-based micro-businesses in both project-supported and non-supported groups
9. Hold three Central Meetings of the Provincial Project Coordinators and Assistant Coordinators during the project
10. Promote the involvement of women in cocoa farming through the activity of the Assistant project Coordinator and Advisor on Women in Agriculture, based in Madang, and through collaboration with TADEP Project ASEM/2014/092.

Key outcomes expected:

1. Establishment by families or farmer groups of village-based, profitable, cocoa advisory, training and market services and other cocoa-based businesses, supported by CCI (REDS), DPI, cocoa companies and financial institutions
2. Enhanced outreach capacity of provincial CCIL, Cocoa Board and DPI extension services through links to self-supporting, village-based extension and training services
3. Better understanding of benefits and difficulties of development of small enterprises and innovative, commercially-driven extension methods to improve uptake of best options under Objectives 2 and 3
4. Better understanding by all agencies of the cocoa value chain, value chain development and the profit motive, and increased expression of entrepreneurship and leadership
5. Wider family-labour involvement in, and benefit from, cocoa production, and improved understanding of the benefits and challenges of greater involvement of women and youth in cocoa production in the different provinces
6. Improved marketing of cocoa through the normal channels of the key buying companies linked to CMFTs and greater niche marketing

7. Improved public-private institution relationships for cocoa research and development

Objective 2: To introduce and evaluate on farms, with farmer participation led by village extension workers, transformative new cocoa cultivars and cocoa selection, propagation, production and postharvest methods

Activities in all villages driven by CMFTs, supported by Provincial Extension Officers and Provincial Project Coordinators, and directed by Project Manager:

1. Introduce new SG2 (hand pollinated) hybrid seedlings from CCIL for immediate planting on farms to allow comparison with existing plantings
2. Establish demonstration blocks of the recommended Hybrid Cocoa Clones from CCIL and local selections in association with budwood garden and nursery businesses (to give local production of clones for sale to farmers after 2 years); in the highlands select clones from the best performing trees at Karimui and test these more widely
3. Select and propagate clones from the best local cocoa trees growing on farms, prospect for more outstanding Trinitario clones, and test new generation hybrid clones
4. Establish demonstration blocks of improved cocoa management methods (rehabilitation of blocks by heavy pruning, frequent pruning of cocoa and shade trees, weekly sanitation pod removal, regular harvesting, fertilisation) on farms and train farmers in these methods by working with them
5. Improve soil fertility through recycling farm waste and organic amendments and conducting field trials of these methods, with an emphasis on the establishment of cocoa growing under *Gliricidia* on kunai grassland in East Sepik and elsewhere
6. Further study the production and physiology of cocoa in the highlands in comparison with the lowlands
7. Monitor pests and diseases, including biocontrol of Pod Borer
8. Conduct surveys, extension, development and field testing of new methods of cocoa fermentation and drying to improve cocoa quality, especially testing and extending the use of simple, cheap active solar driers

Key outcomes expected:

1. Increased production and profitability of cocoa on small, lightly shaded trees of new varieties given constant management attention but requiring less overall labour input than larger, overgrown trees
2. Increased village-level capacity for cocoa rehabilitation, selection, propagation, experimentation and management sustainable as commercial entrepreneurial activity
3. Greater proportion of high quality cocoa trees on farms
4. Wider collection of Trinitario cocoa clones
5. Increased understanding and use of organic farm waste to sustain soil fertility and dispose of sources of pest/disease infestation
6. Greatly reduced losses of cocoa production due to pests and diseases
7. Increased understanding of biocontrol of Pod Borer and the local VSD situation
8. Increased understanding and use of small-scale cocoa fermenting and drying methods, especially involving solar drying, producing high quality cocoa beans with minimal smoke tainting
9. Increased understanding of the potential for cocoa production in certain highland valleys and on kunai grasslands, especially on the Sepik plains
10. Increased capacity to undertake cocoa certification and supply to bulk and niche markets

Objective 3: To introduce and evaluate on farms, with farmer participation led by village extension workers, options for development of new cocoa farming systems integrating food crops, livestock and high-value shade and other tree crops

Activities:

1. Conduct initial discussions and surveys of cocoa farming systems
2. Assess current ways in which food crops are combined with cocoa on farms and establish and assess plots of different cocoa/food crop systems
3. Assess current incorporation of penned livestock in cocoa farms, and test on farms new ways in which livestock production (including goats) can be integrated with cocoa farming
4. Train farmers in use of alternative shade trees for cocoa and encourage adoption of new, high-value shade trees, including coconut, betel nut, bananas, vanilla growing on *Gliricidia,* and small fruit trees (e.g. pawpaw)
5. Study ways in which larger tree crops (e.g. galip nut, oil palm) can be planted on cocoa farms to supplement incomes; investigate the use of solar cocoa driers for drying galip nuts
6. Using digital survey methods (CommCare) monitor the uptake and success of integration of cocoa, food crop, livestock and high-value shade trees and other tree crops, and the involvements of family labour in, and benefit from, diversified cocoa farming systems

Key outcomes expected:

1. Increased knowledge and adoption of the best crop options and planting systems for combining food crops with intensified cocoa growing
2. Increased involvement of women and youth in management of smaller cocoa trees integrated with food crops and knowledge of benefits and challenges
3. Increased knowledge of and adoption of intensified husbandry in pens of livestock, including traditional pigs and chickens but also Muscopy ducks and goats, as a synergistic adjunct to a cocoa/food crop farming system
4. Evaluation of the potential of penned goats as a small ruminant fed on cocoa and shade tree prunings and pod waste
5. Increased support for coconut shade given the increased market demand for dry nuts
6. Increased knowledge and adoption of high-value tree crops such as *Canarium* (galip) nut as shade trees for cocoa
7. Adoption of various diversified farming systems, offering sustained increases in household income and well-being

5 Methodology

Objective 1: To foster the development of self-supporting, village-based cocoa extension services as micro-enterprises supported by financial institutions, commercial cocoa buying and supply companies, and existing research and extension services

Activities led by Project Leader and Project Manager and Provincial Project Coordinators:

1. Inception meeting of all stakeholders
2. Hold planning meetings with all stakeholders in each Province
3. Visit selected villages in each province and in awareness meetings discuss the project with LLGs, Ward Committees, village leaders and farming families, and recruit Village Extension Workers (VEWs, here called Cocoa Model Farmer Trainers, CMFTs)
4. Work with financial institutions to support small businesses based on cocoa advisory, production, postharvest processing and buying, leading to on-going education of the institutions about cocoa businesses
5. Train Village Extension Workers/Cocoa Model Farmer-Trainers (VEWs or CMFTs)
6. Introduce and support CMFTs as self-sustaining advisory businesses in villages
7. Establish other small cocoa businesses in villages (mainly nurseries and cocoa processing businesses; some pruning teams)
8. Using digital survey methods (CommCare), monitor changes in uptake of new cocoa varieties and planting methods, farm health, farm productivity and farmer family livelihoods, and assess development of village-based micro-businesses in both project-supported and non-supported groups
9. Hold three Central Meetings of the Provincial Project Coordinators and Assistant Coordinators during the project
10. Promote the involvement of women in cocoa farming through the activity of the Assistant project Coordinator and Advisor on Women in Agriculture, based in Madang, and through collaboration with TADEP Project ASEM/2014/092.

Objective 2: To introduce and evaluate on farms, with farmer participation led by village extension workers, transformative new cocoa cultivars and cocoa selection, propagation, production and postharvest methods

Activities in all villages driven by CMFTs, supported by Provincial Extension Officers and Provincial Project Coordinators, and directed by Project Manager:

1. Introduce new SG2 (hand pollinated) hybrid seedlings from CCI for immediate planting on farms to allow comparison with existing plantings
2. Establish demonstration blocks of the 18 latest recommended Hybrid Cocoa Clones from CCI and local selections in association with budwood garden and nursery businesses (to give local production of clones for sale to farmers after 2 years); in the highlands select clones from the best performing trees at Karimui and test these more widely
3. Select and propagate clones from the best local cocoa trees growing on farms, prospect for more outstanding Trinitario clones, and test new generation hybrid clones
4. Establish demonstration blocks of improved cocoa management methods (rehabilitation of blocks by heavy pruning, frequent pruning of cocoa and shade trees, weekly sanitation pod removal, regular harvesting, fertilisation) on farms and train farmers in these methods by working with them
5. Improve soil fertility through recycling farm waste and organic amendments and conducting field trials of these methods, with an emphasis on the establishment of cocoa growing under *Gliricidia* on kunai grassland in East Sepik and elsewhere
6. Further study the production and physiology of cocoa in the highlands in comparison with the lowlands

7. Monitor pests and diseases, including biocontrol of Pod Borer
8. Conduct surveys, extension, development and field testing of new methods of cocoa fermentation and drying to improve cocoa quality, especially testing and extending the use of simple, cheap active solar driers

Objective 3: To introduce and evaluate on farms, with farmer participation led by village extension workers, options for development of new cocoa farming systems integrating food crops, livestock and high-value shade and other tree crops

Activities:

1. Conduct initial discussions and surveys of cocoa farming systems
2. Assess current ways in which food crops are combined with cocoa on farms and establish and assess plots of different cocoa/food crop systems
3. Assess current incorporation of penned livestock in cocoa farms, and test on farms new ways in which livestock production (especially goats) can be integrated with cocoa farming
4. Train farmers in use of alternative shade trees for cocoa and encourage adoption of new, high-value shade trees, including coconut, betel nut, bananas, vanilla growing on *Gliricidia,* and small fruit trees (e.g. pawpaw).
5. Study ways in which larger tree crops (e.g. galip nut, oil palm) can be planted on cocoa farms to supplement incomes; investigate the use of solar cocoa driers for drying galip nuts
6. Using digital survey methods (CommCare) monitor the uptake and success of integration of cocoa, food crop, livestock and high-value shade trees and other tree crops, and the involvements of family labour in, and benefit from, diversified cocoa farming systems

Note:

1. Because of difficulties encountered with the use of CommCare in the baseline surveys in 2016-17, and preference for use of paper survey forms that could be referred back to during data analysis, CommCare was not used in the final CMFT surveys.

2. Because of restrictions imposed because of COVID-19, the final focus group discussions and assessments were limited and different local focus group coordinators were employed in each province without prior training. Each focus group coordinator let participants drive the discussions and information collected, because it was important to find out what was important for the participants themselves in terms of what they valued or valued less about their participation in the project. This limited comparisons that could be made between provinces.

6 Achievements against activities and outputs/milestones

Objective 1: To foster the development of self-supporting, village-based cocoa extension and other services as micro-enterprises supported by financial institutions, commercial cocoa buying and supply companies, and existing extension services

No.	Activity	Outputs/ Milestones achieved	Date done	Comments
1.1	Inception meeting of stake-holders at CCI, Tavilo	Developed priorities and plans for conduct of project, plans for recruitment, training and support of VEWs (CMFTs), plans for establishing micro-enterprises	1 Feb 2016	Stakeholders from private companies, provincial governments, Cocoa Board, World Bank PPAP, financial institutions participated in inception meeting. Objectives and workplans were discussed and approved, 'Village Extension Worker – VEW' changed to 'Cocoa Model Farmer-Trainer – CMFT' on advice from Madang DPI and to avoid use of word 'extension' which has colonial overtones and implies 'top-down' rather than participatory education.
1.2	Meetings with stake-holders in each province	Provincial CCI extension officers were nominated as project coordinators. Plans and priorities for project operations were designed with provincial staff. Selection criteria for CMFTs were established.	Feb 2016	Met with Provincial Govt and DPI staff in each province and obtained strong support for the project. The project paid salaries for the coordinator in Simbu Prov. (Dr John Konam in his home province), and assistant coordinators in Simbu, Madang and East Sepik. In Nov 2017 CCI was dissolved and CCI extension staff in the provinces became REDS staff of the PNG Cocoa Board. Provincial DPI staff gave strong support. Broad objectives were adapted to local situations.
1.3	Coordinators visited selected villages and discussed the project with leaders of LLGs, wards, and villages	Agreement from LLGs, wards, villages on involvement in project. Women and men were selected for training as CMFTs.	Feb 2016	There was great enthusiasm from LLG, wards and village leaders willing to participate, and both women and men eager to undertake training, to the extent that the number of villages (CMFTs) to be involved was extended from the 10 originally planned and budgeted for to about 20 in each province (7 in Karimui District, Simbu Prov.).
1.4	Work with financial institutions to support micro-businesses; on-going liaison with institutions	CEO of PNG Dev. Bank attended inception meeting and Trevor Clarke and Alfred Nongkas had several meetings with financial institutions.	Feb 2016	Little progress was made in encouraging financial institutions to invest in cocoa farming, after their unfortunate experiences following the incursion of Cocoa Pod Borer. This required initiative from the Cocoa Board, which was not forthcoming.
1.5	Train Cocoa Model Farmer-Trainers (CMFTs)	Approx. 20 CMFTs from each province (7 in Karimui) were trained by coordinators in the latest CCI cocoa clones, budding, and management, and by UNRE Kairak Training Centre staff in sustainable livelihoods.	Mar - May 2016	Because of transfer of $400,000 funding from Payment 1 to Payment 2 at DFAT's direction, the project began only in New Ireland, led by the CCI Extension Officer Kula Daslogo, who contributed greatly to on-ground development of the project strategy. Of the roughly 20 CMFTs recruited in each lowlands province 18 were men, but all spouses (in one case, a mother) attended training and participated strongly. The training began in Madang, East Sepik and Simbu in Feb 2017

No.	Activity	Outputs/ Milestones achieved	Date done	Comments
1.6	Support CMFTs as self-sustaining advisors in villages	CMFTs established as advisors in villages and paid part-time, to be phased out as they became self-supporting	June 2016 - Dec 2016	In New Ireland CMFTs trained farmers under the supervision and support of Kula Daslogo who repeatedly visited them. Payments to CMFTs were phased out as funds were diverted to other purposes that were not budgeted for (housing for coordinators in Madang and Wewak, vehicles in Madang and New Ireland). CMFTs became self-sustaining through cocoa farming, nurseries and cocoa processing. CMFTs in ESP were not paid.
1.6a	Recruit farming families for training by CMFTs	Each CMFT signed up about 25 farming families	June 2016 – Dec 2016	Families willing to work with CMFTs were signed up in each village and were trained in new methods by CMFTs.
1.6b	Establish data bases	Applications from farmers for assistance received through provincial coordinators and CMFTs	Feb 2016 – Dec 2016	Data base kept for follow-up visits compiled by provincial coordinators. Records kept of all farmers participating - used for follow-up, monitoring and evaluation.
1.6c	Produce and distribute training materials	Production and distribution of: 1. CCI Cocoa Farmer's Handbook and CCI Cocoa Extension Manual 2. CCI Cocoa Farmer's Handbook translated into Tok Pisin, published and 2,000 copies distributed 2. Pacific Islands Cocoa Book written by Trevor Clarke, published and 10,000 copies distributed 3. 20 Powerpoint presentations prepared for use by REDS extension staff	June 2016 – Nov 2017 Nov 2019 April 2020	Handbooks in Pidgin or English were very popular with farmers, promoting technical and livelihood topics. Poor internet connections and cost of Digicel services precluded the development of useful digital applications. Mobile phones were the most useful facilities for connection of provincial coordinators, farmers and project managers. Digital data base systems tested for record keeping during the assessment phase of the project. A Digicel Closed User Group was established to connect project staff but eventually proved too costly and unworkable. In the last two years of the project, Facebook uploads by project coordinators in East Sepik demonstrated the usefulness of this system.
1.6d	Discuss new methods with farmers	CMFTs introduced use of budwood gardens, nurseries, budding methods, cocoa management to farmers	June 2016 – Dec 2020	CMFTs were trained in these methods and returned to their villages as permanent sources of advice to fellow farmers.
1.6e	Plan and conduct Base Line Surveys	Base Line Surveys designed, conducted with paper forms, entered in a data base and analysed	June – Dec 2016	Baseline Surveys were conducted in each province by provincial coordinators and their support staff and DPI staff, using paper forms. An attempt was made to use the CommCare app but this was unsuccessful due to lack of resources to buy smartphones and digital notepads, and lack of resources to charge mobile phones in the field. Project co-leaders George Curry and Gina Kocsberski preferred paper recording based on their long experience in conducting social science surveys.
1.6f	Train farmers	A pool of trained farmers linked and working with each CMFT	June 2016 – Dec 2020	Many farmers were trained in these methods and there was evidence of increased enthusiasm for planting cocoa. Some CMFT groups dropped out but most remained active to the end of the project and other farmers in neighbouring villagers became involved, forming 'satellite' groups.

No.	Activity	Outputs/ Milestones achieved	Date done	Comments
1.7	Establish other small cocoa businesses	Nurseries and cocoa processing businesses were established	June 2016 – June 2019	One CMFT at Yekimbole in East Sepik established a successful wet bean buying, fermenting and drying business, based on use of solar driers introduced by the project. This is a model for future village-level business development. Several CMFTs established commercial nurseries and sold clones and seedlings to other projects (PPAP, NIPG Cocoa Project).
1.7a	Establish pruning and cocoa rehabilitation businesses by groups of youths in villages	Some pruning groups were formed spontaneously by villagers, but the development of businesses driven by young people was neglected.	June 2016 – June 2017	The project relied on CMFTs in each village to initiate small businesses and employ youth, but CMFTs concentrated on cocoa farming and nurseries. One CMFT at Laraibina in New Ireland enthused unemployed youth to get involved in cocoa farming, to the relief of older people in the villages where the youth had been troublesome. CMFT groups have had many youths involved, and they have been involved in pruning blocks for group members, and rehabilitation of old trees by chupon budding - Scot Rambanare's groups in East Sepik an example.
1.7b	Establish budwood gardens and nurseries as small businesses	About 81 village budwood gardens and nurseries were established (22 in NI, 27 in ES, 25 in Madang and 7 in Karimui). Many farmers were trained in nursery management, budding and grafting of cocoa and other trees (e.g. galip). Nursery businesses sold cocoa seedlings and clones to other projects.	June 2016 – June 2017	The nursery business model was largely driven by the demand for clones and seedlings from other projects. In East Sepik, project sites at Poro (West Sepik) and Saparu supplied clones to the World Bank PPAP project, and later many CMFTs sold planting material to the FAO/EU STREIT project. In New Ireland, CMFTs sold clones to the Provincial Government cocoa project. The supply of SG2 seed from Tavilo and Murnass was a problem because of the liquidation of CCI. Some farmers changed to establishing small field nurseries or undertook field planting of seed and field budding to reduce costs.
1.7c	Establish and support cocoa marketing and farm supply businesses in villages	This aspect was neglected.The Cocoa Board Freight Subsidy Scheme supported sale of cocoa from Karimui	June 2016 – June 2017	CMFTs and village farmers were capable of obtaining the best price for sale of their cocoa by comparing prices from several competing cocoa buyers.
1.7d	Establish cocoa fermentary and drier businesses	Small fermentary and drier businesses established by individuals or groups.	June 2016 – Dec 2020	An outstanding example of business establishment, based on buying of wet beans, fermenting and solar drying, was seen in Yekimbole Village, East Sepik. This demonstrated that fermentaries and driers in villages can produce high quality dry beans and get the best prices for growers. Seven extended groups in Madang are in the process of registering to form official Small and Medium Enterprises - Almami Central group, Amiten Group, Kumisanger group, Gumaru Group, Wafen (Seth Mal family), Yukyuk Group, Hobe Family (Sition Gogowi), Nuku Group (Amos Ligai).

No.	Activity	Outputs/ Milestones achieved	Date done	Comments
1.8	Monitor, using digital surveys (CommCare) on smartphones, changes in uptake of methods, farm health, productivity, livelihoods Assess village-based micro-businesses	Digital monitoring was not possible as planned and the logistics of supervising over 20 CMFT sites in each province limited the on-going monitoring of activities, except as overseen by in-person visits from project coordinators in each province.	Dec 2016 - Dec 2020	Final conduct of surveys and focus groups to monitor the success of the project was disrupted by covid 19 restrictions and the mourning period for Michael Somare. All monitoring relied on surveys and interviews recorded on paper forms and on in-person contact with project coordinators in each Provinces.
1.9	Hold three central meetings of project coordinators	Only one central meeting of coordinators was held as airfares proved expensive	29-30 Nov 2016	Coordination between provinces was maintained by regular visits of the project In-country manager, Trevor Clarke, and PNG project managers, Alfred Nongkas (until Dec 2017), Anton Varvaliu and David Yinil (2018-2020), and twice-yearly visits by the project leader, Phil Keane.
1.10	Dr Saul will visit all provinces and hold awareness meetings with women; collaboration with activities of ASEM/2014/092	Dr Saul conducted Family Farm Team meetings in all provinces. This became her main concern after liquidation of CCI.	2016-2020	Dr Saul's involvement in the project was greatly hindered by the fact that she was not employed by the Cocoa Board REDS section after the liquidation of CCI. However, the project continued to support her involvement in all training activities for CMFTs and in Family Farm Team training session in collaboration with ASEM/2014/092. Enthusiastic involvement of women was observed in all project activities. Through staying with the farmers, she created a more conducive environment for exchanging knowledge and ideas in the CMFT groups.

Objective 2: To introduce and evaluate on farms, with farmer participation led by cocoa model farmer-trainers, transformative new cocoa cultivars and cocoa selection, propagation, production and postharvest methods

No.	Activity	Outputs/ Milestones achieved	Date done	Comments
2.1	Introduce SG2 (hand pollinated) hybrid seedlings from CCI for planting on farms	Many SG2 seedlings were planted on farms, mainly in New Ireland, although the supply was limited.	Mar 2016 – Dec 2020	The supply of SG2 (hand pollinated) seedlings was limited after the liquidation of CCIL, due to poor management at Tavilo associated with the loss of key staff, the cutting out of the seed garden in New Ireland, and the transfer of the Stewart Research Station in Madang to KIK.

