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2 Executive summary

Smallholder farmers in PNG face numerous challenges including constraints on the supply of labour, low returns to labour, poor-quality post-harvest processing leading to low prices, and, in some places, land pressures. A new problem which poses an existential threat to the PNG coffee industry is the recent arrival of the coffee pest, Coffee Berry Borer (CBB). To address these challenges, the research included three related components: a smallholder targeted training package for training groups of farmers and cadet extension officers; a demucilager trial (mini wet mill); and a trial of intercropping coffee with food crops. The research required extended periods of fieldwork in the communities where we worked using both quantitative and qualitative techniques. Each component of the project is described below.

Farmer training package - A farmer training package comprised of a suite of 25 modules was developed in partnership with coffee extension officers, smallholders, industry personnel and researchers (three modules developed by CARE International in PNG covering organisational strengthening, leadership and family money management were incorporated into the package). The modules making up the training package have at their core a 'whole of farm' or smallholder-livelihood approach. This means that the modules take a holistic perspective to extension training which recognises that smallholder men and women pursue a range of livelihoods including subsistence, and highly valued socio-cultural activities that are an important component of life quality. Rather than try to transform smallholder farming from low input production to high input farming – a strategy that has not worked well in the past – the approach must work within the reality of PNG farming. A highlight of the package is a module on CBB management developed in association with HORT/2018/194 which is now being used to train farmer groups and extension officers in CBB management. Finally, implementation of the training package by many arms of the industry including CIC, the private sector, and NGOs will help establish strong links between farmers and exporters/processors which are necessary for the long-term sustainability of the PNG coffee industry.

Demucilager trial - The trial with a smallholder coffee group from Bena, Eastern Highland Province (EHP) demonstrated significant labour savings for both men and women. Linked to an exporter the group produced premium grade coffees, generating price premiums of between 39 and 77% above Parchment Class 1. Improved labour returns incentivised increased harvesting effort and garden maintenance, key to managing CBB. Despite initial concerns that women might be marginalised by the technology, women were significant beneficiaries, with the village savings and loans groups established under previous research (ASEM/2014/054) creating a pathway for women's engagement. The savings groups also cultivated strong governance structures within the demucilager group. In the context of several disruptions during the trial – a global pandemic, the arrival and rapid spread of CBB, a disruptive national election, and a volatile coffee price – the trial was a remarkable success. Three key interrelated factors explain this success:

1. Farmer's recognition of the capacity of the technology to resolve a range of challenges that previously acted as disincentives to improve coffee production
2. The solid participation and engagement of women
3. Effective group governance and leadership.

CIC is currently supporting farmer groups to purchase this technology.

Intercropping coffee with food crops - The trials showed that fertilised vegetables in coffee gardens improved coffee yields and other coffee growth parameters. The intercrops also provided another income stream to families, and can be a strategy against loss of family income from CBB, coffee price volatility and drought. Intercropping is also a useful strategy for families confronted with land pressure and wishing to maintain coffee production.

3 Background

Coffee is the primary source of household income for farm families in the highlands, particularly in EHP which accounts for 58% of national production (CIC data). Coffee is an extremely important income source for communities in remote areas where there are few other income opportunities. Despite coffee's economic importance for rural livelihoods and a rapidly growing rural population in the highlands, annual national production has declined to less than one million bags per annum.

CIC and the coffee industry have been concerned for a considerable time about low smallholder productivity, parchment quality and declining national production. ASEM/2008/036 found that yields per hectare were considerably lower than yield data reported for earlier periods at other sites in the Highlands (apart from 2013 UniQuest data which estimated slightly lower yields than ASEM/2008/036). Recent anecdotal evidence from industry experts confirm that smallholder yields have been in long-term decline. ASEM/2008/036 suggested that labour investments in coffee garden maintenance and other inputs have declined.

Declining yields sit alongside poor-quality smallholder coffee. Most smallholders receive low grade Y1 prices for their coffee which is considerably less than the higher quality grades typically produced by plantations. Low quality is an outcome of poor processing of cherry to parchment, particularly the fermentation stage. The low returns to labour received by smallholders act as a disincentive to invest more time and labour in coffee, especially in areas that have good access to urban centres and markets where a range of livelihood options exist. Coffee smallholders are sensitive to returns to labour. However, smallholders can obtain price premiums for producing specialty coffee and coffee produced under certification schemes. PNG exports of coffee under certification labels have been steadily increasing by an average annual growth rate of 16% in the last decade (2014-2023) with certified coffee making up 18% of total exports in 2023 (Manny, CIC, pers. comm. 2024), compared with 5% in 2008 (Giovannucci and Hunt 2009:19). How coffee wastes from processing are managed is often a component of certification schemes. Wastes from smallholder processing of cherry include the pulp, mucilage and water. These wastes contain substantial amounts of nutrients (Kiup 2014).

This project built on the findings of ASEM/2008/036 by addressing the main bio-physical, socioeconomic, and extension constraints on improving smallholder production identified in ASEM/2008/036. These included:

- 1) Low levels of technical knowledge amongst farmers of coffee husbandry and processing;
- 2) Low returns to labour due to poor quality of smallholder coffee parchment and consequent lower prices;
- 3) Disincentives for women to work in coffee due to their limited access to household coffee income and extension training;
- 4) Soil nutrition deficiencies with consequences for food security and coffee yields; and
- 5) Poor farmer uptake of improved coffee management practices due to extension materials not being tailored to the needs of smallholder coffee farmers.

These constraints sit within a low-input system of coffee production that limits investments of time, labour and other inputs in coffee production which was partly attributable to households pursuing a diverse range of livelihoods and socio-cultural activities.

This current project tested some innovations to address these constraints. Given low returns to labour and poor quality were identified as key constraints on improving smallholder

production, this project followed up on promising preliminary results from an earlier ACIAR project (ASEM/2004/17) on demucilagers (Section 7) that showed an improvement in parchment quality. Based on these results this project trialled a demucilager. Changes in coffee quality and labour returns were assessed and particular attention was given to monitoring: the gendered impacts of this technology on income distribution and labour; waste water and nutrient management in the context of farmer groups seeking coffee certification; and the sustainability of the group managing the demucilager.

There are potential environmental issues associated with the adoption of demucilagers. However, this project addressed these potential problems by researching, with smallholders, alternative options to maximize the unrealised nutrient benefits offered by pulp and wastewater rather than the potential negative environmental impacts of an unappreciated and unrealised resource. The goal was to identify strategies to recycle water and nutrients efficiently in compliance with the criteria of the main certification organisations.

A further innovation trialled in this project was intercropping short-rotation fertilised vegetable crops with coffee. Preliminary findings in ASEM/2008/036 showed potential benefits for both male and female coffee farmers. Multiple cropping systems, based around coffee production have been advocated in the Philippines (and elsewhere) because they increase total production per unit of land, increase employment, increase family income and improve the distribution of income within the family (Cubillo 2016). They also increase the diversity of food available to farm families and local markets (Cubillo 2016), thus increasing food security. Trialling intercropping was a way to address the intense land and population pressures in many coffee growing areas near urban centres, as well as to increase the economic returns from coffee gardens and improve the opportunity for women to earn additional income from intercropped vegetables. Although it is acknowledged that intercrops can remove large amounts of nutrients (Njoroge et al. 1993), this can be compensated by the addition of fertilisers or crop residues to the intercrop, as was introduced in this project. Purchasing fertiliser is possible with the increased income from the intercrop as was demonstrated in ASEM/2008/036. Also, captured demucilager or pulper waste can obviate the need to purchase fertiliser.

Work under ASEM/2008/036 was also the starting point for scaling out the impact of the research through developing agricultural extension materials suitable for the low input production strategy that dominates smallholder export cropping systems in PNG. The extension training package developed as part of this project incorporates the best of existing CIC extension materials (previously funded by ACIAR) and the research findings of ASEM/2008/036 and this project. The primary aim of the package was to assist private sector, government, and PPAP and NGO-funded extension officers to train farmer groups and cadet extension officers in the production, processing and marketing of coffee.

Shortly after the commencement of the project, Coffee Berry Borer (CBB) began to spread through the highlands with devastating impact. Eradication of the pest has proven impossible in other coffee growing countries, but it can be controlled by implementing basic CBB control measures, including adopting coffee garden sanitation strategies. However, in the low input farming strategy followed by most coffee smallholders, there was considerable doubt as to whether CBB could be controlled. The arrival and spread of CBB therefore required a reorientation of the farmer training extension package, the demucilager trial and in how field research was carried out. It also led to a successful collaboration with the HORT/2018/194 research team to address CBB in the smallholder setting.

4 Objectives

The overall aim of the project was to increase returns to labour, particularly for women, through the adoption of new technologies and farming practices that improve coffee quality and total production while being compliant with the environmental criteria of the main certification organisations.

The objectives were to:

Objective 1: Develop, field test, refine and facilitate the uptake and use of an extension training package by government, private sector, PPAP and NGO-supported extension providers.

This objective addressed Question 1 in the project proposal:

What are the best combinations of media for each extension training module in terms of retention of information and the uptake of extension advice by smallholders?

Objective 2: Develop a model for demucilager use by farmer groups that delivers social and economic benefits to men and women and which is compliant with the environmental criteria of the main certification organisations.

This objective addressed Questions 2.1 and 2.2:

How can increased returns to labour from higher prices (improved quality) and more efficient use of labour from demucilagers contribute to improving the viability and desirability of coffee production, especially for women?

What is the best strategy of pulp and waste water management from demucilagers that efficiently recycles water and nutrients and which complies with the environmental certification criteria of the main certification organisations and is considered acceptable to coffee smallholders?

Objective 3: Identify and develop culturally acceptable and nutrient efficient coffee-vegetable intercropping systems as a means to both increase coffee yields and incomes and improve income-earning opportunities for women.

This objective addressed Question 2.3:

What are the most culturally acceptable technologies and practices for intercropping coffee with vegetables in a way that increases income for women and improves the nutrition and yield of coffee through its juxtaposition and thus access to nutrients applied to those vegetables?

Objective 4: Assess the social and economic benefits to smallholders of direct cherry sales to processors and quantify changes in the amount and distribution of household income between men and women.

This objective addressed Question 4:

What are the gendered impacts of a switch to cherry sales on labour demands and income distribution?

This objective was dropped following the ban on transport of cherry since the arrival of CBB.

5 Methodology

Fieldwork location, data collection and disruptions

Data collection was carried out largely at the village level among smallholder households. Extensive consultations and meetings were also held with private and public sector organisations over the life of the project.

Given the overarching research question was how to increase returns to labour, especially for women, through the adoption of new technologies and farming practices that improve coffee quality and total production, there was a strong gender dimension to the research and data collection.

Village fieldwork was carried out in EHP, in coffee growing villages in the Bena and Asaro areas near Goroka. These locations were chosen because:

1. In the Bena villages of Sogomi, Safanaga, Kaiyufa and Kokinaga close relationships existed between the PNG farmers and the Australian and CIC researchers. These relationships were developed in two previous ACIAR-funded research projects (ASEM/2008/036 and ASEM/2014/054). Also, at Bena, the community had an active and successful Village Savings and Loans Association (VSLA) group that was keen to trial the demucilager (described below). The VSLA was established under ASEM/2014/054, and had strong governance structures and had been the catalyst for several community-wide projects (Koczberski et al. 2021). VSLA members developed an interest in improving the quantity and quality of their coffee and were keen to adopt more business-minded approaches to their coffee farming practices. The demucilager was seen as a vehicle for members to achieve these goals.
2. Asaro District, the site of the intercropping trials (see below), has rising population and land pressures and was therefore a suitable location to introduce and trial intercropping coffee with vegetables. The Asaro area is also the site of intensive commercial vegetable production for sale to local and distant domestic markets. Recently, there has been a strong shift to fresh food production to the extent that some farmers were removing coffee to plant fresh vegetables. In our Asaro villages of Kenemba, Nahoma and Samunga, coffee farmers were keen to continue with coffee but at the same time there was an interest in increasing commercial vegetable production. Intercropping was attractive to farmers, especially women, because they liked that intercropping would give them both income options, rather than feeling like they needed to choose one or the other.

Fieldwork commenced in mid-2018. There was a delay in commencing fieldwork because of the incursion and rapid spread of Coffee Berry Borer (CBB) since March 2017. All CIC vehicles and staff resources were allocated to the CBB eradication program. To avoid further delays in fieldwork, ACIAR funded a vehicle dedicated to the project and this became available in July 2018. This allowed an intensive data collection period in the second half of 2018 and in 2019. The arrival of CBB also meant a major reorientation of the research focus. This affected all areas of the project and required redesign of the survey questionnaires and qualitative interview questions, modified data collection techniques, and the redesign of the extension manuals to be CBB compliant.

In 2020, further disruptions to fieldwork were experienced with the onset of the COVID-19 pandemic. The pandemic led to the cessation of all fieldwork in PNG by PNG and Australian researchers. Fieldwork by PNG research team members was suspended when CIC staff were put on limited hours and restricted to their homes. In March 2020, travel between

Australia and PNG ceased. In early 2021, travel restrictions were partly lifted in PNG, and CIC staff could go to the office and had some limited access to the field sites. To address some of the COVID-19 related problems in data collection and monitoring, a female village research assistant was recruited at Bena to perform basic data collection and monitoring during the lockdown period. Her work was supported by a village/group leader who also carried out monitoring tasks required for Objective 2. Delays resulting from the COVID-19 pandemic led the team to apply for a six-month project extension, which was approved by ACIAR in June/July 2020.

Before and after the COVID 19 lockdowns in 2020 and 2021, both the PNG and Australian team members regularly visited the study sites. Fieldwork by Australian team members was carried out in:

- 2018: 22 February – 9 March; 1-22 July; August – September; 26 September – 4 October; 5-21 November
- 2019: 9-22 March; 11-27 July; 6-25 October; 17-29 November
- 2020: 24 Feb - 8 March
- 2022: 29 April - 13 May; September-October
- 2023: 11 – 26 April; 16-31 May; 23 July – 12 August

Methods

As outlined in Section 4, the project had four key components. They were:

1. An extension package for training farmer groups and junior extension officers
2. A trial of a low-cost mini wet mill (demucilager), including the design of a system for nutrient recycling of waste from the demucilager (pulp and mucilage);
3. Intercropping of coffee with food crops and nutrient recycling; and
4. Cherry sales to processors (this component did not proceed because of the ban on movements of cherry since the arrival of CBB).

The methods for each of the first three key components varied and are outlined below.

Extension Package

The primary aim of the Extension Package was to assist private sector, government, and NGO-funded extension officers to train farmer groups in the production, processing and marketing of coffee.

The Extension package was developed through several iterative stages. These were:

1. Draft Module Development

The modules were developed on a 'whole of farm' approach to extension training that considered environmental, social, gender and income within broader livelihood strategies that included food production for home consumption and sale. It recognised the everyday livelihood demands and constraints on smallholders and the important role of all family members in coffee production. Incorporated into most modules were certain cross-cutting issues. These were:

- The low input system of production
- Gender

- Diverse livelihoods in addition to coffee
- Market accessible locations vs remote locations
- Coffee Berry Borer

CARE-International in PNG had developed several excellent training modules on group governance and family money management. With the agreement of CARE, these modules were incorporated into the suite of modules as part of the training package. The list of modules and the principles guiding their content are outlined in Section 7.

The extension package was informed by long-term research on the socioeconomics of coffee production, primarily through ASEM/2008/036, ASEM/2014/054 and this project. This research, spanning ten years of working closely with coffee smallholder farmers and their families, provided the socio-cultural context of smallholder livelihoods which informed the content of the modules. Data and information were drawn from many other sources including previous ACIAR research by CIC and their partners, numerous workshops with CIC extension officers and researchers, research undertaken in other countries, and previous CIC extension materials.

Farm families also contributed to the development of the modules through a process of ‘co-production’ of knowledge in which problems were identified by farmers and their families and potential solutions developed in collaboration with them.

2. Refining of draft training modules

For each module, feedback was sought on the accuracy of the content and the effectiveness of the content to improve farmer technical knowledge of coffee husbandry and processing. Draft training modules were reviewed by CIC extension officers and research staff, private sector extension service providers and Australian team members for feedback. Two main approaches were followed to gain feedback. First, specific modules were allocated to individual staff/research team members with technical expertise in the module’s content (e.g. nutrient recycling) while other modules were better suited to collecting feedback from a small group of people in a workshop environment (e.g. Extension Officer Training Guide, Unit 2, Module 1 ‘Getting to know our coffee smallholders’). CIC extension officers provided feedback and input for most modules.

Occasionally, expert advice by those in the private sector and researchers not involved in the project was sought. For example, valuable feedback on the implications of CBB was provided by Ian Newton, Jonah Aranka and Donna Chambers (HORT/2018/194) on a range of modules. In addition, Ian Newton’s team led the development of the training module on CBB, the first of its kind of which we are aware. Also, we had numerous consultations with staff of New Guinea Highlands Coffee Exports, and other private sector and NGO organisations which helped improve the suitability of the content of the demucilager module amongst other modules.

During the development of the modules, CIC extension and research staff also provided resources such as illustrations, photos, posters and quizzes for the modules and prepared the ‘Farmer Notes’ (in Melanesian Pidgin) that supplement each module. Based on the feedback and other input received, the training modules were refined by the Australian team ready for field testing. Most of the edited modules, especially the highly technical modules, were returned to ‘experts’ for final approval of content.



3. Field testing of training modules

Due to the disruptions to the development of the modules and fieldwork schedule outlined above, only the CBB module was fully field tested (in 2023), although solid drafts of modules were discussed with groups of farmers. Extension officers delivering training will be asked to provide feedback on what worked well and what areas of the modules could be improved in future editions.

4. Ratification of training modules by National Training Commission (NTC)

When the full package is published online, the package will be registered with the National Training Council (NTC) to allow CIC to train private sector and NGO-supported extension officers in its use.

5. Printing of modules

At time of writing, the ACIAR publication team is formatting and publishing the modules online and in hardcopy. However, before this and in response to the CBB emergency, the CBB module was rushed into production and made available in 2023 with the World Bank funding printing of this module through PACD. As each module is completed it is made available in open access on the ACIAR website. Hardcopies of the modules will be held by CIC for distribution to extension officers in the government, NGO and private sectors.

Demucilager Trial

The demucilager trial was conducted at Sogomi village, Bena, with members of a village-based farmer cooperative. The group of users of the demucilager overlaps substantially with the Village Savings and Loans Association group, with 59% of the demucilager users belonging to the VSLA. Three quarters of VSLA members are women. During the first half of 2020, site works were completed under the guidance of Mr Nosare Maika, and the demucilager was installed and drying tables erected. Bena group members were trained to operate and maintain the demucilager, and operations commenced in early May 2020.

Prior to and immediately following the installation of the demucilager, several community meetings were organised by members of the project team, including the CIC engineer, to discuss the establishment of the demucilager and the trial with community members. These meetings were important for establishing governance processes, management protocols and the use of the demucilager. The latter stressed the project's emphasis on ensuring the

benefits of the demucilager were spread widely, especially amongst women. Women regularly attended the community meetings. Meetings were also used to explain the purpose of the trial, types of data to be collected and the requirements of the group leader and those individuals/households participating in the trial (e.g. keeping accurate records). An open forum where questions and potential problems could be raised was valuable in ensuring members of the group were fully informed about the trial and the use of the demucilager.

Demucilager trial evaluation

The goal of the demucilager trial was to maximise the socioeconomic benefits of the demucilager for men and women, including the design of a model of operation for the efficient recycling of nutrients and wastewater at the demucilager site. The evaluation of the trial focused on recording the socioeconomic and environmental impacts of the demucilager. This was done by assessing changes in:

- parchment quality
- labour demands
- deployment of labour by gender
- income by gender, and pulp and wastewater management.

A mixed methods approach was adopted with significant field-based data collection carried out. Data collection was a close collaboration between CIC and Curtin University. In 2018-2019, CIC and Curtin researchers visited the field site together, and resided in the village for short periods, to carry out surveys. Between 2020 and 2021, when COVID-19 restrictions prevented the Australian researchers from visiting PNG, survey work was carried out by CIC, and supported remotely by Curtin researchers. Project researchers also established data collection by the group leader (demucilager weigh-in data), and by a village-based research assistant (demucilager labour data) who had also been part of the CIC survey team for an earlier survey.

