Final report

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2 Executive summary

Agroforestry tree species are widely grown in the Pacific Islands and provide multiple products such as food, timber and ecosystem services. Value-added agroforestry products have great potential to deliver both economic and environmental benefits to smallholders in Pacific Island countries. However, a market-driven approach is needed to identify the best opportunities for agroforestry products. This project explored opportunities for new value-added agroforestry products to improve livelihoods in Fiji, Vanuatu, the Solomon Islands and Papua New Guinea (PNG). There were two key aspects of the work:

1) Improving agroforestry production by enhancing smallholder participation
2) Linking producers to markets by value-adding to agroforestry products

Key achievements and impacts

The project team identified market opportunities in the fruit, nut, honey and tree nursery industries, established agroforestry demonstration sites and developed value-adding techniques as key enablers of industry development. The team adopted a transdisciplinary and integrated value-chain approach, with the researchers from different disciplines working together along the value chain on a range of crops. As a result, the project produced diverse livelihood benefits and impacts detailed below.

Enhancing smallholder participation

- **Pilot agroforestry demonstration sites were established** in Fiji (2 sites) and Vanuatu (1 site). In addition, training for women's nurseries was provided to 195 participants to support tree planting. By the end of the project the Nadroumai Women's community nursery in Fiji produced and sold over 3000 seedlings and the nursery was producing a new source of income for the community.
- **The project team developed resources to help smallholders produce honey** (Papua New Guinea). Forest trees that were important sources of honey and pollen were identified with a novel technique, DNA metabarcoding. Beekeeper training was provided to 60 participants and a book on beekeeping aimed at smallholder farmers was written and translated into Tok Pisin.
- **Research on policy in agritourism has been adopted** by key stakeholders in the Vanuatu Sustainable Tourism Policy (VSTP) (2019-2030)
- **This project has built capacity in coffee production** with industry partner Bula Coffee (Fiji) by improving coffee genetics and postharvest drying systems. As a result, Bula coffee have increased the number of villages where they source coffee from 1 village to 83 villages at the end of the project.

Value-adding agroforestry products

- **New value-added agroforestry products were developed** in conjunction with local processors (Vanuatu, Solomon Islands). Products in the Solomon Islands include 3 types of nuts (*Canarium*, *Terminalia* and *Barringtonia*), muesli, dried bananas, dried pineapple and dried paw paws. Products in Vanuatu include chutneys, jams, manioc flour and dried banana. Approximately 750 farmers are now supplying to the processors.
- **Processers were linked to new export markets** (Vanuatu). There were initial chocolate sales in Vanuatu to Oxfam Trading as a result of the value chain assessment. Other opportunities explored included introducing industry partners to Trade Aid (NZ) to facilitate alternative export market channels. A survey of ethical consumers in export markets has been undertaken and shared with industry partners in each of the countries
- **Value-added food training was delivered to 614 female and 90 male participants** (Fiji, Vanuatu and Solomon Islands). Initial training on food safety, food preservation, selling "up the chain", developing new products and value-chain

techniques was provided to market vendors (566 female, 90 male). An intensive 6-week training workshop in Fiji was then provided to 48 women. More than half of the participants were engaged in commercial sales of chutneys and jams at the end of the training.

The impacts of the project in Fiji and Solomon Islands are highlighted in three videos produced by the team. They are available on the following links:

- The Solomon Islands: https://vimeo.com/423068750/c6c4431839
- Fiji - Nadroumai: https://vimeo.com/389910080/eefd3ed6ac
- Fiji- Hart Training: https://www.youtube.com/watch?v=BMEvO4-H8go

Further investment and interventions are needed especially due to the impacts of Covid-19 on the tourism market in the Pacific. Pacific Island countries have a significant opportunity to strengthen the emerging small-scale food processing sector using their unique agroforestry products. Further research and interventions should focus on understanding traditional barriers to women's use of resources, further training in value-adding for smallholders, consistency of supply and quality for domestic and export markets, and support for women's seedling nurseries.

3 Background

Approximately 80% of people in PNG and the Pacific Islands live in rural areas and earn their livelihoods from agriculture, fishing and forestry. More than 90% of rural people are semi-subsistence smallholder farmers and women are often primarily responsible for farming activities. Rural farmers generally have limited markets for their produce, and little access to distant markets. Small scale food processing and value-adding can enhance market access, especially if products can be processed locally and transported to distant markets or central distributors.

Agroforestry tree species are widely grown in the Pacific Islands and provide multiple products such as food, timber and a vast array of non-wood forest products (NWFPs) as well as ecosystem services including soil protection, enhanced biodiversity and climate change adaptation and mitigation. There is great potential to value-add to primary products from agroforestry crops in Pacific countries. Industries based on value-added products can also create employment and enhance business opportunities for small- to- medium enterprises. However, a market- driven approach is needed to identify the best opportunities for value-added products from agroforestry crops. In addition, agroforestry crops, especially tree crops may take several years to produce marketable products and smallholders need incentives in the short term to encourage investment in tree crops. Tree crops can be integrated into agroforestry systems with other short-term crops such as taro, sweet potato and banana to produce a return on investment more quickly. However, there is little information on the performance of these integrated agroforestry systems in terms of the best species selection, crop production, and economic and environmental benefits to smallholders.

This project explored opportunities for new value-added agroforestry products to improve livelihoods in PNG, Vanuatu, Fiji and the Solomon Islands. This research identified the best opportunities for value-adding, and value-adding techniques for these products. The project also investigated integrated agroforestry systems in Fiji and Vanuatu that are likely to have environmental benefits such as catchment revegetation along with economic returns to smallholders. These agroforestry systems will generate income and give smallholders greater access to remote markets, thus enhancing self-reliance, increasing environmental benefits and reducing poverty. A transdisciplinary team with collaborators from the Griffith University/University of the Sunshine Coast, University of Adelaide and Southern Cross University worked with government departments (e.g. NARI PNG, Department of Industry Vanuatu, SPC), NGO's (e.g. Live and Learn, UN Women) and private sector processors (e.g.Lapita café, ACTIV, SolFresh, Bula Coffee, Quintessentials/ Pacific Reforestation (Fiji) Ltd) in all countries.

This research was driven from Pacific government and private sector stakeholders. In the Pacific, improved food security and sustainable forest management are regional priorities. This research also aligns with the Australian Government's aid policies, including enhancing opportunities for women and engaging with the private sector. Women have a central role in household food gardening, growing and tending to agroforestry crops and marketing of horticultural and agroforestry crop products. Promoting value adding of agroforestry crops improves food security and provides economic opportunities for rural women.

Agroforestry systems provide livelihood benefits for small-holders and environmental benefits to degraded catchments. Development of agroforestry systems had been discussed in a series of ACIAR stakeholder workshops (PC/2013/016), where a broad range of stakeholders strongly endorsed the need for development of agroforestry cropping systems. Private sector processing of agroforestry crop products is under-developed and ACIAR's project (FST/2010/013) has demonstrated the potential for new small and medium scale enterprises to be developed around value-added processing of canarium nuts. This project conducted research on existing and potential products and processes in conjunction with the private sector. This project also created opportunities throughout the value chain for new processors and marketers with a range of locally produced value-added products.

4 Objectives

The aim of this project was to improve livelihoods of rural villagers in PNG, the Solomon Islands, Vanuatu and Fiji by exploring opportunities to produce new value-added agroforestry projects.

The project trialled a range of interventions including market research to determine the best opportunities, new value adding techniques and products, capacity building, particularly among women farmers and microenterprises, and business mentoring. The project also established pilot sites in Fiji and Vanuatu to demonstrate agroforestry services and determine crops with best market potential. The specific objectives and major activities of each of the five objectives were:

Objective 1. Identify multipurpose agroforestry crops with market potential to be value-added in all four countries (PNG, SI, VAN, Fiji)

- Inventory and review donor, government, NGO and private programs promoting agroforestry value chains in all four countries
- Conduct key informant interviews and desk studies to analyse existing evaluations of projects and policies identified in Activity 1
- Select the high value agroforestry crops
- Surveys of smallholder farmers (males and females) and review of the literature at the start of the project to establish a baseline and understand the value chain, adoption behaviour, practices on the farm, labour trade-offs and the role of women
- Use a value chain framework to examine, identify and analyse constraints and opportunities for priority agroforestry value chains in all four countries through a mixture of structured interviews and representative sample surveys
- Improve the performance of priority value chains and targeted value-added products by researching a further level of detail on market requirements and value chain improvement opportunities

Objective 3. Enable smallholder and gender equitable participation in agroforestry crop production (VAN, Fiji)

- Identify opportunities, incentives and barriers that enable participation in agroforestry crop production
- Identify which gender may benefit at which stage of the value chain, and determine whether women can be drawn into those activities that add the most value
- Address issues surrounding women's involvement in income generating activities and disseminate information from project down to women

Objective 2: Enhance small to medium enterprises ability to participate in value-adding (PNG, SI, VAN, Fiji).

- Identify key research gaps in value-adding for each crop in each country
- Undertake research on processing methods for each crop in each country
- Identify opportunities, incentives and barriers that enable adoption of value-adding

Objective 4. Develop and pilot testing of catchment revegetation systems linked to markets (VAN, Fiji)

- Recommend species for planting in Fiji and Vanuatu at upper, mid and lower catchments
- Support pilot planting of agroforestry crops with other projects such as FAO/GEF
- Monitor growth and yield of produce from demonstration plots
- Monitor sediment and nutrient status of the pilot sites. Provide information on erosion and nutrient status to modelling efforts at the catchment scale

- Explore mechanisms to facilitate funding of catchment revegetation by tourism operators
- Identify current constraints to supplying the tourism industry with locally grown produce and strengthen linkages between producers and tourism industry stakeholders

Objective 5. Build capacity and disseminate research findings

- Conduct a training needs analysis, an impact pathway analysis and a monitoring and evaluation plan
- Conduct a training workshop on a range of value chain techniques
- Build capacity in business management value-adding and processing techniques with training workshops, especially for female participants
- Connect private sector SME participants with mentors, especially female entrepreneurs
- Build capacity in agroforestry crop production especially for female smallholders by running field demonstration days.

5 Methodology

Overview

This project took a dual approach of addressing both the “market pull” and the biophysical, economic and social needs of agroforestry systems. The “market pull” approach ensured that markets exist for products and that the species promoted for planting improve smallholder livelihoods. This provides more confidence and incentive to smallholders and processors to invest in both planting and value-adding. The biophysical, economic and social aspects of agroforestry crop production were addressed, in tandem with the market pull, to give smallholders confidence that plantings will produce an income in an integrated system with a variety of crops. Analysis of smallholder surveys was assessed early in the project to better understand the value chain, adoption behaviour, farm practices and decision making.

The catchment revegetation pilot projects were conducted only in Fiji and Vanuatu, where there has been a clearly identified urgent need to improve catchment revegetation to improve water quality and reduce the impact of flooding. In addition, the research examined the agri-tourism value chain by facilitating discussions between smallholders and the tourism industry. The project identified possible beneficiaries of market mechanisms such as PES (Payment for Ecosystem Services) or CSR (Corporate Social Responsibility) and engaged in discussions and negotiations to define suitable payment mechanisms that would provide incentives for smallholders to participate in agroforestry crop production.

Research approaches

This project involved a transdisciplinary team using a range of agribusiness research methods, scientific methods (for processing) and social science research (participatory action research) methods. The project used a value chain framework to identify key crops in each country with the greatest potential for value-adding. Opportunities, incentives and barriers that enable smallholder participation in agroforestry crop production, with a particular focus on the involvement of women, were identified. Surveys of smallholder farmers and analysis of previous survey work was assessed early in the project to better understand the value chain, adoption behaviour, farm practices and decision making.

Discussions between smallholders and the tourism industry were undertaken to better understand the agri-tourism value chain and possible environmental payment incentives to encourage smallholder participation such as Payment for Environmental Services (PES) or Corporate Social Responsibility (CSR). Processing methods to meet market requirements such as drying and packaging were investigated. Training days, workshops and field demonstrations were conducted, to increase value-adding and agroforestry crop production understanding for Participatory action groups, female entrepreneurs and smallholders.

The Australian project team worked closely with a range of stakeholders from the private sector in PNG, Solomon Islands, Vanuatu and Fiji. These included:

- individual smallholders
- microenterprises and small-scale entrepreneurs
- small and medium enterprises
- large locally owned firms and multinational corporations.