No.	Activity	Outputs/ Milestones achieved	Date done	Comments
2.2	Establish demonstration blocks of cocoa clones from CCI in association with budwood gardens and nurseries <u>Research Methods:</u> 8-tree blocks of 9 CCI clones and local selections, well pruned Assessed for growth and yield, pests/diseases	An average of 81 budwood gardens were established by CMFTs (7 in Karimui), each consisting of the 18 latest released CCI clones (10 trees of each clone). Few local selections were made due to poor functioning of the Breeding Section at Tavilo, associated with the liquidation of CCI. CMFTs and farmers in Karimui selected and clonally propagated the best trees planted with seed from the original SG2 test planting.	June 2016 - Dec 2019	Budwood gardens were a source of the best CCI planting material for growers to bud in their own nurseries or for field budding. The gardens are a potential source of G x E information for REDS when the breeding section becomes functional. This was a continuous activity as budwood gardens were infilled and completed to provide a local source of planting material for farmers. This will enable the widespread use of the latest CCI clones, derived from the best hybrid seedlings.
2.3	Select and propagate on farms and demonstration blocks the best cocoa types on existing farms; collect Trinitario clones and test new generation hybrid clones on farms	Very little achieved for this activity	Not done	The local propagation and testing of local varieties and trials of new generation hybrid clones were not achieved due to non-functioning of the CCI/REDS breeding section. In 2019 the new manager of REDS began a program to secure the Tavilo Trinitario collection.
2.4	Establish demonstration blocks of improved cocoa management methods (rehabilitation pruning, frequent pruning of cocoa and shade trees, weekly sanitation pod removal and burial, fertilisation) on farms <u>Research Methods:</u> Establish 25-tree blocks of methods Maintained and assessed by farmers and CMFTs	CMFTs established 1 ha model cocoa blocks with their farmer groups and farmers were encouraged to establish or rehabilitate their own blocks. Data on growth, yield and pests/diseases was not obtained by the end of the project as plantings were just coming into bearing.	June 2016 - Dec 2020	The model blocks became demonstration sites for farmers linked to training activities of CMFTs.
2.5	Improve soil fertility through recycling farm waste and use of soil amendments <u>Research Methods:</u> Small demonstration plots (4 x 4 trees) with organic manure alongside standard NPK fertiliser established on farms Soil fertility factors and growth and yield measured in plots Especially investigate soil fertility in relation to the establishment of cocoa on kunai grasslands	Trials were conducted in collaboration with SMCN/2014/048 (Optimising soil management and health in PNG integrated cocoa farming systems) at Panamecho, New Ireland and in Wingei and Yekimbole in East Sepik Recycling and composting of farm waste was demonstrated in East Sepik The project repaired a tractor and obtained a ripper for deep ploughing of grassland soils.	2017-Dec 2020 Ongoing, disrupted by covid	The value of farm-sourced composts for maintaining soil fertility and disposing of infested pods was demonstrated. Preliminary observations of trials demonstrated that it is possible to plant cocoa on Sepik grasslands providing leguminous shade trees are established first. *Gliricidia* established faster after ploughing and aeration of soils, allowing cocoa establishment.

No.	Activity	Outputs/ Milestones achieved	Date done	Comments
2.6	Further study the production and physiology of cocoa in the highlands	A trial involving planting of replicated blocks of the 18 CCI clones at two spacings at 7 altitudes (the 7 CMFT sites) in Karimui was planted and monitored by John Vano Thomas and Peter Bapiwai	2018 - 2020	This activity was to be conducted through a Masters project linked to LaTrobe University, which did not eventuate due to disruption of research capacity at CCI Tavilo due to its liquidation. The intended supervisor at Tavilo, Dr Eremas Tade, was not appointed to REDS and took up a position with KIK. Peter Bapiwai and John Konam are conducting on-going studies of cocoa clones established in the highlands. Trail monitored by John Vano Thomas but assessment was not possible after he was forced out of Karimui by political strife.
2.7	Monitoring of pests and diseases, including biocontrol of Pod Borer	Casual observations of CPB were made throughout the project	Not done	This activity was not conducted as planned due to failure of REDS to appoint the senior plant pathologist and entomologist following the liquidation of CCI.
2.8	Conduct surveys, extension, development and field testing of new methods to improve cocoa quality through better postharvest handling, fermentation and drying <u>Research Methods:</u> Establish field comparisons of currently used fermentation boxes and driers and compare with modified types, including the cheap, active solar drier developed by Trevor Clarke in the Solomon Islands	Several CMFTs built Solomons solar driers for testing and demonstration and this attracted much interest from others so that the demand for these driers increased towards the end of the project. Studies at Agmark Tokiala and CCI/REDS Tavilo and Yekimbole CMFT site in ES showed the potential of the Solomons solar driers.	June 2016 - Dec 2020	Farmers showed enthusiasm for the plastic film covered Solomon solar driers – they proved much cheaper than the combination and kiln driers previously promoted by the Cocoa Board and avoided the problem of smoke tainting of beans. An instruction manual for the solar driers was prepared with the support of REDS staff. Recommendations for cocoa fermentation and drying to be extended to improve cocoa quality

PC = partner country, A = Australia

Objective 3: To introduce and evaluate on farms, with farmer participation led by cocoa model farmer-trainers, options for development of new cocoa farming systems integrating food crops, livestock and high-value shade and other trees

No.	Activity	Outputs/ Milestones achieved	Date done	Comments
3.1	Conduct initial discussions and surveys of cocoa farming systems and the role of women and youth	Questions included in baseline survey	June - Dec 2016	Women participated in all initial training sessions for CMFTs.

No.	Activity	Outputs/ Milestones achieved	Date done	Comments
3.2	Assess current ways in which food crops are combined with cocoa on farms and establish and assess plots of different cocoa/food crop systems. Surveys incorporated into Baseline Surveys under 1.6e. Research Methods: Compare different ways of combining cocoa and food crops with women's involvement Compare results of variable practice and use surveys to assess farmers' attitude	Data on integration of food crops with cocoa were collected during the baseline survey. Casual observations were made throughout the project.	June 2016 – Dec 2016	This aim was neglected as it was evident that farmers routinely combined food crops with cocoa planting – e.g. land was used for food crops during the establishment of cocoa blocks and budwood gardens. Alfred Nongkas advised that it is common practice to combine food crops with cocoa in PNG. Redistribution of funds caused by the doubling in the number of CMFTs meant that an overseas consultant to guide this study was not employed as planned.
3.3	Study on farms ways in which penned livestock production can be integrated with cocoa farming Research Methods: Farmers adopting more intensive animal husbandry with chickens, pigs or goats Production, income and attitudes of farmers assessed	Working with UNRE staff, goat colonies were established at four CMFT sites, one in Madang, one in New Ireland and two in East Sepik	June 2018 - Dec 2020	One colony in Madang failed but two colonies in East Sepik and one in New Ireland were successful and created enthusiasm among farmers, and showed the potential for incorporating goats into cocoa farms. A thriving goat colony at CIS Boram, East Sepik, was linked to the colony at Paliama. Goat husbandry was common in Karimui under the influence of the SDA Church.
3.4	Train farmers in use of alternative shade trees for cocoa Research Methods: Assess on-farm experience with coconuts, betel nut and small fruit trees	Galip nut trees were introduced to farmers on New Ireland and one CMFT nursery propagated seedlings.	Dec 2016 - Dec 2020	Use of galip nut and betel nut as shade trees was observed in East New Britain and Madang. A farmer at Erima in Madang Prov. planted many eaglewood trees on his cocoa farm. Eaglewood was being used as cocoa shade in Karawari, ES.
3.5	Study ways in which larger tree crops such as galip nut and oil palm can be planted on cocoa farms. Investigate the use of solar cocoa driers for drying galip nut	Not done, except that galip nut seedlings were distributed from a CMFT nursery in New Ireland	Not done	Solomon solar driers were being enthusiastically adopted by farmers and will be available for drying galip nuts.
3.6	Monitor the uptake and success of integration of cocoa, food crop, livestock and high-value trees and the involvement of family labour in cocoa farming systems. Surveys incorporated into Baseline Surveys under 1.6e. Surveys will be conducted using digital methods (CommCare) on smartphones	CMFTs were surveyed at the end of the project using paper forms and focus groups were held in each province.	Sept 2019 on	End-of-project surveys and focus groups were disrupted by covid-19 restrictions. Only a limited number of focus group meetings were held.

PC = partner country, A = Australia

7 Key results and discussion

Project perspectives on the key challenges to cocoa production at the start of the project

From the 1970s, planting of seedlings produced by hybridisation of Trinitario and Upper Amazon types and planting of precocious *Gliricidia sepium* as a shade tree was adopted widely in PNG by the commercial plantations and promoted to smallholder village farmers. While smallholder cocoa plantings expanded rapidly in many provinces, hybrid seedling cocoa eventually proved disappointing for smallholders: seedlings grew very fast into tall trees, making management difficult for smallholders, and tree productivity was highly variable, with most production occurring on a small proportion of trees with many 'passenger' trees occupying land for little return, and production declined after a few years. CCI had developed cocoa clones selected from the best of the hybrid seedling trees. These promised uniformly higher yields on farms but were produced only by a few CCI research centres and DPI stations and were not widely available to village farmers who had limited capacity to transport plants growing in soil in polybags. In addition, the heavy labour needed to manage excessively tall, over-grown and overshaded hybrid seedling cocoa, requiring regular pruning of cocoa and *Gliricidia* shade trees, meant that farm families pursuing diverse livelihood strategies did not invest sufficient labour in block management, resulting in low yields with heavy losses from pest and diseases (see below). Smallholders maintained a low labour-input, ‘foraging’ production strategy of primarily harvesting healthy pods with some grass slashing to facilitate access for harvesting. Diseased pods were left in the canopy, leading to heavy losses from Phytophthora Pod Rot (Black Pod). The incursion of the devastating Cocoa Pod Borer (CPB) moth from Indonesia in 2006 increased pod losses to over 80% and caused many farmers to abandon cocoa (Curry et al. 2009).

The use of wood-fired kiln cocoa driers was widely promoted in PNG following plantation practice. With steel kiln pipes and chimneys, these are expensive to build and maintain as pipes and chimneys rust out. Consequently, they are generally poorly maintained, resulting in smoke tainting of cocoa beans that led the ICO to downgrade PNG's fine and flavour cocoa rating from 90% to 70 % in 2019.

A lack of government resources and planning for cocoa extension failed to address these problems and the project aimed to improve farmer training by developing village extension workers (here called Cocoa Model Farmer-Trainers (CMFTs), on advice from Madang Provincial Government staff) as a permanent source of advice and training in villages, linked to the limited government services.

Farmers’ perceptions of the key challenges to cocoa production at the start of the project

Farmers recognised the challenges facing the industry, particularly from CPB which was spreading rapidly throughout the lowland cocoa growing areas of PNG. They identified CPB as the most serious threat to cocoa production (93% of farmers – Fig 7.1), and many of them had abandoned cocoa production and resorted to expanding garden food production for sale at local markets (Curry et al. 2021). Nearly all farmers (96%) intercropped their cocoa with food crops where there were gaps in the cocoa/shade canopy or in blocks that were newly established or rehabilitated under the project. Quite a few farmers in ESP, Madang and Simbu intercropped their cocoa with vanilla, which was fetching a high price, to help compensate for the loss of cocoa income due to CPB.

Heavy pod losses from Black Pod were identified by farmers as another constraint on production (Figure 7.1), which in the pre-CPB period amounted to approximately one-third of mature pods (Curry et al. 2007). Farmers also reported that their trees were too large to manage effectively with over shading being a major problem that exacerbated pest and disease problems and contributed to low yields. Thus, the project was well timed to address these issues.

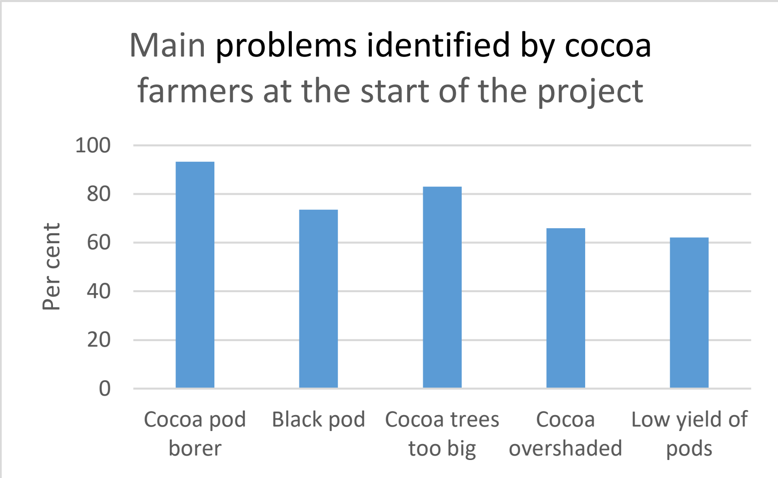

Figure 7.1. Main problems facing cocoa farmers in ESP, NIP and Madang Province at the start of project (n=48).

Other problems commonly reported by farmers at all sites at the start of the project included: little knowledge and skills for cocoa farming in a CPB environment; poor access to markets; low cocoa prices, which partly reflected the fact that village farmers often sold wet bean and the poor quality of dried beans (smoke tainting and poor processing); and the high labour demands required to manage cocoa effectively (Fig 7.2). In the lowland sites, CPB control methods required a significant increase in labour inputs which was difficult to achieve in the context of a diverse livelihood system where cocoa was produced under a traditional 'foraging' production strategy of very low labour inputs (see Curry et al., 2007 for a description of the foraging production strategy).

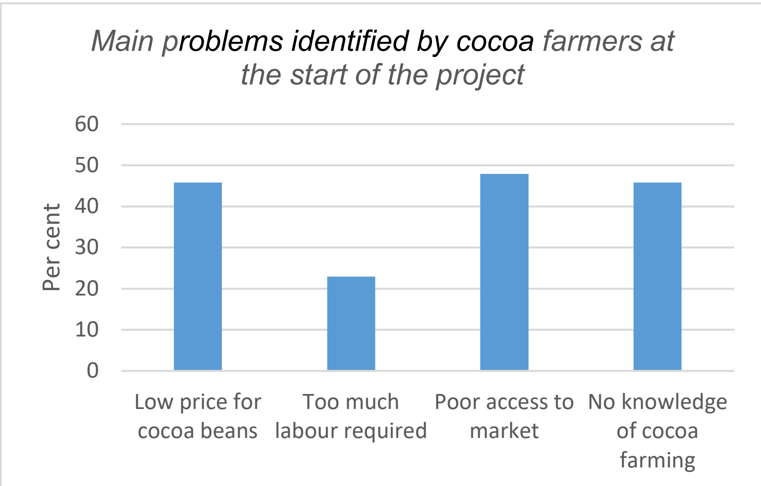

Figure 7.2. Main problems facing cocoa farmers at the start of project (all sites) (n=48).

At the start of the project, household cocoa farming in the lowland study sites was dominated by the male household head, with many women showing little interest in cocoa production and taking a minimal part only in harvesting, husking and weeding. This low level of interest and involvement of women in cocoa production reflects the situation reported in other cocoa and coffee growing areas in PNG where women limit their labour contribution in export crop production due to their poor access to the income from the crop and heavy workloads in food gardening, marketing of food crops and childcare (Koczberski and Curry 2016; Curry et al 2019). A new 'light-touch' approach to management of smaller cocoa clones and solar drying of cocoa promoted in this project requires the attention-to-detail traditionally applied by women farmers to food crop production.

Group formation and leadership

CMFTs were selected in several ways. Forty-two per cent were chosen by the coordinator in each province, 38% by villagers, while the rest were appointed by ward counsellors, self-selected, or, in the case of Simbu, by Provincial Government staff (Fig 7.3). In New Ireland, nearly all CMFTs were chosen by the initial coordinator, with minimal consultation with Provincial and District Rural Development Officers (RDOs or didimen). ESP had the most diverse methods of selecting CMFTs.

The team expected that the method of appointing group leaders would have had an impact on project outcomes by affecting the level of community support. Anecdotally, about mid-way through the project, there seemed to be problems within some groups where the leaders were not chosen by group members. This seemed to be particularly the case in in New Ireland where some RDOs and smallholders expressed dissatisfaction with the selection of CMFTs by the coordinator and his ignoring of RDOs in developing the project strategy. CMFT group members at all sites were strongly of the view that participants should choose their own leaders rather than have them appointed by outsiders. Politics in PNG reaches right down to the family units, and cultural issues are also affected by politics, a fact that is not usually understood. Participants in all the Madang focus groups, for example, were adamant that group members themselves should select their leaders. The reasoning behind this strongly held view is that outsiders are not in a position to know the characteristics of villagers: who is trustworthy and honest and will put the interests of the group before their own or their family’s interest. However, this was not borne out by the data relating to group cohesion or the effectiveness of groups (discussed further below). It is possible that the very small numbers in the subsamples make this effect too difficult to discern. But as a principle of participatory development and to encourage local ‘ownership’ of the project, it is safe to conclude that villagers themselves should choose their leader-trainers.

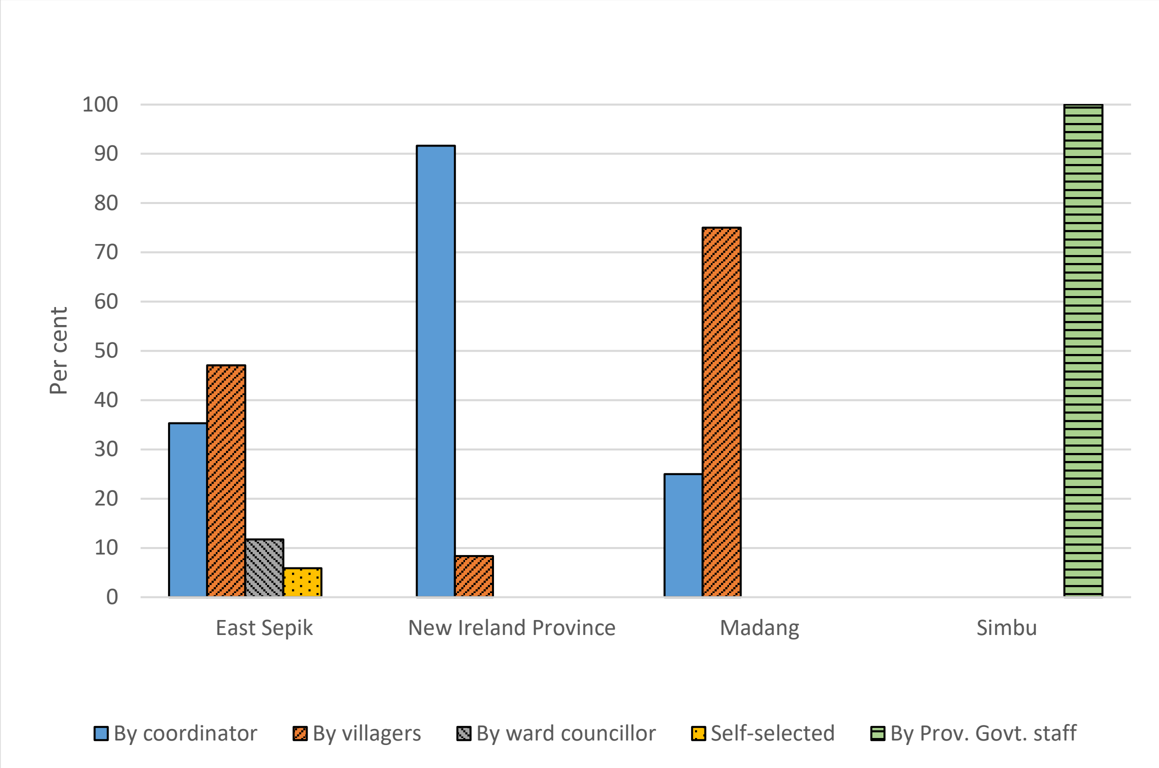

Figure 7.3. Selection of Cocoa Model Farmer-Trainers by province (n=48)

Except for one CMFT and spouse in ESP, all CMFTs had a cocoa block and were experienced cocoa farmers. The primary occupation of just over half (51%) of CMFTs was cocoa farming and a further 31% were church leaders. Church leaders are often perceived to be above the sectional interests of lineages like subclans and can therefore garner more trust where group members are from more than one lineage. The rest were typically village leaders such as magistrates, extension officers or ward councillors, with most of them being at least part-time cocoa farmers.

Active membership and group cohesiveness

In rural PNG, farmers have very limited access to government services and training. It is therefore not surprising that a common problem with internationally funded rural development projects is that villagers often enthusiastically participate in the expectation that cash and other resources will flow to them. Then, when the flow of project services or resources ceases, either during or at the end of a project, people's interest will wane, thereby undermining the long-term sustainability of project outcomes. In other words, groups form to access project benefits and then dissolve when there are no further resources to be gained. Therefore, one way to assess group members' commitment to projects is to examine group cohesiveness, members' commitment to the group and its goals, and whether or not they require resources from outside to sustain their interest both during and after the project.

Overall, there was a high level of commitment and support by group members for the project and their leaders. The fact that the groups were generally cohesive and achieved much in terms of project outputs is indicative of the value and benefits that members derived from their groups.

In 2017 at the start of the project, all the farmer groups were operating, and by late 2020 45% of groups were meeting monthly or more often, with 26% meeting at least fortnightly (Fig 7.4). Group cohesiveness was highest in Simbu where cocoa was a relatively new crop and was being enthusiastically adopted by farmers frustrated by low returns from coffee (Fig 7.5). The overall 'active' (working in group once a month or more) involvement of members is a strong indication of the commitment and interest of farmers to the group model, especially given the competing demands on their time and labour from a range of other daily livelihood activities such as food gardening and marketing, and family, church and community work (Figs 7.6 and 7.7). Yet, despite these non-cocoa labour demands, both men and women were actively involved in group work. The assistant coordinator in Madang Province, Bofeng Mebali, a highly experienced retired didiman supported by the project, developed a concept of farmer self-selection for participation in the sort of farmer training groups tested in this project in which the main resource being provided is knowledge and training and access to improved planting material.