Specific data collection techniques included:

1. *Semi-structured qualitative interviews.* Around 30 semi-structured qualitative interviews were conducted with male and female smallholders and with the group leader from 2019 to 2023. Interviews were recorded either by hand in a notebook and/or by an audio recorder. Informal conversations took place within the village and within people's coffee gardens during the trial. Interviews / discussions sought to identify: barriers to adoption (including by gender) and ways to overcome them; the perceived benefits of the demucilager on household well-being and livelihoods; and the synergies between the demucilager and the VSLA. The latter was to explore how they could be leveraged to develop the group's resilience and the sustainability of both the demucilager and VSLA interventions. After the arrival of CBB at the field site in 2021, interviews began to explore the impact of CBB on coffee production and management of CBB, the effect on use of the demucilager and impacts on household labour and income earning. Interviews also explored how the VSLA provided the means to save and reinvest earnings from coffee sales through the demucilager trial in the context of CBB.

A key focus of many of the interviews was to assess changes to household labour, especially women's labour returns and income from the introduction of the demucilager. The interview questions with women were guided by and drew from the Women's Economic Empowerment evaluation framework (Golla et al. 2011; Buvinic and Furst-Nichols 2014). Four key indicators informed the interviews and included questions

relating to: individual agency; household livelihood advancement; community, household and social relations; and, the institutional environment (Table 5.1).

Table 5.1. Evaluation Framework.

Indicator	Indicators of Change
Individual agency	Access to managing and sharing in coffee labour-saving tools and technologies; acquisition of new farming skills; more control over income and expenditure; more confident to make decisions regarding the production of coffee and intercropped food crops; greater contributions to <i>kastom</i> and church; and women's perceptions of well-being.
Household livelihood advancement	Net household income; economic status of women in the community; access to markets; access to new income sources; reduced competition on land for coffee and vegetable growing; returns to labour; reduced dependency on husband's income; favourable workloads in agriculture; physical living conditions; household vulnerability and asset base.
Community, household and social relations	Relations between husband/wife; mother/sons and daughters in coffee production; control over one's labour; improved community attitudes to women's role in coffee production; and access to technologies and training.
Institutional environment	Greater access to information; training and other services/resources from public and private sector institutions, banks, etc.; increased engagement with external institutions; attitudinal changes within the coffee industry and CIC regarding women and their role in coffee production.

The framework outlined in Table 5.1 also guided the questions asked in community meetings, the household livelihood surveys, household labour allocation surveys and demucilager use and impact surveys outlined below.

2. *Community meetings.* The research team conducted at least two community meetings each year with the farmer group following the establishment of the demucilager, with the exception of 2020 when COVID-19 lockdowns were in place. These meetings were used to gather information and discuss the management and operation of the demucilager, processing problems, use of the mill by gender, parchment quality, CBB, waste recycling and payments to farmers.



Plate 5.1: CIC project leader, Reuben Sengere, speaking at a community meeting. Source: Tim Sharp.

3. *Private Sector collaboration.* The general manager and/or other representatives of NGHCE visited the group at Bena in May 2020, early 2021 and in April 2022. At the beginning of the trial, NGHCE attended one of the community meetings to advise on quality and agreed to buy the group's parchment on the understanding that quality would be rewarded with price premiums. The message about striving for quality in a CBB environment was reinforced to growers during these visits by NGHCE staff. These visits were in addition to the group leader of the Bena group visiting NGHCE's processing factory and quality lab in October 2019 and in April 2023 (Plate 5.2).



Plate 5.2: Bena group leader on tour of the NGHCE cupping room. Source: G. Curry.

4. *Household livelihood surveys.* Baseline household socioeconomic surveys were conducted in Bena in August-September 2018 by PNG and Australian team members. Fifty households were surveyed and interviewed. On most occasions both the husband and wife were present to answer gender-specific questions. The purpose of the questionnaire was to collect data on: household composition (gender, age, education, marital status); household coffee labour and production constraints (e.g. pest and diseases); coffee planting and land use change; coffee marketing and income distribution; Coffee Berry Borer and its impact on coffee production; farmer training; household assets; income sources (both husband and wife); and financial inclusion.

These data were complemented with household data collected from 27 VSLA members during ASEM/2014/054.



Plate 5.3: CIC researcher speaking with a farmer about constraints on coffee production. Source: Tim Sharp.

5. *Household time allocation and dietary surveys.* Time allocation surveys with 21 households (a sub-sample of the 50 households referred to above) were carried out in the non-coffee season during November 2018 and January 2019, and again during the coffee season in June-July 2019 with 18 of the original 21 households. The central purpose of the labour allocation data was to assess any changes in the input of labour by gender into coffee harvesting, maintenance and processing, and to enable comparison with labour data collected in 2010. Dietary data was also collected to assess food security within the community.
6. *Household saving data.* As the trial progressed and as information was gathered through community meetings and face-to-face interviews, the research increasingly focused on the synergies between the demucilager use and the VSLA groups/activities. Attention was given to how both the demucilager use and the VSLA could enhance community benefits and the long-term sustainability of the two interventions. To trace these connections and synergies, beyond the completion of ASEM/2014/054, this project (ASEM/2016/100) continued to carry out surveys of savings, loans use and enterprise development among VSLA members. These surveys were conducted with 63 VSLA members in December 2021 and in May 2022.

7. *Demucilager use and impact surveys.* In May 2022, the PNG and Australian team members conducted questionnaire surveys with 37 households participating in the demucilager trial and who had been using the demucilager during 2021 and 2022. The survey's purpose was to assess people's use of demucilager, the recycling of nutrients in the waste stream of the demucilager and changes in household coffee production and the economic, social and gender impacts of the demucilager. Twenty-one of the 37 households, who had weighed-in more than 30 kg of dry parchment equivalent, were also asked about the impact of the demucilager on labour contributed to different coffee production and maintenance tasks.
8. *Demucilager labour data.* In June to September 2023, to gain a more detailed understanding of who was carrying out the coffee work and how they were remunerated, the team conducted 79 surveys at the point of weighing-in (involving members of 31 different households). The surveys also collected information about processing which has relevance to CBB management. These surveys were carried out by a local village-resident field assistant.
9. *Demucilager weigh-in data.* The research had access to the coffee weigh-in records for each farmer in the group. The project assisted to establish the record keeping process, and the data were used by the group to calculate farmer payments. The weigh-in data was recorded by the group leader. Between 2020 and 2023, the demucilager group recorded all coffee cherry weighed-in, recording both the weight of good cherry, and the weight of any cherry that was rejected during the float test. There was a total of 818 weigh-ins between 2020 and 2023. This data was cross referenced to the farmers' villages, gender and VSLA membership.



Plate 5.4: Growers conducting float test on cherry delivered to the demucilager.

Note: The project recorded the weight of both the good quality cherry, and the poor-quality floating cherry. Source: Tim Sharp.

10. *Observation and participant observation.*

Observations of coffee and food gardens, residences, coffee work, demucilager processing, savings group participation, and group meetings were carried out during the many visits to the Bena field site. Researchers also participated for short periods in coffee processing including float testing of cherry and weighing-in at the demucilager, and management of drying beds. These observations informed the development of survey instruments, and the interpretation of other data.

11. Photographs and videos

Photographic and video records of coffee work and the demucilager operations were taken throughout the trial.

Data entry and analysis

All surveys were paper-based surveys. Paper surveys enable rigorous checking and cross checking of data in the field. They also enable more flexible responses, that can be checked and coded later. The majority of data entry was done in PNG by CIC, although a limited amount of data entry was carried out at Curtin. Data analysis was carried out in Excel.

Supplementary data were also collected by a Curtin PhD student, Jennifer McKellar, who undertook some additional analysis of project data. This analysis will be included in McKellar's forthcoming thesis.

Intercropping

Trial sites and design

The two sites selected for the cabbage-coffee intercropping trial were in Asaro and Bena Districts. However, early in the project it was agreed to consolidate work at Asaro District reflecting: i) a strong desire for Asaro farmers to participate and ii) staff trial time and travel demands exceeding that available in the budget.

Trials were completed over three rounds between 2019 and 2021 at Kenemba, Nahoma and Samunga villages in the Asaro District, and participation by 11, 14 and then 12 families in the respective rounds. A fourth round of trials was started in July 2021 but abandoned because the rains did not arrive.

Two trial designs were implemented:

- Design 1
 - Treatment 2: fertilised cabbage intercropped
 - Treatment 4 (control): no cabbage intercropped
- Design 2
 - Treatment 1: unfertilised cabbage intercropped.
 - Treatment 2: fertilised cabbage intercropped
 - Treatment 3: fertiliser only – no cabbage
 - Treatment 4 (control): no cabbage intercropped

Design 2 was originally planned with four treatments, which was modified to omit Treatment 1 because of reluctance of farmers to implement trials that did not use fertiliser, meaning the treatment was not practical. Design 2 had participation by four farmers with three treatments, and for Design 1, 8-10 farmers participated with two treatments. On average, 12 farming families participating in trials though four rounds of cabbage-coffee intercropping.

The fertiliser that was applied, was N:P:K (12:12:17); 10 g per cabbage at planting, then two further rounds of 20 g N:P:K side-dressed.

Initially, 100 coffee trees (10 x 10) were selected for the trial, but the number was reduced to 25 coffee trees (5 x 5) because of the cost of resources.



Plate 5.5. Coffee intercropped with cabbages, Asaro. Source: G. Koczberski.

Soil sampling

Two sets of soil samples were collected and analysed in 2018 (15 gardens) and 2022 (12 gardens). The first soil sampling was done before the coffee was intercropped with cabbage and the second soil sampling was done after the final round of intercropping. Soil samples were collected from 0-10 cm (topsoil) and 10-50cm (subsoil).

Coffee growth and yields

The monitoring and data collection from the trials was done monthly. The two types of data collected included coffee growth parameters and coffee yield data. In terms of sampling, initial leaf and cherry samples were analysed and coffee tree growth parameters and coffee yields were collected in 2019 and 2020. The coffee growth parameter data included several vegetative parameters; number of lower, middle and upper primary and secondary branches; phenological development of coffee fruit leading up to final harvesting.

Trial data was supplemented with household quantitative and qualitative data. This included:

Household livelihood surveys. Baseline household socioeconomic surveys were conducted at Asaro in August-September 2018 by PNG and Australian team members. Ten households were surveyed and interviewed. The questionnaire survey was the same as that used in the demucilager trial outlined above.

Face-to-face structured interviews and focus groups. In March and July 2019, four in-depth household interviews were conducted at Kenemba, Nahoma and Samunga villages, and one focus group was held at Kenemba. The interviews accompanied a visit to the intercropped coffee gardens. In 2022 one focus group meeting was held with three women at Samunga village. The main purpose of the interviews was to gain women's perspective on the impacts of intercropping in terms of:

- Additional labour demands
- Household income
- Distribution and control of the income from both vegetables and coffee
- Changes in household labour dynamics in coffee and vegetable production
- Health of coffee trees, including pest infestations such as CBB.
- Reducing pressures on land

- Household food production



Plate 5.6. Coffee Berry Borer on some recently harvested cherry Source: G. Curry.

6 Achievements against activities and outputs/milestones

Objective 1: To develop, field test, refine and facilitate the uptake and use of an extension training package by government, private sector, PPAP and NGO-supported extension providers

No.	Activity	Outputs/ Milestones	Completion date	Comments
1.1	Complete drafts of extension training package ready for field testing. <i>PC & A</i>	<p>Twenty-two training modules were developed over the life of the project (see Section 7)</p> <p>Nine modules published and available</p> <p>Five modules at printers</p> <p>Seven modules well developed in draft form/under review</p> <p>One module not started (new coffee grading system and domestic coffee market to be completed by CIC)</p> <p>CARE - 3 modules in circulation</p>	2024	<p>Several major disruptions slowed progress on the training modules. These were:</p> <ul style="list-style-type: none"> • 2020-2021 COVID-19 travel & work restrictions (Australian project staff were not permitted to visit PNG until May 2022 [G. Curry as test case], and then October 2022 for rest of Australian team members). CIC also faced periods of travel restrictions) • 2021-2022 CIC restructure during which all staff had to reapply for their positions (Jan 2021 to Mar 2022) • 2022 PNG elections restricted travel by CIC staff. • 2017- Arrival & spread of the devastating pest, Coffee Berry Borer (CBB). <p>By 2021/22, all of CIC's extension efforts were dedicated to CBB control and containing its spread.</p> <p>Because of the absence of extension material on the control of CBB, the project gave CBB high priority and worked with Ian Newton and his team (HORT/2018/194) to develop a training module on CBB. In addition, the printing of already developed modules was postponed so that these modules, together with modules still in development, could be 'retrofitted' to be CBB compliant. Now all the modules produced under the project have been designed for a CBB environment. This is one aspect that distinguishes these modules from other coffee extension materials.</p> <p>The Extension Training Package is likely to be expanded under CLIM/2022/109 with a module on carbon trading.</p>
1.2	Evaluation of extension officers' views of the effectiveness of the training modules.	<p>Field proven training modules for extension on a range of topics (Section 4.3.1).</p> <p>Y4, Q4 – Y6, Q1 Modules 1-8</p>	2023	<p>CIC extension officers and researchers worked closely with Australian team members in all stages of the development of the modules. Much of the content of the modules reflects the findings of participatory workshops with extensions officers and their view of what</p>

	PC & A	Y4, Q1 – Y6, Q3 Modules 9-17 Y6, Q1 – Y6, Q4 Modules 18-24		might be adopted by smallholders and what might be rejected. Also, there was much discussion with private sector organisations regarding the content of the extension material.
1.3	Assessment of farmers' knowledge & uptake of information from each training module. PC & A	Y6, Q2 – Y7, Q1 Modules 1-24	2023	<p>The disruptions listed in the dot points in Activity 1.1 mean that formal assessment of farmers' knowledge and uptake of information was not possible.</p> <p>Also, the retrofitting of modules to be CBB compliant has also meant field testing has yet to occur.</p> <p>However, given the existential threat of CBB to PNG's coffee industry, drafts of the CBB module were rolled out early for farmer training. Informal evaluations in 2023 and 2024 indicate that the training has been very much appreciated and understood by farmers and private sector organisations.</p> <p>At the Bena field site, CBB training of a group of farmers on 1 June 2023, was very well received. These farmers had been struggling with high infestation rates of CBB since mid-2022. Anecdotal evidence from June 2023 suggests that CBB rates are falling, perhaps because of more frequent harvesting and the removal of all over-ripe cherries and raisins.</p> <p>It has not been possible to undertake a full assessment of farmers' uptake of other modules because of the extension focus on averting the CBB disaster. However, much of the content of the modules reflects the findings of participatory research with smallholders, and discussions with them, of potential solutions to production, processing and marketing problems.</p>
1.4	Finalised training modules to be rolled out as they become ready. CIC, partners & PPAP to be involved in the roll out. PC & A	Ratification of training modules by the National Training Council Y6, Q1 – Y7, Q1 Modules 1-22	As at 28 May 2024.	<p>Nine training modules have been published on-line. Another five modules are with ACIAR for formatting and publishing (see 1.1)</p> <p>Ratification of training modules by the National Training Council will be done when the full package of modules is complete (to be organised by CIC).</p> <p>The World Bank-funded PACD paid for the printing of 1,100 copies of the CBB Module and 52,000 copies of related posters and pamphlets. The CBB module and the suite of modules were launched by the Minister of Agriculture at the project final review on 9 August 2023.</p> <p>Given the very serious threat that CBB poses for the PNG coffee industry, it is highly likely that most of CIC's extension efforts will be focused on CBB for at least the next few years.</p> <p>Groups that have received CBB training and are linked to private sector</p>

				<p>companies, are likely to receive follow-up training using the other modules in the package. The private sector is employing more extension officers for their certification programs and will be able to deliver this extension training to their farmer groups.</p> <p>Certification schemes have shown interest in the modules and are keen to use them as part of their training programs.</p>
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Objective 2: To develop a model for demucilager use by farmer groups that delivers social and economic benefits to men and women and which is compliant with the environmental criteria of the main certification organisations...

No.	Activity	Outputs/ Milestones	Completion date	Comments
2.1	Select village in Bena to establish low cost demucilager to be managed by women's group. PC & A	Agreement reached with village community & NGHCE to establish the trial. Y2, Q1	2018	The farmers group that runs the demucilager has a very close association with the VSLA groups (3 of the 4 groups are women's groups). This has led to strong women's participation in the demucilager. The focus of the VSLA on women's empowerment has transferred to the recognition of women within the demucilager group.
2.2	Design a set of governance processes for management & use of demucilagers. PC & A	Agreement reached on a set of governance issues that also address gender, environmental, & socio-political concerns. Y2, Q4	2019	<p>This was ongoing throughout the project, but formal training was completed by mid-2019</p> <p>Group strengthening was facilitated by the engagement of CARE-International under the VSLA scheme where training in group governance was provided. Ongoing participation in VSLA groups has strengthened group cohesion which has had a positive impact on the management of the demucilager. Due to the role of the VSLA in strengthening group cooperation and governance (including transparency and record keeping), and supporting women's use of the demucilager, ASEM/2016/100 has continued to support and collect data on the VSLA, and the VSLA is recommended as part of a model for establishing demucilagers.</p> <p>In summary, the successful integration of governance practices, the demucilager initiative, and the VSLA demonstrates a noteworthy accomplishment. Qualitative stories of positive impact highlight the meaningful contributions these endeavours have made to the community's economic empowerment and well-being</p>

			2024	<p>A framework for a model of ecopulper/demucilager use and management is under development. It involves several steps:</p> <ul style="list-style-type: none"> • Establishment of a VSLA group for group governance training, financial management, etc • Establishment parameters of demucilager (funding, training, siting and technical aspects) • Nutrient recycling strategies
2.3	<p>Install demucilager & conduct training for operators of demucilaggers . PC</p>	<p>Operators trained in proper use of demucilager. Y3, Q1 – Q3</p>	<p>14-19 July 2019</p> <p>2-13 March 2020:</p> <p>28 April-1 May 2020</p> <p>January 2022</p> <p>March/April 2023</p>	<p>Installation of tanks, water supply & demucilager.</p> <p>Installation of demucilager shed, cherry hopper & drying tables</p> <p>Demucilager calibrated & tested. Group members trained in demucilager operation.</p> <p>Parchment storage house completed & polypipe feed for delivery of parchment from demucilager to drying tables</p> <p>Tobias Kumie, CIC engineer, carried out maintenance on the demucilager.</p> <p>There was strong interest in the demucilager in its first year of operation, with 72 farmers using it. The trial has, however, faced a range of challenges which have impacted the operation and use of the demucilager. The government coffee price subsidy from early to mid-2021 led to higher prices drawing supply away from the demucilager. In May 2021 the demucilager broke down. Due to surging COVID-19 infections at the time, restricting travel and impacting the sourcing of parts, it was out of operation for the remainder of the season.</p> <p>The 2022 season was impacted by high infestation rates of CBB. The coffee group was not processing coffee for NGHCE because they were concerned that the sale of CBB damaged coffee would undermine the group's reputation and jeopardise their relationship with NGHCE (note, some farmers continued to use the demucilager to save labour but sold their coffee to roadside/village buyers). The group's work was also disrupted by the election activities. High coffee prices in 2022 also led to members individually processing to parchment and selling through other channels.</p> <p>In 2023, high coffee prices and the fact that village cherry buyers are less</p>

				particular about quality also kept demucilager use low early in the season (see Section 7). However, the decline in the coffee price after July increased supply to the demucilager.
2.4	Monitor & assess the technical & socioeconomic components of the Bena trial and the two existing demucilagers managed by PNGCE PC & A	Preliminary findings delivered at stakeholder meetings with industry & farmer groups. The costs & benefits of the demucilager identified. Solutions to address emerging problems discussed at the stakeholder meetings. Y3, Q4 – Y6, Q3 Develop a model for demucilager use by farmer groups that delivers social & economic benefits to men & women. Y6, Q4	2018 2018 2018/19 2019 2019 2020-22 2021/22 2022 2020-23 2023 2020-2024	Socioeconomic monitoring completed with the three existing demucilagers: Yonki, Tolu and Komkul. Despite the disruptions listed in 1.1, the following surveys were completed: <ul style="list-style-type: none"> ▪ In September 2018, 50 household socioeconomic surveys carried out in Bena. ▪ In November 2018 and January 2019, 21 household time-allocation surveys were conducted during non-coffee seasons in Bena. ▪ During June-July 2019, 18 household time allocation surveys were conducted during the coffee season in Bena. A follow-up data verification survey was conducted in late 2019. ▪ As part of the Village Savings and Loan Association (VSLA) initiative in 2019, 27 household socioeconomic surveys were completed. These surveys complement data collected for the coffee project. ▪ With COVID-19, monitoring was scaled back in 2020-2022. A village research assistant was recruited to collect some data on demucilager operations while restrictions were in place on CIC fieldwork. ▪ A survey of savings, loans use and enterprise development with 63 VSLA members was carried out in December 2021 and May 2022 to continue to monitor the connections between the demucilager and VSLA groups/activities. ▪ An assessment of 37 demucilager households was conducted in May 2022, focusing on the utilisation of the demucilager and the cultivation of vegetable crops for recycling nutrient waste from demucilager runoff. ▪ The collection of demucilager weigh-in data has been consistently done by village research assistants from 2020 to 2023. ▪ Survey on demucilager labour (79 weigh-ins, June-August 2023) by a village-based field assistant. PhD student, Jennifer McKellar, has examined the gendered impacts of the adoption of this technology on women's social and economic empowerment as part of her larger study on gender relations and commodity production in EHP. She commenced fieldwork in March 2020 but was recalled to Perth by Curtin