The in-country organisations that this project worked closely with during this project were:

- Fiji – Secretariat of the South Pacific, Nadroumai Women’s Club, Bula Coffee, Food Inspired, Shangri-La Resort
- Vanuatu – Lapita Café, ACTIV, Department of Industry, Department of Tourism and various women’s groups
- Solomon Islands – Jedom Trading, Department of Commerce
- PNG – NARI, Mountain Honey.

The overall project uses a value chain framework to identify key crops in each country with the greatest potential for value-adding. A review of the literature along with surveys and interviews with value chain members and stakeholders provided a better understanding of the opportunities, adoption behaviour, farm practices and decision making at both the private and public sector level. Specific methods used for each objective are detailed below.

Objective 1. Identify multipurpose agroforestry crops with market potential to be value-added in all four countries (PNG, SI, VAN, Fiji)

1.1 Inventory and review donor, government, NGO and private programs promoting agroforestry value chains in all four countries
1.2 Conduct key informant interviews and desk studies to analyse existing evaluations of projects and policies identified in Activity 1
1.3 Select the high value agroforestry crops
1.4 Surveys of smallholder farmers (males and females) and review of the literature at the start of the project to establish a baseline and understand the value chain, adoption behaviour, practices on the farm, labour trade-offs and the role of women
1.5 Use a value chain framework to examine, identify and analyse constraints and opportunities for priority agroforestry value chains in all four countries through a mixture of structured interviews and representative sample surveys
1.6 Improve the performance of priority value chains and targeted value-added products by researching a further level of detail on market requirements and value chain improvement opportunities

The methodology for selecting preferred crops began with a review of ACIAR projects and donor, government, NGO and privately driven programs that promote agroforestry value chains across all four countries. This desktop work laid the foundation for key informant interviews that were conducted with 30 people from Government and Non-Government Organisations, 15 processors, 81 industry representatives and many farmers and female stallholders. Criteria for selecting the priority agroforestry value chains were established collaboratively with relevant project partners and stakeholders. This included factors such as potential for value-adding, agroforestry environmental benefits, livelihood benefits, market potential, involvement of women, involvement of the private sector, job creation, support to local communities, supported by government, low risk, ability to be replicated and potential up-take.

When considering each of the agroforestry crops it was very important to identify crops that had the biggest market potential and understand the cultural aspects of each of the value chains, especially in relation to the supply capabilities of the smallholder farmers.

Further, the opportunities that were prioritised needed to have impacts along the entire chain as the outcomes of this research are not purely of a commercial focus. In considering the potential livelihood and environmental benefits of this research, different goals and timelines will ensue. We also examined site specific options (what species suit these sites and what species are available) in Vanuatu and Fiji which is one of the reasons why the broader project team has been involved in these decisions from the start.

Each potential agroforestry crop in all four countries were graded against the weighted criteria that had been established. A simple grading system was used:

- ‘No’ compliance with a criterion resulted in a grade of 1
- ‘Little’ compliance with a criterion resulted in a grade of 2
- Compliance with a criterion resulted in a grade of 3
- ‘Good’ compliance with a criterion resulted in a grade of 4
- ‘Maximum’ compliance with a criterion resulted in a grade of 5

Grading was undertaken by the project team in collaboration with relevant project partners and stakeholders. A matrix of each of the crops and how they were graded against each of the criteria was developed.

The matrix was given strong consideration by the project team and project partners and stakeholders when selecting the agroforestry crops with the most potential for value-adding (Figure 1). The results of the matrix were verified through anecdotal sources (interview and workshops) with stakeholders and other ACIAR project activities were considered when 'best bets' were assessed. An example of the matrix is provided below at Figure 1.

A baseline was required to measure current behaviour, to help identify barriers and opportunities and establish a framework for measuring the impact of this project, longer-term. A combination of desktop analysis, primary research through surveys and making use of a value chain framework for analysis provided information to both formulate a baseline and help identify barriers and knowledge gaps. The information gathered from these studies and surveys, along with in-country expertise, was used to create a simple table to help identify barriers, opportunities, commonalities between countries and knowledge gaps. While this baseline data was gathered through the expected methods of desktop analysis, and surveys, work was also done to engage with key stakeholders across each country in a more focused way, to gather more detailed and specific insights about how and why things are done the way they are. The aim of this value-chain stakeholder engagement was to add value to the more traditional baseline gathering exercise, to build relationships, better understand the drivers of current behaviour and gather insights useful for making positive changes (Appendix 11.2).

The specific activities undertaken, and desktop information analysed to identify the baseline and provide insights into behaviours, barriers and opportunities to deliver results under Objective 1 were:

Household Survey Fiji: In Fiji, 1000 urban households have been surveyed by the University of Adelaide, University of the South Pacific and the Ministry and Agriculture (Fiji) under a previous PARDI project to better understand the value-added chain and their consumption patterns. This data was reanalysed as part of this project for insights into the value-added chain in Fiji and as a baseline for understanding the value chain, labour and the role of women. These insights were also dovetailed into a comprehensive survey of 600 producers (both male and female head of household) and 85 traders in Viti Levu to provide a full picture of the value chain from production through to consumption. (Appendix 11.3).

FAO Gender Assessment in Agriculture: The Food and Agriculture Organisation of the United Nations (FAO) and The Pacific Community (SPC) jointly prepared and published Country Gender Assessment of Agriculture and the Rural Sector in three of the relevant countries, namely Fiji, Vanuatu and the Solomon Islands. These reports provided valuable information on each country, gave a policy and institutional context, a gender analysis of the agricultural sectors and recommendations to each country's government bodies. We were in discussions with SPC during the collection and analysis of this data, so we were confident it would be relevant to our baseline studies.

Oxfam Survey: A survey of 55,000 Oxfam Australian consumers was conducted to better understand the market segment of ethically aware consumers and provide insights into the drivers behind their purchasing behaviour. The insights from this survey are applicable for all four countries and a wide range of value chains and value-added products.

Pacific Agroforestry Product Criteria Matrix							
Criteria	**Weighting**	**Agroforestry Options**					
Sustainable / growing market	**10%**						
Livelihood benefits / employment creation	**10%**						
Sustainable Supply (existing or potential)	**10%**						
Environmental benefits	**10%**						
Private sector involvement along the chain	**10%**						
Govt support / National priorities	**10%**						
Opportunities for Women	**10%**						
First Tier	**70%**						
Resilience to disasters	**5%**						
Value-adding opportunities / capacity building	**5%**						
Enhancing food security (via product or income)	**5%**						
Intervention replicable / potential to scale up	**5%**						
Second Tier	**20%**						
Ability to integrate with other crops	**2%**						
Fit in with local structures and conditions	**2%**						
Potential for export / import sub / PES or CSR	**2%**						
Nutritional benefits, if food / Village use if timber?	**2%**						
Researchable issues that fit with ACIAR's mandate	**2%**						
Third Tier	**10%**						
Total Score out of 100 (Scale x Weight) x100	**100%**						

Figure 1. Example of the matrix used to evaluate the species.

Objective 2: Enhance small to medium enterprises ability to participate in value-adding (PNG, SI, VAN, Fiji).

2.1 Identify key research gaps in value-adding for each crop in each country

This phase of the research partnered with private and public sectors to identify key research gaps in value-adding for each crop in each country and understand the market requirements identified in Objective1.

The matrix developed by the project team (Adelaide University, the Southern Cross University and Griffith University researchers (Appendix 11.1), was used to select the best bet species and products. High ranking products that were under investigation by other ACIAR projects (such as Cocoa, Coconuts, Sandalwood and Breadfruit) were eliminated. Issues that impact on gender equity were also examined. For example, women benefit from harvesting wild coffee, however planting improved coffee for cropping raises land tenure issues. At the midterm review in May 2018, some of these were no longer able to be pursued because of lack of engagement of the private sector, and other opportunities had arisen.

2.2 Undertake research on processing methods for each crop in each country

In conjunction with the private industry partners, research was undertaken on processing methods. The research investigated appropriate processing methods to meet market requirements such as drying, packaging, and quality standards. The key issues that were researched for value-adding were: Stabilizing the product by drying to develop new value-added products; chemical composition; packaging; shelf life and food safety. Variability within nut kernels *for Terminalia catappa* (Vanuatu – Natapoa; Solomon Islands – Alite; Fiji – Tarvola), *Canarium harveyi* (Vanuatu) and *Barringtonia* spp. (Vanuatu - Navele; Solomon Islands – Katnut; Fiji – Cutnut) was undertaken. Edible species of *Barringtonia* include *B. procera*, *B. edulis* and *B. nova-hiberniae*. In Fiji, only *B. edulis* occurs whereas all three species occur in Solomon Islands and Vanuatu (POWO 2021, Thomson et al. 2018). *Barringtonia* species have been intensively selected for desirable fruit and tree characteristics as the village level and many different morphotypes are cultivated, making species identification in the field difficult (Thomson et al. 2018).

Variability in nut size

In the Solomon Islands, Vanuatu and Fiji, work has been undertaken to identify *Barringtonia* spp., *Terminalia catappa* and *Canarium harveyi* trees that bear larger nuts and kernel. The nuts from *Barringtonia* spp. (Solomon Islands, Vanuatu and Fiji) (approx. 20 nuts per tree) and nuts from *Terminalia catappa* (approx. 30 nuts per tree) were collected in different locations in the Solomon Islands, Vanuatu and Fiji. *Canarium harveyi* (30 nuts from each of 10 trees) were collected from Santa Cruz Island in the Solomon Islands.

Chemical composition of nuts

The fruit and kernel of these nuts were weighed, and the dried kernels sent to Australia for oil analysis. After the oil was extracted from the kernels, total oil content was determined, then analysed for constituent fatty acids.

Fatty acid methyl esters (FAMEs) were determined using gas chromatography-mass spectrometry (GC-MS), equipped with flame ionisation detector (FID) (Hamilton et al. 2010). Identification of derivatised FAMEs was done using a Varian 3900 Gas Chromatograph coupled to a Varian 2100T Mass Spectrometer and quantified using a Varian CP-3800 Gas Chromatograph. NIST spectral database was used for matching retention sequences. Integration software was used to measure peak areas which were then expressed as a percentage of total detected FAMEs peaks. The sum of palmitic acid and stearic acid constituted total saturated fatty acids (TSFA) and sum of oleic acid and linoleic acid constituted total unsaturated fatty acids (TUSFA).

An accelerated aging experiment was conducted on *Terminalia catappa* kernels with a moisture content of 1.5%. These kernels were sealed in aluminium foil pouches and incubated at 45°C for 21 days. Hexanal concentration from within the pouches was analysed using an e-nose at day 0 (initial), after 7, 14 and 21 days.

Drying techniques for fruit and nut products

Drying techniques to enhance value-adding for *Barringtonia* spp. and *Terminalia catappa* were undertaken. Nuts were dried in either dehydrators (Solomon Islands and Vanuatu) or a scientific oven with airflow (Fiji). The time and temperature to achieve the desired water activity level/ moisture content were recorded. A solar dryer was also constructed with SolFarm Fresh (Jedom foods) in Honiara.

Drying trials for fruit (pawpaw and mango) were also undertaken using the solar dryer (Solomon Islands) and a food dehydrator (Sunbeam DT5600; Vanuatu). Fresh fruit were sliced and arranged on trays to permit air flow. The solar dryer required two mostly sunny days with an expected temperature between 50-60^{o}C and the dehydrator took 10 to 12 hours at 60^{o}C to dry fruit to a flexible consistency yet contain no visible moisture. Using this process new dried fruit products were developed by the industry partner (see impacts below).

Nutritional and microbial analysis

Commercially prepared samples of value-added products were sent to an independent laboratory in Australia to undertake nutritional analysis. This was used by the industry partners to add nutritional labels to the value-added products for up-chain customers, particularly export markets.

Commercially prepared samples of these value-added products were also sent to an independent laboratory in Australia for microbial analysis. This was to ensures processors methods were safe and provides consumer with confidence in the food safety of the product.

Bee and honey research

Research was undertaken to identify floral sources important to honeybee health and productivity in the eastern highlands of Papua New Guinea. Bee bread and honey was collected from beehives located in sites with predominantly either forested or agricultural vegetation. All bee bread and honey samples were transported to University of the Sunshine Coast for processing and analysis of the extracted DNA. DNA metabarcoding was used to match DNA sequences in honey and pollen to a plant barcode library based on each flowering plant's unique genetic sequence. To analyse fat content in bee bread, the oil of each sample was extracted and weighed for analysis. The lipid profile of each bee bread sample was then analysed by GC-MS.