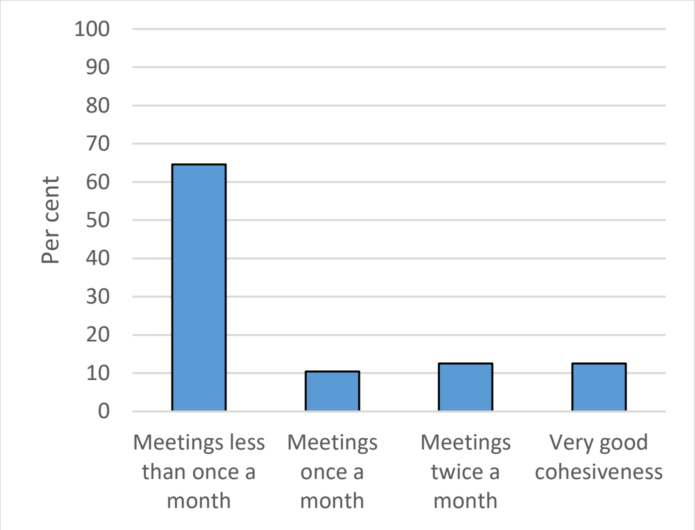

Figure 7.4. Group cohesion rating (n=48).

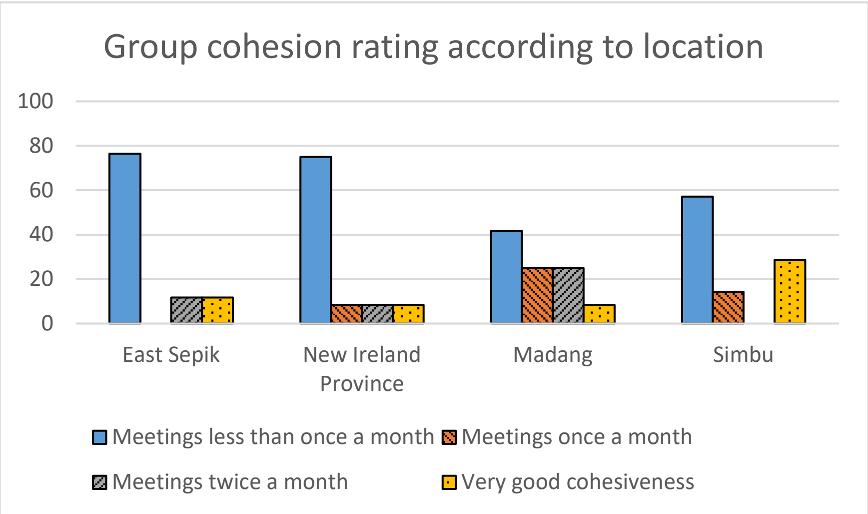

Figure 7.5. Group cohesion rating by province (n=48).

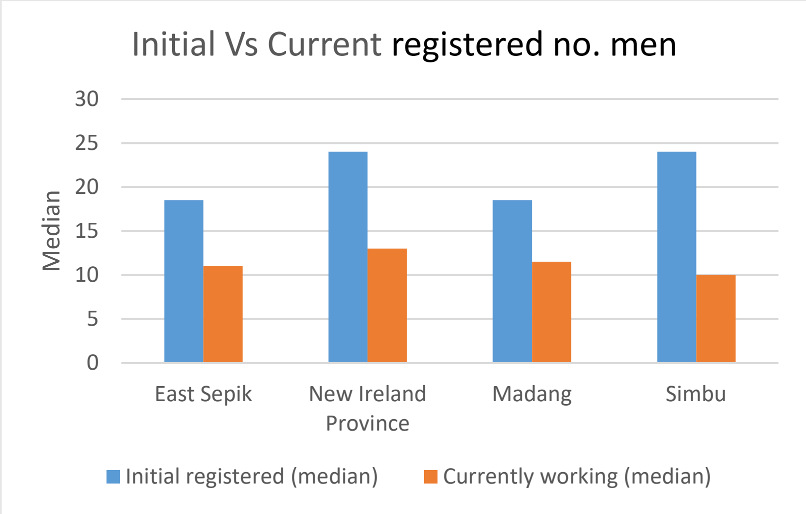

Fig 7.6. Median numbers of initially registered men per CMFT group versus currently active members (n=47).

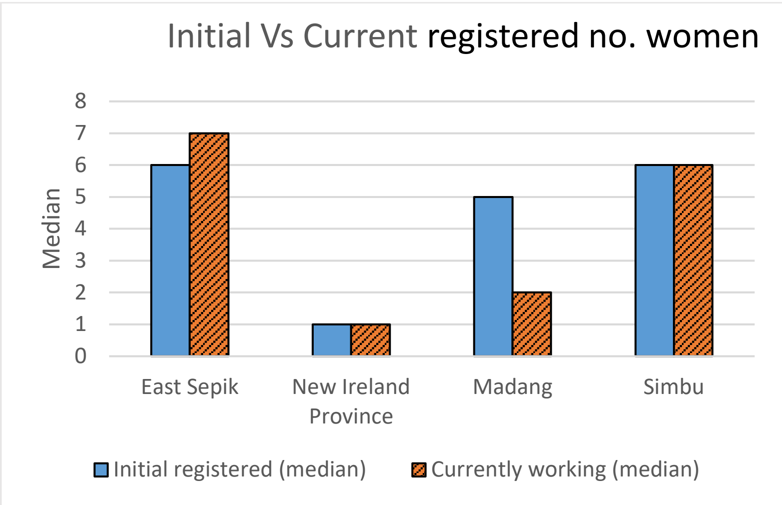

Fig 7.7. Median numbers of initially registered women per CMFT group versus currently active members (n=43).

Women's participation rate in the farmer groups was high, even though historically in PNG, cocoa has been considered a 'men's crop' and women were largely ignored in extension training (Hamago 2021). Interestingly, the retention rate of women in the groups was much higher than that for men (compare Figs 7.6 and 7.7). The median group size for women fell by 11% overall compared with a 46% decline for men. The attrition rate of men reflects the point made above that some men will sign up to projects on the expectation of accessing resources such as cash and tools. If these do not materialise, or the flow of these project resources ceases, they will withdraw from the project, leaving only members committed to the project. In contrast, women's active role in the groups is reflected by women's leadership roles in some of the more successful groups such as Luapul, Rempi, Yekimbole and Niumindogum. Also, many of the CMFTs were husband and wife teams, and these leadership partnerships were highly effective. Eighty-one per cent of CMFTs claimed that they received moderate (23%) or strong support (57%) from their spouse while carrying out their leadership roles (discussed further below). In Rempi Village, Madang Province, an all-women's group was established. However, the level of women's involvement varied across project sites. Women in New Ireland and Madang were much less well represented in groups than women in Simbu and ESP (Fig 7.7). The median number of women per group in the Madang sites dropped by 60% during the life of the project, while there was no decline in the numbers of women in ESP and Simbu, with ESP experiencing a slight increase in the median number per group during the project (Fig 7.7).

The decline in female participation rates at several of the Madang sites is instructive for what it says about men's role in facilitating female participation. Although the data are limited, two interrelated reasons were highlighted in focus groups as to why some women were not actively involved in groups. These included women's poor access to cocoa income and a lack of support from their husbands, as well as other work demands, especially food production/harvesting. Two of the groups in which female participation rates dropped off significantly seemed to reflect men's lack of trust in women to manage cocoa properly. As the focus coordinator reported for both these groups: "Husbands won't teach them to bud because they're afraid women will kill their clones." Similarly, there was some evidence from focus groups that men saw their wives as a source of labour rather than as equal partners in the cocoa business:

> Still same as before [before the formation of the group]. Men bring them [women] along to do cocoa work only when they need them. Otherwise, most group cocoa activity days are attended by only the men

Focus group discussions with women shed light on why women valued the groups so highly, which sustained their high participation rate throughout the project. Women reported consistently that they valued the increased access to the cocoa income that flowed from their greater involvement in household cocoa production. As one male respondent in a focus group in Madang stated:

> Previously, women thought cocoa work was 'men's work'. Involving women in cocoa work has motivated them to now actively participate in cocoa work on their own family blocks

Dr Josephine Saul-Maora, a scientist working on the project, concurred with this view:

> As a female scientist in the 1980s I was pruning cocoa branches infected with pink disease and taking the pruned branches out of the block to be burnt. At first there were only a couple of villagers watching but suddenly there was a crowd peeping at me through the cocoa trees. I was surprised but the plantation manager informed me that the people were curious because they had never seen a female prune cocoa especially in a plantation. The hybrid clones produced at CCI are small and can be managed by women, compared to the huge hybrid seedling passenger trees.

This changed attitude towards cocoa work by both men and women was due mainly to women's increased access to cocoa income. Women in six of the seven female focus group discussions in Simbu unanimously agreed that they now earn more money from cocoa since the development of cocoa production linked to the project. As one Simbu women remarked "cocoa has changed our lives", in reference to the more regular income derived from cocoa production, compared with the strongly seasonal production of coffee (only twice a year). Given the increasing reliance on cash to meet the daily needs of families, more regular access to cash is important for women. More cash not only means women have more capacity to meet basic household needs such as purchase food, clothing and household items, but they can also contribute to other household expenses like school fees, customary obligations (e.g. bride prices, mortuary compensation, etc.), and purchase farm tools.

It is often the case that increased access to income by women can lead to lower work demands on them as they typically spend the income purchasing food (most commonly rice and tinned fish/meat) which reduces the time required to produce garden foods and prepare meals. Also, women's increased access to cocoa income can result in them shifting their labour away from non-cocoa income earning activities such as local marketing of garden crops to cocoa production. Depending on market accessibility for cocoa and food crops and the price of cocoa, women's returns to labour from cocoa may be much higher than from selling fresh garden produce at local markets. For example, the female leader of the all-women's group at Rempi Village, Madang Province, claimed that she could sell a bag of cocoa beans (worth about K500) in 10 minutes to a buyer of her choice in Madang town, yet it would take a full day at the Madang town market to sell her garden vegetables and she would earn only a fraction of that amount and likely be left with some unsold produce. If several income sources are available locally, women will generally allocate their labour where the economic incentives are greatest in terms of income level and their degree of control over that income (for further discussion see Curry *et al*., 2019; Koczberski *et al*., 2021). Most women in the focus groups said that they spent more time on cocoa work since the project began. The most common reason cited was the extra cash earned from cocoa. One Simbu woman expressed a common sentiment amongst women as:

> We did our first sales already and we are happy with the money we earn from cocoa

Women largely sell cocoa as wet bean. It is an easy and quick way to earn cash and they can determine how they spend the money. Thus, due to their greater access to household cocoa income, there are now improved economic incentives for women to allocate more of their labour and time to cocoa. In other words, women's involvement in cocoa is strongly shaped by how household cocoa income is shared by the male household head and distributed to benefit the family. Greater involvement of women applying the same attention to detail as in their food gardens will benefit the new approach to cocoa production involving more regular, 'light touch' management (particularly frequent removal and disposal of infested as well as healthy pods) and affordable processing of wet to dry bean using solar driers.

The sustainability of CMFTs after the project

Ninety-five per cent of CMFT farmers across all sites thought group activities would continue after the project ended, indicating a willingness to continue with the group. All CMFTs considered that they will continue, mainly supported by improved cocoa production or sale of planting material. This indicates that they had built up their confidence to become mentors to other farmers. Some even thought that a 'charitable advisory service' was important. While some CMFTs thought fee-for-service would provide long-term financial sustainability to their groups, such a strategy would be very difficult in rural PNG where market-based relationships are very weak. However, fee-for-service arrangements don't necessarily have to be in cash. In-kind payments such as raising seedlings in return for initial planting material and training, for example, would be culturally appropriate where exchange of planting material for food crops is common. In the focus group discussions, the provision of food in exchange for labour on cocoa farms was often mentioned. There are many stories of payment of doctors in kind, for example, with chickens. A resourceful CMFT group at Balama Village in Madang Province obtained the clearing of a hectare of secondary forest by a logging contractor in exchange for a chicken. A CMFT group in ESP developed a mobile advisor service to other villages which was presumably paid in kind.

Another indication of sustainability is the degree to which the CMFT model was able to be scaled out to new farmer groups outside the project villages. News of the activities and training in project-supported villages spread to nearby and more distant villages, and village leaders sought the assistance of CMFT leaders and group members to start groups in their own village (Box 7.1). The establishment of these new groups was largely self-funded, with group members being trained by project CMFTs. The new groups were referred to as 'satellite' or 'extension' groups. A total of 352 satellite groups were formed serving well over 27,000 farmers. These satellite groups were across all provinces: in Madang Province 137 new satellite groups were formed, serving 3000 farmers; in ESP 107 new groups served 4,000 farmers; in New Ireland 40 outside villages were assisted; and in Simbu the CMFTs helped 28 other groups, serving 900 farmers. In addition, an enterprising businessman from West Sepik, having seen the project strategy and attending a training session with his CMFT wife in New Ireland, extended the project to his home province. Using his own resources, he established 40 groups serving 2000 farmers.

This spontaneous emergence of satellite groups was quite remarkable. Bofeng Mebali was especially important in developing these groups in Madang Province. He prepared a proposal to send to MPs to encourage them to spend their district development improvement funds on setting up CMFTs/farmer groups. The strategy was also adopted by a large New Ireland Provincial Government Cocoa Project serving all cocoa-growing Wards and by a large FAO/EU development project in East and West Sepik.

Box 7.1 Examples of satellite groups and their formation in ESP.

Saparu-Kausimbe Group – led by Benjamin Kapia and spouse Clorina. One of the most isolated groups (two-hour drive to Sepik River, two-hour boat trip down river and into Yuat River). One of the most successful groups with 19 males, 7 females, 34 youth, and certified budwood garden and large nursery. They distributed 20,000 clones outside the village, assisted 50 other villages, and helped form 22 satellite groups with 300 farmers. The CMFT husband and wife team was supported by Benjamin's brother, Sperian Kapia, who took leave from his employment as a schoolteacher to work on the project.

Bararat Group – led by Scott Rambanare and his spouse Maureen. They built a large network of satellite groups, trained many farmers outside their home village and helped other villages; they built up ‘mobile teams’ to work with other villages; Scott was a great promotor of chupon budding to rehabilitate old blocks.

Paliama Passam Group – led by Jonathan Poema who built a network of satellite groups in the vicinity of his village. He was also assisting Passam National High School, near his village, to start a cocoa project as a teaching facility and money earner for the school. The project provided a microscope for the science teachers at the school (courtesy of LaTrobe University).

Training offered to farmers

The project provided training to CMFTs (mainly husband and wife teams) in an average of 24 villages in each lowland province and 7 in Simbu (Table 7.1). There were six project training sessions, usually extending over 2-3 days, two of which were on Cocoa Technology delivered by CCI/REDS staff and some DPI staff. There were four training sessions on sustainable farming livelihoods, including gender equity, health and financial literacy. Two of these sessions were delivered by the University of Natural Resources and Environment (UNRE) Kairak Training Centre, and two were delivered through a collaboration with ASEM/2014/095 (Improving opportunities for economic development for women smallholders in rural Papua New Guinea) that provided Family Farm Team training (FFT). Dr Josephine Saul-Maora, who had been the most senior scientist at CCI before its liquidation, and a role model for women's involvement in science and development, was supported by both projects to provide this training. The Sustainable Livelihoods training by UNRE and FFT was directed at improving the role of women in cocoa farming.

After training from the project, CMFTs provided informal training and advice to farmers in their villages in all facets of cocoa husbandry methods, including establishing and managing a nursery, establishing budwood gardens, budding of seedlings to produce clones, chupon budding to help rehabilitate old cocoa plantings, identifying major pests and diseases of cocoa, solar cocoa processing, and establishing additional satellite farmer groups. To support them, 12,000 copies of two farmer handbooks, one in Tok Pisin, covering all aspects of cocoa production were written and distributed to CMFTs and their group members to guide on-going training of farmers. The CMFTs were supported to work with farmers to establish budwood gardens of superior cocoa clones developed at the

PNG Cocoa Coconut Institute (CCI) and train farmers in bud grafting to propagate clones, thus making them widely available. Some of the more successful CMFTs trained large numbers of farmers in satellite groups. Farmer training was also given during the several field days in each province.

Training in goat husbandry was provided by staff of UNRE to CMFT groups at Niumindogum Village and Paliama-Passam Village in East Sepik, the sites of development of two successful goat colonies (Plate 7.1). The goats featured in the field days at Yekimbole and Paliama and provoked much interest from farmers.

Plate 7.1. Young woman feeding *Gliricidia* prunings to goats at Paliama-Passam Village

Table 7.1. Numbers of CMFTs and farmers trained by the project in each province.

	Cocoa Technology 1		Cocoa Technology 2		UNRE Kairak Centre1		UNRE Kairak Centre 2		FFT (Family Farm Teams) 1		FFT (Family Farm Teams) 2	
Province	CMFTs	Farmers	CMFTs	Farmers	CMFTs	Farmers	CMFTs	Farmers	CMFTs	Farmers	CMFTs	Farmers
NI	22	440	22	440	22	440	22	440	22	440	22	440
East Sepik	27	625	27	625	27	625	27	625	27	625	27	625
Mad-ang	25	625	25	625	25	625	25	625	25	625	25	625
Simbu	7	175	7	175	7	175	7	175	7	175	7	175

Types of training

Training for CMFTs and group members covered most aspects of cocoa husbandry, including propagation techniques (Fig 7.8). Most groups received training across key areas of cocoa production, but less training on processing (apart from solar drying – see below on solar drying) because the emphasis was on bringing cocoa back into production after the depredations of CPB. Some CMFTs concentrated on production and distribution of planting material rather than training, although it is likely they remained a source of advice in their village.

The median numbers of farmers trained per group (CMFT and Satellite) were quite high at about 20 overall for CMFT groups and 15 for satellite groups (Fig 7.9). This indicates that a high proportion of active farmers in CMFT groups participated in training. The median was used because there were some significant outliers in the data where large numbers of farmers received training. For example, one group claimed to have trained 3400 farmers while another trained 615 farmers in a satellite group. It is likely that these numbers represent farmers who received advice informally.

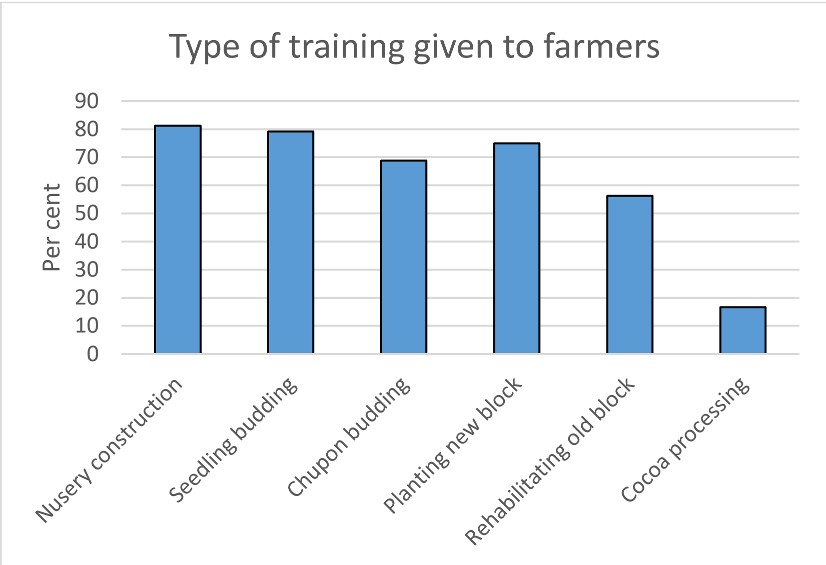

Figure 7.8. Per cent of groups receiving training by type of training (n=48).

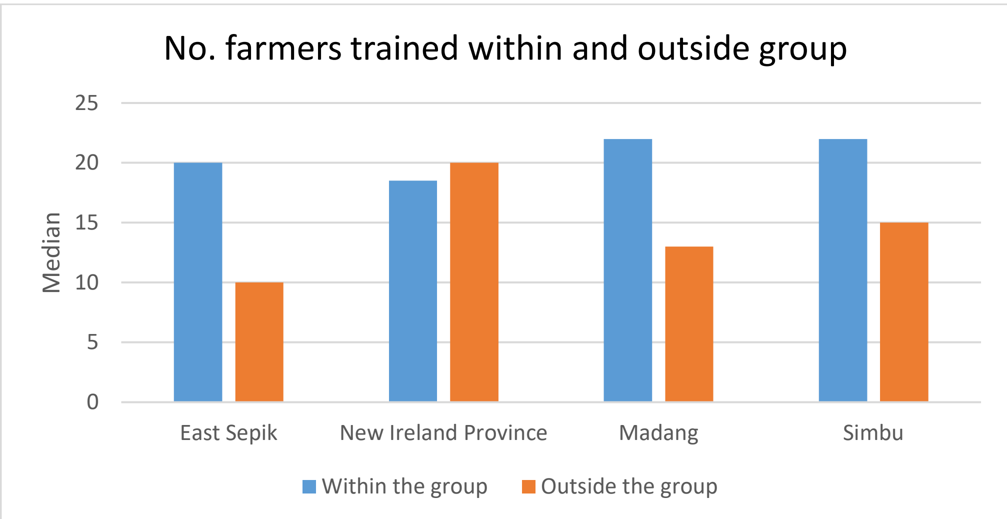

Figure 7.9. Median numbers of farmers per CMFT and outside (satellite) group who received training (n=46).