			2023	<p>when the C-19 pandemic began. She used methods of remote research such as WhatsApp to interview village respondents. This worked relatively well. She worked closely with a village-based field assistant. The skills the field assistant acquired enabled the field assistant to contribute to other data collection for ASEM/2016/100 with CIC, and independently in June 2023. Jennifer was also given access to data from ASEM/2008/036 to supplement her own data. Jennifer's research focus has shifted slightly to ensure its feasibility with remote data collection. Her thesis will be submitted for examination in July 2024.</p> <p>The value of demucilagers is being recognised by industry and has become part of CIC policy.</p>
2.5	<p>Monitor & assess waste streams & nutrient recycling options.</p> <p>PC & A</p>	<p>Models developed of pulp & waste water management that efficiently recycle water & nutrients. Models will comply with the environmental criteria of the main certification organisations. They will be able to be designed for low input farming systems & take into account smallholder labour constraints.</p> <p>Y6, Q3</p>	<p>Macerator tested June 2019.</p> <p>2020-2024</p> <p>2022</p>	<p>Technical aspects of macerating the coffee pulp to gravity feed to bulb onions plots were not resolved. We formed the view that this is not necessary because carrying buckets of cherry pulp to nearby vegetable plots was not an issue for participants. Also, gravity feeding pulp to nutrient recycling sites requires water which can be limited in the dry season. Decisions about site location for future demucilagers should take into account proximity to land for vegetable plots.</p> <p>To benefit from the waste pulp from the demucilager and ensure the waste stream was not damaging to the environment, the coffee group established vegetable plots (first few rounds were bulb onions) within a citrus orchard on which the waste pulp was applied. Women and men were responsible for their own plots.</p> <p>In later years, other crops were cultivated in the plots including ginger and carrots.</p> <p>An assessment of 37 demucilager households was conducted in May 2022, focusing on the utilisation of the demucilager and the cultivation of vegetable crops for recycling nutrient waste from demucilager runoff.</p>

Objective 3: To identify and develop culturally acceptable and nutrient efficient coffee-vegetable intercropping systems as a means to both increase coffee yields and incomes, and improve income-earning opportunities for women...

No.	Activity	Outputs/ milestones	Completion date	Comments
3.1	Plan trials with CIC &	Documented tentative plans of trials	Feb 2018	Co-designed trials planned by CIC and industry staff

	industry staff. <i>PC</i>	Y1, Q2		
3.2	Identify key farmer families & possible trial locations <i>PC</i>	A documented list of potential key farmer families Yr1 Q2	2018	Completed. The Bena site was subsequently dropped because of limited project budget and unprecedented requests from farming families to be involved.
3.3	Consult with selected farmer families to gain consent & explain the trial. <i>PC</i>	A documented record of the discussion (minutes) distributed to those present; checked, then finalised & redistributed. Yr1 Q2	2018	Completed
3.4	Hold a public meeting to explain the trial. <i>PC</i>	A photographic & video record will be captured. Yr1 Q2	2018	The record of the public meeting is available for project reporting and communication purposes.
3.5	Establish trials. <i>PC</i>	A detailed data set on yields of coffee & intercrop under different conditions which can be analysed economically. Farmer families fully knowledgeable about the concept of intercropping & the benefits it conveys. These will be 'rolling' trials & so will continue to be established throughout the project. However, the first trials will be in ground by Y2, Q2	2018 June 2018 Aug-Sept 2018 2019-2021 July 2021	Initial soil sampling and on-ground trial planning at Asaro and Bena was conducted. After some discussion with the field team, it was decided to scale down the operations because of costs. Cherry samples were collected at Asaro and analysed. Nurseries were constructed, and seedlings grown and distributed for planting. Treatments were applied to trial plots. Household socioeconomic surveys carried out in Asaro in June 2018 (c.20hh). Household socioeconomic surveys carried out in Bena in August-September 2018 (c.60hh), Three rounds of intercropping were conducted in Asaro District from 2019 to 2021: Kenemba, Nahoma and Samunga villages. The first, second and third rounds of intercropping cabbages had, respectively, 11, 14 and 12 participating families. Some families increased the area of intercropping at their own expense, and some neighbouring families have adopted intercropping at their own expense after observing the successes of trial participants. A 4th round of intercropping started in July 2021. However, drought conditions in second half of 2021 killed most cabbages. The trials were completed according to plan, albeit with modifications and changes due to cost limitations and seasonal impacts (drought).

				<p>Numerous families participated although not all participated during each round of trials.</p> <p>Instances of intercropping adoption by neighbouring non-participating families were noted, as were families increasing their area of intercropping in some instances. This suggests value of intercropping being experienced by some families and the value of intercropping diffusing beyond the trials.</p>
3.6	Regular monitoring of trials. PC & A	<p>Trials ran from Y1 Q4 to Y4 Q4 according to plan. Maintaining farmer family interest. Data will be collected on trial maintenance.</p> <p>Detailed data on crop/coffee management, yields & nutritional status of both vegetable crop & coffee. Data on changes in soil fertility.</p> <p>Data on expenses, income & labour allocation ongoing.</p> <p>Data analysed and preliminary findings documented to inform Activity 3.9 Y2, Q2 – Y6, Q3</p>	<p>2020-21</p> <p>2019-2021</p> <p>2019-2021</p> <p>2020</p> <p>2019 and 2020</p> <p>2021</p>	<p>Trials were severely impacted by COVID-19 and travel restrictions to trial sites. The COVID-19 and PNG General Elections in 2022 travel restrictions significantly affected the monitoring and data collection of the trials.</p> <p>There were delays in the supply of fertiliser to the farmers which resulted in some cabbages being stunted because fertilisers were not administered at the correct growth stage of the cabbage. This led to some farmers not getting better income from the sales of the cabbages. In some cases, the farmers went ahead to purchase fertilisers using their own funds when there were delays in the delivery of fertiliser. These farmers saw the cabbages as a source of income so they were willing to invest in fertilisers.</p> <p>As an alternative to travel, farming families with mobile phones were contacted regularly, who reported on other families and trial progress. Mobile phones were purchased for some farmers for reporting purposes.</p> <p>All farming families were visited for sampling activities, and trial maintenance discussed with the families.</p> <p>Fortnightly sampling of coffee cherry yield was planned across the coffee harvesting season. However, due to COVID-19 travel restrictions, this was not possible at the start of the 2020 season and in 2021.</p> <p>Data collected for several vegetative parameters (number of lower, middle and upper primary and secondary branches; phenological development of coffee fruit) leading up to coffee yield harvesting. Four rounds of coffee vegetative parameter data sampled between 2019-2020.</p> <p>Leaf and cherry samples were collected for nutrient analysis in 2018.</p> <p>Coffee growth data was collected and entered for 2019 and 2020.</p> <p>Coffee canopy density data was collected from participating farmers in 2021.</p>

			2021	Coffee yield data was collected for the 2021 coffee season and has been entered. Coffee yield data for the 2022 season was not collected because of travel restrictions during the National General election.
			2021	Successful establishment, observation and completion of research trial on coffee-vegetable intercropping with focus on coffee yield showing positive result of increased coffee yield. Report of the respective study shows the yield difference before and during the trial whilst statistical ANOVA report published in the PNG Coffee Journal.
3.7	Farmer-driven trials. <i>PC</i>	Farmer knowledge & interest increased in intercropping. Farmers confident to experiment. Ongoing Y2, Q3 – Y6, Q3	2022	Farm families have increased their interest (increasing area intercropped and neighbouring farmers intercropping) and knowledge (utilisation of open space). Some families are not yet fully aware of the importance of the fertiliser component. Some farmers were experimenting with other crops outside the trials (e.g. intercropped their other coffee plots with crops such as, carrot, ginger, spring onion, sweet potato). However, we were not able to monitor their progress due to COVID-19 and PNG General elections travel restrictions. Due to the 2022 PNG General Elections the CIC staff had restricted travel, thus the progress of the farmers' experiments could not be monitored.
3.8	Provide annual updates to the community through public meetings & attain feedback. <i>PC</i>	Public awareness & maintaining ongoing interest in trials & results. Maintaining community support to participating farmers Y2, Q4; Y3, Q4; Y4, Q4; Y5, Q4; Y6, Q3	2020-21 2021/22 2022 2017	Community meetings were maintained to support participating farmers. However, the community support to participating farmers could not be sustained for the following reasons: <ul style="list-style-type: none"> • 2020-2021 COVID-19 travel & work restrictions • 2021-2022 CIC restructure during which all staff had to reapply for their positions (Jan 2021 to Mar 2022) • 2022 PNG elections restricted travel by CIC staff. • 2017- Arrival & spread of the devastating pest, Coffee Berry Borer (CBB).
3.9	Assess the suitability of intercropping in densely populated areas. Identify barriers to adoption including gender issues. <i>PC</i>	In Y6, Q3 a report (& stakeholder workshop) on the potential suitability of intercropping. The report will: i) identify the economic benefits of intercropping for smallholder families, especially for women; ii) highlight the barriers to adoption including gender &	2019 and 2022	Face-to-face interviews were conducted with a few women in the Kenemba, Nohoma and Samunga in 2019 and 2022 regarding barriers to adoption and gender issues. Aspects of this have also been presented at various conferences and in papers currently being prepared for journals. Despite the disruption affecting the trial and data collection, women farmers remained interested in continuing with intercropping. Some of the benefits highlighted from the face-to-face

		<p>labour issues; iii) outline the nutrient benefits of intercropping for coffee & vegetable production & iv) provide a set of recommendations for the industry to promote intercropping in densely populated areas.</p> <p>Greater gender equity in remuneration from coffee when it is made apparent that women's activities in intercropping benefit coffee production (ongoing from the start of the trials). Y6, Q3</p>		<p>interviews were the opportunities to learn from the trial, the additional income source from cabbage sales and the potential to earn one-off large sums of money if the cabbages were looked after well.</p>
3.10	<p>Develop a training module. <i>A & PC</i></p>	<p>A new training module based on the outputs above. Y6, Q2</p>	2024	Training module prepared and under review
3.11	<p>Hold a public meeting for a final update. <i>PC</i></p>	<p>A photographic & video record will be captured. Y6, Q3</p>	2024	<p>Various restrictions on travel and land access at critical stages of trials due to COVID-19 and PNG National Elections, as well as changes in farmer participation and non-adherence to strict trial design has led to an incomplete and disjunctive dataset to make quantitative interpretation of trends and lessons problematic from a research perspective. Interpretation of results of trials, therefore, rely more on qualitative interpretations of the data. Much of the learnings have been incorporated into the draft Module</p>
3.12	<p>Promote benefits of intercropping through extension module to CIC & other extension providers. <i>PC</i></p>	<p>Greater adoption of good nutrient management through intercropping. Y6, Q2</p>	2024	Training module prepared and under review.
3.13	<p>Soil & plant analysis. <i>A</i></p>	<p>High quality results. Y1, Q4 – Y6, Q2</p>	2018 and 2022	<p>The change in the leading Australian NRM team leader from Dr Michael Webb to Dr Mark Thomas created a delay in the analysis of the soil samples as we had to come up to speed with new changes.</p> <p>As with 3.11, disruptions to trial methodology have made results disjointed and difficult to interpret, so outcomes rely more on quantitative interpretations.</p> <p>Initial soil sampling has been analysed. Initial cherry sampling has been analysed.</p> <p>A final soil sampling of intercropping plots was done in August/September 2022 to</p>

			2022	address the impact of intercropping on soil quality. Samples have been analysed and have informed the module on the farmer training module “Intercropping your coffee garden”.
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Objective 4: To assess the social and economic benefits for men and women of direct cherry sales to processors ...

No.	Activity	Outputs/ milestones	Completion date	Comments
4.1	Select two villages where households are/were selling cherry to PNGCE PC & A			Because of bans on movement of cherry to prevent spread of CBB, this objective is not possible
4.2	Conduct a gender cost/ benefit analysis of cherry sales among members of a farmer group selling (or who sold) cherry. PC & A			Because of bans on movement of cherry to prevent spread of CBB, this objective is not possible

7 Key results and discussion

The four key components of the project were:

1. An extension package for training farmer groups and junior extension officers;
2. A trial of a low-cost mini wet mill (demucilager) and the evaluation of existing village-based demucilagers, including the design of a system for nutrient recycling of pulp;
3. Intercropping of coffee with food crops and nutrient recycling; and
4. Cherry sales to processors (this component did not proceed because of the ban on movements of cherry since the arrival of Coffee Berry Borer in 2017).

7.1 Extension package

This training package was designed to assist private sector, government and NGO-funded extension officers to train farmer groups in the production, processing and marketing of coffee. It was also a resource for the training of cadet extension officers at CIC and for extension officers recruited by private and NGO-sector organisations.

This extension package draws on many sources of information including ACIAR research by CIC and their partners, numerous workshops with CIC extension officers, smallholder men and women who participated in research projects, private sector organisations (e.g. Monpi, NGHCE and Lahamenegu Coffee Factory), NGOs (e.g. CARE International and AAK), international research findings, and previous CIC extension materials, especially the material coordinated and developed by Leo Aroga.

Importantly, the modules have been informed by long-term research on the socioeconomics of coffee production, primarily through this project and its predecessor:

- ASEM/2008/036: Improving Livelihoods of Smallholder Families through Increased Productivity of Coffee-based Farming Systems in the Highlands of PNG

Other ACIAR projects that have been drawn upon for the development of the modules include:

- ASEM/2014/054: Identifying opportunities and constraints for rural women's engagement in small-scale agricultural enterprises in Papua New Guinea
- HORT/2018/194: Protecting the coffee industry from Coffee Berry Borer in Papua New Guinea and Australia
- ASEM/2004/017: Assessment and improvement of quality management during postharvest processing and storage of coffee in Papua New Guinea
- ASEM/2004/042: Assessing and extending schemes to enhance the profitability of the PNG coffee industry via price premiums for quality

Farm families themselves contributed to this research through a process of 'co-production' of knowledge in which problems were identified by farmers and their families and potential solutions developed in collaboration with them.

The modules comprising the package were planned using an adult coffee curriculum mapping process by CIC. This was mapped out with an appreciation that CIC could apply to the National Training Council for endorsement of the package, and formally register a coffee training school. The package of modules should be viewed as a 'living' document

that allows room for further curriculum development as new information and research findings become available.

While formulating the marketing component of the training package, it was identified that CARE-International in PNG had already developed training manuals on group governance and family money management. To prevent duplication of existing resources, CARE agreed to have their excellent training manuals incorporated into the Package.

7.1.1 The ten principles guiding the content of the training package

During the process of researching ways to improve extension and tailor it to the realities of smallholder coffee production in the PNG highlands, ten principles emerged. These principles guided the content of the Training Package and identified the level of resources that smallholders would need to invest to improve their production and livelihoods. Each principle is discussed below:

Principle 1: Recognition that low input production strategies are pursued by the vast majority of smallholder coffee growers

In PNG, as in many other countries, agricultural extension strategies have been premised on the assumption that smallholder farmers were in a transition from low input farming practices (low levels of technology and few or no external inputs) to high input, capital-intensive farming methods using high levels of external inputs, reminiscent of plantation style production. Consequently, most extension training material available worldwide, including in PNG, is based on high input production methods, more in keeping with capital intensive plantation production, using high levels of technology or mechanisation, formal credit and relying on a paid workforce.

Attempts to shift farmers to high input farming have been largely unsuccessful in many countries, including PNG, because a whole range of socio-cultural factors make such transitions difficult for the communities involved. Because traditional low input farming methods are so ingrained, socially and culturally, it means that a great deal of extension training based on high input farming has had little impact because it was unable to accommodate the low input production strategy practised by the vast majority of smallholders across all export and domestic crops for sale or home consumption.

The low input system is characterised by:

- low-cost production with inputs of fertiliser, pesticides, and herbicides considerably below plantation rates of inputs
- limited inputs of labour
- the use of simple processing techniques
- little or no use of formal sector credit
- a heavy reliance on family labour with minimal use of hired labour

Thus, a need was identified for extension training materials for CIC, private sector organisations and non-government organisations (NGO), to be more closely aligned with the low input production strategy. The training package acknowledges and accepts that low input production is the dominant production strategy of coffee smallholders, and therefore extension efforts must accommodate this reality.



Plate 7.1. Smallholders practise low input farming using simple production and processing techniques.

Principle 2: Women play a central role in coffee production

Women play a central role in coffee production, particularly in harvesting and processing, and to date their role has largely been ignored in agricultural extension. Matilda Hamago's JAF-sponsored thesis (Hamago 2019) identified the male bias in training and the difficulties of targeting women in extension when so few female extension officers are employed in the industry.

Women's contribution to coffee production has declined in recent decades because of what they perceive as underpayment of their labour in coffee. Many women now prefer to invest their labour in other livelihood activities like food gardening for markets because they have more control over the income earned. However, when women are paid adequately for their labour in coffee they can contribute much to coffee production, especially to harvesting and processing which is particularly important for CBB control.

The extension materials in these modules seek to enhance women's engagement and participation in coffee on a fair and equitable basis in ways that benefit women and their families.



Plate 7.2. Women play a central role in coffee production activities. Source: Susan May Inu and Pr. Albert Ukaiya.

Principle 3: Smallholder farmers pursue a range of livelihoods in addition to coffee

There has been a tendency in research and extension to examine smallholder coffee production in isolation of the broader livelihood and socio-cultural strategies that coffee households pursue. For example, most research into the coffee industry has neglected to consider the interactions between coffee, food crops and broader livelihood strategies, and what motivates or constrains smallholders to invest time and labour in coffee production. Furthermore, little consideration has been given to the environmental, social, cultural and gendered contexts of coffee production.