2.3 Identify opportunities, incentives and barriers that enable adoption of value-adding

An analysis investigated opportunities, incentives and barriers in the agroforestry industry was undertaken. This focused was on smallholder (particularly women) participation. A SWOT market and stakeholder analysis identified constraints and opportunities for value-adding, strategic development and action. This data was used to inform participatory action groups and improving links between stakeholders. Increased understanding of market chains for smallholder agriculture producers has enabled adoption of value-adding opportunities resulting in improved income and livelihoods. Opportunities for increasing incentives and linking with the tourist industry were explored.

A cost-benefit analysis was undertaken with a medium sized business in Melanesia. Cost-benefit analysis is used to determine profitability of business scenarios (Harris and Roach 2005). This economic analysis investigated current production against three expansion opportunities. Challenges, such as cyclones, seasonal supply of raw materials and transport

costs that a medium sized business in Melanesia may experience during a 10-year investment period were considered. Net Present Value and the Cost-Benefit ratio for the different options is used to identify the most favourable option (Harvard Business Review Press 2014). Net Present Values under the different scenarios were presented to the managing director. Benefit-cost ratios for the different scenarios were developed to indicate the feasibility and when each scenario would show a positive return for investment.

Objective 3. Enable smallholder and gender equitable participation in agroforestry crop production (VAN, Fiji)

3.1 Identify opportunities, incentives and barriers that enable participation in agroforestry crop production

The research investigated opportunities, incentives and barriers that enable smallholder participation in agroforestry crop production, with a focus on the involvement of women and the private sector. The study methodology involved three elements: Consultation with women close to agroforestry pilot sites and the formation of participatory women's groups; a literature review and; a SWOT analysis to identify opportunities, incentives and barriers to participation in agroforestry crop production.

As a part of the initial participatory community consultation process, open ended surveys were conducted with small groups of women, in their communities, to gain an understanding of existing women's roles in crop production and agroforestry. Opportunities, incentives and barriers that enable smallholder participation in agroforestry crop production were identified, with a specific focus on the involvement of women (Appendix 11.5). Key observations have been collected from field research and through feedback from Participatory Action Research groups formed as part of the project. These groups provided key insights into motivations for altering existing practices to incorporate agroforestry and the production of local tree crops.

3.2 Identify which gender may benefit at which stage of the value chain, and determine whether women can be drawn into those activities that add the most value

Following on from these initial surveys a larger women's group was established bringing together women from neighbouring communities. This participatory women's group was used to disseminate information down from the project to women directly. This participatory group enabled greater inclusion of women in the outcomes of the project as well as enhancing their skills for generating income.

A SWOT analysis was undertaken at the beginning of the project in lower, middle and upper catchments. Social/cultural, environmental and economic sustainability of smallholder participation in agroforestry crop production and impacts of land tenure and access constraints were assessed. This SWOT analysis included both primary data from smallholders, as well as secondary information from government departments and published materials. Land tenure can act as an incentive or disincentive to smallholder participation in agroforestry crop production.

A literature review was conducted to identify which gender may benefit at the various stages of the value chain and whether women can participate in those activities that add the most value.

3.3 Address issues surrounding women's involvement in income generating activities and disseminate information from project down to women

In Fiji, women in Nadroumai community participated in the coffee value chain by wild harvest of berries and selling to Bula coffee. Discussions revealed that they were unable to plant

coffee due to land tenure issues, but growing seedlings in a nursery was possible. This led the project team to assisting with the establishment of a nursery and training for women of the Nadroumai village.

In Vanuatu, the ACTIV Cooperative works with women and men in a handicraft, cocoa, coconuts, herbs and tourism. Discussions revealed that there were no opportunities to purchase improved cocoa genetic material for propagation in Vanuatu. This project assisted ACTIV with nursery and grafting training to allow ACTIV to construct a nursery and develop improved cocoa plants.

Objective 4. Develop and pilot testing of catchment revegetation systems linked to markets (VAN, Fiji)

4.1 Recommend species for planting in Fiji and Vanuatu at upper, mid and lower catchments

Agroforestry species for pilot sites were selected following consultations with local community in both Fiji and Vanuatu and local forestry expert Dr Lex Thomson. This research identified agroforestry crops and pilot sites with the greatest potential for value-adding in terms of economic (market), social (cultural) and environmental impact. The preferred species for traditional tree crops are *Inocarpus*, *Terminalia*, *Barringtonia*, Breadfruit, Sandalwood, Citrus, Coffee, Cocoa and Mango. Tree crops have a long lead time to produce returns, with lags of several years before a crop is produced.

Pilot sites were selected following lengthy consultation so that the pilot sites could address the smallholders' needs and provide sustainable use of resources. Choice of sites also relied on the landholder having secure lease title on the site and their willingness to maintain the plantings (weed and stock control, watering etc.). Sited were selected in different areas of the catchment to demonstrate plantings suitable to each area.

Fiji Trial Site 1 – Nadroumai Village (in partnership with Shangri-La Resort)

This site provided an opportunity to plant an integrated system within the village and provide remediation for downstream reef area. i.e. best coffee varieties as well as a suitable combination which could include *Terminalia*, *Barringtonia*, Tahitian chestnut (ivi), Breadfruit, Mango, Pineapple and Coffee.

Fiji Trial Site 2 – Korotari near Labasa

This site focused on an agroforestry system better suited to a drier and more degraded site. It was adjacent to a large forestry reserve and on steeper terrain so was more suitable to lower input levels. It was better suited to these upper catchment species and included Sandalwood, *Terminalia* and Mango. This site was adjacent to a large forestry reserve.

Vanuatu trial Site 1 – Santo Lapita farm

The focus was on developing an integrated system of crops including *Canarium*, *Terminalia*, *Barringtonia*, Tahitian chestnut (ivi), Breadfruit, Mango, Pineapple, Tamanu, Coffee and Cocoa.

This project supported a post grad student at the University of the South Pacific (Fiji) who undertook an analysis of land suitable for agroforestry systems in the Sigatoka Valley (Fiji). He conducted a structured evaluation using Multi-criteria decision analysis (MCDA) to rank competing alternatives land users and combined the results spatially using Geographic information systems (GIS). The species he included in the model were cutnut (*Barringtonia edulis*), breadfruit (*Artocarpus altilus*), lemon (*Citrus limon*), sandalwood (*Santalum yasi*),

tropical almond (*Terminalia catappa*), Tahitian chestnut (*Inocarpus fagifer*), and vesi (*Intsia bijua*). This land use modelling determined suitable areas to develop agroforestry systems.

4.2 Support pilot planting of agroforestry crops with other projects such as FAO/GEF

Planting material was difficult to obtain in nurseries. This indicated the potential for smallholders (particularly women) to be involved in growing seedlings to support other projects. This project established a nursery at Nadroumai village (Fiji), and trained the Nadroumai women to grow seedling trees. The nursery has supplied more than 2,500 seedlings to the Global Environmental Fund reforestation project.

4.3 Monitor growth and yield of produce from demonstration plots

Due to the time delays in obtaining sites with appropriate leases and establishing tree crops, the most viable agroforestry activity to monitor was nursery production. The project monitored the production of seedlings grown and sold from the Nadroumai nursery. Since the commencement of the project, the nursery at Nadroumai was established and produced over 2500 plants.

4.4 Monitor sediment and nutrient status of the pilot sites. Provide information on erosion and nutrient status to modelling efforts at the catchment scale

In both Fiji and Vanuatu, watershed protection and conservation are major priorities, with few examples of systems to protect vulnerable catchment areas from the impacts of severe climatic events (particularly flooding) and threats to water quality (nutrients and sediment).

The project established three trial agroforestry sites in Fiji and Vanuatu. These sites were at Nadroumai Village near Sigatoka (Fiji), Korubua community at Korotari near Labasa (Fiji) and Jubilee Farms on Santo Island (Vanuatu). Site (slope, vegetation cover and current erosion vulnerability) and soil descriptions (soil texture, bulk density and permeability) have been undertaken to provide an understanding of biophysical conditions and productive capacity across a broad range of potential sites for revegetation in Fiji and Vanuatu.

Field measurements and soil sampling were conducted at five sites on Espiritu Santo (Santo), Vanuatu and adjoining areas of natural fallow, traditional gardens or pasture. The sites were either trials or agroforestry plantations established by ACIAR projects from 2007 onwards. Within these sites, various treatments were assigned based on site, location, age, and agroforestry / agricultural regime. Chemical, physical (bulk density and permeability) soil parameters were analysed at each site and treatment. Soil was described at each site. Notable characteristics for each site and individual plot/treatment were described during site visits, such as plant composition and arrangement, site history and spatial/ topographical features. Chemical and physical data soil underwent statistical analysis to detect differences in parameters between sites and treatments.

4.5 Explore mechanisms to facilitate funding of catchment revegetation by tourism operators

A participatory action group was formed to facilitate discussions and strengthen linkages between government officials, producers and the tourism industry to address the problem of catchment erosion. A discussion paper and stakeholder analysis evaluated constraints and opportunities for agroforestry systems through avenues such as PES and CSR in pilot site catchments.

An analysis of capacity and infrastructure to support agroforestry development was undertaken, listing supporting needs such as nurseries, infrastructure needs, and existing

training/capacity building was assessed and documented. In response to this analysis where nurseries were identified as providing an opportunity for women to engage with agroforestry, nurseries were established in Nadroumai (Fiji) and ACTIV (Vanuatu) to support tree revegetation plantings and training of women's groups conducted.

A method of incentivising small-scale agroforestry uptake by farmers was investigated. Working with Shangri-La Yanuca Resort (Fiji), the project designed a *Payment for Ecosystems Services* project to engage farmers in catchment remediation through establishing agroforestry plots in buffer zones alongside the river.

Through involvement in developing the Vanuatu Sustainable Tourism Policy, this project has influenced policy development towards a sector-based certification scheme to mandate tourism investment in conservation actions in Vanuatu.

4.6 Identify current constraints to supplying the tourism industry with locally grown produce and strengthen linkages between producers and tourism industry stakeholders

A participatory action group was formed to facilitate discussions and strengthen linkages between government officials, producers and the tourism industry to address constraints with supplying locally grown produce to the tourism industry

Objective 5. Build capacity and disseminate research findings

5.1 Conduct a training needs analysis, an impact pathway analysis and a monitoring and evaluation plan

A consultant was engaged to develop an impact pathway analysis and a monitoring and evaluation plan. This was updated during the mid-term review.

An important component of the monitoring and evaluation has been the production of three videos to highlight the accomplishment of this project.

5.2 Conduct a training workshop on a range of value chain techniques;

5.3 Build capacity in business management value-adding and processing techniques with training workshops, especially for female participants

In response to this training needs analysis, training workshops on business development and management for small scale entrepreneurs and small to medium enterprises were conducted in each country. These improved participants' (especially female smallholders) capacity to operate microenterprises.

Food Inspired, a hospitality consultancy company from Fiji was initially contracted to conduct a series of introductory workshops demonstrating food safety and value-adding to fruit and vegetables. These workshops also included a value chain component delivered by University of Adelaide and ultimately reached more than 500 participants across Fiji, Vanuatu and the Solomon Islands. Food inspired training was well received and received much positive feedback. Three women produced value-added products, however most of the participants lacked confidence to develop their skills, buy raw materials or obtain the necessary licence to sell cooked food. Feedback was that this initial training contained no hands-on experience and insufficient time to build skills, confidence and experience. Inconsistent quality prevented ongoing sales to hotels and restaurants.

Food Inspired was then contracted to build on the initial training to work more intensely with women from the Housing assistance and relief Trust (HART) community, Lovu, Lautoka (Fiji). This new training program was conducted as multiple training workshops with small groups to build the skills and confidence to produce a consistent quality product. Due to

Covid-19, the target market for these new value-added products was directed more towards the local domestic market. The other objectives of this training and ongoing mentoring were to:

- Give the participants skills and confidence to ensure food safety practices and hygiene are always observed.
- Produce a consistently high-quality product (jams, chutneys and relishes) to meet hospitality market requirements.
- Provide training and mentoring in business management to ensure a reliable avenue for ongoing employment and assist with marketing.

This training has improved participants' (especially female smallholders) capacity to operate microenterprises. The project team also worked individually with processors to develop capacity. Rural farming Ni Vanuatu women, at a pilot workshop held in conjunction with The Master Tree Growers, were surveyed to assess the effectiveness of peer-mediated learning. The aim of this survey was to increase the impact of ACIAR investments by consolidating existing research knowledge and promote greater investment in planting, processing and marketing of high value agroforestry species in Vanuatu.