Plate 7.2. Training in budding cocoa seedlings for women on Mushu Island, East Sepik, June 2020.

Plate 7.3. Training in budding of cocoa seedlings conducted for the EU/FAO STREIT Program at Saure Village, Wewak District; there were 82 participants, including many women, Nov 2020.

The training in propagation techniques (Plates 7.2, 7.3) was a radical departure from conventional methods of distributing planting material in PNG. Previously, the production and distribution of clones was restricted to CCI and innovative companies like Agmark.

Under this conventional method of distributing improved planting material, the clones were distributed to farmers in polybags, but this overlooked the extremely expensive and difficult logistical task of transporting clonal plants growing in soil in polybags, produced in the few CCI and DPI research stations, out to the farms. This was characteristic of the top-down attitude to extension in that famers were not thought to have the technical skills, for example, to undertake budding successfully. The project proved otherwise: with appropriate training and encouragement farmers became very proficient and skilled in propagating clones as evidenced by the very large numbers of clones produced and distributed by famers themselves.

Gender and family farm team training
A priority was to ensure both men and women benefitted from the project outcomes. Project activities with farmers were underpinned by a 'family farm team' approach with an emphasis on the family level with the goal of creating more gender equitable outcomes with all family members benefiting from improved cocoa production. The Family Farm Teams training (FTT) approach, which was developed through earlier ACIAR funded projects in PNG (ASEM/2010/052 and ASEM/2014/095) was employed in this project (see Pamphilon & Mikhailovich 2016; Pamphilon *et al*., 2017). FFT training was conducted at all sites (Table 7.1), with over 160 CMFT male and female farmers attending the three-day training programme. Both husband and wife were encouraged to attend training. The three-day training covered four key areas:

- Module 1: Working as a Family Farm Team for Family Goals
- Module 2: Planning your Family Farm as a Family Team (including video)
- Module 3: Feeding your Family Farm Team
- Module 4: Decision-making and Communicating as a family farm team

Whilst no assessment was completed on the impact of FTT training or the extent to which participants applied what they learned, anecdotal evidence suggests that the training was well received (focus groups). However, the same training programme has received very positive feedback from other parts of PNG, suggesting that the training can lead to more cooperative and improved gender relations within families that help strengthen the income and food security of families (Pamphillon & Mikhailovich 2016; Pamphillon 2019). Following one of the training sessions in Madang Province, a husband and wife who attended were so impressed that they started their own farmers' group and provided their own FFT training using the printed materials they had received.

Farmer's handbooks
As mentioned above, 12,000 handbooks (about 100 pages, A5) were printed and distributed through the Cocoa Board and Provincial DPI offices, schools, a correctional institution in ESP, and cocoa buying companies. Approximately 800 of them were distributed amongst CMFT groups, and an unknown number were allocated to satellite groups. Stocks of books have been left with the REDS provincial coordinators and DPI staff for on-going distribution. All groups in New Ireland and Simbu received copies of the handbook and most groups in Madang (Fig 7.10). The distribution in ESP was lower, with 63% of groups receiving copies. While those who received the handbooks were very positive about them and found them useful, the distribution of books within and between groups and between genders was uneven (Fig 7.11 and focus group data).

The number of handbooks available per group who received handbooks ranged from an average of 2 per group in Simbu to 31 per group in Madang (two large outliers in the data removed from the Madang average). The large number per group in Madang would suggest that women had more access to the handbooks than at other sites were fewer handbooks were distributed. In Simbu where the smallest proportion of handbooks were distributed, some men in focus groups complained of the shortage of handbooks and how difficult there were to access. For women, access to the handbooks was worse with only one woman in a Simbu focus group saying she had access to the handbook – she was married to a CMFT. It appears there was some hoarding or misappropriation of handbooks that were delivered to Karimui; no doubt these will eventually find their way to farmers.

Some groups claimed in focus groups that they managed the handbook shortage by forming subgroups to share resources. One group in Madang, for example, formed subgroups of five members, and allocated one handbook per subgroup with members sharing their handbook. In this way they ensured each group member had access to information in the handbook.

While there was certainly a gender bias in access to handbooks with women having much more restricted access than men, especially in sites like Simbu where so few books were distributed, the solution is not simply to print more books for women. Literacy rates are very low in rural PNG, especially amongst women; the average years of schooling received by people aged 25 years and older is just 3.9 years (UNDP 2014). Poor literacy was cited by women themselves as a reason for their lack of engagement with the handbooks. In addition, in focus groups in Madang, women reported that their primary source of information about cocoa was their husbands. Just less than a third of women, while all men, in half the Madang focus groups stated that the CMFT was their primary source of extension information. It appears that the handbooks will be of most use to village leader-trainers who can read them as a source of information to pass on to farmers. There were reports of farmers who rehabilitated their cocoa blocks using only a handbook as their guide.

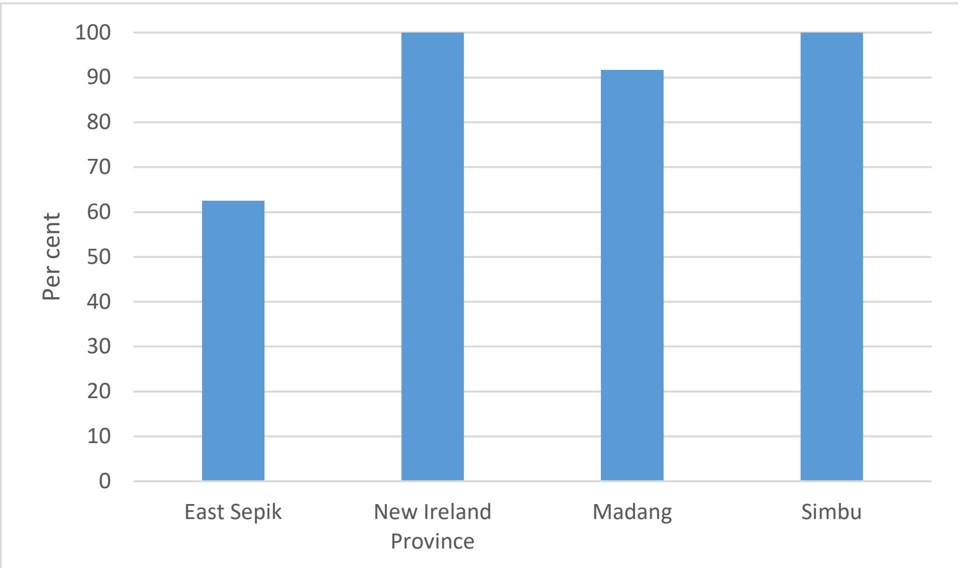

Figure 7.10. Proportions of groups that received cocoa farmers' handbooks (n=47).

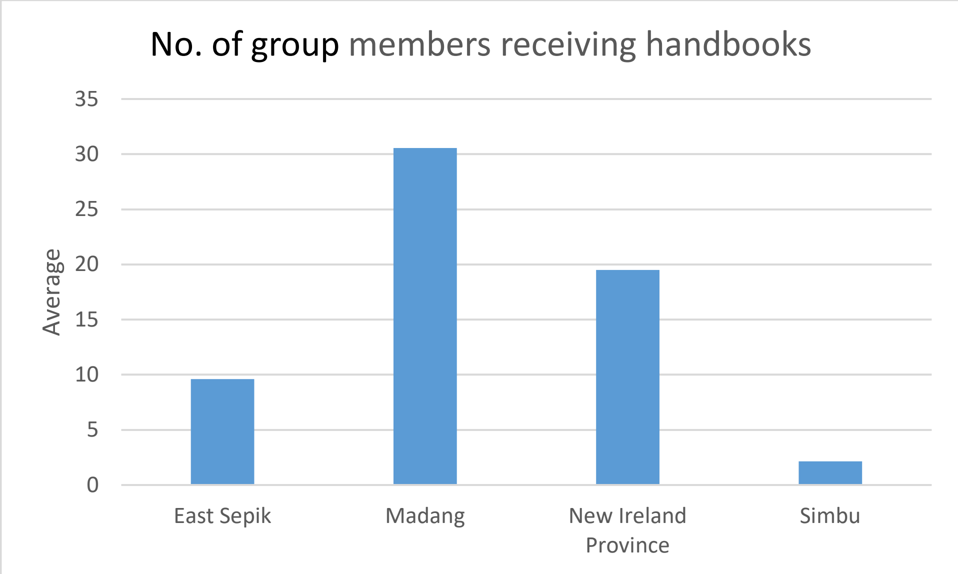

Fig 7.11. Mean numbers of members per group who received handbooks by province (only for groups that received them) (n=45).

At first sight the extent to which group members appeared to be using the handbooks appears disappointingly low (Fig 7.12). With just 38% of groups claiming that over half their members were using the books suggests a poor uptake. However, we suggest that this reflects the frustration of farmers having very limited access to handbooks by individual group members rather than the usefulness of the books to farmers *per se*. If we consider the Madang sites where handbooks were readily accessible and high proportions of farmers had their own copies, 72% of these groups reported that more than half their members were using the books.

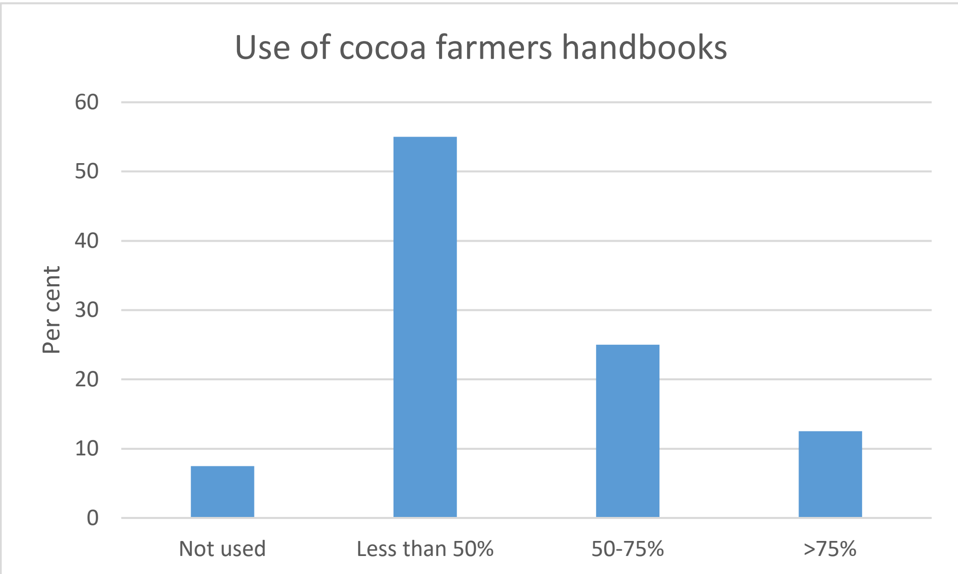

Figure 7.12. Use of cocoa farmers handbooks by group members (estimates of proportions of farmers using handbooks – only for groups receiving handbooks) (n=40).

Farmers in groups that had received handbooks were asked directly about their utility. Apart from one group in New Ireland which was not functioning effectively, all of the CMFT groups across the four provinces found the books useful. For the reasons outlined above regarding the low literacy levels, this view was probably more representative of men than women. This suggests that if these handbooks were more widely available, they would provide a useful resource for group members and especially for the village leader-trainers who can use them to guide their advice to fellow farmers. They are also a valuable resource for schools such as Brandi Secondary School and Passam National High School in ESP, with which the project initiated cocoa projects as teaching facilities for students, many of whom would return to work on family farms. It was evident from several visits by project staff to these schools that they lack reference and teaching materials and these books can help in a way that is relevant to the needs of the students.

Field days

Field days, especially those involving hands-on demonstrations, are an effective tool for disseminating extension knowledge and skills to large numbers of farmers (Plate 7.4). Field days were an integral part of project design and were carried out in all project provinces, though their format and scale varied amongst sites and provinces. For example, there were two large field days in ESP to which members of all ESP CMFT groups were invited, and these attracted large numbers of farmers and local political leaders, one of whom donated K150,000 to support the CMFT activities in the village (Paliama-Passam). It was estimated that about 200 farmers, a large proportion of whom were from CMFT groups in the province, attended a field day at Yekimbole Village and 300 at Paliama-Passam. Project coordinators and several CMFTs and DPI staff provided training at the field days. A field day at Balama Village in Madang Province was attended by 250 people, including many senior DPI staff. In Simbu, CMFTs contributed cocoa displays to two large Karimui Cultural shows in 2018 and 2019. These field days attracted a high proportion of CMFT members as well as large numbers of farmers who were not in CMFT groups.

In contrast, field days in Madang and New Ireland were smaller affairs. They were referred to as 'mini field days' conducted by the CMFT from the particular village, assisted by CMFTs from other villages, as distinct from the first field day at Komolobuo in New Ireland which was very expensive because many staff from CCI Tavilo were brought in to conduct training sessions. About half of groups who responded to the CMFT survey indicated they hosted field days. Median attendance rates were 50, suggesting that famers who were not part of the CMFT groups also attended these field days. The two final field days in New Ireland, conducted by groups of CMFTs and Provincial Government and District Government DPI staff, addressed the wider audience of CMFT (project) groups and the groups formed under the New Ireland Provincial Government Cocoa Project. Training sessions for the NIPG project were led by women RDOs, Barabara Makapa and Bolomes Arawes. Men and women’s views on field days were not sought during focus groups but many women attended field days which were obviously an exciting event in isolated villages. At a field day at Laraibina Village in New Ireland, a group of three older women sharing an umbrella attended all the various training sites with obvious interest. It emerged that they were from a neighbouring village and spoke highly of the Laraibina CMFT team, David and Christina Waulis, who they knew had taken a group of disruptive young men from their village and convinced them to return to cocoa farming, bringing peace to their village.

Plate 7.4. Field day and nursery at Lumi, West Sepik, in association with the Tenkile Conservation Alliance, where cocoa farming is being promoted to reduce the pressure on hunting of the endangered kangaroos for food, Nov 2019.

The distribution and uptake of new planting material

As explained above, the transfer of cocoa propagation skills to farmers was a major departure from traditional extension methods of disseminating planting material in PNG. Empowering farmers through training to bud and graft enabled them to create clones from a relatively wide selection of planting material, including the best of their own planting material as well as the latest 18 clones from CCI. Thus, there was a rapid and large expansion of new and rehabilitated plantings. With these skills, farmers were able to then select the ‘best of the best’ for second generation planting, thus equipping themselves to undertake their own selections for their local areas.

Selection of well-adapted planting material, especially for food crops, is second nature to PNG farmers. It has been a distinctive feature of official cocoa development in PNG since the introduction in the early 1900s of highly genetically variable Trinitario cocoa that offered opportunity for selection of superior types (Green, 1938). Traditionally, farmers selected cocoa on several criteria including robustness (low maintenance requirements) and longevity, as well as yield (Curry *et al.* 2007). They therefore had some control over the desirable characteristics of their cocoa, albeit the process of selection was slow. With the new skills acquired in cloning during the project, this process of selection has been accelerated, giving farmers more capacity to respond to changing environmental conditions. For instance, a CMFT in ESP reported that he was propagating a tree he thought showed resistance to CPB.

Budwood gardens, clones and budding skills

All CMFT groups, except one group in ESP and another in New Ireland, established budwood gardens containing 18 of CCI’s high yielding clones selected also for having a low level of susceptibility to pests and diseases (Plates 7.5, 7.6). Ten trees of each clone type were established, giving a total of 180 trees per budwood garden. Three groups established larger budwood gardens, but for this analysis of clone attrition we consider only those CMFT budwood gardens that planted 180 trees. These budwood gardens became an important source of planting material for CMFT group members, satellite groups and other projects such as the New Ireland Provincial Government Cocoa Project and the FAO/EU STREIT project in East and West Sepik and some Madang districts.

An indication of the high value CMFTs placed on CCI clonal material was their survival rate in the budwood gardens. On average, across all CMFT sites, 16.7 of the 18 clones were still present in the budwood gardens in the second half of 2020. This ranged from 15 clones in budwood gardens in ESP to the full 18 clones for the Simbu groups. Establishing 10 trees of each clone enabled a high rate of clone survival (Figure 7.13). It is generally acknowledged that clones require higher maintenance levels for their survival than the more robust seedlings, and especially hybrid seedlings, smallholders have traditionally planted (see Curry et al 2007 for further discussion).

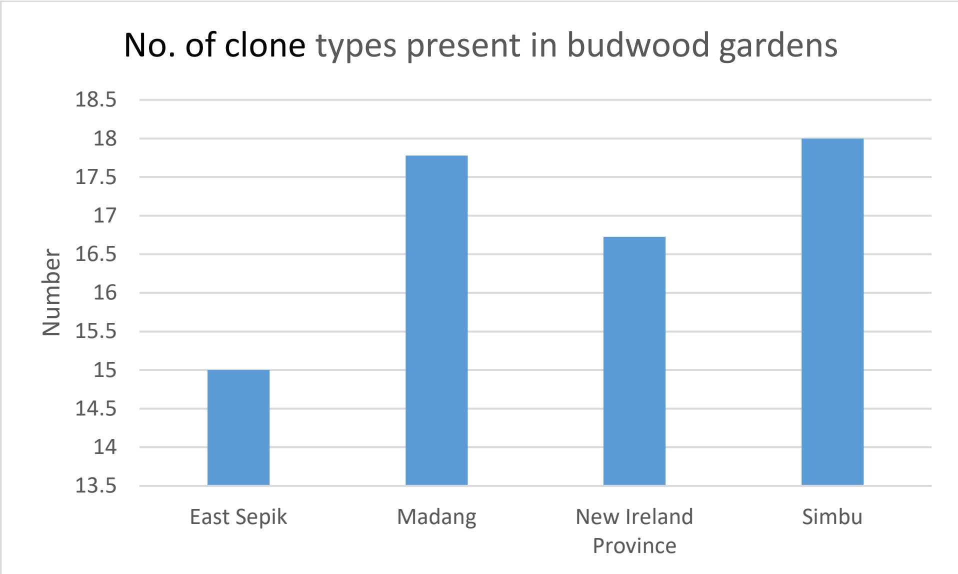

Figure 7.13. Average number of clone types surviving in budwood gardens form original 18 types planted, by province (n=41).

In ESP, Madang and Simbu, farmers adopted chupon budding techniques (Figure 7.14). In old cocoa plantings, chupon budding was frequently used to rehabilitate trees with improved planting material. Farmers proved very adept at this form of propagation. In ESP and Madang, almost all CMFT groups adopted this technique. In New Ireland a different strategy was pursued using SG2 seed distribution. Problems at CCI led to delays in seed delivery resulting in the budding being delayed (discussed further below). In Simbu, where there were no old cocoa blocks amongst CMFT farmers, 37% of groups adopted this technique to replace poorly performing young trees planted from highly variable open-pollinated progeny from the SG2 seedlings in the original test planting at Karimui. Some farmers became acknowledged professional ‘budders’ and would bud for other farmers as well as themselves.

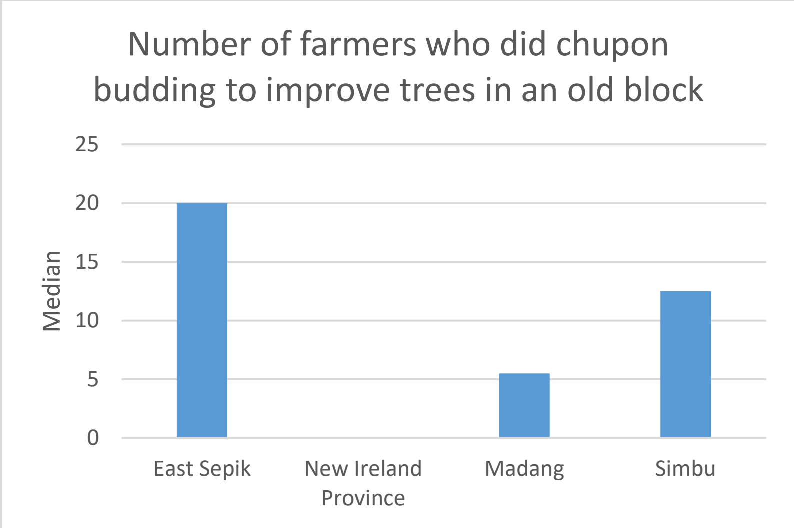

Figure 7.14. Median number of farmers per group who undertook chupon budding (n=47).

The focus groups in Madang provide further insights into budding and its uptake by farmers. All ten focus groups in Madang received training in budding techniques, and all of them thought the training was ‘useful’. Of those present at the focus group, 88% had received training in budding and grafting, and, perhaps surprisingly, 5% more farmers had adopted and practised budding/grafting than had been trained in the technique. This suggests that some farmer-to-farmer training occurred. While it is recognised that the farmers attending focus groups were more likely to be CMFT supporters, the uptake suggests a high level of interest in clonal propagation techniques.

There was considerable variability between and within provinces in the numbers of budded clones and SG2 hybrid seedlings distributed to CMFT group members (Figure 7.15). In New Ireland, for example, there was a higher reliance on SG2 planting material with a median number of 200 seeds distributed per CMFT group member (median of 0 for other provinces). From early in the project, the project coordinator, Kula Daslogo, pursued a strategy of using SG2 as rootstock with the idea that any unsuccessful budded seedlings could still be useful and be improved with chupon budding if they proved unproductive. However, with the liquidation of CCI, the SG2 seed supply ceased. Then, like the groups in the other provinces, growers proceeding with budding of unselected seedlings from their own farms to rehabilitate and expand their holdings.