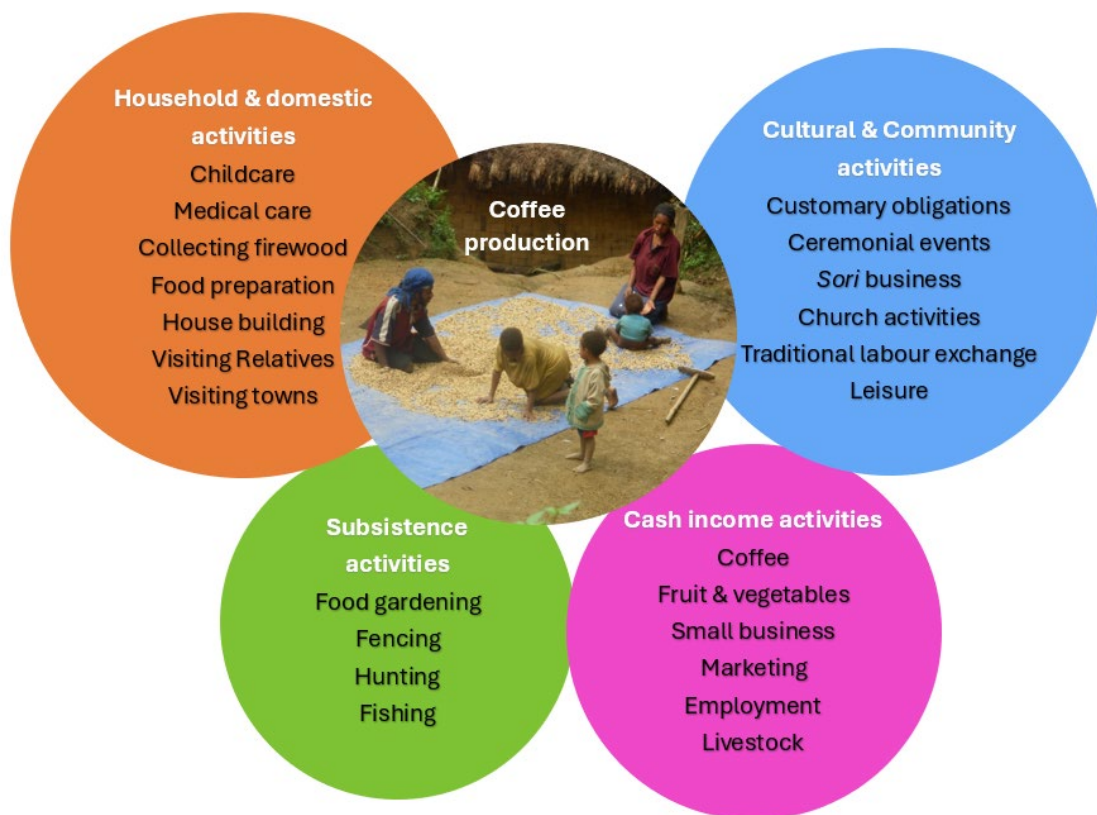


Figure 7.1. Coffee farming-livelihood system of smallholders.

In addition to socio-cultural reasons, smallholders pursue low input production strategies because most of them maintain a diverse range of livelihoods, including subsistence production. This means smallholders are often reluctant or unwilling to commit a large amount of time and labour to any one livelihood activity such as export crop production as it often means trading off time in other activities such as customary activities or subsistence gardening, which are highly valued in their own right by both men and women.



Plate 7.3. Coffee smallholder livelihoods.

Principle 4: Coffee farmers are not all the same

There are major social, economic and demographic differences between farmers and farm families which affect their motivation and capacity to produce and market coffee. The more important dimensions of these differences include:

- remote and accessible locations
- the age cohort of farmers
- gender
- education levels
- other income earning opportunities within households, including formal employment
- household composition and number of dependants (young children and ill and incapacitated family members)

These differences impact farmers' extension needs and their incentives to produce coffee. To address the disparity in education, for example, the modules are supplemented with 'farmer notes' in *Tok Pisin* which are beneficial for farmers with minimal formal education.



Plate 7.4: Many farmers in remote locations carry their coffee long distances over steep terrain while others have it transported by aeroplane which is very costly.

Principle 5: The adoption of agroforestry principles will enhance ecosystem services and generate other benefits for farmers and their families

It is becoming clear to researchers that many of the traditional farming techniques of farmers in PNG and elsewhere were highly sustainable, providing stable production through time, without a dependence on costly external inputs. Traditional farming methods are often based on agroforestry principles, which are becoming increasingly recognised throughout the world as contributing to the resilience of farming systems, especially in the context of climate change. Agroforestry has been practised successfully in PNG for thousands of years, and some of the key principles contributing to sustainable low input systems of coffee production are emphasised throughout the modules.

The importance of shade trees is highlighted in the modules. Shade trees not only improve the supply of soil nutrients (e.g. from shade tree leaf fall and nitrogen fixation) and biological diversity but may also save labour in weeding through weed suppression from shading and mulch, and provide a wide array of valuable resources such as firewood and timber, and also give a source of supplementary income.

Throughout the modules there is an emphasis on coffee farming methods that generate ecosystem services which in turn improve the sustainability of coffee production (ecosystem services being the benefits for people derived from the environment). These modules include: low-cost, labour-efficient methods of diversifying incomes and promote ecosystem services that enhance nutrient recycling, reduce the incidence of pests, diseases and weeds, thereby reducing the need for fertilisers, pesticides and herbicides.

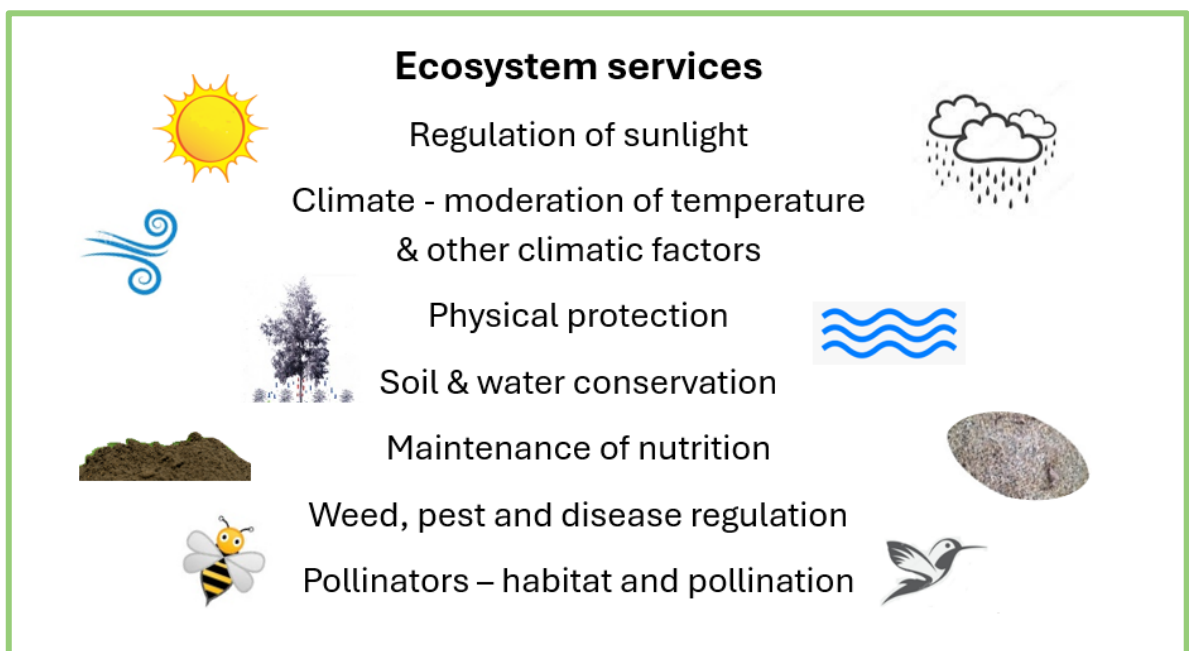


Figure 7.2. Some of the ecosystem services enhanced by coffee shade trees.

Principle 6: Coffee farmers should make more efficient use of nutrients by adopting simple nutrient cycling strategies in their coffee gardens

A lot of nutrients are exported from coffee gardens in harvested cherry, weeding debris and prunings. Valuable nutrients can be returned to the coffee garden for reuse by the coffee trees through employing strategies that require little labour but which maintain or

improve nutrient capital. Throughout the modules, particularly the 'Soil Fertility and Nutrient Maintenance' module, the monetary value of nutrients lost from the system is highlighted when farmers do not recycle organic wastes such as coffee pulp and other coffee management by-products like pruning clippings.



Plate 7.5. Coffee pulp which is high in nutrients is often left at the pulper. These valuable nutrients can be returned to the coffee trees as mulch.

Principle 7: Coffee Berry Borer (CBB) is here to stay and farmers and other stakeholders must learn to live with the pest

CBB arrived in PNG in 2017, and since then it has devastated many coffee growing areas as it spreads throughout the highlands and parts of lowland PNG. Eradication of the pest has proven impossible in other coffee growing countries. However, coffee production can continue successfully if basic CBB control measures are implemented.

There is no doubt CBB has created a challenging situation for the smallholder farmer, but the implementation of CBB sanitation strategies may improve coffee yields and quality in the long-term. As well as a module devoted to CBB management developed with Ian Newton, Jonah Aranka, Donna Chambers and Mark Kenny through ACIAR project HORT/2018/194, strategies designed to minimise the impact of this pest are incorporated throughout the training package.



Plate 7.6. Damage to coffee berries and parchment caused by CBB. Sources: CBB photograph – Andrew Johnson, University of Florida; other photographs – Donna Chambers.

Principle 8: Farmer groups are the basic unit for extension delivery

At the ratio of one CIC extension officer to over 60,000 farmers, it is not possible to service the extension needs of individual growers (Curry et al. 2017: 55). Overall, government extension delivery has been insufficiently resourced and spread too thin to have any meaningful impact on coffee farmers' level of technical knowledge. However, by training farmer groups and by training private sector and NGO-employed extension officers, CIC will be able to leverage-up its extension resources to service many more growers.

From 2004, CIC initiated the Farmer Demand Driven Extension program so that extension could be more aligned with farmers' needs. The program worked with farmer groups to identify farmer training needs. This was a valuable program on which the modules build.



Plate 7.7. Working with farmer groups to identify their needs.

Principle 9: Use the private sector wherever and whenever possible to create mutually beneficial relations between farmers and exporters

There has been little emphasis on linking farmer groups to markets or export companies to create a strong price signal for quality (Sengere et al. 2019). In our research, farmers and other industry players saw this as particularly important, especially given that group training and marketing have the potential to meet the growing traceability and quality demands of the expanding specialty coffee market.

If CIC were to draw on the resources of the private and non-government sectors to leverage up extension efforts in coffee, there would be many benefits for farmers and the industry such as:

- many more farmers and farmer groups receiving extension advice
- improved market access for growers through stronger linkages between farmer groups and exporters/processors
- access to private sector extension associated with certification
- access to credit from the private sector
- strengthened price signal for quality



Plate 7.8. Farmer group representative engaging with the private sector.

Principle 10: Coffee extension materials must, as far as possible, be compliant with the main certification standards to create additional opportunities for farmers.

Certification can generate significant benefits such as price premiums for farmers. The modules follow an extension approach that will facilitate the path to certification for smallholder groups. There are two modules on certification in the Extension Training Package.



Figure 7.3. Some of the certification programs active in PNG.

7.1.2 Conclusion

The ten principles that guided the development of the modules making up the training package for farmer groups and cadet extension officers have at their core a 'whole of farm' or smallholder-livelihood approach. This means that the modules adopt a holistic perspective to extension training which recognises that smallholder men and women pursue a range of livelihoods in addition to coffee and that the needs and desires of farmers are not all the same. Rather than try to transform smallholder farming from low input production to high input farming, the approach works within the reality of PNG farming. PNG smallholder families pursue diverse livelihoods, including subsistence, and highly value socio-cultural activities that are an important component of life quality. Finally, implementation of the training package by many arms of the industry including CIC, the private sector and NGOs will help establish strong links between production and marketing which are necessary for the long-term sustainability of the PNG coffee industry.

Modules in the Extension Package:

REFERENCE	TITLE
EXTENSION OFFICER TRAINING GUIDES	
UNIT 1: EXTENSION PRINCIPLES	
Introduction	Smallholder coffee production in Papua New Guinea Training Package
EO_U1_M1	Introduction to the Coffee Extension Officer and Farmer Training Guides
EO_U1_M2	The extension officer - roles & effectiveness
UNIT 2: KNOWING YOUR FARMERS	
EO_U2_M1	Getting to know our coffee smallholders
EO_U2_M2	What factors affect smallholder coffee production?
CARE	Organisational Strengthening Training "Course Facilitators' Guide"
FARMER TRAINING GUIDES	
UNIT 1: BECOMING A COFFEE FARMER	
FT_U1_M1	Knowing your coffee tree
FT_U1_M2	Coffee nursery development
FT_U1_M3	Establishing a new coffee garden
UNIT 2: MANAGING YOUR COFFEE GARDEN	
FT_U2_M1	Weed control
FT_U2_M2	Maintenance pruning and rehabilitation
FT_U2_M3	Shade management
FT_U2_M4	Drainage
FT_U2_M5	Pest and disease management
FT_U2_M6	Coffee berry borer management
FT_U2_M7	Soil fertility and nutrient maintenance
FT_U2_M8	Intercropping in your coffee garden
UNIT 3: HARVESTING AND PROCESSING COFFEE	
FT_U3_M1	Coffee harvesting and processing
FT_U3_M2	Coffee grading systems and pricing
FT_U3_M3	Establishing a mini wet factory
UNIT 4: COFFEE MARKETING	
CARE	Organisational Strengthening Training
FT_U4_M1	Understanding the domestic coffee market
FT_U4_M2	Coffee certification
FT_U4_M3	Fairtrade certification
CARE	Family Money Management

7.2 Demucilager (mini wet mill) trial

7.2.1 Overview

The demucilager trial with a smallholder group at Sogomi, Bena, began in 2020. The demucilager is managed and operated by a well-functioning farmer group which Curtin and CIC researchers first began working with during the previous project, ASEM/2008/036.

The demucilager was conceived as a means to address a number of long-standing challenges facing smallholder coffee production in PNG including constraints on the supply of labour, low returns to labour, and poor quality post-harvest processing leading to low prices (Overfield 1998; Curry et al. 2019; Bourke 2022). Household surveys at Bena in both 2010 (ASEM/2008/036) and 2018 (ASEM/2016/100) cast light on these challenges. In 2010, labour supply was in the top three constraints affecting coffee production for 42% of households, and 27% said it was their most significant constraint. In 2018-19, a smaller proportion of households ranked labour as their most significant constraint on coffee production (16%), but a greater proportion (53%) ranked labour amongst their top three constraints. Poor returns to labour, at Bena, have resulted in more coffee growing households shifting their attention away from coffee to domestic fresh food production and marketing and other activities which offer a better return on their labour (Inu 2015; Curry et al. 2019). Low returns to labour also stem from low levels of block maintenance as well as poor quality post-harvest processing, particularly at the fermentation and washing stage, which leads to farmers receiving lower prices for their coffee. The arrival of CBB has further reduced the returns to labour for smallholder farmers.

7.2.2 The demucilager technology

Demucilagers are used to process coffee cherry to parchment. The machines, which typically include an integrated pulper, remove the pulp of the cherry as well as the mucilage – the pectin-rich layer that remains around the bean following pulping. In PNG, the mucilage is most commonly removed by fermenting the beans. Smallholders typically do this in woven plastic or hessian bags. The fermented beans are then washed to stop the fermentation and then dried. In contrast, demucilagers remove the mucilage mechanically¹, eliminating the fermentation step. The output parchment is clean and can be transferred straight to the drying beds, without the need for washing. Demucilagers also reduce the drying time of parchment (tests by Kumie recorded a reduction in the drying time from 11 days to 7 days (Kumie and Sharp in prep.). This is significant as the fermentation, and subsequent washing and drying are often performed poorly by smallholders, and this negatively affects parchment quality and therefore the price.

7.2.3 The impacts of the demucilager

A major goal of the trial was to assess the impact of the demucilager on:

1. Quality and price
2. Household labour and returns to labour
3. Coffee garden maintenance and pest and diseases, and

¹ The mucilage is stripped off the beans through the friction of beans rubbing against one another as they are forced upwards within a perforated cylinder.

4. Women's participation in household coffee production

Each is discussed below.

Quality and price

The Bena demucilager group demonstrated it can produce high quality coffee (Table 7.1 and Plate 7.9). Through the trial, a partnership was established between the group and an exporter, NGHCE. In 2020, pre-CBB, the group made two deliveries to NGHCE totalling 1.7 tonnes. Both deliveries achieved very high quality scores, with 91% of the delivery achieving a Plantation AX grading. The quality fell slightly in 2021 and 2022, with the group's coffee achieving B grade, still a very good coffee, though a larger proportion of the delivery fell into lower grades. In the 2023 season, although production volume increased, the spread of CBB at the Bena field site led to a further drop in quality. It is probable, however, that the demucilager contributed to achieving a better result than if the group had used their traditional fermentation techniques.

Table 7.1: Bena demucilager group coffee sales volumes and quality, 2020-2023.

Season	Green bean sold (Kg)	Highest grade	Proportion of sale at highest grade
2020	1714	Plantation AX	91%
2021	514	B	82%
2022	312	B	77%
2023	1323	Y1	89%



Plate 7.9. Beautiful clean cherry ready for processing with the demucilager and high-quality parchment sun drying.

The quality achieved by the group was rewarded by the price they received. In 2020, 2021 and 2022, the demucilager coffee received a price substantially above the parchment class 1 factory door price (Figure 7.4). The factory door price was higher than the prices paid by roadside buyers, which was the most common avenue to sell parchment for 58% of Bena farmers. In September 2023, the price paid by the exporter was much lower, reflecting both a drop in quality and a low point in global coffee prices, and at the tail of a substantial decline in the international price over the preceding year (Figure 7.4).² Despite the low price, the group would still have received a better price than had they sold the coffee to roadside buyers. This challenge and approaches to mitigate this risk are discussed later.

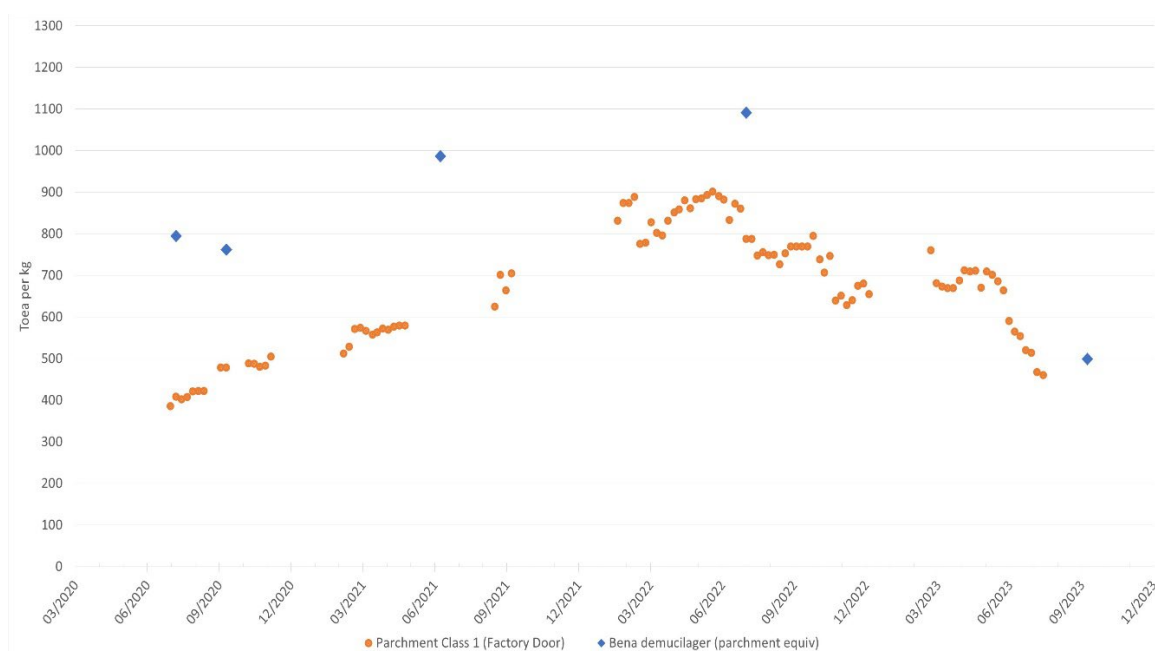


Figure 7.4: Prices received for the Bena demucilager coffee and parchment class 1 prices, 2020-2023.

Note: The parchment class 1 prices are the average factory door prices reported by coffee processors and exporters to CIC. Source: CIC weekly price reports.

Household labour and returns to labour

Data on the impact of the demucilager on labour was collected in Bena in May 2022 from those who had weighed in equivalent of more than 0.5 bags parchment over the 2020 and 2021 seasons) (n=24). Male and female heads of households were asked whether the time spent by each of them on particular coffee production activities had increased, decreased or stayed the same since they commenced using the demucilager.

The vast majority of respondents reported reduced labour on pulping, fermenting, washing³ and drying. Very similar results were reported for men and women (Figures 7.5 and 7.6). Previously, most smallholders at Bena (and other sites where demucilagers have been installed) pulped cherry using hand pulpers, and used bag fermentation which requires considerable labour in carrying the bags to and from the hamlet to a water source or carrying

² At the time of writing, the CIC weekly market prices for the period after mid-August were not available.

³ Respondents were asked about washing, but not specifically in relation to carrying of either coffee or water, and this is a task more likely to be undertaken by women.

water to the pulping site – often near the farmer’s house for washing. The pulper-demucilager combination is around 2.5 times faster than a hand pulper, and over 30 times faster than pulping using a stone, a method often employed in remote locations (Curry et al. 2017) (Plate 7.10).