5.4 Connect private sector SME participants with mentors, especially female entrepreneurs

Exchange visits and mentoring between smallholders and established entrepreneurs in three Melanesian countries was established to provide smallholders with successful examples of enterprise development and to gain practical insights into the successes and failures of establishing a business. Aspiring female entrepreneurs were connected with successful female role models. Subject-specific training was provided in general financial information, how to add value to agroforestry crops and operate a plant nursery.

These relationships relied on networking and information-sharing. An experienced successful entrepreneur from Vanuatu was engaged to work with a small business owner in Solomon Islands and others in Papua New Guinea. This entrepreneur was chosen for her proven experience (operated business for >20 years) and her ability to relate to Melanesian entrepreneurs. As a result of discussions between Votausi Mackenzie-Reur (Lapita Café) from Vanuatu and Jenny Kellie (Farm Fresh Foods) from the Solomon Islands, Jenny used her knowledge and skills to mentor women from Kolupa village in the Solomon Islands.

A networking meeting of Melanesian processors to promote value-adding of indigenous nuts in the Pacific was held in Papua New Guinea. Participants from Papua New Guinea and Vanuatu shared their experiences and common problems of sourcing raw materials and consumables, establishing a sustainable pricing policy, maintaining quality and monitoring moisture content to minimize microbial contamination, maximize shelf life and storage.

5.5 Build capacity in agroforestry crop production especially for female smallholders by running field demonstration days

Land tenure in Fiji and Vanuatu are major constraints to women's involvement in Agriculture. This and the scarcity of seedlings in these countries provided an opportunity for the project to establish nurseries in Nadroumai (Fiji) and Port Vila (Vanuatu). Nursery training provided at these sites increased women's capacity to participate and manage these nurseries.

A gender-sensitive training programme grounded in the female farmer-to-farmer strengths-based and interactive training approach was implemented in both Fiji and Vanuatu as a strategy to better engage women in agroforestry and build their capacity based on their

priorities. The gender-sensitive training programme was based on the concept of women only ‘storian sessions’ which enables a collaborative environment to address the research problem and empower communities. These culturally appropriate (‘Talanoa groups’) enable female participants to participate in a non-threatening environment in Fiji.

This programme was conducted with six female Ni-Vanuatu farmers over 12 months, meeting each month. The training used peer-to-peer, activity-based learning methods with participants working through a series of training activities and discussions. New knowledge, skills and competencies were developed in topics such as agricultural, livestock extension and financial management through sharing of existing local knowledge and experience.

6 Achievements against activities and outputs/ milestones

The project team took a transdisciplinary, integrated value-chain approach. Many activities had multiple impacts across several objectives and milestones and produced a range of impacts throughout the value chain. Here, we have allocated activities to the most relevant milestone.

Objective 1: To Identify multipurpose agroforestry crops with market potential to be value-added in all four countries

no.	activity	outputs/ milestones	completion date	comments
1.1	Inventory and review donor, government, NGO and private programs promoting agroforestry value chains in all four countries	Interim report Report summarising insights from previous studies	Yr1 M2 Yr 1 M 6	An inventory and review of donor, government, NGO and private agroforestry programs was undertaken in all four countries (Appendix 11.1).
1.2	Conduct key informant interviews and desk studies to analyse existing evaluations of projects and policies identified in activity 1.1	Interviews completed and report produced	Yr2 M4	Key interviews and desktop review were undertaken (Appendix 11.2).
1.3	Select the high value agroforestry crops	Report on species selected in 4 countries	Yr1 M9	Priority agroforestry crops were selected for each country in a collaborative process with project partners and stakeholders (Appendix 11.1).
1.4	Surveys of smallholder farmers (males and females) and review of the literature at the start of the project to establish a baseline and understand the value chain, adoption behaviour, practices on the farm, labour trade-offs and the role of women	Interim report Baseline smallholder survey and data from previous projects will be collected for appropriate crops across all four countries	Yr 1 M12 Yr 2 M12	Surveys, literature review and market surveys have been analysed and reported to provided valuable insight into consumer demand. These have provided industry partners with opportunities (Appendix 11.3).

1.5	Use a value chain framework to examine, identify and analyse constraints and opportunities for priority agroforestry value chains in all four countries through a mixture of structured interviews and representative sample surveys	Analysis of all structured interviews and representative sample surveys Report detailing the insights from the analysis and communication of these results back to all relevant private and public sector stakeholders	Yr2 M12	Insights and details from the surveys, literature review, farmers surveys, producers' surveys and the Oxfam survey were disseminated to industry partners. Training programs have provided opportunities to increase participation in the value chain (Appendix 11.4). Three case study videos in Fiji and Solomon Islands have been developed. These demonstrate the real impact stories from people that this project is helping. These can be viewed on: https://vimeo.com/389910080/eefd3ed6ac https://vimeo.com/423068750/c6c4431839 and https://www.youtube.com/watch?v=BMEvO4-H8go
1.6	Improve the performance of priority value chains and targeted value-added products by researching a further level of detail on market requirements and value chain improvement opportunities	**Communicate market requirements and value chain improvement opportunities to project partners and stakeholders** Report on improvements made to selected value chains	Yr3 M12 Y4 M9	Market requirements and insights from this project have been disseminated to stakeholders and participants of the various training sessions and workshops.

PC = partner country, A = Australia

Objective 2: To Enhance small to medium enterprises ability to participate in value-adding

no.	activity	outputs/ milestones	completion date	comments
2.1	Identify key research gaps in value-adding for each crop in each country	Report detailing key processing needs for target crops in each country	Yr1 M9	Processor key needs were identified and have informed processing research.

2.2	Undertake research on processing methods for each crop in each country	Interim Report Methodologies and techniques for value-adding that are appropriate to each country and market requirements, e.g., methods of cracking, oil extraction, packaging, food safety standards etc. **New value-added products from tree-crop systems**	Iterative research in each country Yr 2 M11 Yr 3 M12 Yr 4 M12	Research to create value-added products has been undertaken in 4 countries. Chemical composition and variability in *Terminalia* and *Barringtonia* nuts (Van, SI, Fiji) has been undertaken and new value-added products developed. Research on bees and honey was undertaken in PNG.
2.3	Identify opportunities, incentives and barriers that enable adoption of value-adding	SWOT and market analysis considering the economic sustainability for each product. Financial analysis and economic impact assessment of selected commercial products	Yr 2 M12 Yr 2 M6 Yr 4 M6	Plant nurseries and nursery training were identified as opportunities for involvement in Agroforestry production (Appendices 11.7 and 11.8). A cost-benefit analysis of a medium sized Melanesian business assessed growth opportunities and is being used to assist management decisions.

PC = partner country, A = Australia

Objective 3 Enable smallholder and gender equitable participation in agroforestry crop production.

No.	Activity	Outputs/ milestones	Completion date	Comments
3.1	Identify opportunities, incentives and barriers that enable participation in agroforestry crop production.	SWOT analysis considering the social/cultural, environmental and economic sustainability of smallholder participation in agroforestry crop production. Identify land tenure constraints to revegetation in Fiji and Vanuatu	Yr 1 M12	Swot analysis of agroforestry in Fiji and Vanuatu identified land tenure constraints (Appendices 11.5 and 11.7). Lack of nurseries was a major barrier to participation and has been addressed by several nursery workshops (Appendix 11.6).

3.2	Identify which gender may benefit at which stage of the value chain, and determine whether women can be drawn into those activities that add the most value	Literature review considering gender issues in value-adding and agroforestry crop production.	Yr 2 M12	A literature review considering gender issues in value-adding and agroforestry crop production was completed (Appendix 11.8).
3.3	Address issues surrounding women's involvement in income generating activities and disseminate information from project down to women.	Formation of participatory women's groups which brings together women from neighbouring communities to enhance women's skills for income generation. **Use the participatory women's groups to disseminate information and educate women on agroforestry crop production and income generating activities.**	Yr 1 M5	Increasing women's income through nursery training for Women's Participatory groups was identified (Appendix 11.9). Women's PAR groups were established in Nadroumai (Viti Levu - Fiji), with ACTIV (Port Vila – Vanuatu) and with Lapita Café (Malo - Vanuatu) to facilitate training and disseminate information.

PC = partner country, A = Australia

Objective 4: Develop and pilot testing of catchment revegetation systems linked to markets

No.	Activity	Outputs/ milestones	Completion date	Comments
4.1	Recommend species for planting in Fiji and Vanuatu at upper, mid and lower catchments	A range of species as best bet options within catchments that have multipurpose outcomes for communities and the environment documented. Report detailing the market opportunities for different species and how these can incorporate in existing and improved production systems	Yr1 M9	Recommended species have been identified and included in the agroforestry pilot sites. **Tree species** include: *Barringtonia procera, Barringtonia edulis, Terminalia catappa, Inocarpus*, *Artocarpus*, *Santalum* and Citrus. **Cash crops** include coffee (Sigatoka), pineapples and vegetables (Labasa) and cocoa (Efate and Santo).

4.2	Support pilot planting of agroforestry crops with other projects such as FAO/GEF	Pilot Site Design and establishment report for 3 sites **Trials established in 3 locations (2 in Fiji and 1 in Vanuatu)**	Yr 1 M9 Yr2 M6	3 Demonstration sites were established: in Nadroumai (Sigatoka, Fiji) and Labasa (Vanua Levu, Fiji) and Santo (Vanuatu). Additional sites were also established. Ongoing development of the 3 demonstration sites has continued. To provide enough planting material for the pilot sites and additional demand, nurseries have been established by women's community groups in Fiji and Vanuatu.
4.3	Monitor growth and yield of produce from demonstration plots	Interim Report on growth and productivity in Pilot sites. Final report and workshop listing supporting needs such as nurseries, infrastructure and training/capacity building Report on scaling up as well as recommendations for ongoing pilot expansion.	Yr 3 M11 Yr4 M11	In Fiji, the nursery at Nadroumai has sold 4,000 seedlings (>$10,000FJD) since the start of the project. The nursery also has 10,000 eucalyptus and 30,000 pine seedlings. This year, sales of vegetable from the Nadroumai demonstration plot generated an additional $1500.00FJD.
4.4	Monitor sediment and nutrient status of the pilot sites. Provide information on erosion and nutrient status to modelling efforts at the catchment scale.	Report on baseline situation in afforestation sites Report on impact of tree planting on water quality and sediments at 3 pilot sites.	Yr 2 M6	Fiji: SCU undertook initial monitoring of soil nutrient status and soil permeability at both Nadroumai and Labasa. As there has been extensive logging of the catchment, it is impossible to measure sediment and water quality in the reef areas and downstream from the pilot site. Vanuatu: SCU collected baseline data on soil nutrient and permeability during 2018 and 2019. Final report Appendix 11.10.
4.5	Explore mechanisms to facilitate funding of catchment revegetation by tourism operators	Discussion paper exploring mechanisms to facilitate funding of catchment revegetation by tourism operators	Yr2 M 12	The project team influences the Vanuatu Government policy to finance conservation from sustainable tourism certification.
4.6	Identify current constraints to supplying the tourism industry with locally grown produce and strengthen linkages between producers and tourism industry stakeholders.	Participatory action research (PAR) group formed and strengthen linkages between producers and tourism industry stakeholders. **Report on PAR to identify current constraints to supplying the tourism industry with locally grown produce**	Yr2 M2 Yr 2 M12	The project team has worked with the Vanuatu Sustainable Tourism Policy Committee to develop policy that increases agroforestry capacity and the linkages between producers and tourism industry.

Objective 5: Build capacity and disseminate research findings

No.	Activity	Outputs/ Milestones	Completion date	Comments
5.1	Conduct a training needs analysis, an impact pathway analysis and a monitoring and evaluation plan	Workshop conducted training needs identified impact pathway analysis produced M & E plan created, M and E conducted	Yr1 m3 Yr 2 M6 (M&E) Yr 3 M9 (M&E)	Workshops to Identify training needs of stakeholders were undertaken. A Participatory Impact Pathway Monitoring and Evaluation Plan has been developed and revised at the midterm reviewed in 2018 to reflect changes in the project. Three videos to demonstrate the outcomes from this project have been produced and are available on the links below: Fiji- Nadroumai Nursery https://vimeo.com/389910080/eefd3ed6ac Solomon Islands- Producer and farmers: https://vimeo.com/423068750/c6c4431839 Fiji - Food Inspired training: https://www.youtube.com/watch?v=BMEvO4-H8go
5.2	Conduct a training workshop on a range of value chain techniques	Workshop conducted	Yr 1 m 12	Training workshops in food safety and value-adding were conducted in Fiji (12), Solomon Islands (2) and Vanuatu (4). 529 women and 87 men participated in these workshops. Once Covid hit, value chain and value-adding training workshops were conducted in Fiji to focus on the domestic market. Additional training was provided at the joint workshop with the Master Tree Growers association in Malo (Vanuatu).
5.3	Build capacity in business management value-adding and processing techniques with training workshops, especially for female participants	**Training workshop delivered to 30 public and private sector stakeholders in each country**	Yr 2 M5 Yr 4 m6	Training workshops to build skills in business management and value-adding have been delivered and are detailed under Section 7: Key Results and Discussion (Table 5).
5.4	Connect private sector SME participants with mentors, especially female entrepreneurs	Report on the opportunities for different stakeholders that identifies how women can be drawn into those activities that add the most value	Yr 3 M12	Networking between industry partners has occurred across the 4 countries and has resulted in increased capacity of entrepreneurs and women groups.