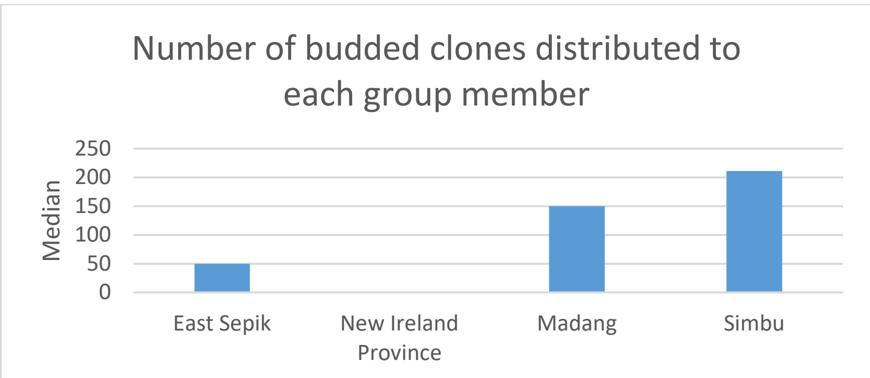

Figure 7.15. Median numbers of budded cones distributed per CMFT group member by province (n=44).

Plate 7.5. A budwood garden being established under *Gliricidia* shade on former kunai grassland at Suaru Village, Madang Province. Clone CCI-B1 (also known as K9) is recognised as an excellent clone and performed well in most budwood gardens.

Plate 7.6. Budwood garden at Niumindogum Village, East Sepik, with vanilla being established on a shade tree in foreground.

Satellite groups

Large quantities of planting material were distributed to satellite groups by CMFT groups, and the figures presented here are conservative because many transactions were informal and not documented. However, CMFTs estimated that in total over 42,000 plants consisting of almost 20,000 clones and 22,000 SG2 hybrids were distributed to satellite groups (around 17,000 famers in satellite groups received planting material). Overall, 58% of CMFT groups supplied clones to satellite groups and 36% of groups supplied SG2 hybrids. Each CMFT group that assisted its satellite groups with planting material provided a mean of 763 clones and 1586 SG2 hybrid seedlings.

This scaling out of project benefits beyond CMFT groups suggest that the model of extension on which this project was based offers a viable alternative to top-down conventional extension. Improved planting material supplied to core groups of farmers (CMFT groups) was distributed quite rapidly and at low cost to farmers who were not part of the initial intervention (satellite groups). We come back to this point later in this section.

New cocoa blocks and rehabilitation of old blocks
As anticipated, the decision of CMFT farmers to establish new blocks or to rehabilitate their old cocoa blocks depended on their situation prior to the project (Figures 7.16 and 7.17). The rate of establishment of new blocks amongst CMFT farmers was highest in Simbu where cocoa was a recent introduction. These farmers established a median of three new blocks per farmer compared with about one new cocoa block per farmer amongst farmers who established new blocks in the other provinces (Figure 7.16).

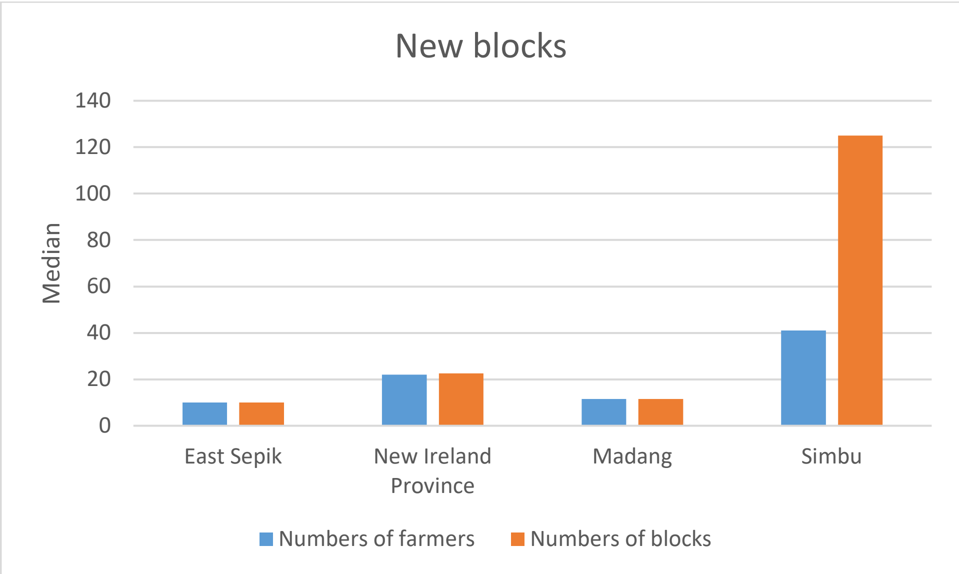

Figure 7.16. The median numbers of farmers per CMFT group who established new blocks versus the median numbers of new blocks per group by province (n=47).

Regarding rehabilitation of cocoa blocks, the median number of farmers per group and number of blocks per farmer were highest in ESP, closely followed by Madang CMFT groups (Figure 7.17). In these two provinces smallholder production had been hit hard by CPB and there were many abandoned blocks at the start of the project. The emphasis in these provinces was bringing these blocks back into production through rehabilitation. At the time of the surveys, block rehabilitation was still ongoing. Some participants in focus groups mentioned that their blocks had not yet started producing after rehabilitation.

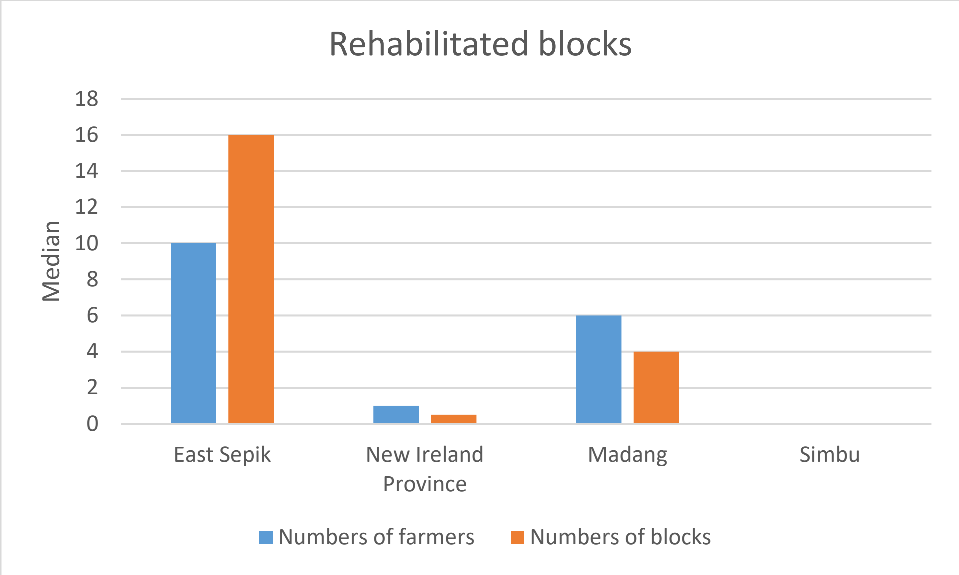

Figure 7.17. The median numbers of farmers per CMFT group who rehabilitated old blocks and the median numbers of rehabilitated blocks per group by province (n=43).

Innovation and appropriate technology
The tremendous innovative potential of village farmers was evident during the project. They changed from conventional raising of plants in polybags in large central nurseries introduced at the start of the project to the use of small field nurseries or field planting of seed and field budding, obviating the need for costly nurseries and the arduous task of transporting plants in polybags. Farmers enthusiastically adopted the idea of endogenous village extension training, forming many satellite groups in addition to project CMFT groups. They also took up and adapted a range of low-cost and beneficial technologies including various designs of solar driers, cheap budding knives, plastic film substitutes for expensive budding tape, chupon budding with new clones to renovate old trees, farmer selection of good trees, new methods of clonal propagation of trees, and the integration of vanilla with cocoa.

In this section we consider several of these innovations involving the adoption and adaptation of introduced technologies: solar driers and propagation techniques that were enthusiastically adopted and modified by farmers. These are described below.

Solar dryers (see 'Solar Drier Manual' in Appendix)
The widespread problem of smoke-tainted cocoa beans, resulting from faulty kiln pipes and poor maintenance of village-based fermentaries, has plagued the PNG cocoa industry for several decades. The impact on farmers is low cocoa prices. To overcome the problem of smoke tainting, this project developed and tested solar driers in the CMFT project study sites. The solar drier used had been designed and developed by two of the project researchers (Trevor Clarke and John Konam) in an AusAID project in the Solomon Islands. Most cocoa produced globally, including the global standard cocoa from Ghana, and all cocoa in Sulawesi, Indonesia under similar climatic conditions to PNG, is sundried using cheap and simple methods that are readily available to smallholder farmers.

However, smallholders in PNG have had very limited access to this type of technology. Apart from eliminating smoke tainting, the solar drier used in the project (known as the Solomon Island drier) has several advantages over the wood-fired kiln-pipe drier which has been the Cocoa Board mandated process for drying cocoa in PNG, derived from expatriate plantation experience. The key advantages for smallholders are:

- low cost — about one tenth of the price of a conventional wood-fired kiln pipe drier,
- easy to transport and build — essential materials are light and easy to transport to

isolated villages and assemble (the basic structure can be made from locally available materials),
- labour saving — no need for firewood collection and stoking of fires,
- improved cocoa quality apart from reduced smoke tainting - some growers in ESP are receiving a 10% premium for solar-dried cocoa.

The collection of firewood and stoking of fires are very laborious tasks for both men and women. Shortages of firewood are increasingly becoming a problem in many rural areas of PNG, adding to time and costs for sourcing firewood. This is in the context of labour shortages with labour being one of the main constraints on smallholder cocoa management and production in PNG (Curry et al, 2007). Solar driers have the potential to increase the quality and quantity of smallholder cocoa and increase their returns to labour through improved labour efficiency and higher prices (for quality), and a 50% gain in sale value from selling dry bean instead of wet bean.

The solar drier was initially tested at the Agmark Tokiala Plantation in ENBP, before establishing and testing the drier design among the CMFT groups. Initially a test drier of the standard Solomons design was built at Yekimbole Village by CMFTs Nola and Chris Sasingian who learned to use it to establish a cocoa buying and drying business with their village group. This was so successful that they built two more, each about three times the size of the first. They developed a cheaper form of drying bed consisting of bamboo slats covered in shade cloth instead of the expensive steel cocoa mesh provided for the initial drier. In 2019 they began helping other villages to build solar driers, sourcing rolls of plastic film. An initial Solomons design drier was built in Balama Village in Madang Province and officially opened at a field day where many farmers saw its potential. Especially in Madang Province, farmers in new satellite groups developed a variety of alternative designs of plastic covered structures. By the end of the project in East Sepik, Madang and Simbu Provinces, a total of 40 plastic covered solar driers had been built by CMFTs and satellite groups. Both men and women rated the driers highly because they could now harvest and work in the field and dry cocoa at the same time (they didn't have to constantly attend to hot-air driers). Other outcomes and impacts reported by farmers included:

- Modifications to the design of the original solar drier by farmers to better suit the conditions in the village. Farmers showed great initiative in modifying and adapting the Solomon solar driers to better suit the available materials in the village and their budgets. In Karimui they used bamboo poles for the frame and bamboo slats instead wire 'cocoa' mesh for the drying bed. At one of the Madang Province sites, the CMFT adapted her solar drier used for coffee to better match the Solomon solar drier.
- Women reported that the solar drier required significantly less labour, was cleaner and the work raking beans on drying racks was lighter. In ESP, women were especially interested in the solar driers as they could control the processing of wet bean without having to collect firewood and tend kilns.
- Some CMFTs reported plans for increasing the number of driers in their village. The improved affordability of the driers was an important incentive.
- Some farmers reported cocoa buyers paying a premium, in some cases of up to 10%, for solar dried cocoa beans. Thus, smallholder farmers were for the first time receiving a premium price for their crop by selling dry bean untainted by smoke.
- A handbook on design and operation of solar driers was written and presented to the PNG Cocoa Board in order to obtain its approval for them. Although a blanket approval at the executive level had not been obtained, provincial Cocoa Board staff were registering them and solar dried cocoa samples won prizes in the Cocoa Boards Festival of Cocoa Excellence in 2019.

The roll out of many of solar driers was late in the project and the full number of driers (40) was not captured in the quantitative survey where only 14 were documented. However, the focus groups and comments noted in the qualitative surveys provide some insight into the views of farmers (men and women) on solar driers. Generally, comments were very positive with participants referring to how solar driers have made workloads lighter because they did not need to collect firewood. Some mentioned that they were planning to install solar driers and were looking forward to reducing the time spent gathering and transporting firewood for cocoa drying. Some women noted that access to solar driers had made them more confident in cocoa work because they were anticipating seeing higher income from dry-bean sales, rather than the lower incomes from sales of unprocessed wet bean on which they had relied previously.

Plate 7.7. CMFTs Nola and Chris Sasingian in their solar drier at Yekimbole Village, East Sepik

Plate 7.8. Solar drying in Wafen Village. Note the two designs of Solomon driers in the background and a blue tarpaulin placed on a bed of river stones, Jan – Feb 2021. The village has been visited recently by senior managers of a chocolate manufacturing company based in Port Moresby, Paradise Foods, keen to buy solar dried cocoa beans. 68 members of the farmer group are interested in establishing solar driers.

Whilst overall, comments were very positive, a few points of concern were raised in some focus groups and during quantitative surveys. These related to a tiny number of cases where solar drier assets were effectively appropriated by group leaders, the difficulty some groups faced in sourcing building materials for solar driers (mainly the polythene sheeting), and the distance that women had to carry wet bean for processing. Each is discussed briefly below.

In PNG the appropriation of group assets by group leaders is relatively common and is the cause of the failure of many groups (Jackman 1988; Sengere 2016). In ESP, the wife of a CMFT reported that her husband had sold a dryer supplied by the project, treating the asset as if it were his own rather than a group asset. In another case in Madang, a woman whose uncle managed the solar drier claimed he was paying her wet bean prices for cocoa while he pocketed the increased value from the dry bean sales after processing. In another case in Simbu, one CMFT used the project nursery only to expand his own plantings of cocoa, and the solar drier was used almost exclusively to process his own cocoa. Although these are isolated cases, they are indicative of the types of problems that can beset groups and reduce their effectiveness.

Several farmers mentioned difficulties in sourcing materials for the solar driers, especially the cheap plastic sheeting. It was not clear whether this was due to insufficient information regarding where to purchase materials or whether they found the cost prohibitive. Another related issue concerning access to solar driers was raised by some women in Simbu who said the solar drier, at 2.5 km away, was too far away to make use of it. It is anticipated the low cost of these driers will encourage sub-groups living near each other to fund and establish their own solar driers. Also, the cost of the UV resistant polythene film, to date imported only by Agmark by arrangement with the current project, is likely to be reduced once more suppliers become involved.

Alternative propagation techniques and tools

To facilitate technology uptake to increase returns to labour and to make technologies affordable for farmers, the project encouraged local adaptation and innovation of project inputs. Farmers experimented with new ways of propagating cocoa and sought alternatives to expensive tools and equipment such as budding knives and budding tape.

A new method of producing chupon clones:

Some farmers in Simbu successfully used sections of bamboo internodes filled with soil for marcotting chupons (water shoots or suckers on the trunk) from high performing cocoa trees. Pieces of internodes with soil were taped at the base of chupons, which formed roots in the soil. The rooted chupons were cut off the main trunk and planted to give clones of the mother tree. These new trees from marcotting produced pods in under 18 months. They have the advantage over the usual budded seedlings in giving orthotropic growth, like a seedling, instead of the fan-branch (flat) growth of the budded seedlings that are usually made using buds from fan branches and need formation pruning to produce a well structures tree.

Field planting to obviate the need for expensive central nurseries:

At the start of the project, the conventional use of substantial nurseries, consisting of wooden frames, shade cloth and wire supports for shade cloth, and raising of rootstock seedlings in polybags was recommended and funded. The supply of materials, especially polybags, often held up progress in replanting cocoa. But part-way through the project many farmers built small nurseries near their cocoa plantings (in one case the shade cloth provided by the project was cut up and distributed separately to farmers for 'mini-nurseries') and some turned to field planting and budding of seedlings, thus avoiding the cost of nursery construction and maintenance (especially for watering of seedlings in polybags which had been a problem during dry periods). A CMFT in ESP reported that she had more success budding field-planted seedlings than seedlings raised in polybags, probably due to their better water relations. Also, field planting and budding avoids the plant check associated with transplanting of plants from polybags. In focus groups, several farmers referred to the cost and labour involved in carting plants in soil in polybags. The use of large central nurseries is another hang-over from plantation agriculture and central research facilities, where labour and vehicles are available to carrying plants in polybags. It was evident during the project that they were inappropriate for smallholders with limited capacity to carry the potted plants into isolated farms. Women talked of only being able to carry a few plants in bilums. In contrast, field planting involves carrying seed (100 seed in a couple of pods) and field budding involves carrying a handfull of bud sticks. It requires the skill required for budding and the attention to detail require to care for small plants in the field (the skills women have always applied to food crops). It should be noted that the massive cocoa boom in West Africa has been based on planting seed in the field.

Cheaper methods of budding:
The high cost of budding tape and commercial budding knives has confined budding to CCI research stations and some companies. Farmers began using cheap alternative stretchy plastic film such as strips cut from plastic shopping bags as budding tape. A farmer in New Ireland successfully used shopping bag plastic for field budding to replant his farm with clones. Professional budders at the Hawain nursery in ESP developed a method of using trade store cling wrap to produce convenient roles of budding tape with the same stretchiness and self-adhesive qualities as commercial budding tape. They wrapped clingwrap multiple times around the petiole of a taro leaf and then cut the cling wrap and petiole into rolls about 1.5 cm wide suitable for use as budding tape (Plate 7. 9).

Plate 7.9. Cling wrap being rolled from a large commercial role on to a taro leaf petiole, ready to be cut to make a cheap rolls of budding tape about 1.5 cm wide.

Often in PNG, labels for clones and field trials have been cut from aluminium drink cans using scissors; if marked with a solid pen, these can provide permanent indented labels.

Knives made by cutting hacksaw blades in half on an angle, grinding them sharp and adding a wooden handle were developed by the project as a cheap (K5) alternative to expensive (K175) professional budding knives. Later, farmers themselves found an even cheaper alternative by sharpening small K1 knives purchased from trade stores (Plate 7.10).

Plate 7.10. Steps towards appropriate low-cost technology in budding knives, with expensive imported budding knife on the left.

It became evident that an achievement of the project was to demonstrate the possibility of cheaper alternatives to expensive, conventional techniques and materials (e.g. kiln drying, cocoa nurseries, expensive commercial budding equipment and materials), which gave farmers the licence to experiment with even cheaper alternatives. The idea that alternatives were possible was empowering for farmers and was just as important as the development of the alternatives methods and equipment themselves.

The outcomes of the project

The demonstration of the effectiveness of the farmer-trainer model as a permanent source of advice and training in villages, as discussed above.

Increased cocoa production

The outcomes of the project in terms of increased production are difficult to discern at the provincial level, except for Simbu where nearly all of the province's production was associated with the project (Table 7.2, Plate 7.11). Although the production level is relatively small, Simbu's cocoa production in Karimui valley increased by 640% from 2015/16 to 2018/19 which represents substantial income gains for smallholder families. Production in ESP also increased markedly, by 36% linked to increased enthusiasm for cocoa production to which the project contributed. This increase in production is likely to be maintained after the end of the project through the involvement, that began in March 2020, of a large FAO/EU-funded cocoa project that has adopted and scaled-up this project's strategy in East and West Sepik.

While production at the provincial level fell in both Madang and New Ireland, there was a general increase in most of the CMFT sites, except where it was too early for the yield benefits of rehabilitation to take effect (the increased yield response to rehabilitation can take two years) (Table 7.2). Production data at the individual and group levels is very difficult to obtain because cocoa is sold in different forms (wet bean or dry bean) to multiple buyers in different locations. So, information was collected from farmers themselves as to whether they experienced increased production or not.

Table 7.2. Provincial production of cocoa dry bean by province.

Province	2015	2016	2017	2018	2019	Per cent change 2015 to 2019
East Sepik	8,220	10,776	9,448	8,843	16,937	36
Madang	6,844	6922	6,069	5,784	5,377.1	-19
New Ireland*	282	340	298	284	260.4	-12
Simbu	2	3	8	12	25.0	640

(Source: PNG Cocoa Board)

* A portion of New Ireland's production is sold through ENBP.

Plate 7.11. CMFT Wanpis Alowai with an outstanding cocoa tree grown from seed from the test planting of SG2 hybrid seedlings at Karimui, Simbu

To assess the impacts of the project on production, we sought farmers' views on changes in cocoa production and the levels of CPB infestation which have a direct bearing on cocoa production. The large majority of groups, except in New Ireland, reported increased cocoa production since group formation (Figure 7.18). In New Ireland, where there had been delays in sourcing planting material, only half of groups reported improved cocoa production. Some of these groups were still waiting for their new or rehabilitated blocks to come into production. The focus groups also indicated that production had increased or was showing signs of increasing as blocks started coming into production. All ten focus groups in Madang reported increased production with one group highlighting the need for farmers to maintain their blocks and to bring CPB under control:

> Neglected blocks continue to give low production due to high CPB incidence; better managed blocks are seeing improvement in production because of more controlled CPB infestation levels (focus group response in Madang)

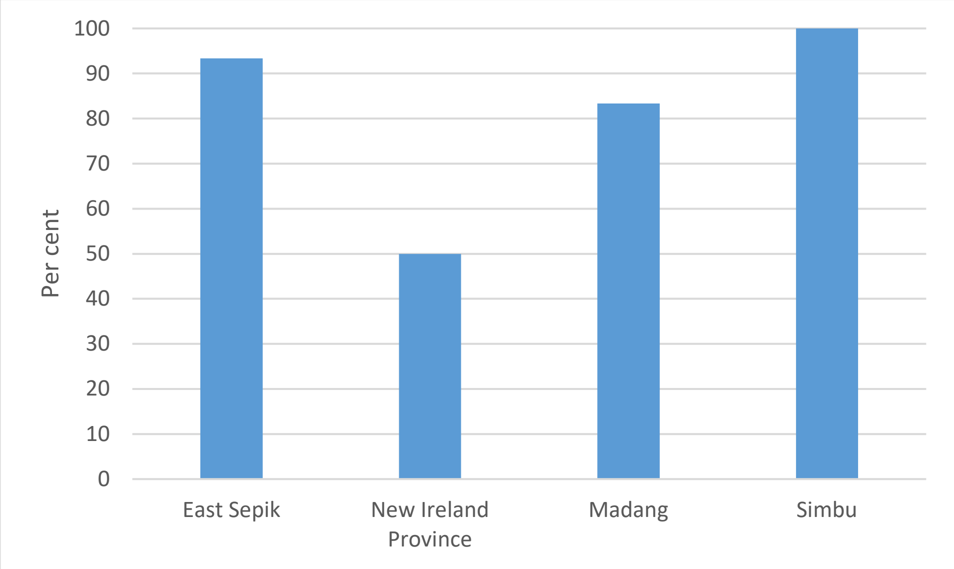

Figure 7.18. Percentages of groups that reported increased cocoa production (n=46).