Plate 7.10: Changes in technology in coffee processing: stone pulper, hand pulper and demucilager.

Demucilagers also use much less water (0.2 l/kg cherry), thereby reducing the amount of water to be carried. At Bena, water tanks were established uphill from the demucilager. The reduced time on pulping and processing was also associated with introducing more centralised processing, packing and selling of the group’s coffee. The residual labour fell on a small number of group members, particularly the group leader. This explains why a small number of growers reported increased time spent pulping, drying, packing and selling.

The demucilager impacted labour through improved prices thus providing an incentive for farmers to invest more time in coffee. Most men and women reported an increase in time spent harvesting. This is a strong indication that smallholders using the demucilager experienced improved returns to labour. Higher harvest rates were also because the use of the demucilager freed up smallholder labour time (especially on pulping and washing) during the peak coffee season.

Smallholders also reported spending more time grading their cherry. They did so because substandard cherry would be rejected by the demucilager operator. Farmers had previously done little grading of their cherry because village-based and roadside buyers paid less attention to quality.

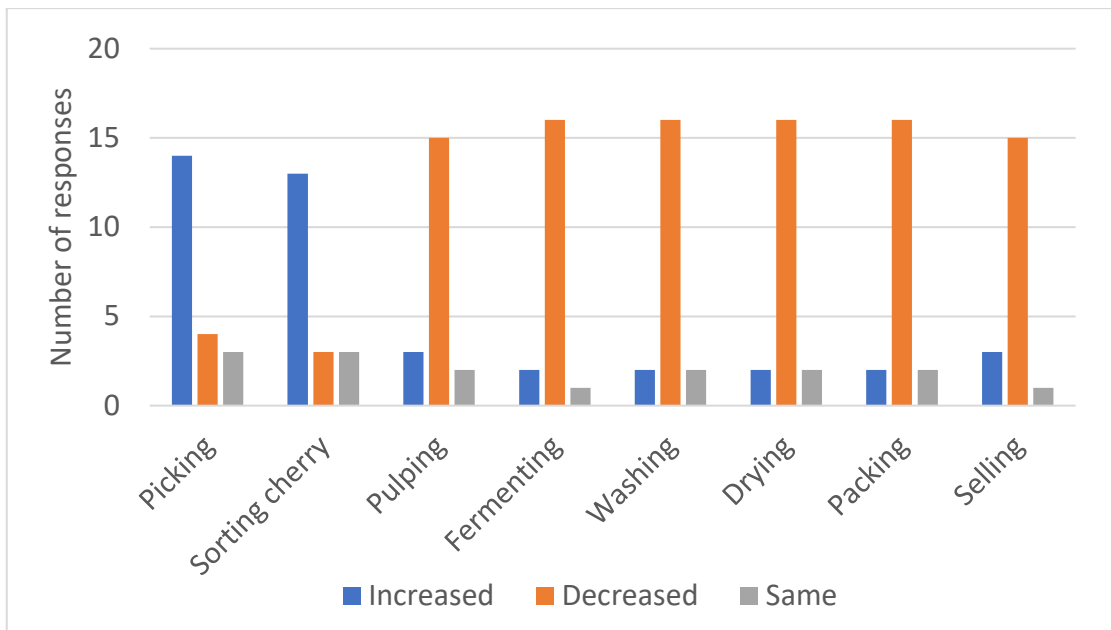


Figure 7.5: Impact of demucilager use on different coffee production tasks reported by male head of household, Bena 2022 (n=21).

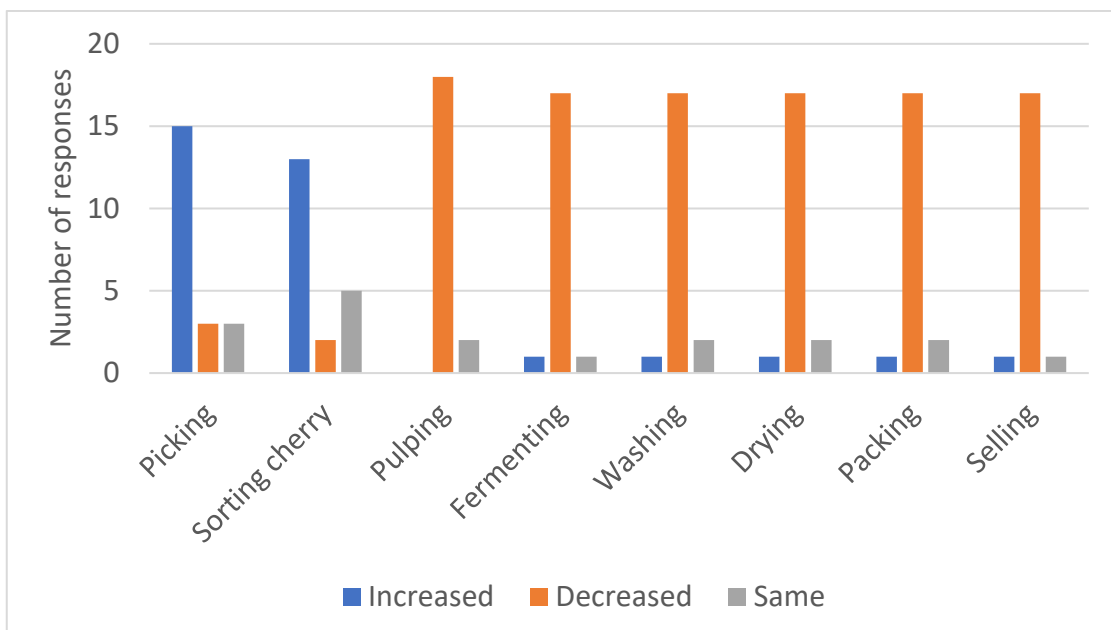


Figure 7.6: Impact of demucilager use on different coffee production tasks reported by female head of household, Bena 2022 (n=21).

Coffee garden maintenance and pest and disease control

The price premiums received by smallholders can provide incentives for them to direct more labour to coffee husbandry. Smallholders increased their labour time weeding and pruning coffee trees (Figure 7.7). Coffee garden maintenance tasks generally occur outside of the peak coffee season. Thus, any increased investment in garden maintenance does not stem directly from the labour efficiencies resulting from using the demucilager, but rather from smallholders placing greater value on their coffee. Smallholder coffee growers typically carry out little garden maintenance, which leads to lower yields. Whilst smallholders recognise the benefits of these tasks to coffee production, few choose to do maintenance when prices are low. As in other cash crops, higher prices will commonly stimulate garden

maintenance. This in turn improves returns to labour through improved yields and because weeding facilitates access for harvesting. Pruning of coffee and shade trees does the same.

Very few coffee farmers in PNG undertake any pest and disease control (Curry et al. 2007; 2017). Surveys undertaken at Bena during the trial found that most households did not report an increase in their pest and disease control efforts. However, substantial pest and disease control was occurring due to the increased time smallholders spent harvesting (Figures 7.5 and 7.6). Research by the HORT/2018/194 team, in collaboration with this project, identified that the most effective strategy to manage CBB is full and regular harvesting (in combination with an end of season strip pick). This helps reduce CBB infestation rates by removing CBB reservoirs and breaking the insect's reproductive cycle (Newton et al. 2023). The demucilager, by incentivising increased harvesting effort, was therefore contributing to CBB management. Many farmers also reported increased weed control and coffee pruning, both of which contribute to management of pest and diseases within coffee gardens. Table 7.2 summarises the impacts of demucilager adoption on coffee production and maintenance.

The research team also carried out similar surveys at other demucilager sites at Yonki (EHP), Tolu (Jiwaka), and Komkul (Jiwaka). The findings at these sites were very similar.

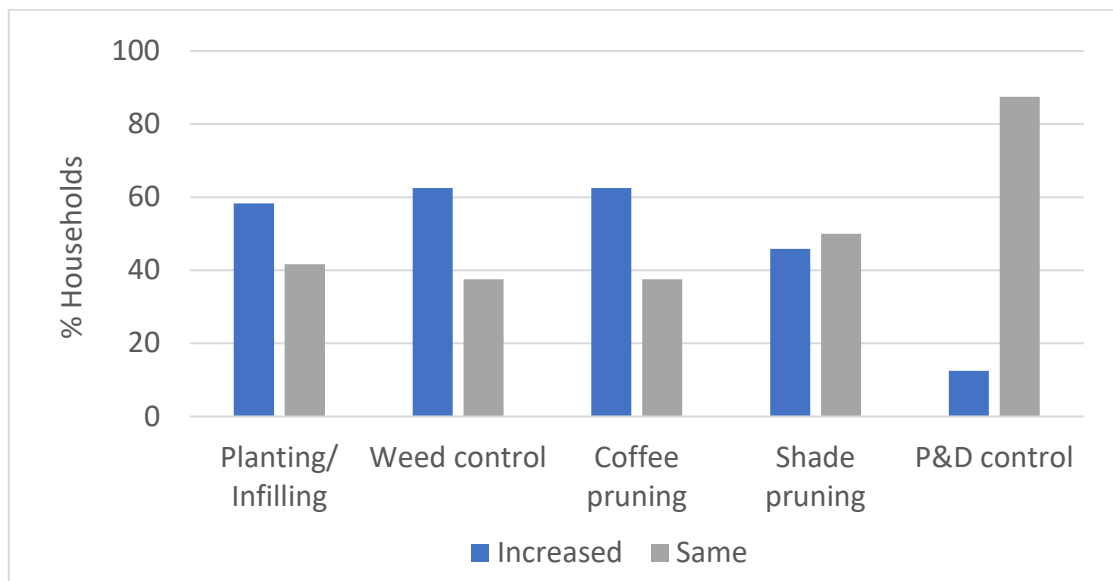










Figure 7.7: Impact of demucilager use on coffee garden maintenance activities in the 2021 season reported by households, Bena.

Table 7.2: Summary of impacts of demucilager use on coffee production and maintenance tasks.

Coffee task	Impact on coffee labour	Explanation
Harvesting		Increase due to improved returns to labour from labour efficiencies and higher prices (quality)
Pulping		Done at demucilager site, but some float test and sorting before cherry brought to demucilager
Fermenting & washing		Tank water eliminates need to transport water for processing, or to cart cherry/pulped beans to water source
Drying		Done at demucilager site. Faster drying time.
Pruning		Becomes worthwhile because of increased returns to labour
Shade management		Becomes worthwhile because of increased returns to labour
Weeding		Becomes worthwhile because of increased returns to labour, and to improve access for harvesting
Pest & disease control		Increased harvesting rate, and more frequent harvesting, is key to managing CBB infestation levels.

Women's participation

Women have embraced the introduction of the demucilager. Over the four seasons, men made up 61% of the farmers' weigh-ins, and women 38%.⁴ Men and women weighed-in with the same frequency, with on average men weighing-in 7.9 times, and women 7.8 times. Men, however, weighed-in more on each occasion, 27.6 kg compared with women's 19.7 kg, leading to men weighing-in a total of 217 kg of cherry on average, and women 153 kg. Although men have benefited more than women, women's participation has still been strong. Given men's historical dominance in the coffee sphere and their control over household coffee income, women in the community have benefitted more than might have been anticipated. The results indicate the demucilager has supported a shift in intra-household labour relations and women's access to household coffee income. There was a decline in women's participation relative to men in 2021 and 2022, a period when usage of the machine was low and CBB was disrupting livelihoods. However, women's participation recovered again in 2023 with women making up 44% of users.

Participation in the community's Village Savings and Loans Associations (VSLAs) appears to have been a strong enabler of women's use of the demucilager. VSLAs were piloted in the community under ASEM/2014/054 (Koczberski et al. 2021) and there are now four successfully operating VSLA groups in the community, three of which are women's groups. There is a close association between the community VSLAs and the demucilager, with both

⁴ There is one user for whom gender data does not exist.

projects being coordinated by the same community leader. Anyone within the community can weigh-in cherry at the demucilager, however, VSLA members have been the strongest participants, particularly women. Of the men who have used the demucilager, 42% are members of the VSLA, whereas 88% of women weighing-in at the demucilager are VSLA members.⁵ The number of women involved in the VSLA is much higher than men, so there is a higher likelihood that a woman from within the community weighing-in cherry would be a VSLA member. Nevertheless, the VSLA pilot at Bena actively sought to increase potential sources of income for women, and it has been successful in encouraging their participation in the demucilager group.

7.2.4 Adoption of the demucilager at Bena

There has been wide interest in the use of the demucilager by the Bena group. Cherry was weighed-in 818 times at the Bena demucilager between 2020 and 2023. A total of 105 individuals, from 89 different households, used the demucilager during that period. As expected, the number of users each year has varied (Figure 7.8) and there has been considerable variation in the frequency with which individuals and households have used the demucilager. Households have, on average, used the machine just over 9 times, but one household has used the machine 44 times, while seven households used the demucilager once.

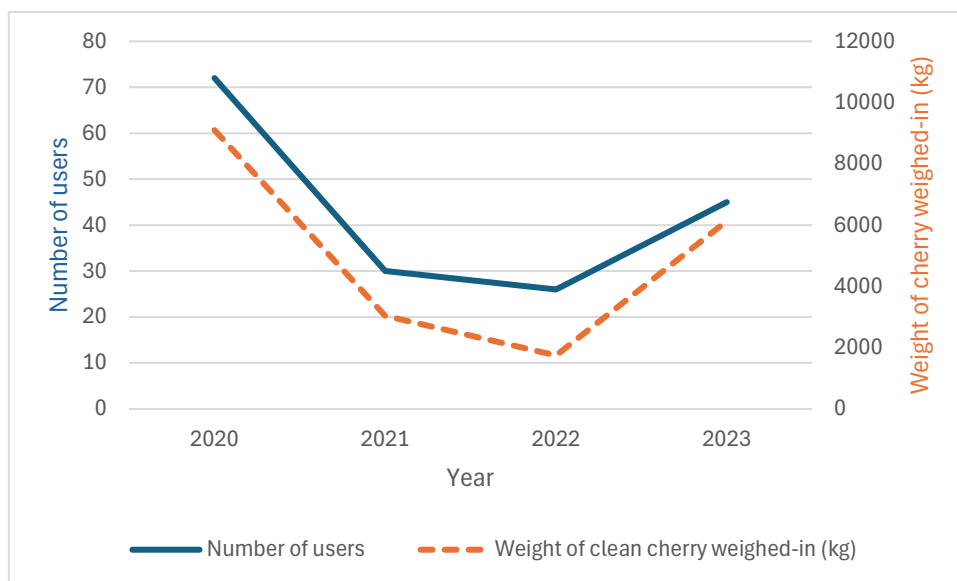


Figure 7.8: Number of users and total weigh-in amount, Bena demucilager, 2020-2023.

The average total weigh-in per household over the season was 136 kg in 2020. This declined in 2021 and 2022 seasons, when the group faced substantial challenges, then recovered in 2023 to 143 kg per household. Again, there is considerable variation in the level of use. The largest 25% of users weighed-in on average 565 kg. This compares to the smallest 25% of users that weighed-in on average only 37 kg. Individuals have, however, increasingly weighed-in greater amounts on each occasion, with the average weigh-in amount doubling between 2020 and 2023 (Figure 7.9).

⁵ VSLA membership is analysed based on membership in 2020.

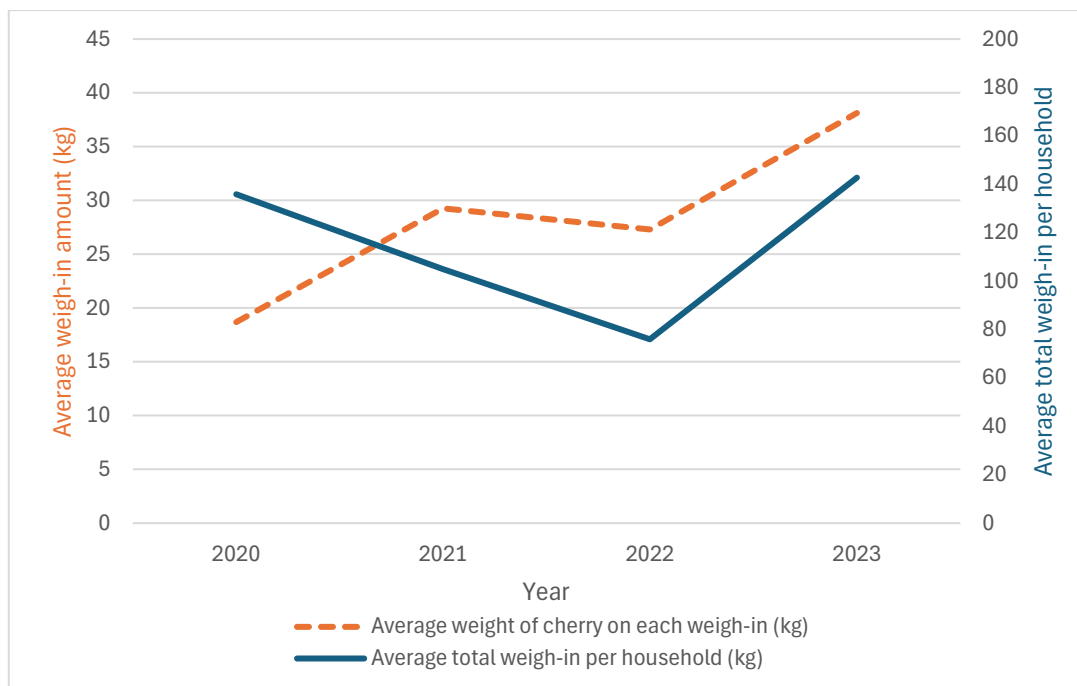


Figure 7.9: Average weigh-in amount and average seasonal weigh-in per household, Bena, 2020-2023.

Distance has had less of an influence on participation than might have been anticipated, particularly given that most cherry is carried by foot to the demucilager.⁶ The demucilager is located at Sogomi, which is the village closest to the main road, and downhill from the other villages. Safanaga is the closest of the other villages, around a 20-30 minute walk. Kaiyufa and Kokinaga are the farthest villages, both around 40-60 minutes' walk. Despite its proximity, farmers from Sogomi have contributed only 20% of the cherry, whereas, Kaiyufa has contributed 38% of the cherry to the demucilager over the four seasons. Farmers from Kokinaga were keen participants in the first season in 2020, weighing-in 29% of cherry, however, very few farmers from that village used the demucilager in subsequent seasons. Distance is a contributing factor, however, given that Kaiyufa is a similar distance, and that Kokinaga is serviced by trucks whereas Kaiyufa is very infrequently serviced by trucks, it is not an insurmountable obstacle. It is not known, what has led to low participation by Kokinaga.

7.2.5 The challenges faced by the trial

The demucilager trial occurred within an extremely changeable and challenging operating environment. In the first four years of the demucilager's operation, the trial and the Bena farmer group have had to manage a global pandemic, the arrival of a serious coffee pest (CBB) and its rapid increase in infestation levels at the trial site, a disruptive national election, and a volatile coffee price (Figure 7.10).

⁶ Of the 79 weigh-ins surveyed in 2023, only one farmer had used a vehicle for transport to the demucilager.