5.5	Build capacity in agroforestry crop production especially for female smallholders by running field demonstration days	Demonstration days delivered to 200 public and private sector stakeholders in Fiji and Vanuatu Communication and extension Report- including extension material and case study to stakeholders in Fiji and Vanuatu	Yr 3 M12 Yr 4 M6	Capacity building workshops for women and smallholders have been undertaken to demonstrate appropriate technologies. These have included the following: Trees in Agriculture and Enhancing returns from Agroforestry species workshops. Training workshops to build capacity is detailed under Section 7: Key Results and Discussion (Tables 5,7 and 8).

7 Key results and discussion

We researched market opportunities and value chain constraints using an integrated value chain approach for a suite of agroforestry products. Commercial, cultural and environmental drivers were considered as part of the value chain analyses. The research identified opportunities in the fruit, nut, honey and tree nursery industries and then focussed on appropriate value-adding, small scale processing and drying techniques as key enablers of industry development. The project team adopted an integrated value chain approach and were truly transdisciplinary, since the researchers from different disciplines worked together to address project challenges and create new knowledge.

This approach resulted in several new value-added products and produced livelihood benefits for many stakeholders. These new products and benefits included new nut products (Solomon Islands), linking processers to export markets (Vanuatu), women's nurseries to support tree planting and improvements to coffee production (Fiji) and resources to help smallholders produce honey (Papua New Guinea).

The impacts and livelihood benefits of the project on industry partners, smallholders, and new producers who have commenced producing value-added products are highlighted in three videos:

- A video reporting outcomes from the work with the Nadroumai women's group, Shangri-La resort and Bula Coffee at Nadroumai (Fiji) is available at: https://vimeo.com/389910080/eefd3ed6ac
- A video reporting outcomes working with Jedom trading and the women from Kolupa village (Solomon Islands) is available at: https://vimeo.com/423068750/c6c4431839
- A video report detailing value-added training at HART village working with Food Inspired (Fiji) is available at: https://www.youtube.com/watch?v=BMEvO4-H8go

Objective 1. Identify multipurpose agroforestry crops with market potential to be value-added in all four countries (PNG, SI, VAN, Fiji)

The needs of the private sector were assessed in the first year of the project and the learnings from the first year's research are detailed in Appendix 11.1. The needs of the private sector changed as the project evolved and some of the learnings from year one and the later years are discussed below.

1.1 Inventory and review donor, government, NGO and private programs promoting agroforestry value chains in all four countries

1.2 Conduct key informant interviews and desk studies to analyse existing evaluations of projects and policies identified in Activity 1

Key findings from the evaluation of policies and past and existing projects:

We found that in PNG and Fiji, improving opportunities for value-adding is a critical part of the national development strategies. Previous ACIAR projects in the Pacific have demonstrated that value-added products from agroforestry crops can enhance livelihoods and the stakeholders interviewed strongly endorsed the need to develop and demonstrate agroforestry cropping systems that provide livelihood benefits and address issues in degraded catchments. This research highlighted methods to enhance opportunities for women.

The research also highlighted that smallholders need the confidence that the agroforestry produce will be economically profitable and will work in a socially acceptable manner. Short term cash flow is needed to provide return on investment while tree crops are growing.

1.3 Select the high value agroforestry crops

Crops were chosen from the selection criteria according to their economic (market), social (cultural) and environmental potential. The main crops identified for particular focus by country included:

Papua New Guinea

- Dried fruit – addresses issues with cold chain logistics, while building on opportunities with experienced commercial project partners such as New Guinea Fruit Company. Crops with most potential include pineapple and mango.
- Honey – link into existing ACIAR project on the impacts of mites on productivity and ACIAR's Canarium project with regard to encouraging retailers to take more locally produced products.

Fiji

- Coffee – leveraging supply opportunities with commercial enterprises Bula Coffee, with trials including both wild coffee, and coffee planted in differing agroforestry systems and sites.
- Drying and Processing Fruits and Nuts – Linkages with project partner Friends and its established network of growers. Particular interest in breadfruit flour and three nut varieties (Tavula, Vutu and Ivi). Drying remains of interest to avoid shelf-stability and cold chain logistics issues.
- Agritourism – across the agroforestry trial sites and the various crops, linking resorts' restaurants to producers and their environmental and production 'stories'. Nadroumai Village and the Shangri-La Resort are Trail Site 1.

Vanuatu

- Drying and processing fruit and nuts – Techniques for cracking (nuts) and drying (fruit and nuts) explored with products including Canarium, *Terminalia*, Tahitian chestnut, *Barringtonia*, Breadfruit, Mango, Cocoa and Pineapple produced in integrated agroforestry cropping systems.

Solomon Islands

- Processing and drying nuts – Strong links possible with other ACIAR projects being undertaken in PNG on drying techniques for nuts, particularly Canarium, *Barringtonia*, King Tree and Tahitian chestnut.

1.4 Surveys of smallholder farmers (males and females) and review of the literature at the start of the project to establish a baseline and understand the value chain, adoption behaviour, practices on the farm, labour trade-offs and the role of women;

1.5 Use a value chain framework to examine, identify and analyse constraints and opportunities for priority agroforestry value chains in all four countries through a mixture of structured interviews and representative sample surveys

We used survey results and a literature review to improve understanding of the value chain, adoption behaviours, on-farm practices, labour trade-offs and the role of women in agriculture. We then applied a value chain framework to identify the constraints and opportunities for value chains across the four countries.

Knowledge gaps, blockages in the existing supply/value chains and common challenges and opportunities across all four countries have been identified (Appendix 11.2 and Appendix 11.3).

The following opportunities were identified by structured interviews and the literature review:

- Value-adding can improve food security
- There is increasing understanding for the need to integrate land planning
- There is willingness within the tourism industry to become involved in agritourism
- Large donor-funded reforestation and agricultural diversification programs (FAO-GEF has a pilot project that focuses on conservation of critical catchment areas, such as coastal zones, hills and gullies)

The Fijian survey revealed the following:

- The top permanent crops grown in Fiji are chillies, pawpaw, banana, dhania, duruka, pineapple, cassava, coconuts, dalo, sugarcane, and yaqona (Kava).
- The main commercial crops grown are eggplant, tomatoes, okra, long beans, Chinese cabbage, cucumber, English cabbage, watermelon, bora beans, and pawpaw.
- Farmers mainly sell in markets or roadside stalls to buyers because they pay cash.
- Most farmers experienced an improved standard of living in their household.
- Most of the decision-making is undertaken by the wife and husband together. Female respondents were primarily deciding herself on decisions about the children's health and education and the household's livelihood strategies.

The following constraints were identified:

- Smallholders need confidence that agroforestry plant will produce income
- Smallholders need incentives in the short and medium term to encourage investment in tree crops
- Need to incentivise smallholders through training
- Need to strongly engage with the private sector and encourage small-scale entrepreneurs to enhance value-adding to products.

The insights gained from surveys of consumers, retailers and tourist operators have informed subsequent project activities to better understand targeted value-added products, market requirements and value chain improvement opportunities.

1.6 Improve the performance of priority value chains and targeted value-added products by researching a further level of detail on market requirements and value chain improvement opportunities

We used the survey of Oxfam customers to provide insights into the purchasing patterns of ethical Australian consumers, the potential for value chain development and export of products from the Pacific to Australia. Results from the survey indicated that 90% of Oxfam customers believe that giving back to communities in need was very important. They are willing to help but want high-quality and unique products (80%). 75% prefer foods with pure or natural ingredients and 64% enjoy travel and supporting places they have visited. The main motivation to purchase products from the Pacific is the "story behind the product". Information was disseminated to producers in Fiji, Vanuatu and Solomon Islands. This project has used this information to support industry partners to improve packaging and labels to tell their unique story.

When considering what recommendations can be made from a study such as this one, it is useful to look at the different stakeholder groups.

From the perspective of the producers and value-adders in the Pacific there are several useful insights on which they can act upon:

- There is demand for Pacific products from ethically conscious Australian consumers, with 67.5% of Oxfam Australia Trading respondents registering an interest in purchasing products from Fiji, Vanuatu, Solomon Islands or PNG
- The target market tend to be mainly women, who have a high level of education, are more mature in age, are either working or retired, belong to a middle to high income group and might only purchase products every few months or once a year.
- While price is always going to have some importance, enterprises in the Pacific need to keep in mind that it ranks very low in important attributes with this consumer group, so how they communicate the important attributes (physical and non-physical) of their product becomes a lot more important.
- Considering the importance this target group put on the 'story' of the product and the 'brand' of the retailer, it is important that Pacific-based exporters don't just pick the first market channel that offers to buy their product to sell into the Australian market. A better strategy would be to do some homework and assess the suitability of that buyer to not only meet their price, quality and service needs, but also consider whether they will be able to service the targeted market and continue to sell the 'story' of their product.
- Engagement and sales through an online platform will no doubt grow more in a range of business models as consumer shopping patterns continually evolve. Companies will need to keep this in mind when they are developing their own sales strategies as well as when assessing the retailers they may be looking to partner with.

From the perspective of other stakeholders such as ACIAR, other funding agencies and relevant government departments across the Pacific, it is important that this type of market opportunity is better understood so an appropriate enabling environment can be created to help support Pacific enterprises wanting to export their products. Some of the key insights to note include:

- The country of origin within the Pacific doesn't seem to matter much to this consumer group, so marketing efforts could be based on the broader Pacific angle. This is a significant marketing insight, as a collective or umbrella brand could be a way of networking Pacific producers and reducing the financial and general business risk and cost for smaller producers, while having a greater cut-through with the target market.
- There is a strong willingness to purchase Pacific products even if Australian customers haven't visited the Pacific before which gives some hope to countries like PNG and the Solomon Islands that don't have the larger tourist industry that Fiji and Vanuatu do. However, if Australian consumers have visited the Pacific, then they are more aware of the local products which raises their willingness to purchase even more (80%). This is especially the case for chocolate, coffee and indigenous nuts that seemed to enjoy a substantial increase in demand from respondents who had visited the Pacific before. This highlights the need to work closely with the tourist industry when looking to promote the export of local products.
- Certification can be an important driver of consumer purchasing behaviour, but it is important to understand what this means from a consumer perspective. The study of the 5 logos in this project has shown that the retailer brand can be just as strong in communicating some of the values of the certification schemes. Companies will need to make individual choices around what best suits their needs and the value chains and markets they are looking to sell into, but aid funders and policy makers need to keep this in mind when recommending and delivering larger projects

Negotiations with Oxfam resulted in chocolate sales by ACTIV (Vanuatu) of $17,490.00. Although Oxfam Australia has ceased trading, the results are still relevant. Ongoing negotiations are proceeding with Trade Aid NZ and Beanbaryou to further increase trade from Pacific industry partners into NZ and Australia.

The impacts of Objective 1 have also been shown through less-traditional methods such as including filmed interviews with stakeholders, to more effectively demonstrate the genuine impacts made in the personal accounts of the individuals and communities this project aims to benefit.

Objective 2: Enhance small to medium enterprises ability to participate in value-adding (PNG, SI, VAN, Fiji).

2.1 Identify key research gaps in value-adding for each crop in each country

Discussions with private sector processing partners identified research priorities for value-adding in each country. Value-adding opportunities in 3 of the 4 countries focused on drying tree nuts as they are rich in protein, improve food security and do not require cold chain logistics. Processors were particularly interested in *Terminalia* and *Barringtonia* as they provide processors with another range of raw products to utilise their factory during different seasons. Processors were also interested in drying fruit for similar reasons. Obtaining larger kernels increases financial returns for farmers and processors. Coffee and honey were also identified. Our research identified key research gaps in each country as follows:

Fiji: A coffee producer who was purchasing wild harvested coffee, was interest in improving coffee genetics and increasing production. Assistance was provided with advice on, and equipment for, drying to maintain quality and developing new packaging. This has resulted in expansion of the business and export sales. Impacts are detailed below (under capacity impacts).