The extent to which production increased was quite large across all groups that experienced growth in production during the project (Figure 7.19). Sixty-six per cent of groups were estimated to have increased production by more than 25%, with 36% experiencing more than a 50% increase in production. As to be expected, there was variation in the rate of improvement amongst provinces. Of the groups that experienced an increase in production in New Ireland, the increase was 25% or less. It is anticipated that New Ireland will soon catch up with the production increases of the groups in other provinces. Perhaps the main outcome was a general sense from CMFT surveys, focus groups and casual observation of CMFTs and farmers that there was a renewed enthusiasm for cocoa planting and management following the devastation of the CPB incursion. The Technical Manager of one of the main cocoa buying companies, NGIP-Agmark, reported markedly increased intake of cocoa beans in 2021.

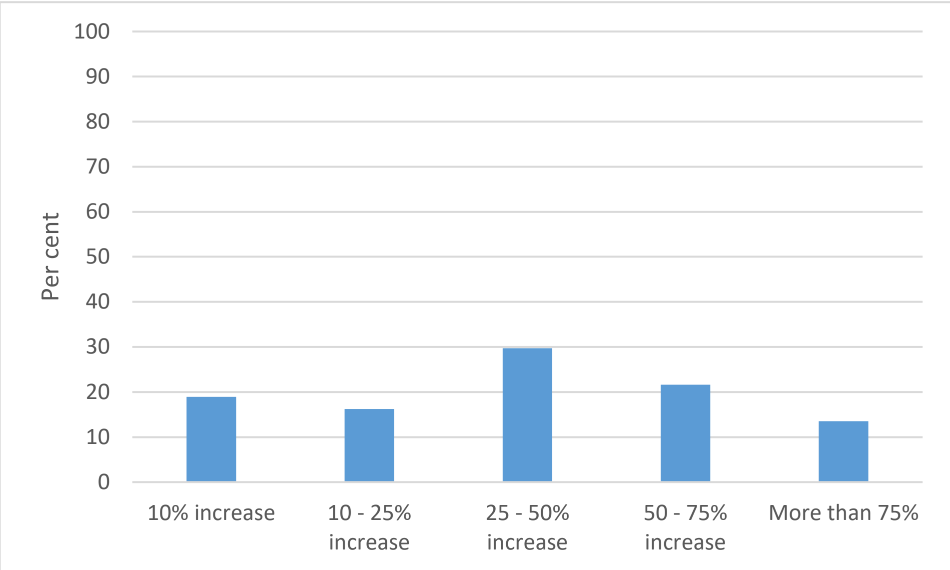

Figure 7.19. Estimated percentage increases in production across all CMFT groups for those groups where production increased (n=46).

Improved CPB control

Bringing CPB under control for increased cocoa production was a major objective of the project. This message was driven hard in extension in the lowland sites where cocoa had been devastated by this pest. Across all sites, except Simbu at 1200 metres above sea level where CPB was not present, 86% of groups reported that the CPB situation had improved. This ranged from 75% of groups in Madang to 100% of the New Ireland groups. In fact, on his final visits to New Ireland, Trevor Clarke was unable to find in fermentaries cocoa beans with typical symptoms of CPB damage and CMFTs reported that CPB was less of a problem. This is quite a remarkable achievement for the project. When seeing for themselves a decline in CPB in response to their labour inputs in general maintenance and CPB control, it provides hope for the future and gives them confidence that their investments in their cocoa blocks will generate returns. The selection of comments below from coordinators of focus groups highlights some of the uncertainties smallholders felt concerning whether their labour investments to control CPB will pay off:

> CPB infestation levels still too high so they continue to do other things with better income-generating potential
>
> Because of the struggle with CPB, women are more focused on faster and higher income-generating activities (e.g., betelnut selling) than in cocoa work
>
> [She is] not sure if CPB can be completely eradicated, and thinks she may be wasting her time [trying to control CPB]

Although progress in CPB control has been remarkable overall, some farmers, as the comments above reveal, still have reservations about whether they will ultimately be able to control CPB and increase cocoa production. A potential risk for cocoa production is that alternative livelihoods that were developed and expanded during the CPB incursion (chiefly garden foods for local markets, vanilla and betel nut production) will remain more attractive livelihood options to smallholders than cocoa. But this risk is low because, generally, income from marketing of garden foods did not fully compensate for the loss of pre-CPB cocoa incomes, and while vanilla is generating good returns at present, most smallholders will continue to grow vanilla as a cocoa intercrop. The cocoa-vanilla combination is good for cocoa because investments in block maintenance in weed and shade control for vanilla also benefit cocoa, thereby also helping in the control of CPB. The cocoa-vanilla combination was promoted as part of this project, and was driven by the high world price of vanilla due to drought in the main producing country, Madagascar, and should remain an important component of extension efforts into the future.

Changing attitudes to cocoa

The increased efforts to control CPB and improve production are reflected in farmers' improved attitudes to cocoa farming. Overall, only 4% of CMFTs reported no change in the attitude of farmers to cocoa since the commencement of the project, while 59% reported 'moderate' change and 37% 'much' change. The improved attitude to cocoa was positive across all provinces with Simbu CMFTs having the most positive outlook (Figure 7.20).

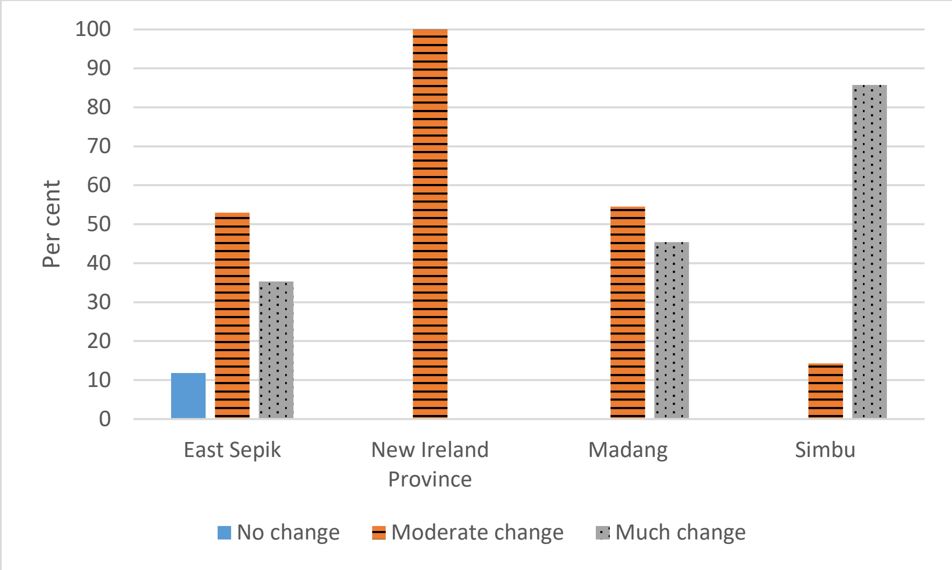

Figure 7.20. CMFT views of the success of the CMFT group in changing attitudes to cocoa by province (n=46).

Gender and men's changing attitudes to women in cocoa

The improved attitudes and confidence in cocoa also extended to an improved attitude of men to women's participation in cocoa production. Women have long been marginalised in perennial export crops in terms of decision-making and income distribution, and this has led to women's dominance in the marketing of food crops where they have greater control over their labour and income (for a discussion, see Curry et al 2019). The FFT and UNRE livelihood training encouraged men to have a more positive view of women's role in cocoa production and this was also encouraged by involving women in all extension activities during the project. Overall, only 13% of CMFTs thought there was 'little evidence' of a changed attitude to women's participation in cocoa while 71% thought there was 'moderate' change and 18% 'much' change. The spouses of CMFTs were asked the same question and the corresponding percentages for their views were 16%, 68% and 16%, which were very similar to their CMFT husbands' assessments.

The focus groups cast further light on how changed attitudes to cocoa production and women's involvement in cocoa are translating into improved confidence in the future of cocoa as a livelihood. Of 118 men across all the Madang focus groups, 86% said their confidence in cocoa had grown since joining their group and 14% said that their level of confidence had not changed. For the 72 women in the focus groups, 64% said their confidence had risen, 33% had remained the same and for 3%, their confidence had declined (declined primarily because CPB had not yet been brought under control). Some of the notes of interviewers in the quantitative survey shed further light on how attitudes to women in cocoa are changing:

> Family Farm Team Training and other trainings have helped involvement of women in cocoa production activity; for cocoa cash crop is currently main crop cultivated (interviewer's note of view expressed by a woman in ESP)
>
> Respect and involve women in decision-making and participation (interviewer's note of view expressed by a man in ESP)
>
> Mobile team groups [have] been established and women are being involved in pruning, budding and field training (interviewer's note of discussion with a man in ESP)
>
> Farmers have come to understand that cocoa production is family business — so women participation is now considered (interviewer's note of view expressed by a man in ESP)

> Women gradually [becoming involved] in cocoa activities — slowly taking part (interviewer's note of view expressed by a man in NIP)
>
> Little evidence of change. Farmer gradually realising importance of women in cocoa farming (interviewer's note of view expressed by a man in NIP)

Other provinces assisted

West Sepik Province

Wilson Miroi, after attending initial CMFT training with his wife Cathy Miroi and observing the project activities in New Ireland, used his own funds to establish the project strategy at Poro in his home province of West Sepik, building on a budwood garden and nursery he had established previously. One of the staff of his engineering business, Grace Klembasa, became his nursery manager and established her own farm and farmer group. A cocoa sample she submitted was awarded a medal in the Paris Salon du Chocolate in 2019. Using the carpenter who built the solar drier at Panamecho in New Ireland, Wilson built an identical solar drier. Supported by the project team in East Sepik, he conducted a Farmer Field Day at Poro in September 2019. Altogether, Wilson's project extension is supervising 40 farmer groups with 2000 farmers.

Assistance was given by the East Sepik coordinators to the Tenkile (tree-kangaroo) Conservation Alliance based at Lumi, West Sepik, 11 hours drive from Wewak. They established a CMFT site led by Mathew Akon, and established a budwood garden and nursery.

West New Britain Province

Trevor Clarke made an extension trip from 15 to 18 October 2019 to three villages in the Open Bay area – the Sabali Care Centre where about 2000 people from Ulamona Village were refugees from the eruption of Uluwun volcano and were living under harsh conditions, Matanakunai Village where about 25 groups expressed interest in planting cocoa, and Baia Village. Altogether, 2000 seeds of the 10 latest hybrid crosses from Tavilo were planted for testing in the three locations. Many farmers expressed interest in planting cocoa in preference to oil palm, which they considered too much hard work and tended to deplete soils (minimum of 2 ha planting).

East New Britain Province

Trevor Clarke developed and tested solar driers at the Agmark Tokiala Plantation and later with Otto Kuaimba at Utmae. The project head office was located in the Agmark building in Kokopo where the company's Technical Manager, Graham McNally, was a constant and valuable advisor to the project managers.

Relationship between inputs and outcomes

The effect of external support (RED/ACIAR) for CFMTs vs no external support

The project provided various forms of support for more than half the groups. However, whether a group received project funding or not did not seem to affect group performance in terms of increased cocoa production (Table 7.3). Indeed, of the 20 groups with no external support, all of them reported increased cocoa production. This probably reflects group members' greater commitment to the project, given that they were relying on their own resources to engage in the project.

Table 7.3. Relationship between production of cocoa bean and support CMFT received (n=61).

		Project funded (n=37)	LLG funded (n=4)	No outside support (n=20)
Cocoa bean production increased?	No	22	50	0
	Yes	78	50	100

Similarly, ACIAR or REDS payments to the CMFT did not have a clear effect on group performance in terms of the proportion of groups that reported increased cocoa production (Table 7.4). Financial support did not appear to be a critical factor in the success of groups.

Table 7.4. Relationship between production of cocoa bean and ACIAR/REDS part-time payments to the CMFT (n=46).

		No payments made (n=15)	Part- time payments to CMFT Year 1 (n=8)	Part time payments to CMFT in Year 1 and 2 (n=23)
Cocoa bean production increased?	No	7	0	30
	Yes	93	100	70

There are at least two possible explanations for these results. First, groups where members had to rely on their own resources were likely to be more committed to the goals of the project – they were not in the group to extract resources (e.g., funding and tools) provided by the project or other external agents and probably understood that the project was mainly providing knowledge and training rather than direct material benefits. Second, some group members expressed dissatisfaction and disillusion when a small number of CMFTs appropriated or attempted to appropriate assets such as tools that were provided by the project. When this occurs the sense of injustice engendered amongst group members can undermine commitment to the group and the project, rendering groups dysfunctional. In other words, external funding can sometimes have the opposite effect to that intended and provide opportunities for nepotism resulting in the breakdown of groups. The following comments highlight some of these concerns:

> Notes by interviewer on quantitative surveys:
>
> Madang: Lack of interest in cocoa. Increased [cocoa production] seen only in CMFT and family block. Other members not working.
>
> Madang: Lack of co-operation from the farmers with the CMFT – most left project group. Project was not a success – only the CMFT and family OK.
>
> Focus groups (some of these comments refer to the same CMFT:
>
> Simbu: Our CMFT … kept the budwood garden to himself.
>
> Simbu: CMFT … [kept] the central nursery and the solar dryer [for] himself
>
> Simbu: Our CMFT … 'hijack' the freight subsidy scheme to his own advantage. For example, when there is funding for freight subsidy, the CMFT and others who have

> the same interests as him, use the subsidy costs for freighting their own cocoa and not as group for all farmers.
>
> Simbu: Clones were unfairly distributed because the CMFT got them for his own use
>
> Simbu: The CMFT … uses it to dry his own cocoa because he has plenty [of] cocoa
>
> Simbu: Only the CMFT got the clones and not the farmers in the group.
>
> Madang: Some farmers laid claim to CMFT's tools; other farmers lost interest due to lack of access to tools for cocoa work
>
> Madang: No group tools; only CMFT was given tools
>
> Madang: … many original members left the group when they realised the working tools were only for the CMFT [they were intended for the whole group]

Some of these problems were seen at first hand by project coordinators. The particular CMFT in Simbu had been selected by Provincial Government staff, not by the local farmers in his Ward, and early on neglected his fellow farmers. The project gave him funds to have fermentation boxes made for all seven CMFT groups in Karimui (Simbu) but these were all kept for himself. In ESP, one of the most active CMFTs caused problems by not immediately distributing to group members money received for the sale of clones and not immediately deploying materials provided for construction of a solar drier. The large village meeting house was burned down. The coordinator was able to sort out this problem.

Selection of CMFTs and their effectiveness

It was stated above in this section, that there did not appear to be a relationship between how CMFT leaders were chosen and group success. Because a relationship was not discerned between method of leader selection and group performance does not mean that a relationship did not exist. Count numbers in sub-categories were probably too small to detect differences in the performance of groups, and/or the performance indicators were not sensitive enough to detect the effects of leadership selection. However, many smallholders expressed strong views in the quantitative surveys and focus groups on the performance of group leaders and how they were selected. Indeed, many asserted strongly that group members themselves should choose their own leaders, and some CMFT groups had replaced under-performing leaders. A selection of comments by interviewees and smallholders is presented below:

> Notes from the coordinator of the Madang focus groups:
>
> Farmers prefer to select their own CMFT because they know each other's personal characteristics. [Group] leaders should be someone who has the capacity to support and sustain the group
> Farmers should convene and elect someone they know who is committed to helping the farmers
> Group members should select CMFT based on the group's own criteria: proximity, landownership, etc., have to be taken into consideration
> Better for group to select their own CMFT because … [they know] what their own members are capable of
>
> Simbu focus groups:
> Comment on a poorly performing CMFT leader: We will appoint a new person
> Comment on a poorly performing CMFT leader: We as new farmers and the whole community will meet and select a new CMFT
>
> Comments from the quantitative surveys:
>
> ESP: We as the CMFT group was not fully satisfied of the working materials and that's why we are too slow. That's the problem with the CMFT

> New Ireland: Change of CMFT from [the husband] to his wife has affected [improved] farmer interest and commitment
>
> Simbu: Let the community select the CMFT, not the project staff officers and government officer

Interestingly, husband and wife CMFT teams performed much better than CMFTs working without the support of a spouse. As stated above, a high proportion of CMFTs were supported in their roles by their spouses, many of whom were active in group activities (Figure 7.21). Women acting as group leaders alongside their CMFT husbands provided role models for other women and certainly would have encouraged female participation in group activities like training.

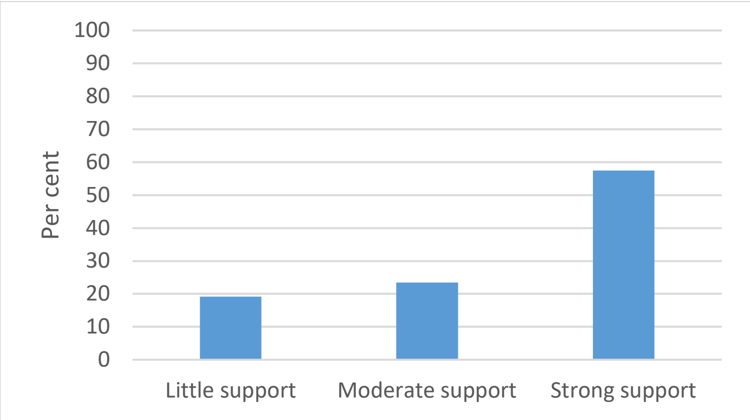

Figure 7.21. The level of support provided to CMFTs by their wives. (n=47).

The level of spouse support for CMFTs was strongly and positively associated with increased cocoa production (Table 7.5). Ninety-six per cent of CMFT groups where the CMFT had 'strong support' from their spouse with typically the wife active in the group reported increased cocoa production. Although the numbers are small, only 57% of groups reported increased production where the CMFT receive little support from the spouse. When the two sub-categories of 'little' and 'moderate' support are combined (n=18), 61% of groups reported increased cocoa production compared with 96% of groups where the CMFT received 'strong' support. It was often observed by project managers that women played an important role in project activities, attending all training sessions and taking notes, and being present during visits to villages.

Table 7.5. Relationship between production of cocoa and support of spouse in CMFT activities (n=45).

		Q7. Little support (n=7)	Moderate support (n=11)	Strong support (n=27)
Q45. Cocoa bean production increased?	No	43	36	4
	Yes	57	64	96

Husband and wife CMFT teams proved very successful in this project and promoted a more gender inclusive approach to extension with female smallholders more likely to see cocoa as a family business rather than the preserve of men, which has been the case traditionally. With labour shortages long recognised in research as a constraint in cocoa (and coffee) production, the involvement of women in extension leadership will help drive positive change for women and families in cocoa production. Therefore, involving women in leadership positions in extension in cocoa should be a fundamental tenet of all future extension initiatives in PNG (see Hamago 2021 for a discussion of these strategies).

Future directions

During the project it became evident that many of the problems faced by village smallholder cocoa farmers were due to inappropriate technologies they had been encouraged to adopt since pre-independence times and which were based on misconceptions of farmers' real needs and capacities. For example, the use of hybrid seedling cocoa has been problematic – it was promoted because of perceived hybrid vigour, giving high early yields on some trees. However, it was highly variable with many trees being non-productive and occupying land and requiring work for no return. It was vegetatively precocious and needed heavy labour for pruning. It also suffered early yield decline compared with the Trinitario cocoa it replaced.

High labour demands because of the vigorous vegetative growth of hybrids were exacerbated by the high labour demanding *Gliricidia* shade tree which was promoted widely throughout the cocoa growing regions of PNG. *Gliricidia* is extremely fast growing and if not pruned regularly and severely, it quickly overshades cocoa creating an understorey microclimate conducive to high levels of pests and diseases. Because most smallholders followed a foraging production strategy of low labour inputs, most cocoa blocks were over-shaded with high levels of pests and diseases. With the arrival of CPB in these poorly maintained and overshaded blocks, the impact on production was catastrophic with almost 100% loss of production in many places.

Thus, the cocoa planting material and shade trees were inappropriate technologies for PNG smallholders, leaving their most important livelihood vulnerable to environmental risks.

To overcome the variability of hybrid seedling cocoa, CCI selected and tested the best individual hybrid trees and propagated them as clones. Some clones were selected because they were slower growing and produced smaller trees that were more suitable for smallholders. However, these latest-release CCI clones were available only from the few CCI and DPI research stations and were not widely available to farmers.