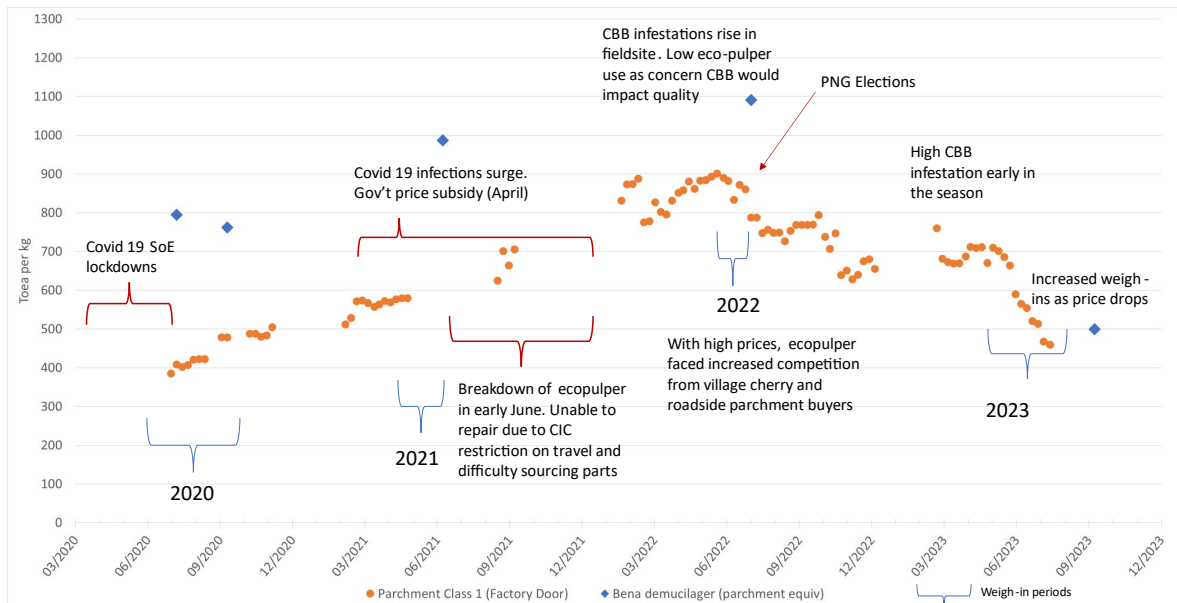


Figure 7.10: Challenges faced by the Bena demucilager trial, 2020-2023, plotted showing average factory door prices and demucilager coffee prices (parchment).

Note: Note: The parchment class 1 prices are the average factory door prices reported by coffee processors and exporters to CIC. Source: CIC weekly price reports.

The trial began in 2020, with the first cherry weighed-in in early May 2020. This coincided with the start of the COVID-19 pandemic and associated restrictions on movement (Aroga 2022), though notably at the time there were very few COVID-19 infections in the country. Despite this, there was great initial enthusiasm, and cherry was regularly weighed-in at the demucilager from early May until mid-September (a period of 137 days). There was wide interest, and farmers were very happy with the price they received.

After a strong start in 2020, processing at the demucilager was underway early in the season (early April), however, from the start the 2021 season was marred by several challenges.

COVID-19 infections were very low throughout 2020, however, from early March 2021 infection rates in PNG started to spike. In response the PNG government introduced a coffee price support scheme in April 2021, delivered through CIC to a select number of exporters and processors (Aroga 2022). The finances to support the scheme were quickly exhausted, but when first introduced it led to a jump in the price in a market that was already rising. In the middle of the 2020 coffee season, the parchment class 1 factory door price was just above K4 per kg, but by the middle of the 2021 season the factory door price was approaching K6 per kg. These higher prices encouraged some farmers to sell their coffee independently rather than through the demucilager group. As COVID-19 rapidly spread, farmers were also reluctant to travel into town to sell their garden produce in local markets, and so with this regular source of income constrained, income from coffee increased in importance. There is a delay between weighing-in coffee at the demucilager and being paid for that coffee, and so many farmers preferred the smaller but immediate payment (*kwik moni*) offered by village-based and roadside coffee buyers. This led to low usage of the demucilager.

After a difficult start to the year, the demucilager broke down in early June 2021. With COVID-19 infections soaring, CIC staff travel was restricted, and it was difficult to source replacement parts, and this led to a long delay in repairing the machine. No more cherry was processed for the remainder of the season. With the demucilager broken, a few group members attempted to sell traditionally processed coffee as demucilager coffee to the

exporter. This was detected immediately, and growers were paid the Y1 price, the typical price paid for low grade smallholder parchment. This was a valuable lesson to group members.

By the 2022 season, the demucilager was fixed again (repaired by late March), but three factors combined to keep throughput low. CBB infestation levels had soared at the field site.⁷ Farmers were concerned that selling the infested cherry to NGHCE would ruin their reputation (some continued to use the demucilager but sold their parchment locally). They were also concerned that much of their cherry would be rejected by the group.⁸ So farmer use of the machine dropped (Figure 7.11). When one Australian team member was finally able to travel again, early in the season, he took a sample of demucilaged beans to NGHCE for testing. Of the sample tested, 80% was rated as premium quality and therefore would attract a premium price. The remaining 20% would attract the Y1 price, the price they were receiving before the demucilager and the same price they were receiving since the group ceased selling to NGHCE. But another factor was also impacting supply to the group.

Global coffee prices were rising rapidly. The factory door price per kg rose from just under K6 in mid-2021 season to a peak of over K9 in June 2022 – more than double the price prevailing in early 2020 when the trial commenced. The increase in the price of coffee in 2022 led to increased operation of cherry buyers in the village (something indirectly supported by VSLA loans and enterprises). These buyers pulled supply from the demucilager by offering immediate cash payment. Village and roadside buyers were also less concerned about quality, willing to take infested coffee and not float testing. Farmers were also comparing the previous seasons' demucilager coffee premium price with the prevailing high prices at the factory door – at the peak of prices in 2022 farmers would have been getting similar prices on the roadside as the premium price they had received in 2020. Farmers would have received a higher price had they sold through the demucilager group: those who sold their coffee at the factory door in March would have earned around K3 more per kilogram had they sold through the demucilager group. Nevertheless, they were satisfied with the immediate payments they could receive from the village or the roadside which is suggestive of a target income. In surveys (n=37), 35% of farmers reported to have sold cherry to a village buyer in 2021, and 89% reported to have processed some of their coffee to parchment with a hand pulper and fermentation. Some of this was cherry that had been rejected from the demucilager, however, farmers were also processing high quality cherry themselves.

⁷ CBB was first detected in Papua New Guinea in the Banz area in 2017 and has since spread rapidly through the main coffee growing areas in the highlands. In 2018 household surveys in the community, only one farmer (of 50) reported to have seen evidence of CBB in their garden, although there were reports of its presence further down the valley.

⁸ Since 2022, a primary focus of the project was to work with Ian Newton and his team (HORT/2018/194) to develop labour efficient and cost-effective strategies for CBB control in the smallholder context of PNG. This included a farmer training module on CBB which was launched, along with other training modules, by the Minister of Agriculture on 9 August 2024. The Bena community was amongst the first communities to receive training on these CBB control strategies.

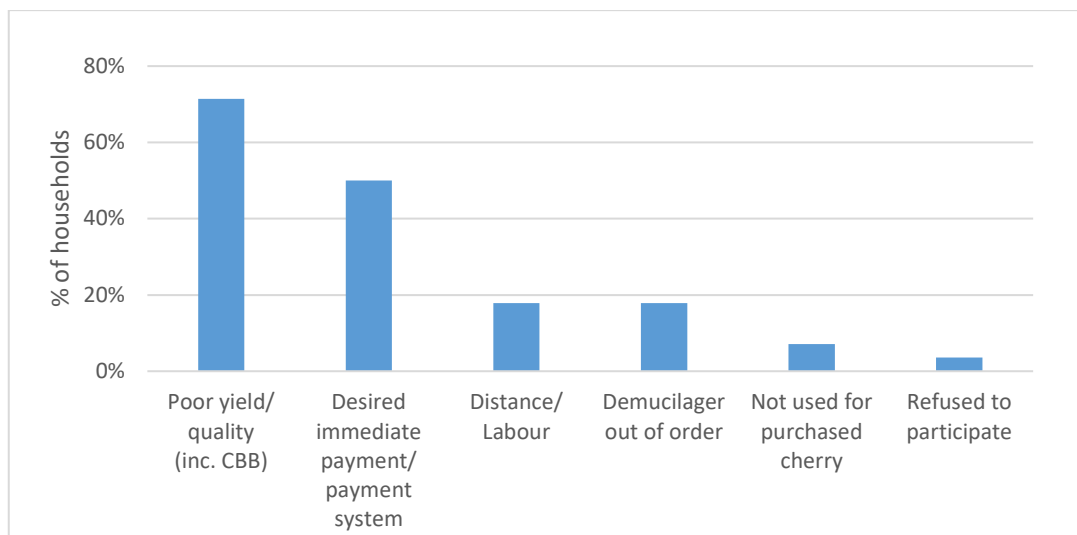


Figure 7.11: Reasons for smallholders' under-utilisation of the demucilager (n=28, multiple responses accepted).

Then the 2022 PNG elections arrived, and money was injected into the rural economy which distracted people from their coffee. People in the community became pre-occupied with the campaigning in the lead-up to the polling period through the middle of July, in which candidates set up campaign houses and reportedly distributed money, food and alcohol within the community. The announcement of the results also spurred significant disruption within the community. With all these challenges, the demucilager was operated for a very limited period between 12 May and 21 June 2022, and throughput was low.

Geography also helps explain the low weigh-in in 2021 and 2022. In the first season, there was strong initial interest from a large number of people across the four communities. A large proportion of the cherry in the first year came from growers in the more distant sites, who have larger coffee holdings. However, in 2021 and 2022, the closer two villagers made up an increased proportion of the supply. This was because the more distant sites are at higher elevations and their coffee matures later than the lower elevation sites. Because the demucilager was only operated early in the season in 2021 and 2022, it was not able to capture the later maturing higher altitude cherry.

In 2023, the demucilager has run through the full season and farmers from further uphill have again weighed in substantial amounts of coffee.⁹ Another factor has also driven increased use of the machine in 2023. In early 2023, CBB infestation levels were high and prices were high, but there was only a trickle of cherry coming into the demucilager. Most coffee was being directed to village cherry buyers or being sold independently. But in the last two months the international price of coffee collapsed. As this happened, village buyers scaled back and the demucilager faced less competition, and substantial amounts of coffee began to again flow to the demucilager.

Selling through the demucilager within a rapidly declining market, like that which occurred through the 2023 coffee season, is a risk for the farmers because of the delay between the time when a farmer weighs-in their coffee at the demucilager and when the group's coffee has reached a volume sufficient to be delivered to the exporter for sale. In 2023, some of the farmers weighing-in cherry early in the season when coffee prices were higher may

⁹ As noted earlier, there are two communities with coffee at higher elevations. One of the communities contributed a large proportion of the coffee in 2023. Farmers for the other community have not reengaged with the demucilager. The reasons for this were unclear at the time of writing.

have received a better price through alternative channels. The opposite is, of course, true during periods of rising prices.

Through these periods of repeated disruption, a challenge for the group leadership has been to maintain and rekindle interest in the trial and reestablish trust amongst community members.

7.2.6 Lessons learned and recommendations

The very significant challenges faced by the group have meant that throughput at the demucilager is below what the project had hoped for. Given the challenges, however, it is remarkable that the group has been as resilient as it has, which is testament both to the leadership within the group and the potential returns that farmers in the community see from the project. There have also been important learnings from the trial both by the group itself and by the researchers. There are very positive signs for the future of the Bena demucilager. Participation is again increasing, and the amount of cherry being weighed-in is also increasing. With the pandemic behind them, and with knowledge about how to live with CBB, the challenge for the group is to increase their throughput. For the exporter to be able to market the group's coffee as a micro-lot and be sold as a unique single origin coffee, something that would further increase the premium they receive, they need to reach at least 1800 kg (30 bags) per lot delivered, and ideally multiple times a season. The group are aware of this and have plans for how this may be achieved.

From the outset, one concern that the project had was that the demucilager may be dominated by men, and that men would disproportionately benefit from it, as is common with introduced technologies globally. Men have been more engaged with the demucilager than women, however, there are strong indications that women are benefiting from the technology. Also, given men's dominance in the coffee sphere, women in the community are benefiting more than might have been anticipated.

There are also strong indications that the VSLA has been an important pathway for women's participation in the demucilager group. The VSLA was established to create economic opportunities for women. It has done this, including in coffee. One indication of the economic opportunities for women is that 28% of loans taken out by them were used for coffee. Interviews with women have highlighted positive changes in gender relations, and these changes mean that Bena women are likely better positioned to negotiate access to the benefits. Building on the VSLA was identified as an opportunity within the mid-term review, and this continued throughout the project.

We see significant opportunity for demucilagers to be used to address some of the challenges confronting smallholder farmers and the industry more broadly. We also see VSLAs as a means to achieve a more equitable distribution of benefits. This sentiment is shared by the group leader, who has come to see the VSLA as a base upon which to build other forms of community development. One of the strengths of the VSLA, and why there is benefit in establishing a VSLA in a community prior to the installation of a demucilager, is that it helps to establish good governance practices and as an activity it draws the group together on a regular basis providing an opportunity for other group activities. We also know that coffee exporters are keen to work with strong sustainable groups.

Another, reason for encouraging the uptake of demucilagers amongst smallholder groups is the opportunity to manage CBB. There are a few key things that smallholders need to do to manage CBB. They need to harvest in full, harvest regularly, and conduct an end of season strip pick, and they need to do it across a wide area (Newton et al. 2023). The demucilager can contribute to all these areas. Price incentives and freed up labour time encourages full and regular harvesting. These incentives exist across a whole area, contributing to area wide management. This and the end of season strip pick are also enabled by group coordination.

7.2.7 Recycling nutrients from demucilager waste through vegetable plots.

Another element of the demucilager trial was to develop a model for the recycling of nutrients from demucilager waste, to both generate economic benefits for smallholders and to ensure that these nutrients did not create an environmental impact on waterways, a requirement of a number of coffee certification schemes.

In the Bena trial, the nutrients in the waste stream (pulp and mucilage) from the demucilager were recycled through vegetable plots in the citrus orchard where the demucilager was located (Plates 7.11 and 7.12). In the first few planting rounds, bulb onions dominated plantings and provided income to women (and some men) in the group. The onion seedlings were raised centrally, then transplanted into plots each managed by individual members of the VLSA group (Plate 7.13). Sales were coordinated by the group. Intermittent COVID-19 travel restrictions affected the marketing of bulb onions in 2021. When Curry visited in May 2022 most growers were maintaining their plots, but were diversifying into other crops like ginger and carrots (Plate 7.12). In a demucilager and vegetable plot survey of 37 households conducted during Curry's visit, 79% of interviewees had vegetables in their plots in 2022.

The recycling of nutrients from demucilager waste is compliant with the environmental criteria of the main certification organisations. Demucilagers should be considered by groups with certification or plans to be certified.



Plate 7.11. Bulb onion plots for recycling waste nutrients from the demucilager.



Plate 7.12. Vegetable plot planted with ginger for recycling nutrients in the waste stream from the demucilager.



Plate 7.13. VSLA members at bulb onion plots.

Demucilager conclusion

The trial has clearly faced many challenges, but within it there have been strong signs that, given sufficient support, demucilagers hold significant promise for the coffee industry. We know that with this technology smallholders can produce excellent coffee, of consistent quality, that can fetch a premium price. We also know that demucilagers improve smallholder labour efficiency. There are clearly improvements in the returns to labour, and smallholders recognise this – this is reflected in recent investments by the group (Plate 7.14). We now know what to do to address CBB, and demucilagers provide incentives to smallholders to adopt these practices. We also see that coupled with the VSLA we observe strong participation of women and benefits to women in what is typically a male dominated domain. Recommendations regarding the demucilager are given in Section 9.



Plate 7.14: New building to house demucilager was under construction in 2021, and on the right, the new parchment storage house was finished in 2022.

7.3 Intercropping trials

7.3.1 Overview of intercropping trial

ASEM/2008/036 demonstrated very promising results from intercropping of coffee with fertilised (pulp or mineral) short-rotation vegetable crops and recycling nutrients to develop sustainable production systems for both coffee and food through efficient use of land and nutrients. Intercropping was of particular benefit to women by enhancing food security and cash incomes.

Most smallholder coffee in PNG was originally established as shaded coffee systems. However, due to natural senescence and the removal of trees for firewood and building material, smallholder coffee is now often shaded less than that which is optimal to sustain production under a zero nutrient input system.

Most farmers are, however, reluctant to purchase and apply fertilisers to coffee. This is despite their acceptance that many marketable crops such as vegetables and fruits require fertiliser to achieve an acceptable yield.

With lower shade levels, substantial amounts of light now pass below the coffee canopy and it is thus sensible to use that space to grow vegetables. This alternative production system has the potential to increase actual land area available for vegetable production at no cost to the area available for coffee production. In addition, coffee will benefit from access to nutrients applied to the nearby vegetables. Intercropping is also likely to bring additional benefits, due to people visiting their coffee plots more frequently as part of more frequent food gardening activities. These potentially include weeding, pruning, pest and disease monitoring (including of CBB infestation) and theft prevention.

Intercropping of vegetables in areas of high light within coffee gardens is reasonably common, though often these vegetables are not fertilised. The intercropping trial then sought to identify culturally acceptable technologies and practices for intercropping coffee with vegetables in a way that increases income for women and improves the nutrition and yield of coffee through its juxtaposition and thus access to nutrients applied to those vegetables. An trial was established to test the intercropping of fertilised cabbages under coffee trees (Plate 7.15).

7.3.2 Key findings and discussion of intercropping trial

Table 7.3 summarises the effect on coffee yield of fertilised cabbage through intercropping experienced by 10 Asaro farmers.

As shown in Table 7.3, there was an overall benefit in the direction of coffee yield change experienced by farmers due to intercropping with fertilised cabbage in Asaro District. The three farmer-decreases in coffee yield ranged from negative 0.5 to 0.8-fold, whereas the remaining 7 experienced increases in the range of 1.5 to 15-fold. These positive trends may be attributed to access to additional nutrients to the coffee trees from fertilising the cabbages, and possibly through side-benefits of weed and plot management because of intercropping practices (see below).

Table 7.3. Effect of intercropping coffee with fertilised cabbages on coffee yield.

Farmer Code	Average coffee yield (g cherry/tree)			
	Fertilised Cabbage	Direction of increase	Control	Fold increase
Asaro 1	9	--->	11	0.8
Asaro 2	175	<---	113	1.5
Asaro 3	167	<---	101	1.7
Asaro 4	106	<---	52	2.0
Asaro 5	108	--->	182	0.6
Asaro 6	76	--->	157	0.5
Asaro 7	57	<---	22	2.6
Asaro 8	110	<---	55	2.0
Asaro 9	45	<---	3	15.0
Asaro 10	121	<---	28	4.3

Three rounds of cabbage intercropping trials were completed with an average of 12 families participating in each round.

The trial staff noted that some trial farmers increased their areas of intercropping beyond the trial gardens, and nearby, it was seen that farmers who had not participated in trials also

started intercropping for themselves. While on the face of it this wider adoption was a positive for widening adoption of intercropping in the community, it is also a risk if these non-trial-managed attempts fail through poor or wrong practices.

The adoption of coffee intercropping, encouraged through evidence of success, is likely to show positive impact to adopters. These include addressing land shortages caused by population increases (especially around town fringes), hence addressing a growing need to increase the yields/income per unit area of coffee gardens. Successful intercropping also has the prospect of: (i) increasing family income resilience by hedging against low coffee prices and/or drought; (ii) increasing net family income through the additional income stream; and (iii) a more regular annual income than from coffee alone. The addition of home-grown fresh vegetables to family diets will also have positive impact nutritionally, as well as reducing the need to purchase vegetables.



Plate 7.15. Coffee intercropped with cabbages at Asaro.

Interviews and focus group meetings with women indicated that despite disruptions affecting the intercropping trial and data collection, many remained interested in continuing with intercropping or to restart intercropping when the time was suitable (the last interviews conducted during the extended dry period). Women identified many benefits of intercropping and being part of the trial. These included:

1. *Learning benefits.* As one woman said, we have learnt “a new way to grow coffee and a new way to make money”. Many women remained interested to continue to practise what they had learnt from trialling intercropping of cabbages. Many learnt new coffee management practices, the importance of timely fertiliser application, new nursery skills and confidence to try new vegetable crops and intercropping techniques. Several talked about how they did (or would do) things differently the second time they intercropped vegetables. For example, there was a desire among some women to try growing broccoli or to rotate cabbage with peanuts.
2. *Additional path to earn extra money.* Although the profits earned from a harvest round of vegetables varied enormously (from K20 to over K100) among the women interviewed, all welcomed the additional income and were interested to continue intercropping as a means of increasing their portfolio of income sources. All women interviewed pointed out the increasing role of cash in everyday life and the need for money to meet customary and routine household expenses. As one woman said, “town life has now come to us in the village”. Some women pointed out that coffee was big

work for little income: low income returns due to husbands' controlling most of the coffee income. However, intercropping enabled women to have greater control over the income they earned from their labour, as well as access to a more regular income. This was appreciated by women as it enabled them to not only meet household needs, but they could use the cabbage income to distribute money to family members and sisters (a valued cultural practice).