The project team identified an opportunity for the Nadroumai Women's Club to propagate trees and sell them as there is currently strong demand for trees for reforestation in Fiji. The project team has assisted the NWC with propagation materials and provided ongoing training and mentoring for the plant nursery.

An opportunity was identified to provide training for women selling fresh produce in the market to value-add and market their produce to up-chain customers. These up-chain customers needed reliable and consistent high quality, food safety, lists of ingredients on the label and high-quality packaging. This training was aimed providing an opportunity for these women to engage with up-chain customers such as resorts and the food service sector.

Vanuatu: A processor expressed interest in developing tree nuts and fruit into an integrated agroforestry crop system. This system included manioc, which is often difficult to source, to ensure supply for their value-adding processing facility. Research on drying methods, composition and nutritional analysis for products developed was also identified. Another producer identified a need to access export market opportunities for single origin chocolate.

Solomon Islands: The tree nuts of interest to processors were Ngali (*Canarium indicum*), Alite (*Terminalia catappa*), and Katnut (*Barringtonia* spp.). Specific research needs included drying methods and technology and new product development. Nutritional and compositional analysis of developed products and solar drying technology was required. Nutritional analysis of dried fruit (pawpaw, pineapple, banana and muesli) was also required.

Papua New Guinea: Beekeepers required more information about the floral sources of the honeys. Research on floral sources of honey and impact of agroforestry species on bee

nutrition has been undertaken. Although interest was expressed by a processor in value-adding dried pineapple and banana, engagement with the private sector failed to occur.

2.2 Undertake research on processing methods for each crop in each country

This activity was a major component of the project. We examined a range of products and technologies for the opportunities identified above. Our research activities focused on the following aspects of value-adding, processing and agroforestry for the identified crops:

- **Variability in nut size.** This is important for commercialisation as larger kernels increase the return for effort for both farmers and processors (Pakau et al. 2010; Wallace et al. 2016). Samples of *Barringtonia*, *Terminalia* and *Canarium* fruit were collected from Solomon Islands, Vanuatu and Fiji for to assess size.
- **Chemical composition of nuts.** This affects the storage potential of value-added products. Chemical analyses of nuts provide information on the health benefits, nutritional analysis, and shelf life of value-added products.
- **Drying techniques for fruit and nut products.** Drying stabilises the products enabling farmers and producers more time to store and sell their produce.
- **Nutritional and microbial analysis.** Nutritional analysis is required for nutritional labels for up chain customers, particularly export markets. Microbial analysis ensures processors methods are safe and provides consumer with confidence in the food safety of the product.
- **Bee and honey research** were undertaken in Papua New Guinea. Our market research identified the potential for a niche honey industry based on Papua New Guinea rainforest honey. The bee research was focused on the floral sources of honey in the Eastern Highlands of PNG, and ways to provide resources for smallholders to improve bee health and beekeeping skills.

Key findings:

Variability in Nut size (Van, Solomon Islands, Fiji)

The size of *Canarium harveyi*, *Barringtonia* and *Terminalia* kernels from trees in Vanuatu, Solomon Islands and Fiji was examined to improve the commercialisation.

Canarium harveyi nuts from Santa Cruz Island in the Solomon Islands displayed low within-tree variation (32.9 g – 39.3 g) in fruit weight and (4.31 g – 6.05 g) in kernel weight.

Barringtonia spp.

The fruit mass in Vanuatu and Fiji was significantly higher than that of Solomon Islands (66.38 g, 65.52 g and 61.41 g, respectively (Figure 2a). The average kernel weight *Barringtonia* spp. varied between Solomon Islands (9.95 g), Vanuatu (7.61 g) and Fiji (5.63 g) (Figure 2b). The average kernel to fruit ratios were 8.55% for *Barringtonia* spp. in Fiji, 16.27% in Solomon Islands and 12.59% in Vanuatu (Figure 2c).

Tree-to-tree variations in kernel mass and kernel to fruit percentage were found in all three countries. Nuts with larger kernels and kernel to fruit weight increase financial returns to farmers and processors when commercialised (Wallace et al. 2016). The kernel mass of over 3 g for the newly commercialised *C. indicum* has been suggested to be economically viable (Leakey et al. 2008). The average kernel mass of *Barringtonia* spp. was well above 3 g even in Fiji where kernel mass was significantly lower than other two countries. However, we found a high within-tree variations in the kernel weight ranging between 0.35 g and 20.99 g regardless of country of origin. This study clearly highlighted that tree selection for commercialisation of *Barringtonia* spp. would need to be at the country or even village level.

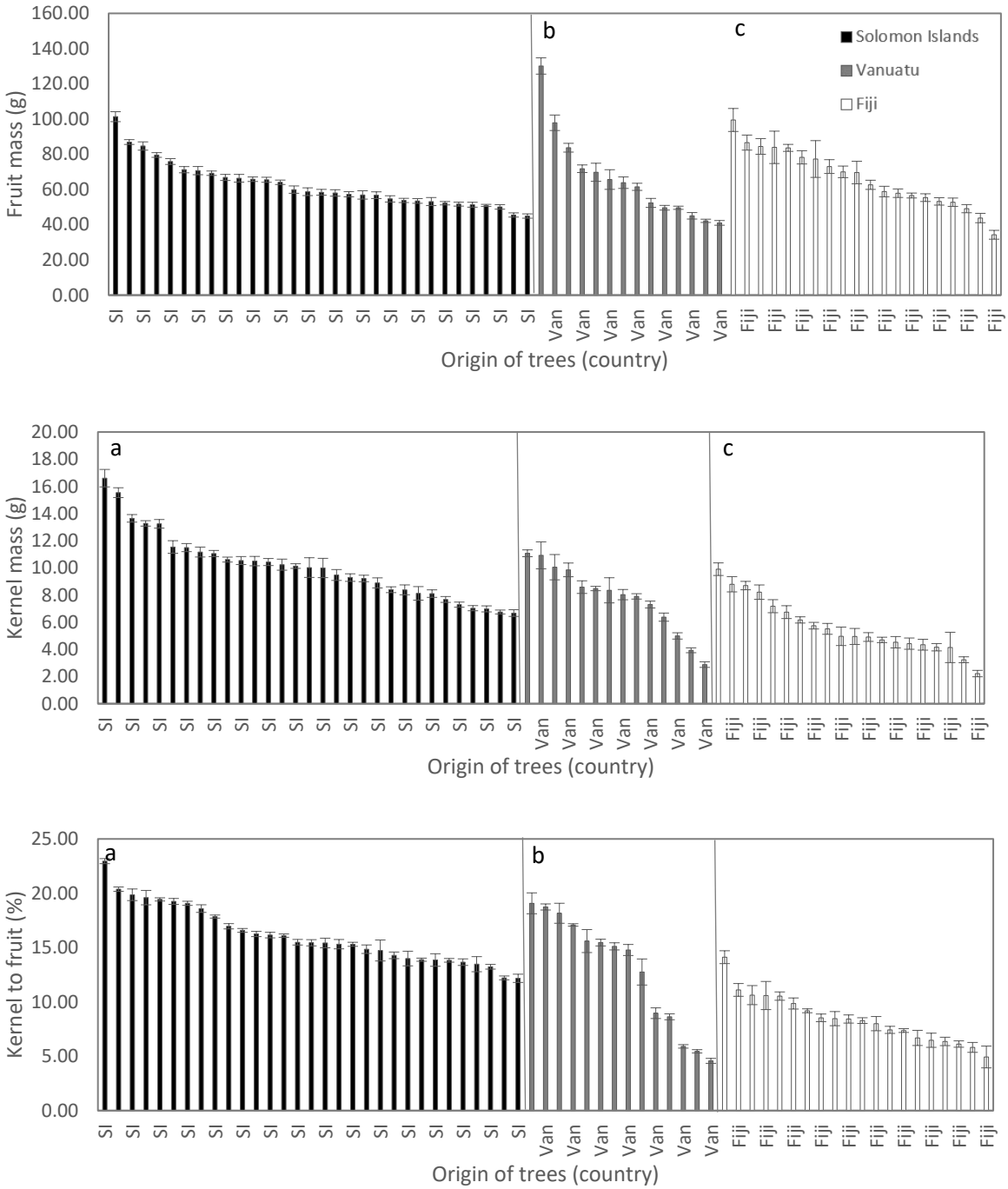


Figure 2. Mean and standard errors of fruit mass (a: Solomon Islands, b: Vanuatu, c: Fiji), kernel mass (a: Solomon Islands, b: Vanuatu, c: Fiji) and kernel to fruit (a: Solomon Islands, b: Vanuatu, c: Fiji) in *Barringtonia* spp. Solomon Islands (SI: black columns), Vanuatu (Van: Dark grey columns) and Fiji (Fiji: white columns). Differences among trees in their fruit mass, kernel mass and kernel to fruit were based on, one-way ANOVA, $p<0.05$ in each country. Modified least significant differences of fruit mass: a:1.72, b:4.05, c:1.15; kernel mass: a:0.13, b:0.15, c:0.03; and kernel to fruit a:0.7, b:0.75, c:0.65

Terminalia catappa

A significant tree to tree variations was observed for all measured kernel attributes from all three countries. Kernel mass is an important factor in tree selection (Wallace et al. 2016). The kernel mass varied significantly among trees, but the smallest kernel masses were found in Fiji. The average kernel mass for *Terminalia catappa* was Solomon Islands (1.66 g), Vanuatu (1.58 g) and Fiji (0.33 g). (Figure 3).