The promotion of wood-fired kiln cocoa driers was another vestige of pre-independence plantation methods that has been inappropriate for village smallholder farmers. The kiln driers are expensive to build and maintain, and the steel kiln pipes rust out, leaking smoke and leading to smoke tainted cocoa beans. Nearly all the cocoa in West Africa and Sulawesi is fermented and sun-dried with very simple and cheap structures that have helped boost smallholder production and quality. In fact, the world standard for high quality cocoa in Ghana is all processed using simple methods of fermentation in heaps of cocoa beans on banana leaves spread out on the ground and sun drying on simple raised bamboo platforms.

In future, development and promotion of new technologies must be driven by the real needs and capacities of farmers. Determining real needs and capacities requires fundamental change in cocoa extension from top-down, externally managed and guided extension initiatives and technologies, to farmer-centred and bottom-up approaches in which farmers themselves determine priorities and manage on-farm trials. A high degree of farmer control allows them to adapt, modify or reject technologies and innovations recommended as options by external experts. None of these ideas for extension are new; but they have yet to make much impact on extension in PNG. This means that the role of the external agency is to facilitate options for farmers and to provide training in priority areas as determined by male and female smallholders themselves.

For greater empowerment of farmers and to increase cocoa production in PNG, it is imperative that government regulations on smallholder cocoa production be reviewed and revised. For example, regulations regarding construction of fermentaries and buying of cocoa need revising to encourage farmer enterprise; cocoa quality can be assured by checking prior to export and with price incentives for quality, not by many regulations dating back to pre-independence times that discourage farmers from processing their own cocoa and receiving the full value of their production.

Based on the results of the current project, the following priorities for further study are suggested:

1. Factors that contribute to the development of village farmer groups and their leaders as village extension workers need further study. Linked to the government research and extension services, these can provide a permanent, self-supporting, village extension and education system to promote new cocoa and food crop horticulture, and sustainable, healthy livelihoods for all family members. In this project, many farmers expressed the view that village extension workers/leaders must be selected by the people they are serving, not by outside agents. It was also evident that they need not be paid, but rather rewarded with frequent and regular contact with the government or private company officers, regular training that they can pass on to other farmers, and perhaps with tools and materials that are seen as belonging to the whole farmer group. It was found that payment of CMFTs sometimes led to jealousies and resentments that damaged the cohesiveness of the groups.
2. Methods of integrating cocoa with food crops in 'kakao-kaikai' gardens to benefit cocoa production, household food and income security and the role of women need further study. For example, is cocoa better managed as a result of greater involvement of women who can apply to cocoa the sort of intensive methods that they practise in food gardens? Are there fewer pest/disease problems when cocoa is integrated, with wider spacing and with systems such as alley-cropping, in village food gardens than when grown in separate monoculture blocks as a 'plantation' crop? Nutritional foods (Module 3 in FFT) have to be inter-cropped with cocoa for the farmer's consumption - the farmers need to be healthy to maintain healthy cocoa.
3. During the project, the integration of vanilla production with cocoa was an innovation driven by farmers, especially in ESP, responding to the very high price of vanilla because of damage to the crop in the main producing country, Madagascar. Poor processing (curing and drying) linked to a sudden upsurge in production has reduced the price received by farmers and this requires further extension effort along with study of integration of the crop with cocoa. In this project, farmers mainly trained the vanilla vines on *Gliricidia* shade trees but some also trained them on cocoa trees. Labour inputs for all the agricultural activities should related back to individual Family Goals (FFT Module 1). Family labor also relates to FFT Module 1 – Balance Family Circle. The family cannot try to do more than the family labor unless the family is willing to pay for hired labour (Balens Diwai).
4. Continued development of cocoa genetic resources and breeding is needed to: meet biotic threats such as Cocoa Pod Borer and Phytophthora Pod Rot; adaptation of the crop to new areas such as the highlands or land with coralline soils; and selections of types better suited to smallholder farming (smaller, more uniform and durable trees requiring less labour for pruning and harvesting, and resilient when neglected if prices are low or labour is scarce). Longevity of cocoa trees must also be considered as farmers are reluctant to replace established

trees. When hybrid seedlings were introduced in the 1970s, farmers were encouraged (even directed) to remove all their old Trinitario trees; many ignored the direction and kept their best old trees and some of these are still productive to this day and provide a valuable repository of well adapted genotypes selected by farmers.

5. Further study is required of the suitability of particular trees as shade for cocoa. *Gliricidia* has proved to be unsuitable for cocoa unless its foliage, developed as a fodder source for livestock, can be used to support production of livestock. *Gliricidia* was promoted as a replacement for *Leucaena leucocephala* when its defoliation by psyllids rendered it useless as shade in PNG and Indonesia. However, psyllid-resistant types have been developed in Indonesia. *Leucaena* is a more ideal shade tree than *Gliricidia;* while a relatively fast-growing legume like *Gliricidia,* it grows tall and requires little pruning, throws a light shade, and is a valuable timber source. Many farmers, driven by the high price being paid for betel nut, especially in the highlands, are planting betel nut as shade for cocoa. Galip nut has been shown by the National Agricultural Research Institute (NARI) to be a valuable shade for cocoa. Some farmers in ESP are considering eaglewood (*Aquilaria* sp., *Gyrinops* sp.) as a shade tree.
6. Further development is needed of methods of improved management of Cocoa Pod Borer and Phytophthora Pod Rot, building on the work of Konam et al. (2011) and Daniel et al. (2011) – especially the assessment of the effectiveness of sanitation harvesting and easier ways of disposing of infested pods and pod husks (such as burying them among the windrows of cocoa and shade tree prunings that harbour active ant populations, or covering them with shade cloth to contain pests and pathogens while they decay.
7. Further study is needed of the extent and possible augmentation of natural biocontrol of Cocoa Pod Borer and other insect pests. There is anecdotal evidence that the recent incursion of fire ants (*Wasmannia* sp.) from the Solomon Islands is providing a degree of biological control of CPB and this need further study.
8. Further development is needed of designs and operating methods of affordable solar cocoa driers for smallholder farmers to enable more widespread use of small-scale village fermentation and drying of cocoa, to avoid smoke-tainting of cocoa, to reduce the labour and demands for firewood, and to increase the involvement of women and youth in processing and sale of cocoa.
9. Further study is needed of the integration of goat husbandry with cocoa, especially feeding of goats by cutting and carrying *Gliricidia* prunings to generate an added income from pruning the shade trees as well as benefiting the cocoa by preventing overshading. Goat manure is a valuable resource to augment composting of farm waste to produce an organic fertiliser. These are standard practices in traditional goat husbandry in Indonesia.
10. Studies to promote the growth of shade trees and cocoa on kunai grasslands should be pursued. During the project it was evident that if trees such as *Gliricidia sepium*, *Acacia mangium*, palms, fruit trees, and galip nut can be established, cocoa can be grown in their shade. There was evidence that grassland soils are fertile and that the main problem is with their texture and structure, which can be modified by ploughing and planting of supporting tree species.
11. Research is required to compare the cost effectiveness of wood-fired kiln driers and solar driers when they are used at less than full capacity. Women typically harvest small amounts of cocoa in the off-season which they sell as wet bean rather than dry bean partly because it is uneconomical to use a kiln drier for small lots. With fuels costs eliminated for solar driers, opportunities arise for women to value add to their cocoa by processing smaller quantities to produce dry bean in the off-season.

8 Impacts

8.1 Scientific impacts – now and in 5 years

Because of the liquidation of CCI, most of the scientists who were involved in project planning and were intending to lead the formal research aspects of the project were unable to participate as intended.

The main research impact was the demonstration that the development of village-based farmer groups as foci for training, education and encouragement of smallholder farmers has real potential as a cost-effective extension system. This is providing that such farmer groups are coordinated by trusted village leaders and supported by government research and extension institutions and cocoa-buying companies. Over the past four decades, extension services in PNG have been ineffective, very poorly resourced, and have become fragmented and uncoordinated over four levels of government (National, Provincial, District and Local Level Government) (Sitapai 2012). While private sector cocoa buyers and development agencies have conducted training programs with farmers in an attempt to address this deficiency, they were usually based on intermittent 'training and visiting' extension methods that are expensive to run and fail to engage farmers in ways meaningful to their lives. The farmer-centred approach of this project to extension provided insights into how a more effective and inexpensive extension strategy using appropriate technologies for smallholder men, women and families might operate and be delivered in PNG. The key to successful extension is the genuine adoption of bottom-up approaches, with farmers setting priorities, engaging in on-farm trials of new technologies in which they are empowered to adapt, modify or design technologies (e.g. Plate 7.?) to better meet their needs, economically and socio-culturally (e.g. take account of lifestyle factors that influence production strategies). While this extension strategy has been adopted successfully by 74 core CMFT groups, it has already been adopted spontaneously by a further 352 satellite groups serving over 27,000 farmers. With support of REDS, it is anticipated that this low-cost model of cocoa extension will continue to be scaled out, especially if some of these satellite groups begin assisting new groups to form. The strategy has been adopted by a large Provincial Government Cocoa Project in New Ireland and by a large FAO/EU development STREIT project in East and West Sepik and parts of Madang Province.

The many cocoa budwood gardens consisting of 10 trees of each of the 18 latest-release CCI cocoa clones allowed farmers to assess the performance of the clones in their local environments, including the highlands. At the end of the project, Dr Epaina, who was in the process of being re-appointed to lead the cocoa genetics and breeding program at REDS (formerly CCI), planned to get CMFTs to assess the performance of the clones. Unfortunately, the project ended before this was possible although a revitalised REDS section could pursue this work.

The project demonstrated that cocoa production has great potential in the highlands where the people are very much in need of an alternative commodity crop to coffee, which has been declining over the last decade. The growth of many lowlands trees in the highlands indicates an effect of current climate change that appears to also affect cocoa. The great genetic diversity of the Trinitario cocoa first introduced to PNG in the 1890s and of hybrid seedling cocoa (resulting from crossing between Upper Amazonian and Trinitario cocoa since the mid-1960s) allows selection for pest and disease resistance (as clearly shown for resistance to Vascular Streak Dieback; Keane and Prior 1991). It is possible that this genetic diversity has also allowed selection for new types of cocoa adapted to higher altitudes, as evident in the project – some highly productive trees were evident among the cocoa planted by farmers at altitudes of about 1200 masl (twice the upper altitude limit often cited for cocoa) in the project. With the budding skills taught in the project, these can be propagated clonally and they await further testing for quality and other characteristics.

A less labour-intensive method of disposing of CPB and Phytophthora infested pods and pod husks by in-situ composting under windrows of cocoa and *Gliricidia* prunings was suggested by a farmer and requires testing in formal studies.

There was evidence that CPB is decreasing as a problem in some locations and this requires further study. This was an aim of the current project that could not be pursued because the senior entomologist at CCI was not employed under the Cocoa Board REDS section after the liquidation of CCI. Many farmers believe that the spread of Solomon Fire Ants provides an effective biocontrol of CPB and this requires study.

This project has generated new understandings of the role of women in cocoa production and how to facilitate their inclusion in the industry. The new extension models used in this project bring new insights into ways to foster and strengthen women's engagement in cocoa which are also relevant to other commodity crop sectors like coffee. The findings on the impact of the scheme on household production and the social and economic outcomes for women and smallholder families provide lessons on what works, why it works, and in what contexts. This is valuable information for extension providers in other commodity crop sectors planning to improve the participation of women and establish more equitable and inclusive extension services. For example, a much higher proportion of groups headed by husband and wife teams had success in improving cocoa production than groups headed solely by men. Also, female leaders provide a role model for women and encourage a family farming approach to cocoa production.

There was preliminary evidence in field trials at Wingei and Yekimbole in East Sepik that cocoa can be grown on kunai grasslands on the Sepik Plains if the ground is prepared by deep ploughing or ripping and shade trees are first established. Potential shade trees at Yekimbole were shown to be *Gliricidia sepium* and *Acacia mangium*. Collaboration with SMCN/2014/048 (Optimising soil management and health in PNG integrated cocoa farming systems) showed that the soil is fertile and that its structure is the main impediment to its expanded use in agriculture. At Suaru Village in Bogia District of Madang Province, the CMFT group established a productive budwood garden and cocoa blocks under *Gliricidia* shade on foothill grassland.

Pigeon pea from India was introduced and showed promise as temporary shade for cocoa with the added benefits of its contribution to soil improvement and provision of legume seeds as a protein-rich food source.

With further support by projects and the PNG Government to restore the research and extension capacity of the REDS section of the PNG Cocoa Board, all of these preliminary studies could be tested and applied widely with substantial practical benefit within 5 years.

8.2 Capacity impacts – now and in 5 years

The coordinators and their support staff in Madang, New Ireland, East Sepik and Siimbu provinces greatly developed their capacity as extension leaders during the project. All showed great organisational and extension capacity that was stymied just prior to the project by the organisational collapse of CCI functions when it was dissolved and incorporated into the Cocoa Board in 2017. The lack of operational funding from CCI and the Cocoa Board severely curtailed their engagement in the project, which meant that project funds had to be redirected to support their involvement (e.g. by improving office facilities, providing all office and extension equipment, supporting office and casual staff laid off after the liquidation of CCI, vehicle purchase and maintenance, all fuel and travel allowances, and housing for some staff). Most importantly, the project provided them with a strategy to work directly with village farmers, that included developing an extension manual summarising all the research and development outputs from CCI over many years, extension handbooks for distribution to farmers, and vehicles and resources to visit villages at widely scattered locations in the provinces, including some very isolated and previously neglected sites.

The highly experienced CCI extension officer and project coordinator in New Ireland, Kula Daslogo, commented that the project was the best he had been involved in as it gave him the initiative to develop a productive strategy to involve village farmers in their own development and supported him to implement it. He was an important contributor to the early adaptation of the project on the ground and built and tested the first Solomons solar driers outside CCI Tavilo and Agmark Tokiala, one being an innovative combined solar and hot-air kiln drier built in Panamecho Village. He helped the Governor of New Ireland, Sir Julius Chan, initiate a separate project funded by the province, using the same strategy as the ACIAR project but covering many more villages. Unfortunately, Kula was not offered a contract by REDS following the liquidation of CCI in Nov 2017 and took up a senior position in the Kokonas Indastri Korporesen (KIK). He continued to work with the CMFTs he had developed, on integration of coconuts and cocoa. Sadly, he died in January 2020, along with his granddaughter, when his boat capsized in rough weather as he travelled from New Hanover to his home island of Tingwon. John Joseph, Kula’s former assistant under CCI, took over as project coordinator in New Ireland and thrived in the role, working effectively with the Field Services section of the Cocoa Board (not always the case in other provinces) and building up the relationship with the provincial government cocoa project. Some provincial DPI staff were provided with motor bikes and extension handbooks to support the provincial government cocoa project, and many participated in field days.

The coordinator in Madang Province, Aitul Weoh, was a newly appointed and inexperienced CCI extension officer when the project began and lacked even a vehicle, a driver’s licence and office. The project provided a vehicle and supported him to get his driver’s licence, funded renovation of an office in a run-down complex in Madang town owned by the provincial DPI, and employed a retired senior extension officer, Bofeng Mebali, to work with him and help him build up his experience and confidence. After a slow start, the project became very successful in the province. The project also gave guidance and support to Provincial DPI staff such as Tomoli Wowomi who became a highly productive leader of the project in the isolated Rai Coast region of Madang Province, accessible only by boat. A senior DPI officer in Madang, Godfried Savi, assisted Aitul by driving him to potential CMFT villages at the start of the project, was a constant source of advice and encouragement throughout the project and made the project work 'core activity' for his DPI staff, thus giving them a focus for their work. DPI staff also participated in the baseline surveys.

In East Sepik, the highly experienced CCI extension/research officer and project coordinator, Jimmy Risimeri, implemented the project with the support of an assistant coordinator, Chris Toli, employed by the project. The project provided them with a vehicle to visit isolated project sites, which became indispensable when Jimmy’s original, run-down CCI vehicle was made inoperable by an engine fire. With the liquidation of CCI, Jimmy was not employed by REDS, and so took a job with KIK. He was replaced by a highly experienced Cocoa Board extension officer, John Meth. After a period of outstanding and enthusiastic service to the project, John was replaced by a junior CCI/REDS extension officer, Timothy Sam, who, with the support of the project, grew magnificently into his new role of senior REDS extension officer and as project coordinator. Douglas Kawasi, formerly a junior CCI extension officer, became an assistant project coordinator and developed his experience and confidence to the extent that the Cocoa Board proposed to post him as senior extension officer to another province. Joel Hori had just completed his degree at UNRE when the project commenced and built up his practical experience and confidence during the project. In 2020, Timothy, Douglas and Joel began working closely with the newly commenced FAO/EU STREIT Project in East and West Sepik that continued the ACIAR project strategy. Recently Jimmy Risimeri has been employed also by the STREIT Project.

Although working in West Sepik was not part of the original project remit, two highly successful developments there grew out of the project. The Tenkile (Tree-kangaroo) Conservation Alliance, based at Lumi and led by Jim and Jean Thomas, asked to become a CMFT group with the ACIAR project and a thriving group was established and trained by the coordinators based in East Sepik. Several 11-hour trips were made from Wewak to Lumi by Timothy Sam and support staff to establish a budwood garden and train budders. Wilson Miroi, the husband of a CMFT in New Ireland, Cathy Miroi, attended the initial CMFT training there with her and decided to implement the project at Poro in his home province of West Sepik using his own resources. He is a successful engineering contractor and encouraged his employees to work as cocoa farmers between contracts. He had previously established a collection of the CCI clones and built a nursery and established many farmer groups. One of his employees, Grace Klembasa, became his nursery manager and a very successful CMFT and farmer leader, twice winning the prize for best cocoa sample at the Cocoa Board Cocoa Festivals (in Kokopo, 2017, and Lae 2019). Wilson and Grace built up a network of 40 farmer groups serving about 2000 farmers, many of whom were people forced to relocate inland following the catastrophic tsunami of 1998 that killed over 3000 people in coastal villages.

Many CMFTs became very competent, confident and entrepreneurial extension workers, taking it upon themselves to encourage and train farmers outside their own villages. One example was Kokurai Omurup, the CMFT in Tamane Village near Madang town, who developed many other farmer groups and became a contract trainer for the Cocoa Board and other projects. Scott Rambanare became an important leader in his home area in East Sepik, assisting with field days and helping to build up many satellite groups. Yekimbole CMFTs, Nola and Chris Sasingian, promoted the building of many Solomons solar driers, becoming suppliers of the rolls of plastic film used in the driers. David Kapia, one of the two CMFTs in Panamecho Village, New Ireland, was employed as a technical advisor and nursery manager by the Business for Development project building up cocoa farmer groups on Simberi Island with the St. Barbara Gold Mining company. CMFT Norman Mondo in Karimui became a prominent cocoa farmer and was twice sent by the Cocoa Board to the Paris Salon du Chocolate to represent PNG. In the final survey of CMFTs and focus groups discussions, nearly all CMFTs interviewed declared that they would be able to continue in their training and mentoring roles after the project, sustained by their improved cocoa farming and sale of planting materials. Some even suggested that there was potential for them to develop a fee-for-service capacity (monetary or in-kind). In-kind payments such as raising seedlings in return for initial planting material and training, for example, would be culturally appropriate where exchange of planting material for food crops is common.

Staff at REDS Tavilo developed their capacity to prepare extension literature and Powerpoint presentations for use in their on-going work with farmers. The MS Word files for the PNG Cocoa Extension Manual and the PNG Cocoa Farmer's Handbook (both English and Tok Pisin versions) remain with REDS staff who will be able to update them and use extracts for their work. Twenty short PowerPoint presentations on all aspects of cocoa and vanilla production can be used or modified by staff in their work. The cocoa extension handbooks prepared by the project leave behind a framework for future training sessions conducted by Cocoa Board and DPI extension staff and a resource for education in institutions such as schools and corrective services facilities.

Some project staff were trained to conduct the Family Farm Teams training to farmers in the main project sites. The senior and highly competent staff member of CCI, Dr

Josephine Saul-Maora, who was poorly treated after the liquidation of CCI, turned her attention to the Family Farm Team training to empower women farmers, which had long been of concern to her. It is hoped that she will be able to maintain a long-term consultancy business for this work. The FFT training has proven very successful in shifting the perceptions of men and women farmers about the importance of collaborative family teams in village farming.

The project established cocoa projects as educational facilities in two schools in East Sepik (Brandi Secondary College and Passam National High School) and supported a cocoa project in the Boram Corrective Services Institution, Wewak. Microscopes (surplus from LaTrobe University) were presented to science teachers at the above schools in East Sepik and a school in Simbu Province, all of which lacked useful microscopes.

The human capacities released among REDS and DPI extension staff and village leaders are benefitting the provinces immediately and should certainly be providing continuous benefit in five years' time.

Unfortunately, the planned intention of the project to build the research and extension capacity of staff at CCI Tavilo was undercut by the chaotic liquidation of CCI in late 2017 and incorporation of its cocoa functions into the REDS division of the PNG Cocoa Board, during which five of the most senior, highly trained (three with Ph.Ds.) and competent staff were not recruited into the new REDS structure. Junior replacements for these staff were not recruited until near the end of the project. The agronomy section of CCI largely survived the liquidation and built a good collaboration with the project, especially through the establishment of soil fertility trials in New Ireland and East Sepik. The outstanding cocoa breeder, Dr Peter Epaina, while supported by the project, and later re-employed by REDS, developed plans to select cocoa types better suited to smallholder farmers and types adapted to the highlands.

8.3 Community impacts – now and in 5 years

Community impact is already evident beyond the initial CFMT project sites. While this extension strategy was initiated in 74 core CMFT groups, by the end of the project it had been adopted by a further 352 satellite groups serving over 27,000 farmers. The establishment of CMFTs and farmer leaders in satellite groups will enable communities to develop and control their own capacity for community and farmer education and training. All the human capacities mentioned above will have important on-going benefits in villages.