3. *Potential to earn a one-off large sum of money.* Several women were motivated to continue intercropping because they claimed a large cabbage harvest of 5-7 bags of good-sized cabbages could provide a substantial lump sum of money that could be used to meet large expenses, such as contributing to large customary payments or to help fund the purchase of a costly item, like housing materials (roofing iron, concrete) or school fees. Also, some women mentioned that a large cabbage harvest meant they could sell all their crop in one sale to market intermediaries (Sharp 2021). This was attractive to some women because it obviated the need for them to expend a lot of time selling their produce at town markets. Time and transport costs were minimised.
4. *Noticeable difference in the health of coffee.* When asked about the health of their coffee trees in the trial blocks, a noticeable difference in the health status of coffee trees in their non-trial coffee gardens was observed by all women interviewed. Plate 7.16 shows healthier looking coffee trees with dark green leaves in the plot intercropped with cabbages and fertilised (right), compared to the yellower leaves of non-intercropped unfertilised coffee (left).



Plate 7.16: Intercropped and fertilised coffee trees (right) alongside non-intercropped unfertilised coffee trees (left).

Finally, the higher rate of female participation in the coffee garden means more labour is available to tend the garden through weeding and means there are 'more eyes' on coffee trees for early warning for pests and diseases like CBB, and on-going management. Also intercropping has the potential to minimise the financial impact of CBB on families by providing an additional income source as coffee income falls due to the pest.

7.3.3 Challenges

Numerous hurdles were encountered that impacted the trials. These included the COVID-19 pandemic and national elections in PNG in 2022, each of which caused disruptions to communities and farming, as well as to project staff movements, i.e., CIC staff overseeing

the running of the trials and Australian team visits for hands-on progress reviews. A drought also impacted one round of trials.

8 Impacts

8.1 Scientific impacts – now and in 5 years

The project has generated valuable new knowledge that is having scientific impact now and is likely to continue to do so into the future. Much of the scientific impact will be generated by publication outputs including the farmer training modules that will inform future research and extension strategies. The farmer training modules, for example, have been designed around the low input system of production that dominates smallholder production in PNG and much of the developing world. While continuously evolving and adapting to socio-cultural, economic and environmental change, the low input system of production enables a range of livelihoods and socio-cultural practices to be pursued. This not only creates more resilient livelihoods but also accommodates highly valued socio-cultural practices, which make low input production systems strongly resistant to change.

Traditionally, agricultural extension and research was premised on the basis that farmers were in transition from low input systems of production to high input ‘modern’ farming methods, and the objective of agricultural extension and research was to facilitate this transition by encouraging increased inputs of labour, finance and technology. This has meant that a great amount of research and extension has not succeeded in achieving this transition, and in many cases has been strongly resisted by targeted populations. The farmer training modules, designed around the low input system of production (see the 10 principles, Section 7) are now leading to a rethinking of extension strategies at CIC, and are likely to shape extension thinking in the private sector in PNG and in other countries.

There has been interest in the modules from several certification organisations, and there is a possibility that they might be adapted for use amongst smallholders in Timor Leste. The key findings and new knowledge from the research that are leading to scientific impacts in research and extension thinking include:

- An improved understanding of the low input production strategy and the factors contributing to its resilience and resistance to change
- The constraints on labour supply, including the reluctance to use hired labour (labour shortages are among the top constraints on smallholder coffee production)
- Socio-cultural activities are a highly valued by smallholder communities and considerable time and resources, including cash, are devoted to them
- Smallholders pursue a diversity of livelihoods which can limit time and labour allocated to coffee
- The development of training materials for extension providers that are oriented towards smallholders, by accommodating low input production strategies
- Emphasis on the need to align innovation with socio-cultural values and livelihood priorities to facilitate ‘appropriate’ types of technology adoption that are more likely to be adopted
- Integration of a social understanding of smallholder practices into the development of strategies to address CBB.
- An understanding of the nutrient flows in coffee-based farming systems to enable sustainable coffee intercropping systems
- Improved understanding of the role of agroforestry for delivering ecosystem services including more sustainable coffee production systems (e.g. Tilden et al. 2024)

- Intercropping coffee with short rotation fertilised vegetable crops boosted coffee yields because the addition of fertilisers offset nutrient losses from garden exports
- As a farming system, intercropping is likely to assist CBB management and the identification of other pests and diseases through ‘more eyes’ being on the problem because of more frequent visits to coffee garden

8.2 Capacity impacts – now and in 5 years

The project has placed much emphasis on capacity building of Early Career Researchers (ECRs) in Australia and PNG. A two-day writing workshop for ECRs at CIC in March 2019 (see annual report for 2020) led to publication of a collection of seven papers for a special issue of the *PNG Coffee Journal* (see <https://pacificlivelihoods.com/special-issue-journal-publications/>).

ECRs have been working on papers for a second issue of the journal which is anticipated to be published in late 2024. The following papers have been submitted for review:

G. Curry, L. Aroga and G. Tilden - *The ten key principles guiding the development of the ACIAR extension package of modules for training farmer groups and cadet extension officers*

T. Kumie and T. Sharp – *The potential of demucilagers for improving smallholder coffee quality and managing Coffee Berry Borer in Papua New Guinea*

G. Tilden, J. Aranka and G. Curry - *Shade and coffee: a marriage made in heaven!*

G. Tilden, L. Aroga and G. Curry - *The content and structure of the ACIAR extension package of modules for training farmer groups and cadet extension officers*

R. Buimeng, P. Talopa and S. Yanage - *Optimum Spacing of Compact Arabica Coffee in Papua New Guinea*

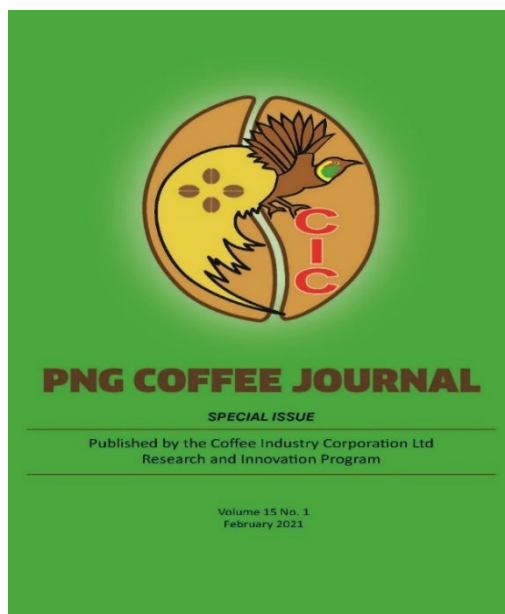
P. Togonave, B. Apis, E. Kiup, M. Webb, M. Bafeo, J. Aranka - *Nutrient Management Implications of Growing Food Crops within the Coffee Gardens.*

And a further few papers are in draft form:

M. Hamago, E. Peter, G. Koczberski, and G.N. Curry - *Strategies for improving women’s engagement in coffee and cocoa production in Papua New Guinea.*

L. Aroga, G. Curry and G. Tilden - *COVID 19 Impact Assessment: How formal linkages between farmer groups and exporters processors sustained the coffee industry through the COVID-19 pandemic*

M. Bafeo and R. Irrikati - *Maximizing callus yield by understanding callus production pattern of Omuru 1 in somatic embryogenesis for effective mass propagation and distribution in Papua New Guinea.*



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Plate 8.1. Front cover and table of contents of the 2021 issue of the *PNG Coffee Journal*.

The reinvigoration of the PNG Coffee Journal, after it was inactive for ten years, has provided an excellent avenue for publication both for research coming out of the project, and for other research being carried out at CIC. It has given Early Career Researchers (ECRs) experience of the publication process. It has also given other CIC staff experience as journal editors.

PNG and Australian team members developed skills in conducting online meetings. This unplanned skill development occurred due to COVID-19 travel restrictions forcing the project to conduct its mid-term review online (and many of the researchers also participated in the ASEM-2014-054 final review online). This has led to a subsequent increase in the use of this technology for team communication, and in other projects. The WhatsApp mobile phone app has also proved useful when internet connections are poor.

Matilda Hamago completed her M. Phil thesis on “*Experiences of Female Agricultural Officers in Papua New Guinea. A study of the coffee, cocoa and oil palm sectors*”. Bound copies of her thesis were presented to her by G. Curry in May 2022 (Plate 8.2). Esley Peter, a researcher at the Cocoa Board, also completed his M.Phil. thesis on private sector cocoa extension early 2022. Esley and Matilda are co-authoring a paper on extension which will be published in the *PNG Coffee Journal*.



Plate 8.2. Ms Matilda Hamago being presented with a copy of her thesis in May 2022.

Ms Matilda Hamago and Mr Leo Aroga were both awarded Alumni Research Support Facility grants (ARSF) to undertake small projects on the impacts of COVID-19 on the coffee industry. Leo's report has been published and Matilda's is in progress.

Following her studies, Matilda Hamago has taken on leadership roles in research at CIC, including as CIC lead for CLIM/2024/101 *Evaluating carbon markets as a pathway to establishing climate resilient coffee agroforestry systems in PNG*.

Emma Kiup completed her M.Phil at JCU during the preceding project ASEM/2016/100. Emma took on a leading role in the intercropping trials within the project, and has recently started her PhD studies at University of Sydney. Emma also gained experience presenting at a major international conference, World Agroforestry Congress in France in 2019.

Australian PhD student at Curtin, Jennifer McKellar, had her fieldwork in Bena substantially impacted by the pandemic. Unable to travel to PNG, Jennifer has worked closely with a village-based research assistant whom she interacts with through WhatsApp. This research assistant was recruited in May 2022 to the project's survey team carrying out the surveys on demucilage use, and on VSLA. This was so successful that in 2023 she was recruited to independently carry out further survey work in the village, and on another research project led by Koczberski. This gave her the experience of working closely with the CIC research officers, giving her new research skills, and building the project's capacity to collect data remotely.

Jennifer McKellar's PhD thesis titled, *The intersection of the socially embedded economy and participatory development projects in Eastern Highlands Province, Papua New Guinea*, is due to be submitted in July 2024.

Alois Ndrewou completed his PhD thesis titled, *The impact of Cocoa Pod Borer on the livelihood responses of farmers in East Sepik Province, Papua New Guinea*, in May 2024. Alois is now Director of the Centre for Natural Resources Research & Development (CNR RD) at the University of Goroka (UoG), Papua New Guinea. He is also currently a researcher on CLIM/2024/101 *Evaluating carbon markets as a pathway to establishing climate resilient coffee agroforestry systems in PNG*.

In 2023, Vincianna Andrew completed her fieldwork for her M.Phil research at Curtin on smallholder coffee agroforestry systems and smallholder livelihood choices in the Highlands of Papua New Guinea.

Tim Sharp (Curtin) after progressively taking on responsibilities within the research (as well as on ASEM/2014/054), is now co-leading (with Steve Crimp, ANU) an ACIAR-funded SRA CLIM/2024/109 *Evaluating carbon markets as a pathway to establishing climate resilient coffee agroforestry systems in PNG*.

During fieldtrips to PNG, Curtin researchers have presented the following workshops on writing and publication to staff and postgraduate students of the University of Goroka:

George Curry (2022). "Principles of good writing". 11 May 2022.

Gina Koczberski (2023) "What is Research and how do you do it?". 28 May 2023.

Tim Sharp (2023) "Referencing, paraphrasing and plagiarism". 28 July 2023.

Community members from the demucilager trial site at Bena have also engaged in capacity building activities. Through involvement with the Village Savings and Loans Associations piloted under ASEM/2014/054, community members and leaders developed skills in good governance, transparency, numeracy and record keeping. These skills have contributed to the successful functioning of the demucilager group. Group members have also been trained in how to operate the demucilager, and now independently operate and carry out basic maintenance on the machine. The group's leader has also had the opportunity to tour the exporter's factory and cupping room, to build knowledge of coffee quality, and supplementary information sessions were delivered by the exporter at Bena. The Bena group were also amongst the first groups to receive training on CBB management in June 2023, based on the farmer guide on CBB management developed by the HORT/2018/194 team in collaboration with ASEM/2016/100 researchers.

Through the work of three ACIAR-funded projects in his community, the group leader has become a strong supporter of the research. He has also taken on the ideas of research. After the establishment of the demucilager, the leader independently set up his own trials to assess and improve coffee drying by the group. This followed a trial of different types (manure and demucilager waste) and quantities of organic fertiliser inputs in the bulb onion plots to educate farmers about the benefits of nutrient recycling.



Plate 8.3. Bena Group leader, Pr Albert (second from right), being introduced to cupping quality at NGHCE.

The greatest capacity impact from the project will be from the rolling out of the farmer training guides to public and private sector extension organisations, and through them to coffee growing communities. The development of extension officer training guides will contribute to the delivery of the other modules. These modules have the potential to increase the capacity of a great number of coffee farmers throughout the highlands region.

There is strong interest in these as a resource, including by four certification organisations who engage in extension.

8.3 Community impacts – now and in 5 years

8.3.1 Economic impacts

Extension package

The farmer training modules are designed to assist private sector, government and NGO-employed extension officers to train farmer groups and cadet extension officers in most areas of coffee production, processing and marketing (Section 7). The training modules have the potential to deliver major economic benefits to coffee farmers and their families as well as the coffee industry more generally, which is a major employer in the country. The package seeks to increase smallholder production and productivity, with an emphasis on quality and the sustainability of coffee-based farming systems while minimising dependence on costly external inputs.

The package adopts a ‘whole of farm’ system approach to extension training that considers environmental, social, gender and income set within broader livelihood strategies that include food production for home consumption and sale. The training modules promote the adoption of low input strategies of coffee husbandry including pest and disease management and nutrient recycling, coffee processing methods, marketing including certification and the adoption of new technologies to improve labour efficiency. Agroforestry and nutrient cycling are emphasised as effective low labour input methods for building resilience and reducing vulnerability to the effects of climate change. All of these have economic impacts that are likely to be significant.

With CBB posing an existential threat to PNG’s coffee industry and particularly to the livelihoods of smallholders, the CBB training module became the priority. It was developed with HORT/2018/194 and began to be used in training in 2022/23. Prior to this module being developed, there was very little information available to the industry, and much of what was available was incorrect. This training module alone is having enormous positive economic impact by keeping many smallholders in the industry who would otherwise have left the industry.

While having a less dramatic and immediate economic impact, the other modules in the package (Section 7 provides a list) will have a significant impact on coffee production through time as they are rolled out by government and private sector extension agencies. Importantly, they meet a need from industry, especially by processors/exporters seeking certification of their farmer groups. As the private sector embraces the trend towards coffee certification for their farmer groups, they are often obligated to ensure extension training is delivered to farmer groups as part of the certification requirements. Several certification organisations have indicated an interest in the training package, and with most modules being fully compliant with the criteria of certification organisations, adoption is likely to speed up and enhance the economic impacts of the package

Demucilagers

The economic impacts of the demucilager are significant now and are likely to increase dramatically as the technology is adopted and rolled out to farmers. There are two elements to this: 1) increased returns to labour through price premiums from improved quality; and 2) increased returns to labour through efficiencies of labour by eliminating processing (pulping, fermentation, washing and drying) and marketing. We have yet to fully analyse the

increased returns to labour through labour efficiencies, so here we consider price premiums alone.

Farmers received much higher prices for their demucilaged coffee. For the data available (2020-2022) to enable calculations of price premiums, growers received premiums over Parchment Class 1 of 77% in 2020, 70% in 2021 and 39% in 2022, the latter when CBB infestation rates were high. These premiums were lower than if we had compared the prices with roadside prices, which is the usual point of sale for smallholders. Thus, there is considerable scope to revitalise the PNG coffee industry through improved smallholder productivity, better quality parchment coffee and by scaling-out this technology.

The improved returns to labour from the demucilager could have several significant economic impacts for smallholders and the coffee industry. These include:

- helping smallholders to remain in coffee production
- freeing up labour time which encourages greater harvesting effort
- better control of CBB through improved incentives to fully harvest coffee and undertake good coffee sanitation practices
- opening new livelihood opportunities such as:
 - community members being paid to hand sort the dried parchment. This processing stage is normally carried out by the processor at the mill, with the cost deducted from the price paid to the grower. This can be as much as K2 per kg, and has considerable income benefits for women who are usually employed by processors to undertake this work
 - recycling of nutrients from the demucilager waste stream (coffee pulp, skins and mucilage) through vegetable plots can provide an additional income source for smallholder families as well as meet stringent certification criteria
 - a VSLA group associated with the demucilager could buy cherry for processing using group savings. This could potentially generate significant returns for VSLA group members and make more efficient use of the demucilager by utilising excess capacity

For sustained economic impact, the establishment of a VSLA group and a successful savings round should be a prerequisite to the establishment of a group-managed demucilager. Successful scaling-out of the technology is crucially dependent on issues of group governance, leadership and transparency being addressed. Good record keeping is also essential. With the very high failure rate of business groups in PNG, it is imperative that these issues are addressed before the scale-out of the technology. A key factor in the success of the Bena demucilager group was the training in group governance, leadership and money management that came with CARE-International in PNG's training program for VSLA groups – there was a very close overlap in the memberships of the demucilager and VSLA groups (this is not to downplay the remarkable leadership qualities of the group leader).

This would help address many of the problems encountered in business groups in PNG while creating additional economic opportunities for members. The presence of a VSLA group opens new livelihood opportunities for a demucilager group with coffee income accumulated and invested in various new livelihood activities as occurred in Bena. This would scale up the economic impact of the demucilager by fostering new enterprises that increase the multiplier effect of coffee income entering the community.

Finally, demucilagers have been recognised by CIC as a technology to improve parchment quality and labour efficiency. CIC has adopted demucilagers as an approved technology and is facilitating their rollout. Five demucilagers have recently been imported on behalf of farmer groups (prepaid by the groups). The rollout of this technology has the potential to generate very large economic impacts in the smallholder coffee industry in PNG.

Intercropping

The continuation and uptake by families of intercropping coffee with cabbages indicates the early acceptance and uptake of this technology. Indeed, many of the participant families extended the area intercropped and many neighbouring farmers trialled this concept on seeing the success of trial participants. In areas near town where land pressures are increasing, there is considerable scope, and potential economic impact, from up-scaling this concept. The farmer training module on intercropping coffee provides this avenue. The positive economic impacts of intercropping include:

- a new income stream to hedge against poor coffee prices, coffee pests and diseases (CBB), and drought
- regular intercrop harvests provide a more steady stream of income and increases family net income
- women have new income streams with financial agency
- increased financial return per farmed area, and is therefore a strategy to address land shortages in the community

8.3.2 Social impacts

Much of the social impact has arisen from the strengthening of social and economic relationships within the farmer groups. The fostering of social capital within the group through many shared activities including the demucilager and bulb onion plots, as well as VSLA training activities under ASEM/2014/054, have spilled over into other areas of people's lives and led to successful livelihood activities. The focus on group governance and transparency and the forming of group constitutions under the VSLA project has strengthened group cohesion. The success of the VSLA has also strengthened support for other community activities including the demucilager project component and the bulb onion project, and in turn these activities strengthened the VSLA.

The strongest positive social impacts have been for women and families, and these impacts are anticipated to increase further. Women have been very active in both the intercropping and demucilager trials, and with the bulb onion plots for the recycling of nutrients. Participation in the community-driven bulb onion project closely overlaps with VSLA membership, and because VSLA membership was two-thirds women in 2019 and three-quarters women in 2020, women have been major beneficiaries. Activities associated with ASEM/2014/054 have also benefited women and families as their financial literacy skills and access to micro-credit have positively shaped their engagement in this project (see ASEM/2014/054 final report). One potential risk associated with the introduction of new technology is that the technology is frequently controlled by men. Weigh-in data from the demucilager, as well as interviews with women, have shown that women have been active participants and beneficiaries from this technology.

The intercropping trial is dominated by women farmers at Asaro. It is providing women with a new source of income, and is helping to address what is often a site of household tensions and inequality as men typically control the income earned from coffee (Curry et al. 2019). The intercropping of coffee with cabbages is leading women to invest more labour in the coffee plot to tend to cabbages. Women control the sale and income of the cabbages and in this way, intercropping is creating a more gender equitable distribution of the income earned from a coffee plot. Intercropping within coffee plots is also increasing the total land area available to women for fresh food production. This is especially important for land-short families. For land-short families, intercropping can also increase food security with associated health benefits.