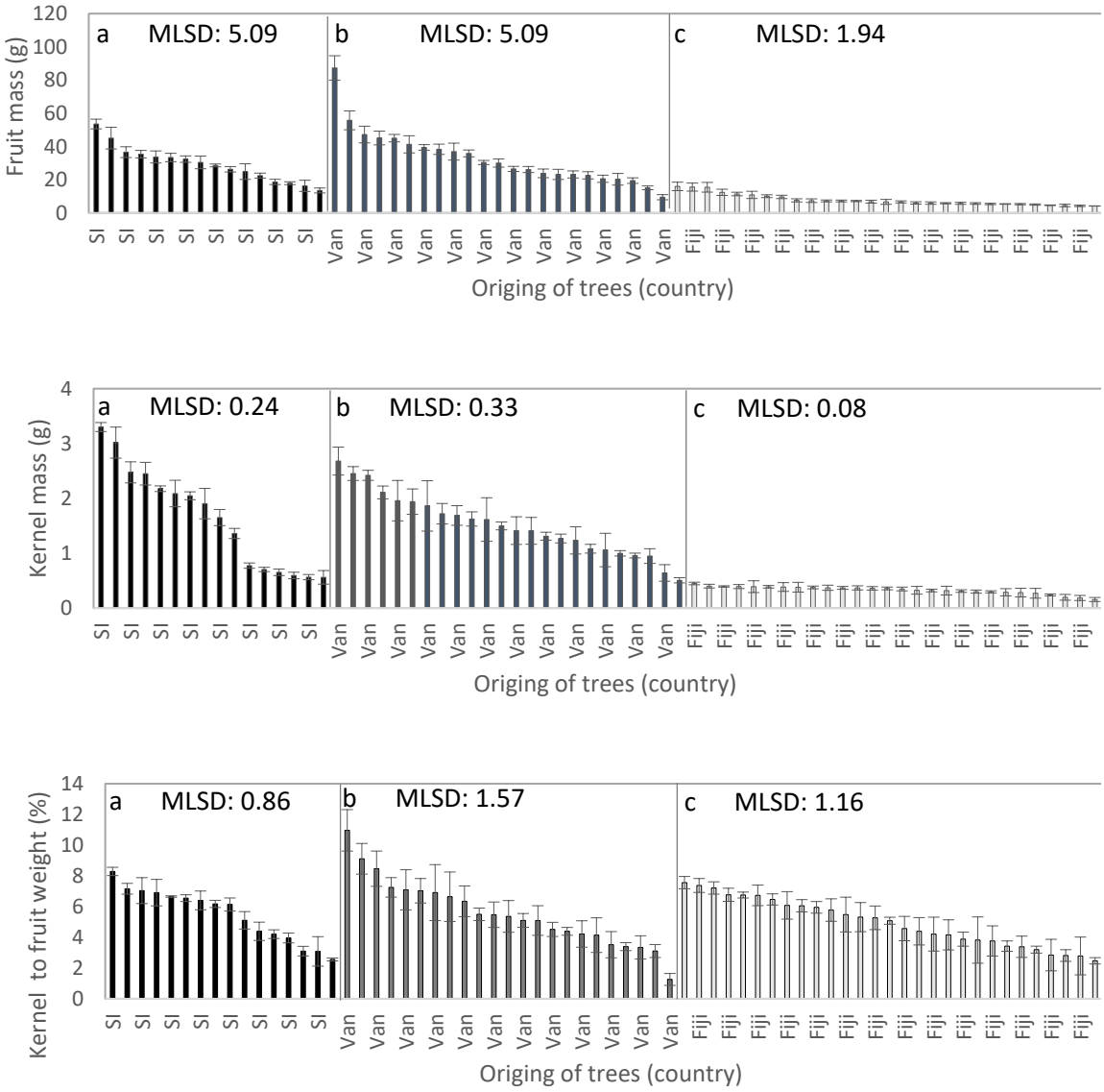


Figure 3. Mean and standard errors of fruit mass in (a: Solomon Islands, b: Vanuatu and c:Fiji), kernel mass (a: Solomon Islands, b: Vanuatu and c:Fiji) and kernel to fruit weight (%) (a: Solomon Islands, b: Vanuatu and c:Fiji) in *Terminalia catappa.* Solomon Islands (SI: black columns), Vanuatu (Van: Dark grey columns) and Fiji (Fiji: light grey columns). Differences among trees in fruit mass, kernel mass and kernel to fruit weight were significant within each country (n=30, one-way ANOVA, $p<0.05$), MLDS: Modified least significant difference of fruit mass in Solomon Islands: 5.09, Vanuatu:5.09 and Fiji: 1.94; MLSD of kernel mass in Solomon Islands: 0.24, Vanuatu: 0.33 and Fiji: 0.08; MLSD of kernel to fruit weight in Solomon Islands: 0.86, Vanuatu: 1.57 and Fiji: 1.16

Chemical composition of nuts (Van, Solomon Islands, Fiji)

Unsaturated fatty acids are beneficial for human health but are susceptible to oxidation (Bai et al. 2019; Gama et al. 2018; Ros 2010). Total oil from the *Barringtonia* and *Terminalia* trees in each country were significantly different with significant differences between trees within each country. This research is currently being prepared for two journal publications (Section 10.2). Topics include: “The physical and chemical characteristics of *Barringtonia* spp. nuts in three Pacific Island countries”, and “Physical and chemical characteristics of *Terminalia catappa* nuts in three Pacific Island countries”.

Barringtonia spp.

The average *Barringtonia* total oil was significantly higher in Vanuatu (47.11 %) than Solomon Islands (38.96%), and Fiji (26.2%) (Figure 4). There was also large variability in total oil between trees.

In general, the total unsaturated fatty acids were more dominant than total saturated fatty acids in *Barringtonia* (Figure 5). Five forms of saturated fatty acids and five forms of unsaturated fatty acids were detected (Figure 5). The dominant saturated fatty acid was C16:0 (palmitic acid) followed by C18:0 (stearic acid), C20:0 (arachidic acid), C14:0 (myristic acid), and C22:0 (behenic acid) (Figure 5). The C18:1Cis (oleic acid) was the dominant unsaturated fatty acid and C18:2 (linoleic acid) was the second most dominant unsaturated fatty acid in Solomon Islands and Vanuatu whereas C18:2 had greater concentrations than C18:1Cis in Fiji (Figure 5). The total saturated and unsaturated fatty acid concentrations varied significantly among individual trees in all three countries. The total saturated fatty acid concentrations were on average 46.08 % (Solomon Islands), 38.57 % (Vanuatu) and 31.64 % (Fiji) (Figure 5). In contrast, the total unsaturated fatty acid concentrations were on average 53.94 %, 61.44 % and 68.38 % in Solomon Islands, Vanuatu and Fiji respectively (Figure 5).

Oleic acid was the most dominant monounsaturated lipid in *Barringtonia* spp. in Solomon Islands and Vanuatu but not in Fiji. Unsaturated fats are more susceptible to oxidation than saturated fats, however, high concentrations of oleic acid have been associated with high oil stability and high oil shelf life whereas the high concentrations of linoleic acid result in low oil stability and low shelf life (Bai et al. 2019; Gama et al. 2018; Ros 2010). The oleic acid and linoleic acid concentrations are not the only factor affecting nut shelf life. The presence of phenolic compounds and antioxidants has also been associated with oil stability of nuts (Gama et al. 2018). *Barringtonia* nuts may have health benefits and prolonged shelf life when processed properly leading to additional food security.

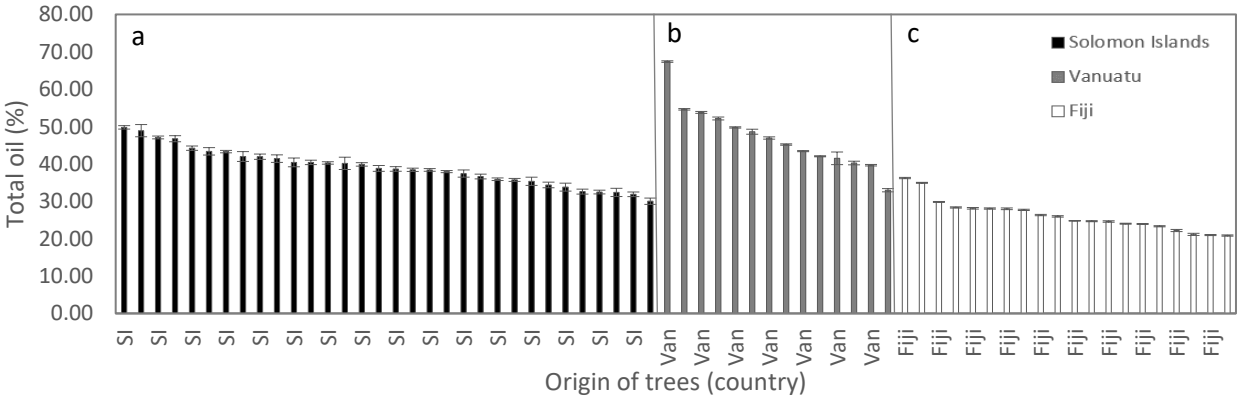


Figure 4. Mean and standard errors of total oil percentage in *Barringtonia* spp. (a: Solomon Islands, b: Vanuatu, c: Fiji). Solomon Islands (SI: black columns), Vanuatu (Van: Dark grey columns) and Fiji (Fiji: white columns). Differences among trees in their total oil were based on one-way ANOVA, $p<0.05$ in each country. Modified least significant differences of a:1.37, b: 0.92, c: 0.29

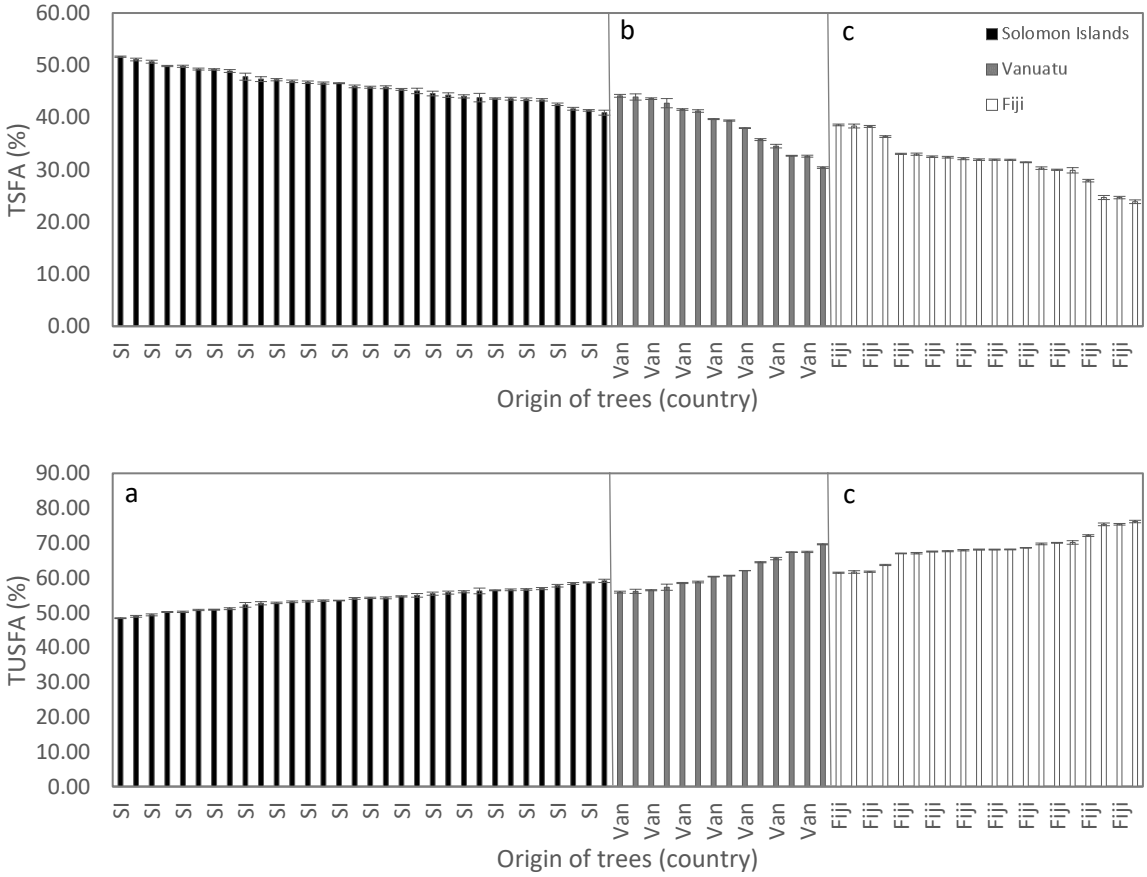


Figure 5. Mean and standard errors of total saturated fatty acid (TSFA: a: Solomon Islands, b: Vanuatu, c: Fiji) and total unsaturated fatty acid (TUSFA: a: Solomon Islands, b: Vanuatu, c: Fiji) concentrations in *Barringtonia* spp. Solomon Islands (SI: black columns), Vanuatu (Van: Dark grey columns) and Fiji (Fiji: white columns). Differences among trees in their TSFA and TUSFA were significant at each country based on one-way ANOVA, $p<0.05$. Modified least significant differences of TSFA: a:0.53, b:0.55, c:0.39; modified least significant differences of TUSFA: a:0.54, b:0.55, c:0.39

Table 1. Descriptive statistics of *Barringtonia procera* for fatty acid compositions in each country

	C14:0	C16:0	C18:0	C20:0	C22:0	C16:1	C18:2	C18:1C	C18:1T	C20:1	TSFA	TUSFA
Solomon Islands												
Mean	0.11	39.46	6.06	0.41	0.05	0.12	20.33	32.58	0.86	0.05	46.08	53.94
N	160	160	160	160	160	160	160	160	160	160	160	160
Minimum	0.03	32.66	4.82	0.25	0.01	0.04	13.46	26.72	0.27	0.02	39.66	48.15
Maximum	0.22	45.62	8.07	0.85	0.14	0.62	28.68	39.84	1.56	0.17	51.85	60.34
Vanuatu												
Mean	0.04	29.40	8.84	0.26	0.04	0.03	23.32	37.77	0.29	0.03	38.57	61.44
N	70	70	70	70	70	70	70	70	70	70	70	70
Minimum	0.01	17.01	0.63	0.14	0.01	0.01	15.35	27.19	0.00	0.01	30.17	54.37
Maximum	0.18	38.39	15.12	0.82	0.11	0.16	32.99	45.68	0.96	0.11	45.63	69.83
Fiji												
Mean	0.03	21.80	9.47	0.30	0.04	0.02	36.16	32.13	0.00	0.05	31.64	68.36
N	100	100	100	100	100	100	100	100	100	100	100	100
Minimum	0.01	14.40	4.68	0.11	0.02	0.003	21.58	17.05	0.00	0.02	22.72	60.91
Maximum	0.07	31.71	12.22	0.47	0.42	0.06	47.22	46.72	0.00	0.40	39.09	77.28

TSFA: total saturated fatty acid; TUSFA: total unsaturated fatty acids; C: cis; T: trans

Terminalia catappa

The oil content of *Terminalia catappa* varied significantly among trees in each country. The total oil was on average 59.37% (Solomon Islands), 55.34% (Vanuatu) and 56.86% (Fiji), with kernels from Solomon Islands having significantly higher total oil than Vanuatu (Figure 6). The total unsaturated fatty acid concentrations were more abundant than that of total saturated fatty acid concentrations in all three countries (Figure 6). The average total unsaturated fatty acid concentrations vs total saturated fatty acid included 54.44% vs 46.04 % in Solomon Islands, 55.70% vs 44.30% in Vanuatu and 61.40% vs 38.60% in Fiji, respectively (Figure 6b). Kernels from Fiji contained significantly higher unsaturated fatty acid concentrations than those collected from Solomon Islands and Vanuatu (Figure 6c). Both total unsaturated fatty acid and total saturated fatty acid concentrations significantly differed among individual trees regardless of country of origin. The most dominant saturated and unsaturated fatty acids included C16:0 (palmitic acid), C18:2 (linoleic acid) and C18:1Cis (oleic acid), respectively regardless of country (Table 2). This may have health benefits and prolonged shelf life when processed properly.