By the end of the project there was renewed enthusiasm for cocoa farming, following the devastation and moral-sapping incursion of Cocoa Pod Borer, during which pod losses were over 80%. Clearly, a commodity crop such as cocoa can provide great community benefit, providing money for community obligations, school fees, high protein food, tools, mobile phones, radios, transport, etc.

The project demonstrated that cocoa production does not have to occur at the expense of food crop production and farmers in PNG have become adept at integrating the crops. There is evidence that integration of cocoa and food crops could benefit cocoa production.

Despite claims that cocoa marketing in PNG is a problem, it was evident during the project that farmers are very familiar with the marketing of dry cocoa beans and are able to shop around the several competing cocoa buying and exporting companies to obtain the best price. A telling comment from a woman farmer (Agatha Igag, the leader of the all-women's group at Rempi in Madang Province) was that she could sell a bag of cocoa beans (worth about Kina 500) in 10 minutes in Madang town, while she would have to sit in the town market all day to sell market vegetables for just a few Kina, and then would have to take home any unsold produce.

The benefit of integrating vanilla production with cocoa farming was also evident during the project, which coincided with a boom in vanilla production driven by high world prices. Vanilla vines were seen being trained up *Gliricidia* shade trees and even on cocoa trees growing in budwood gardens and cocoa blocks. The cocoa-vanilla combination was actively encouraged because investments in block maintenance in weed and shade control for vanilla also benefit cocoa, thereby also helping in the control of CPB. However, in their rush to produce vanilla, farmers often neglected the procedures needed to produce the highest quality beans and the project produced literature to instruct farmers on appropriate fermentation and drying of the beans to give the highest prices.

The potential benefits from integration of goat husbandry into farming systems in PNG was demonstrated at two sites in East Sepik and one site in New Ireland. Goats were already a common presence in Karimui under the influence of the SDA Church. Goats can provide a valuable source of protein in the human diet as well as contributing to disposal of farm waste, weed control and preparation of composted fertilisers. They are a much more easily managed animal, readily integrated into village life, than the large Brahman cattle introduced in projects during pre-independence times (another introduced technology that was inappropriate for smallholder village farmers). The benefit of village goat husbandry is evident in neighbouring Indonesia, which might provide a source of advice and goat breeds.

A major benefit of the project for women was their incorporation into project training programmes. Through the training, the project improved women's role in and benefits from cocoa production. Furthermore, the wider use of solar cocoa driers, through the lighter, cleaner work involved compared with the heavy and time-consuming work involved in collecting and cutting firewood and stoking wood-fired kiln driers, has facilitated the involvement of women in making higher-value dry cocoa bean for sale. This has given women more opportunity to sell dry cocoa bean, as opposed to lower value wet bean as in the past. Their greater access to the cocoa income has acted as an incentive to devote more time to cocoa as a family business activity.

Because the solar driers do not require firewood, this means that small quantities of wet bean can be processed to dry bean without much loss of scale economies. Conventionally, it was not economical to process small lots of wet bean with a kiln drier because the labour cost per unit of dry bean increases as the quantity of wet bean for processing declines relative to drier capacity. Thus, during the off-season, women typically pick and sell small quantities of wet bean because the labour and cost of using a wood-fired kiln to make small quantities of dry bean is not worth it. However, solar driers provide women with an opportunity in the off-season to value add to their cocoa through processing small quantities of wet bean to dry bean. This aspect of production was not investigated in the project, but it is likely to generate much higher returns to women's labour.

This expanded role of women in cocoa farm decision-making and benefits has helped address a major impediment to development in Papua New Guinea, namely gender inequity. It is well established that the lack of female extension officers and the neglect of female farmers in extension activities have been identified as serious impediments to effective village development (e.g. Hamago 2019; FAO 2019; World Bank 2014). The project attempted to address these inequities. While the nominated CMFTs were mainly men, spouses attended all training sessions and participated in all project activities such as field days. Women appreciated the 'whole-of-family involvement' approach (cocoa as a family business) to cocoa farming that helped foster women's ongoing interest in the project. Also, the importance placed on shared family benefits from cocoa farming, emphasised in the training of CMFTs in Sustainable Livelihoods (conducted by the Kairak Training Centre of UNRE and Family Farm Team training in collaboration with ASEM/2014/095) meant that there was an expectation that men would share more of the cocoa income with their spouse to ensure the whole family benefitted from their work in the group.

8.3.1 Economic impacts

It is difficult to quantify the economic impacts of the project, but they have certainly been large. In Simbu Province (Karimui District) cocoa production increased by 640% from 2015/16 to 2018/19, or from 2 tonnes in 2015 to 25 tonnes in 2019, as a result of the project, which was the first major scaling up of farmer interest in the initial test planting of cocoa by CCI. It is difficult to quantify the economic impact in the other provinces although most groups reported increased control of CPB and improved cocoa production since the start of the project. While 74 core CMFT groups were established, a further 352 satellite groups were formed serving over 27,000 farmers. Groups established budwood gardens and most were bringing CPB under control, so it is anticipated that the economic impacts will be large and will continue to increase through time as old planting material is replaced by high yielding clones and farmers are better able to control CPB.

With an emphasis on women and family farming in the project, it is anticipated that the economic impacts are likely to be shared with women. At this stage it is not possible to quantify these impacts but women in the focus groups considered that they were benefiting from their greater involvement in cocoa production.

Another area where economic impacts are anticipated to be high is because of the use of solar driers that involve much lower capital and operating costs than conventional kiln driers and improved returns to labour through improved quality, more efficient use of labour and a higher proportion of cocoa sold as dry bean than as wet bean. As explained in Section 8.3, the latter is particularly the case for women who conventionally sold small quantities of wet bean in the off-season when crop levels are low and it was not economical to use kiln driers. Solar driers provide women with an opportunity in the off-season to value add to their cocoa through processing small quantities of wet bean to dry bean. This aspect of production was not investigated in the project, but it is likely to generate much higher returns to women’s labour.

Cocoa production has increased over the last two years (pers. comm. G. McNally, NGIP-Agmark Technical Manager), mainly linked to increased enthusiasm for cocoa following a demoralising outbreak of CPB after 2006 and realisation that improved management can greatly reduce damage by pests and diseases.

8.3.2 Social impacts

The project demonstrated that villagers can control their own education and training activities and show initiative to develop their own farming methods and strategies. Most of the CMFTs involved in the project declared that they could continue in the role after the project, supported by their improved cocoa production, sale of planting material and processing and sale of cocoa beans.

Women became strong contributors to the project, both as a part of husband/wife CMFT teams, and as leaders of some of the most successful CMFT groups, including an all-women’s group at Rempi Village, Madang Province.

The development of three successful goat colonies on cocoa farms in the lowlands (at Laraibina, New Ireland, and Niumindogum and Paliama, East Sepik) showed the potential for the animal to become an important part of an integrated farming system that can improve the availability of dietary protein in PNG, as seen in it its neighbour, Indonesia, and as developing spontaneously in the highlands under the influence of the SDA church.

A successful goat colony at the Boram Correctional Institute in Wewak became linked to the project through development of a cocoa project there.

Cocoa projects initiated at the Boram Correctional Institute and at two secondary schools in East Sepik showed how knowledge of cocoa farming can be integrated into the education system, especially in rural areas where many young people will return to their villages as farmers.

8.3.3 Environmental impacts

Most of the project sites and developments occurred on existing farmland devoted to cocoa production and involved demonstration that cocoa and vanilla production can be greatly increased on existing farms, for example being grown under the shade of coconut, betel nut and galip nut trees and being integrated with food crop production. This reduces the incentive for farmers to clear more rainforest for cocoa production, as has occurred dramatically in West Africa over the past few decades.

Demonstration that the vast and largely underused kunai grasslands in PNG have potential for production of a cash crop such as cocoa could enable PNG to increase cocoa and vanilla production without encroaching further on rainforest.

Demonstration that cocoa has great potential as a tree crop alongside coffee in the highlands opens up further prospects for land stabilisation and use of the extensive and under-used grasslands in the highlands.

All training programs emphasised the importance of management rather than chemicals in controlling pests, diseases and weeds, and the project demonstrated that pests and diseases can be managed with improved regular 'light touch' management combined with cocoa varieties with a degree of pest/disease resistance. Integration of cocoa with food crops can help control weeds, as seen during the establishment of budwood gardens in this project.

8.4 Communication and dissemination activities

The main communication and dissemination activities involved the formation, training and support of Cocoa Model Farmer-Trainers as permanent leaders and trainers in villages, supported by CCI/REDS and DPI provincial extension staff.

Several farmer field days were held in each provinces to disseminate project ideas and developments – New Ireland (Komolobuo, Nov 2017, Laraibina and Sena, June 2019; Umbukul and Bo, March 2020), Madang (Balama, May 2019; Amiten, Nov 2019; Kumisanger, May 2020; Rempi; Mabonob; Suaru; Korona), East Sepik (Yekimbole, Nov 2018; Paliama, May 2019), West Sepik (Poro, Sept 2019; Lumi, Nov 2019), Simbu (Nov 2018, Karimui Environment, Agric and Cultural Show).

Coordinators made many radio broadcasts on cocoa project activities on NBC Radio and on church-based stations. This was an effective way of delivering ideas and knowledge to farmers who rely on local radio broadcasts for important news and information. In East Sepik, a prominent broadcaster, Jonathan Poema, was also a very effective CMFT and publicised his work on radio. With the project coordinator in East Sepik, Timothy Sam, who is also a musician, wrote and broadcast a song to publicise their work.

The following extension publications were prepared and used in the project, filling a gap in the availability of up-to-date extension literature for farmers:

Clarke, Trevor (2019) *Pacific Islands Cocoa Book*, layout and design by KokoSiga Fiji

Ltd., 120 pages, ISBN 978-982-101-048-1 - this book was prepared during the project and 10,000 copies were purchased by the project and distributed to farmers during 2020.

Buk Bilong Kakao Fama, PNG Cocoa Coconut Institute (2018), 118 pages – this is a Pigin English translation of the Papua New Guinea Farmer's Handbook prepared during the project by project staff and designed and published by KokoSiga P/L in Fiji. 2000 copies were purchased by the project and distributed to farmers.

Solar Drier Manual

Pruning Manual

Papua New Guinea Cocoa Extension Manual, PNG Cocoa Coconut Institute (2017), layout and design by KokoSiga Fiji Ltd., 312 pages

Papua New Guinea Cocoa Farmer's Handbook, PNG Cocoa Coconut Institute (2017), layout and design by KokoSiga Fiji Ltd.,112 pages

(The last two were written prior to the project under a contract to Phil Keane from the World Bank Productive Partnerships in Agriculture Project, but the final editing of the books was completed by staff involved in HORT/2014/096)

Two cocoa farmers handbooks were distributed to CMFTs and farmers – the Pidgin English version of the CCI Cocoa Farmer's Handbook ('Buk Bilong Kakau Fama') and Trevor Clarke's 'Pacific Islands Cocoa Book'. The original CMFT groups in Madang received an average of 35 cocoa handbooks and 18 books in New Ireland. Only about 6 books were received per group in East Sepik (several CMFTs claimed to have received no books) while only an average of 2 were received per group in Karimui although most claimed to have access to them. It appears that some CMFTs did not distribute the books as intended. In surveys the books distributed to CMFTs and farmers were always said to be useful, farmers mentioning that their many photos and diagrams and simple text were helpful.

Twenty short Powerpoint presentations on all aspects of cocoa production and on-farm processing and on vanilla production and processing were produced and distributed in digital form to REDS staff and other interested people. These were prepared as models able to be adapted by extension staff after project managers observed that PowerPoint presentations delivered at Farmer Field Days were not effectively communicating with farmers – the presentations were often far too long and academic, with masses of text crammed on slides that were unintelligible to the farmer audience. The project manager explained the need for a simpler, less academic presentation based mainly on annotated drawings and photographs, providing a platform for the undoubted verbal communication skills of the extension staff. The staff usually had computers, projectors and generators for digital presentation of information in villages.

9 Conclusions and recommendations

Conclusions are preliminary after testing of the village-based extension system for only about 3 years after its establishment in a limited number of sites spread over four provinces. Restrictions imposed by covid-19 severely reduced assessment of the project through final focus groups and surveys.

9.1 Conclusions

1. The spontaneous development of many self-funded cocoa farmer groups in villages linked to project-initiated CMFT groups was evidence that the system of establishing a network of village extension workers, linked to and advised by government-funded extension staff, has potential to transform agricultural education in villages. The same strategy should be applicable also to general education in villages such as education in health and nutrition, financial literacy, politics and governance. However, the CMFT model has the advantage, in times of very restricted government budgets, that cocoa farming and related activities (e.g. cocoa trading, cocoa processing to dry bean, transport, nurseries, pruning teams, management consultancies) can create a strong revenue stream to support the village education and training system. It also has the advantage that it uses the skills developed by men and, especially, women in their lives as self-sufficient subsistence gardeners, and relies upon their own available resources of land and labour. The system could be linked also to the education and training activities of cocoa buying companies, churches and NGOs. The essential lesson from the project is that there is ample talent in villages to undertake and lead these activities, and change the model from one in which an urban elite teaches villagers, to one in which the village people guide their own education and lives, recruiting outside help as they see fit.
2. There was evidence of increasing enthusiasm for cocoa farming and recognition that cocoa can still provide a good source of income in villages, following the incursion of CPB.
3. The project clearly demonstrated the potential benefit to cocoa quality, farmer income and the role of women of deployment of affordable solar driers.
4. The great potential for cocoa to provide an income source alongside coffee in highlands provinces was demonstrated in the project work at Karimui. This is a global first. Many farmers in the highlands have appreciated that cocoa production can provide an income every few weeks, compared with coffee that provides income only every 6 months. Many sites in highland provinces were identified as having potential for cocoa production, often at lower altitude and with better marketing access than Karimui.
5. There was evidence that a degree of natural biocontrol of CPB is occurring in some locations, and that improved management and deployment of cocoa clones is reducing the damage caused by CPB.
6. Preliminary results demonstrated the potential for establishing cocoa growing on kunai grasslands, providing tree cover is established first.
7. The reaction of farmers to preliminary trial colonies demonstrated that goat husbandry has a place in village cocoa farming.

9.2 Recommendations

The findings of the project have generated several research questions that require further investigation to enable the results of the project to be built upon:

1. What are the necessary conditions for establishing effective village extension workers/educators (CMFTs/VEWs) and farmer groups or associations able to support livelihood improvement for cocoa growing villages?

2. Can extension training that provides skills in sustainable livelihood development and participatory research facilitate the operation of village farmer groups to benefit from greater access to cocoa farming knowledge by men, women and youth?
3. How does participatory research-based Monitoring, Evaluation and Learning (MEL) enhance farmer's participation in research and uptake of innovations?
4. Can diversified farming systems such as cocoa-food crop systems reduce labour costs and improve productivity through crop diversity, improved labour efficiency and greater involvement of women?
5. What cocoa planting materials (e.g. clones, hybrid seedlings and Trinitario types) can be developed to meet the needs of smallholder and highland farmers?
6. Can the labour cost of management of CPB and Black Pod be reduced and effective control increased through better biocontrol and disposal of infested pods?
7. Can affordable and labour-saving solar cocoa driers be developed and approved by the Cocoa Board to enable village farmers to produce high quality bean?
8. Will solar driers with much lower operational costs enable more off-season cocoa to be processed to dry bean, and what will be the gendered impact of this change?

Based on observations and feedback in the project, it is recommended that –

1. The project demonstrated that a system of village-based education, training and research, based on village organisations coordinated by entrepreneurial and popular leaders and linked to government and private agencies, has great potential to transform agriculture and other services in villages. However, further study is required of the best way of establishing and supporting such a system. It became evident in the project that the village extension workers (called Cocoa Model Farmer-Trainers in the project) should be chosen by the villagers and not imposed by government agencies.
2. The project showed that husband and wife teams as group leaders are very effective. Future extension initiatives based on groups should encourage husband and wife leadership teams where possible.
3. During the project, cheaper and less labour-intensive ways of planting cocoa and rehabilitating old cocoa blocks were developed, including chupon budding with selected clones, field planting and budding of seedlings rather than development of central nurseries (farmers remarked on the difficulty of transporting plants in polybags of soil, preferring field planting or smaller on-site nurseries). Further study is required of these farmer-friendly methods rather than the plantation-influenced use of large central nurseries, often developed more as political showpieces than effective development tools. During the project many larger nurseries, including some developed in the early stages of the project, were seen to have been abandoned.
4. While it was observed that farmers routinely integrate food crops with cocoa plantings (e.g. as seen in all cocoa budwood gardens established during the project) further study of 'kakao-kaikai' gardens to benefit cocoa production, village livelihoods and the role of women is needed – e.g. is cocoa better managed (as a result of greater involvement of women) and are there fewer pest/disease problems when it is integrated, with wider spacing, in village gardens than when grown as monoculture blocks?
5. There is a need to develop cocoa planting material better suited to smallholder farming, with traits such as smaller trees requiring less labour for pruning and harvesting, a degree of resistance to Cocoa Pod Borer, Black Pod and Vascular Streak Dieback, and able to endure and recover from periods of neglect when cocoa prices are low or labour is limited. This will require restoration of the excellent cocoa breeding and selection program at the REDS Tavilo Research Centre that has been in abeyance for a decade. Graham McNally, the Senior Technical Manager for NGIP-Agmark, one of the two main cocoa buyers in PNG, has indicated that there are still significant quality issues to be addressed in the hybrid

clones, including low wet to dry bean recovery rates, depressed butter fat content, and small bean size.

6. Further development of cocoa planting material adapted to the highlands is required, including full testing of the CCI collections and recommended clones introduced there during the project, and collection and testing of useful cocoa types identified and selected by farmers during the project. The project showed the great potential to select such cocoa from among the great genetic diversity of hybrid seedling cocoa developed in PNG, showed the existence of many sites in the highlands suitable for cocoa production, and showed the enthusiasm for development of the crop among community leaders and farmers in the highlands.
7. Farmers showed great initiative in modifying and adapting the Solomon's solar driers introduced during the project. Development of the design and operation of these affordable solar cocoa driers for smallholder farmers will enable them to obtain the full value of their crop by selling dry beans. It will reduce smoke tainting of beans, reduce the labour and demand for firewood required for wood-fired kiln driers, and provide benefits for women who can manage solar driers near their homes.
8. While the feedback from CMFT surveys and focus groups in the project provided evidence that farmers consider Cocoa Pod Borer (CPB) to be less of a problem than at the start of the project, this requires further detailed study. Based on Indonesian experience, it is expected that predators and parasites of the pest will build up and contribute to biological control but this requires detailed study. The role of the Solomons Fire Ant that has spread widely across PNG in recent years requires study – there is evidence from Bougainville that it controls CPB. Less labour-intensive methods of disposing of infested pods and pod husks than burial are required. A farmer in this project suggested that pods can be buried under the windrows of prunings that accumulate between rows of cocoa and harbour vigorous ant populations. The use of fine mosquito netting to cover piles of pod remains is also worthy of study. The CCI clones said to have some resistance to CPB require further testing. This research requires the restoration of the research capacity in entomology and crop protection degraded by the liquidation of CCI.
9. Initial field trials in collaboration with SMCN/2014/048 (Optimising soil management and health in PNG integrated cocoa farming systems) in East Sepik showed potential for developing cocoa with *Gliricidia* shade trees on kunai grassland. Deep ploughing of the heavy grassland soils enabled the establishment of shade trees. A field trial in East Sepik is continuing.
10. The project developed three successful goat colonies on cocoa farms, demonstrating their potential to be integrated into a diversified farming system as commonly seen in Indonesia. For advice on goat husbandry by smallholders under tropical conditions, PNG should turn to its immediate neighbour, Indonesia, where goats are integral to the smallholder farming systems and provide an important source of dietary protein.
11. The REDS section of the PNG Cocoa Board is sorely in need of support to build up its research and extension capacity after its inception following the liquidation of CCI in 2017 and failure to employing talented scientists and extension leaders from CCI.

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HORT/2012/026 - Developing more effective management strategies for cocoa pod borer in new outbreak areas of Papua New Guinea
HORT/2014/094 - Developing the cocoa value chain in Bougainville
HORT/2014/096 - Enterprise-driven transformation of family cocoa production in East Sepik, Madang, New Ireland and Chimbu Provinces of Papua New Guinea
ASEM/2014/095 - Improving opportunities for economic development for women smallholders in rural Papua New Guinea
HORT/2010/011 - Improving the sustainability of cocoa production in eastern Indonesia through integrated pest, disease and soil management in an effective extension and policy environment

SMCN/2014/048 - Optimising soil management and health in PNG integrated cocoa farming systems

HORT/2018/114 - Basic research on the cocoa pod borer in Papua New Guinea to permit effective pest management

10.2 List of publications produced by project (Appendices)

Clarke, Trevor (2019) *Pacific Islands Cocoa Book*, layout and design by KokoSiga Fiji Ltd., 120 pages, ISBN 978-982-101-048-1 - this book was prepared during the project and 10,000 copies were purchased and distributed to farmers and coordinators during 2020-2021.

Buk Bilong Kakau Fama, PNG Cocoa Coconut Institute (2018), 118 pages – this is a Pigin English translation of the Papua New Guinea Cocoa Farmer's Handbook and was prepared during the project by project staff and designed and published by KokoSiga P/L in Fiji. Two thousand copies were purchased by the project and distributed to CMFTs and farmers.

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Solar Drier Manual

Pruning Manual

11 Appendixes

11.1 Appendix 1:

A summary of CMFT sites

Project chronology Feb 2016 – March 2021

Pacific Islands Cocoa Book by Trevor Clarke

Buk Bilong Kakau Fama – PNG Cocoa Coconut Institute

PNG Cocoa Farmer's Handbook – PNG Cocoa Coconut Institute

PNG Cocoa Extension Manual - PNG Cocoa Coconut Institute

Solar Drier Manual

Pruning Manual