8.3.3 Environmental impacts

Nutrient recycling has been a major theme running through the research including coffee husbandry (recycling weeds and tree prunings), shade management (nitrogen fixation and shade tree roots bringing up nutrients from deep in the ground and making these available to coffee trees through leaf litter) and managing the waste stream from the demucilager. Here we consider the demucilager.

The recycling of nutrients from the 'waste' stream of the demucilager is a critically important aspect of the model of demucilager use we have developed. Waste nutrients in the form of pulp and mucilage are recycled through vegetable plots in a citrus orchard where the demucilager is located. With the recycling of nutrients in waste streams, the demucilager will comply with the key environmental criteria of the main coffee certification organisations.

Farmers are changing the way they understand and manage waste nutrients. There is greater awareness among farmers of the importance of nutrient recycling in coffee production. A significant environmental impact of the project is the growing realisation amongst farmers that coffee waste (coffee pulp, skins and mucilage) is a valuable resource containing many important nutrients. Previously, most farmers discarded the pulp and skins at the pulping sites or disposed of the 'waste' in waterways. Most of the farmers in the communities where we work who still use traditional low-input processing methods, now recycle the coffee 'waste' through their coffee or vegetable gardens.

Intercropping also has environmental benefits through fertilising which addresses nutrient imbalances by adding to the soil's nutrient capital, and hence can increase soil quality and resilience. Soil management and increased organic returns to the soil from intercrop residues also increase soil nutrition and structure, reducing erosion and increasing water retention.

The environmental impact of this research has been incorporated into extension training modules on nutrient recycling and intercropping.

8.4 Communication and dissemination activities

The Pacific Livelihoods website (<https://pacificlivelihoods.com/>) (Plate 8.4) was established in 2018 to disseminate the outputs of this project and other projects in which members have been/are involved. This also includes students engaged in ACIAR projects as well as project partners in Australia and PNG.

Publications and reports from ACIAR-funded projects are readily accessible on the site: <https://pacificlivelihoods.com/publications/>

As at 21/5/2024, there were 18 blogs on the Pacific Livelihoods website related to ASEM/2016/100. These are listed in Section 10.2.



Pacific Livelihoods

Working to understand and enhance the livelihoods of the people of the Pacific.

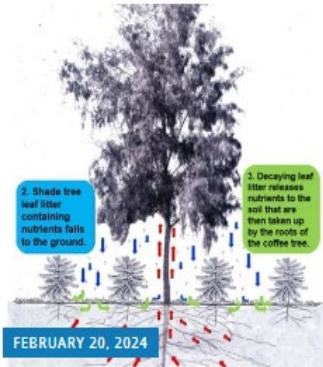
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MAY 7, 2024

New Publication – Ecosystem services in coffee agroforestry



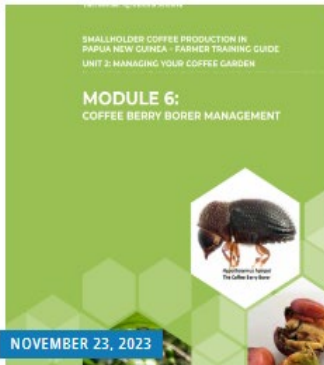
FEBRUARY 20, 2024

Innovative training package targets smallholder coffee farmers



FEBRUARY 16, 2024

Coffee and Women in Papua New Guinea



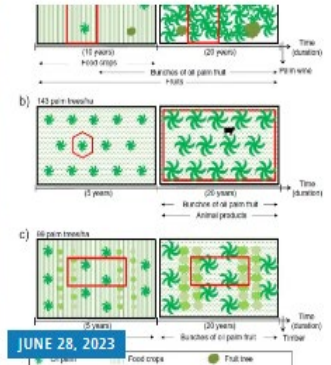
NOVEMBER 23, 2023

Assisting PNG coffee farmers to manage the devastating pest, Coffee Berry Borer



AUGUST 23, 2023

Coffee berry borer success story



JUNE 28, 2023

Publication – The ESSU concept for designing, modeling and auditing ecosystem service provision in intercropping and agroforestry systems. A review

Plate 8.4. Pacific Livelihoods website homepage as at 21 May 2024: <https://pacificlivelihoods.com/>

PNG Coffee Journal

First special issue

An important dissemination route has been the collections of papers for special issues of the *PNG Coffee Journal* (Section 4). The *PNGCJ* is circulated amongst government and private sector organisations that have an involvement in the PNG coffee industry. The papers for the first special issue are available at: <https://pacificlivelihoods.com/special-issue-journal-publications/>. To promote involvement of the private sector in CIC research and extension, Mr Joeri Kalwij of New Guinea Highlands Coffee Exports was invited to write an “industry perspective” on the research papers.

Second special issue

Papers submitted for review

G. Curry, L. Aroga and G. Tilden - *The ten key principles guiding the development of the ACIAR extension package of modules for training farmer groups and cadet extension officers*

T. Kumie and T. Sharp – *The potential of demucilagers for improving smallholder coffee quality and managing Coffee Berry Borer in Papua New Guinea*

G. Tilden, J. Aranka and G. Curry - *Shade and coffee: a marriage made in heaven!*

G. Tilden, L. Aroga and G. Curry - *The content and structure of the ACIAR extension package of modules for training farmer groups and cadet extension officers*

R. Buimeng, P. Talopa and S. Yanage - *Optimum Spacing of Compact Arabica Coffee in Papua New Guinea*

P. Togonave, B. Apis, E. Kiup, M. Webb, M. Bafeo, J. Aranka - *Nutrient Management Implications of Growing Food Crops within the Coffee Gardens.*

Papers in preparation:

M. Hamago, E. Peter, G. Koczberski, and G.N. Curry - *Strategies for improving women's engagement in coffee and cocoa production in Papua New Guinea.*

L. Aroga, G. Curry and G. Tilden - *COVID 19 Impact Assessment: How formal linkages between farmer groups and exporters processors sustained the coffee industry through the COVID-19 pandemic*

M. Bafeo and R. Irrikati - *Maximizing callus yield by understanding callus production pattern of Omuru 1 in somatic embryogenesis for effective mass propagation and distribution in Papua New Guinea.*

B. Apis, E. Kiup, P. Togonave, M. Webb, M. Bafeo and J. Aranka (in prep.). *Investigating the Potential of Smallholder Coffee Gardens as Potential Carbon Sinks Light of Climate Change.*

In addition, a prominent private sector plantation owner and processor has been invited to provide an industry perspective on the papers.

In 2021, the Pacific Livelihoods group also hosted a seminar series involving a network of PNG and Pacific focused researchers from Australia and overseas including our PNG-based research partners. The seminars were pre-recorded and made available on the Pacific Livelihoods website. The seminars engaged with themes closely connected to the project including the changing economic landscape of the PNG highlands, the socio-cultural factors shaping technology adoption, farmer-researcher knowledge networks, and the impact of COVID-19 on PNG. Around 20 people participated in each of the online seminar discussions, and many more viewed the pre-recorded videos online. See <https://pacificlivelihoods.com/seminars-2/>

Other publications and conference presentations are listed in Section 10.1.

9 Conclusions and recommendations

9.1 Conclusions

Smallholder farmers in PNG face numerous challenges including constraints on the supply of labour, low returns to labour, poor-quality post-harvest processing leading to low prices, and, in some places, land pressures. A new problem which poses an existential threat to the PNG coffee industry is the recent arrival of the coffee pest, Coffee Berry Borer (CBB). The research has sought to address these challenges through three related components: a smallholder targeted training package; a demucilager trial (mini wet mill); and an intercropping trial of coffee with food crops.

Farmer training package - A farmer training package comprised of a suite of 25 modules was developed in partnership with coffee extension officers, smallholders, industry personnel and researchers. The modules making up the training package have at their core a 'whole of farm' or smallholder-livelihood approach, recognising that smallholder men and women pursue a range of livelihood activities and highly valued socio-cultural activities. The modules were developed to align with the low-input farming strategy employed by most smallholder farmers, and therefore enhance the likelihood of farmer adoption. The CBB management module developed in association with HORT/2018/194 is now being actively used to train farmer groups and extension officers. The implementation of the training package by many arms of the industry including CIC, the private sector and NGOs will help establish strong links between farmers and exporters/processors which are necessary for the long-term sustainability of the PNG coffee industry.

Demucilager trial - The demucilager trial with a smallholder coffee group from Bena (EHP) demonstrated significant labour savings for both men and women. Linked to an exporter the group produced premium grade coffees, generating price premiums of between 39 and 77% above Parchment Class 1. Improved labour returns incentivised increased harvesting effort and garden maintenance, key to managing CBB. Women were significant beneficiaries, with the village savings and loans groups established under previous research (ASEM/2014/054) creating a pathway for women's engagement. The savings groups also cultivated strong governance structures within the demucilager group. The 4-year trial occurred in a very challenging period which included a global pandemic, the arrival and rapid spread of CBB, a disruptive national election, and a volatile coffee price. Amidst these challenges there are strong signs that, given sufficient support, demucilaggers hold significant promise for the coffee industry. The research has demonstrated that with this technology, smallholders can produce excellent coffee, of consistent quality, that can fetch a premium price. It also significantly improves the efficiency of smallholder labour. There are clearly improvements in the returns to labour, and smallholders recognise this. There is now a clear strategy for managing CBB, and demucilaggers provide incentives to smallholders to adopt these practices. We also see that coupled with the VSLA we observe effective group governance and strong participation of women and benefits to women in what is typically a male dominated domain. The technology has been accepted by CIC which is currently supporting farmer groups to purchase this technology. The greatest risk is that they are undermined by poor group governance, and for this reason it is critical that strategies to develop strong group governance accompany the scale-out of demucilaggers. The research has shown that VSLAs are an effective mechanism for achieving this.

Intercropping coffee with food crops - The research trials have demonstrated the value of intercropping. The planting of fertilised vegetables in coffee gardens improved coffee yields and other coffee growth parameters. The intercrops also provided another income stream to families, and can contribute to livelihood resilience by assisting farmers to manage loss of family income from CBB, coffee price volatility and drought. Intercropping is also a useful strategy for families confronted with land pressure. In recent years, in rural areas with good access to urban centres, an increasing number of farmers have been shifting land and

labour away from coffee to fresh food production for domestic markets. The development of sustainable intercropping strategies will enable these farmers to retain coffee production as part of their livelihood strategy.

9.2 Recommendations

The success of the three components of the research stem from their alignment with the values and priorities of smallholder coffee farming families, and because they enable farmers to address not only agricultural challenges, but also social and economic challenges. The development of the training guides, and two trial interventions, have worked from a whole of farm perspective, recognising diverse livelihoods and agricultural practices. Included here is an emphasis on agroforestry practices, which recycle nutrients, reduce labour requirements, and are suited to a low input production strategy. From the research emerge several recommendations:

- Adoption of new agricultural practices and technologies, will rely on the perceived value of the practice or technology itself, but also critically on the alignment of the innovation with smallholder priorities and values both from an agricultural and economic perspective as well as from a socio-cultural perspective. This alignment is frequently overlooked within projects leading to poor adoption. There is value in drawing together in a systematic way the lessons learned from cases of 'failed' and 'successful' adoption of new technologies and innovations to better understand processes of adoption.
- It is essential that strategies to support good group governance are integrated within the project. This finding was discovered from the synergies that emerged, initially accidentally but then actively cultivated, between the VSLA savings groups piloted under ASEM/2014/054 and the demucilager trial. There is strong value in drawing these elements together in a more planned way to create a model of effective community development.
- One challenge is the impact of delayed payments on adoption. The delay is primarily due to the time for a group to produce a micro-lot that the exporter can then sell at a premium. If the time between weighing-in cherry and being paid for that cherry can be shortened it is likely that cherry supply will increase. It is important that groups seeking to adopt demucilagers address this issue at the outset.
- The demucilager trial has demonstrated significant promise in accessible sites. The benefits of this technology, may be even greater for remote areas. In these sites, coffee is the most important source of income, but high transport costs often undermine the viability of coffee. By improving the quality of the coffee, and therefore the prices remote growers receive, demucilagers could enhance the viability of coffee, particularly during periods of low prices. There is value in taking the lessons learned from the present project and adapting and trialling this in a remote site.
- The development of the farmer guides, the recycling of nutrients from the demucilager, and the intercropping have demonstrated the value of coffee agroforestry systems to improving returns to labour, enhancing sustainability and adapting to climate change. More research, however, is needed to improve our understanding of these systems, and how they can be enhanced to support farmers to address the new challenges they face.

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10.2 List of publications produced by project

Journal articles

- Tilden, G.M., Aranka, J.N. and Curry, G.N. (2024). Ecosystem services in coffee agroforestry: their potential to improve labour efficiency amongst smallholder coffee producers. *Agroforestry Systems* **98**, 383-400. <https://doi.org/10.1007/s10457-023-00917-0>
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- Ndrewou, A. (2024) The impact of Cocoa Pod Borer on the livelihood responses of farmers in East Sepik Province, Papua New Guinea. PhD thesis, Curtin University.
- Gena, R. (2021). [Examining the Success and Constraints of Women Fresh Produce Resellers at the Lae Urban Food Market in Morobe Province, Papua New Guinea.](#) MSc thesis, Papua New Guinea University of Technology.
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Conference/ workshop presentations

Curry, G.N., Koczberski, G., Sengere, R., & Hamago, M. (2023). Smallholder coffee in Papua New Guinea: diffusion, impacts and future challenges. Presented to the Geography Association of Western Australia, Geography school teachers and University students. Curtin University, 19th May.

Sharp, T.L.M., Busse, M. and Bourke (2023) Change in PNG's marketplaces over the past 60 years. ANU Development Policy Centre Seminar Series, Canberra/Online

Sharp, T.L.M. (2023) Referencing, paraphrasing and plagiarism. University of Goroka workshop, Goroka (28/7/2023)

Curry, G.N. (2022). Principles of Good Writing. Presented to staff and postgraduate students at the University of Goroka, 11 May, 2022.

Koczberski, G. (2023). What is research and how do you do it? Presented to staff and postgraduate students at the University of Goroka, 28th May 2022.

Koczberski, G. and Curry, G.N. (2022). The Role of Social Science in Understanding Food Security in Papua New Guinea. Keynote address to the 9th Huon Seminar, PNG University of Technology, Lae, 31 August 2022.

Curry, G.N. and Koczberski, G. (2022). How does technology adoption interact with socio-cultural change amongst smallholder farmers in Papua New Guinea? Presented at the Australian Centre for Pacific Islands Research (ACPIR), USC, 30 March 2022.

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Curry, G.N., Nake, S., Koczberski, G., Oswald, M., Rafflegeau, S., Lummani, J.L., Peter, E. and Nailina, R. (2021). The Influence of Socio-cultural Factors in Technology Adoption in the Developing World. Presented at ISTOM, Angers, France, 21 October

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- Curry, G.N., Koczberski, G., Sengere, R. and Sharp, T. (2021). Land And Livelihoods in Papua New Guinea. Presented at the IAG Rural Geography Study Group Seminar, 22 September, 2021.
- Curry, G.N. (2021). Disruptive and Incremental Innovation in Agriculture: Sociocultural Factors in Technology Adoption in the Developing World. Global South Nexus: DBE Winter Seminar, 22 July, 2021.
- Curry, G.N. et al. (2021). Disruptive and Incremental Innovation in Agriculture. Pacific Livelihoods seminar, 21 July 2021
- Koczberski, G. Curry, G., and Sengere, R. (2021). Land and livelihoods in Papua New Guinea. Geography Discipline Seminar, 21 April, Curtin University
- Sharp, T.L.M. and Busse, M. (2021) Changes in open air markets in PNG. Pacific Livelihoods Seminar Series, Online.
- Curry, G.N., Nake, S., Koczberski, G., Oswald, M., Rafflegeau, S., Lummani, J.L., Peter, E. and Nailina, R. (2020). Disruptive and Incremental Innovation in Agriculture: Socio-cultural Factors in Technology Adoption in the Developing World. Presented at the IAG/NZGS conference, Sydney, 5-10 July 2021
- Curry, G.N. and Koczberski, G. (2020). In March, I was invited (with G. Koczberski) to present the findings from a recently completed four-year food security project to the PNG Scientific Secretariat in Port Moresby, PNG. The project has been the largest investigation into the status of food security among smallholder farmers in PNG since the 1990s. The project involved over 640 farmers across five provinces.
- Apis, B. (2019) Coffee and Leguminous Ground Cover and Intercropping Trial. Presented at the Coffee Research and Extension Advisory Committee (CREAC) meeting, 9 September 2019.
- Curry, G.N., Nake, S., Koczberski, G., Rafflegeau, S., Lummani, J., Germis, E., Nailina, R. and Peter, E. (2019). Breaking open the black box: the socioeconomic factors explaining adoption or rejection of innovations in agroforestry. Keynote address presented at the 4th World Congress on Agroforestry: Strengthening Links between Science, Society and Policy (20-25 May, 2019), Montpellier, France.
<https://agroforestry2019.cirad.fr/>
- Curry, G.N. Sengere, R., Webb M. and Kiup, E. (2019) Improving Livelihoods of Smallholder Coffee Communities in PNG: the Mini Wet Mill Trial. Invited address to the PNG Institute of National Affairs, Port Moresby, 24 October, 2019.
- Hamago, M. (2019) The Role & Impact of female Extension Officers on the Participation of Women in Export Crop Production in PNG. Presented at the Coffee Research and Extension Advisory Committee (CREAC) meeting, 9 September 2019.
- Kiup, E. (2019) Improving Livelihoods of Smallholder Coffee Communities in PNG. Presented at the Coffee Research and Extension Advisory Committee (CREAC) meeting, 9 September 2019.
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- Koczberski, G., Curry, G., Sengere, R. (2019). The transformation of rural food production for urban markets: Informal land rentals and entrepreneurial opportunities for women in the Eastern Highlands of Papua New Guinea. International Geographical Union Conference, University of the South Pacific, Suva, Fiji. June 2019.
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- Sharp, T.L.M. (2019) Uneven Development in Papua New Guinea. Geography Association of Western Australia Conference, Perth.
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- Koczberski, G., Curry, G., Sengere, R. & Inu, S (2018). *Informal land rentals and women entrepreneurs: a case study from the Eastern Highlands of Papua New Guinea*. DevNet conference, Christchurch, NZ, December 2018. <https://devnet.org.nz/wp-content/uploads/2018/08/Informal-land-rentals-and-female-entrepreneurs-in-PNG-Koczberski-et-al.pdf>
- Curry, G., Germis. E. & Koczberski, G. (2018). *The Changing Moral Economy of Land Transactions on Customary Land for Small-scale Agricultural Development: an example from Papua New Guinea*. DevNet conference, Christchurch, NZ, December 2018. <https://devnet.org.nz/wp-content/uploads/2018/08/The-changing-moral-economy-of-customary-land-transactions-in-PNG-Curry-et-al.pdf>
- Blogs published on the Pacific Livelihoods site: <https://pacificlivelihoods.com/>*
- Ecosystem services in coffee agroforestry. <https://pacificlivelihoods.com/2024/05/07/new-publication-ecosystem-services-in-coffee-agroforestry/> (7/5/2024)*
- Innovative training package targets smallholder coffee farmers. <https://pacificlivelihoods.com/2024/02/20/innovative-training-package-targets-smallholder-coffee-farmers/> (20/2/2024)*
- Coffee and Women in Papua New Guinea <https://pacificlivelihoods.com/2024/02/16/coffee-and-women-in-papua-new-guinea/> (authored and published by SA COUNTRY WOMAN magazine) (16/2/2024)*
- Assisting PNG coffee farmers to manage the devastating pest, Coffee Berry Borer <https://pacificlivelihoods.com/2023/11/23/assisting-png-coffee-farmers-to-manage-the-devastating-pest-coffee-berry-borer/> (23/11/2023)*
- Coffee berry borer success story <https://pacificlivelihoods.com/2023/08/23/coffee-berry-borer-success-story/> (Authored by HORT/2018/194 research team and published by NSW DPI) (23/8/2023)*
- Market-driven extension services: targeted smallholder interventions. <https://pacificlivelihoods.com/2023/06/01/publication-market-driven-extension-services-targeted-smallholder-interventions/> (1/6/2023)*
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Female Extension Officers in Papua New Guinea

<https://pacificlivelihoods.com/2021/06/16/female-extension-officers-in-papua-new-guinea/> (16/6/2021)

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