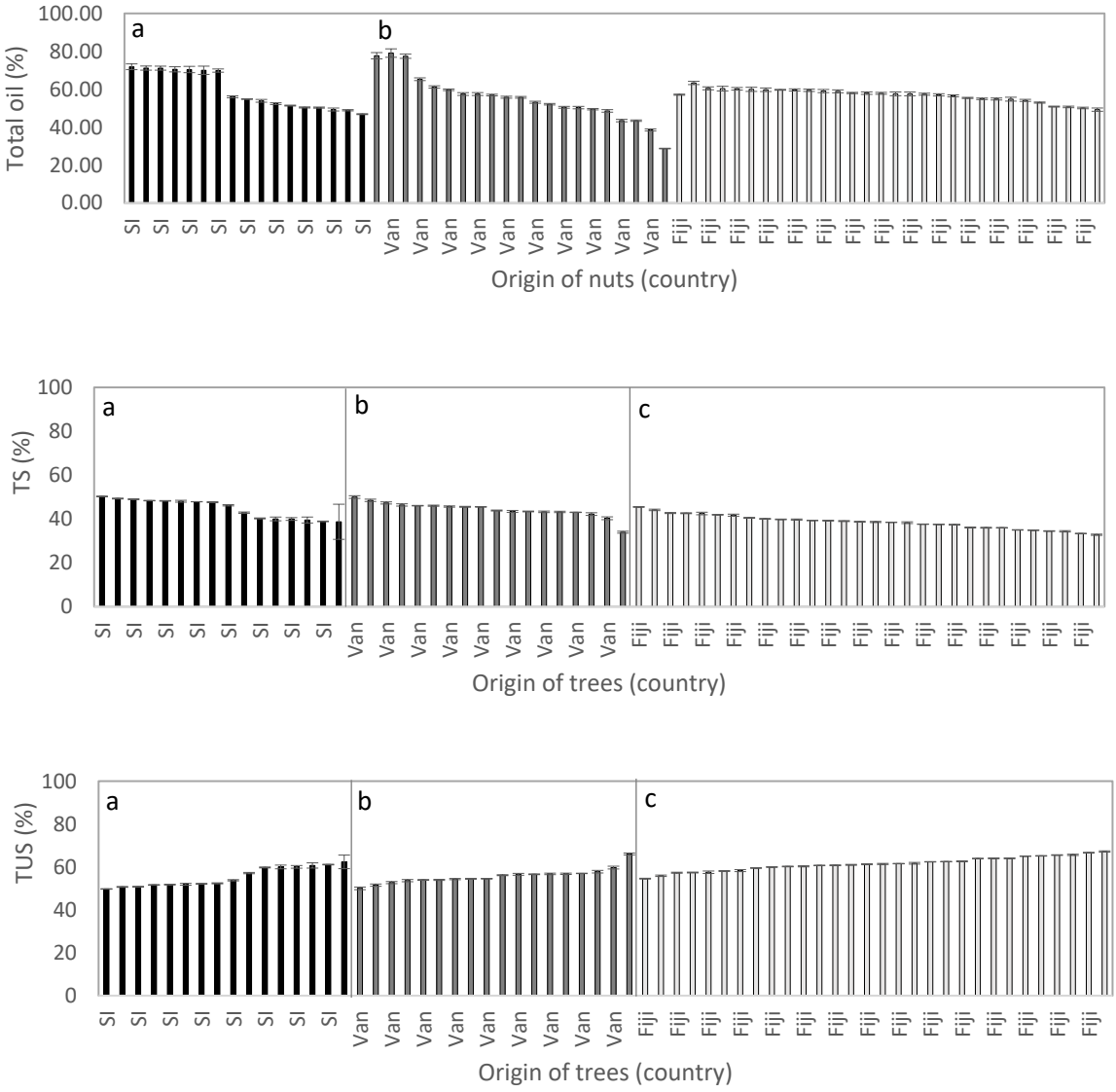


Figure 6. Mean and standard errors of total oil percentage in *Terminalia Catappa*, total saturated fatty acid (TS) and total unsaturated fatty acid (TUS) from Solomon Islands (**a:** SI, black columns), Vanuatu (**b:** Van, Dark grey columns) and Fiji (**c:** Fiji, light grey columns). Differences among trees in their total saturated fatty acid and total unsaturated fatty acid concentrations were significant at each country (one-way ANOVA, $p<0.05$), MLDS: Modified least significant difference. MLSD of TS in Solomon Islands: 2.10, Vanuatu: 0.66 and Fiji: 0.39; MLSD of TUS in Solomon Islands: 0.97, Vanuatu: 0.66 and Fiji: 0.39

Table 2: Descriptive statistics of *Terminalia catappa* for fatty acid compositions collected from Solomon Islands, Vanuatu and Fiji

		C14:0	C16:0	C18:0	C20:0	C22:0	C16:1	C18:2	C18:1 *cis*	C18:1 *trans*	C20:1
Solomon Islands	Mean	0.04	40.37	5.22	0.35	0.06	0.26	23.81	29.73	0.61	0.04
	N	68	68	68	68	68	68	68	68	68	68
	Minimum	0.03	30.29	4.18	0.21	0.03	0.12	16.52	22.12	0.29	0.01
	Maximum	0.09	55.73	7.93	0.72	0.17	0.61	33.47	36.49	1.19	0.12
Vanuatu	Mean	0.03	39.86	4.28	0.11	0.03	0.08	20.31	34.90	0.37	0.03
	N	90	90	90	90	90	90	90	90	90	90
	Minimum	0.00	28.69	2.90	0.06	0.01	0.04	12.72	27.37	0.19	0.01
	Maximum	0.11	46.74	6.70	0.18	0.17	0.16	31.63	41.93	3.21	0.09
Fiji	Mean	0.02	34.16	4.29	0.11	0.03	0.06	20.83	40.15	0.33	0.03
	N	150	150	150	150	150	150	150	150	150	150
	Minimum	0.004	27.71	2.93	0.06	0.004	0.03	12.06	30.99	0.17	0.004
	Maximum	0.06	40.91	6.94	0.19	0.07	0.12	30.10	50.20	0.58	0.07

Oil stability using accelerated aging

The initial hexanal concentrations were 30.2 ppm and reached to 149.2 ppm by day 21 following the incubation (Figure 7). The hexanal concentrations was also significantly higher in day 7 of incubation than those of at day 0 (Figure 7). As hexanal is used in the nut industry as an indicator of deterioration, this indicates the potential storage capacity.

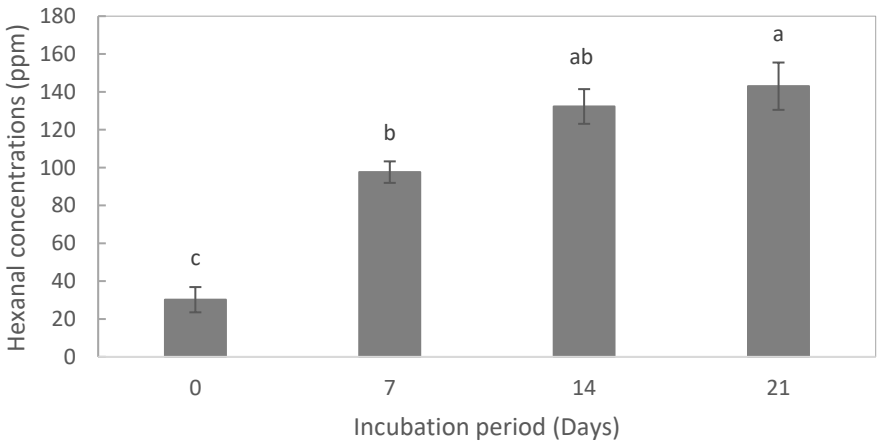


Figure 7. Hexanal concentrations of *Terminalia catappa* over 21 days of incubation at 45°C.

Drying techniques for fruits and nuts

Drying *Terminalia* and *Barringtonia* nuts (Vanuatu, Solomon Islands, Fiji)

We conducted several drying trials to dry *Terminalia* and *Barringtonia* nuts from the moisture content when harvested down to below 2% M/C. This is needed to ensure the value-added product is stabilised to minimise rancidity and mould growth during storage.

Our drying trials of found that moisture can be reduced from initial moisture contents above 25% to below 2% when *Terminalia* kernels are dried at 40°C for 9 hours. Similarly, *Barringtonia* kernels if cut in half, can be dried at 40°C for 48 hours or 45°C for 24 hours or if cut into smaller pieces before drying, can be dried for 12 hours at 45°C (Table 3).

Table 3: The duration and temperatures used for drying *Terminalia* and *Barringtonia* nuts, mean initial moisture content (M/C) and mean final moisture content of the samples. Mean standard errors have been presented in the parentheses.

Terminalia catappa	**Duration/ temperature**	**Mean Initial M/C (SE)**	**Mean Final M/C (SE)**
Solomon Islands – March 2017	6 hours at 43°C	29.9% (0.16)	8.78% (1.11)
Vanuatu – April 2017	9 hours at 40°C	43.1% (One sample only)	10.6% (One sample only)
Solomon Islands – January 2018	6 hours at 40°C	41.2% (One sample only)	No Data available
Vanuatu- March 2019	17 hours at 45°C	27.32(1.677)	1.5 (0.2129)
Barringtonia	**Duration/ temperature**	**Mean Initial M/C (SE)**	**Mean Final M/C (SE)**
Solomon Islands – March 2017	6 hours at 43°C	32.57% (1.56)	8.78% (0.68)
Vanuatu – April 2017	9 hours at 40°C	24.57% (1.48)	6.53% (1.33)
Solomon Islands – November 2017	23 hours at 46°C	24.5% (One sample only)	5.2% (One sample only)
Solomon Islands – January 2018	12 hours at 46°C	24.6% (One sample only)	No data available
Fiji – September 2018	63 hours at 40°C	33% (One sample only)	2.9% (One sample only)
Fiji – September	40 hours at 45°C	33% (One sample only)	1.8% (One sample only)

Drying fruit (Vanuatu, Solomon Islands)

We undertook drying trials for pawpaw and mango to develop appropriate drying techniques using a solar dryer (Solomon Islands) and dehydrator (Vanuatu). The solar dryer required two mostly sunny days with an expected temperature between 50-60°C and the dehydrator took 10 to 12 hours at 60°C to dry fruit to a flexible consistency yet contain no visible moisture. Using this information new dried fruit products were developed by the industry partner.

Nutritional and microbial analysis

Samples of these new products (dried pawpaw, pineapple, banana, *Terminalia* and *Barringtonia* nuts and muesli) were sent to a NATA accredited laboratory in Australia for nutritional analysis. The nutritional analysis was provided to the industry partners and used to develop packaging and labels. These products were also sent to accredited laboratories for microbial analysis to ensure the product safety.

Bee and Honey Research (PNG)

Honey has great potential as a value-added crop for farmers in PNG. We identified a range of trees and shrubs that are foraged on by bees for honey and pollen (Figures 8 and 9). Floral diversity is important for honeybees and has been shown to support honeybee health at all life cycle stages (Alaux et al., 2010). Our research has shown that rainforest trees and forest cover are critical resources for honeybees. Many of the trees we identified in the honey samples are endemic to PNG, and some were IUCN listed, near threatened hardwood timber species, that occur nowhere else.

This research is currently being prepared for three journal publications listed under publications produced by the project (Section 10.2). Topics include pollen collecting behaviours, fatty acid profiles of pollen resources and floral sources of honey.

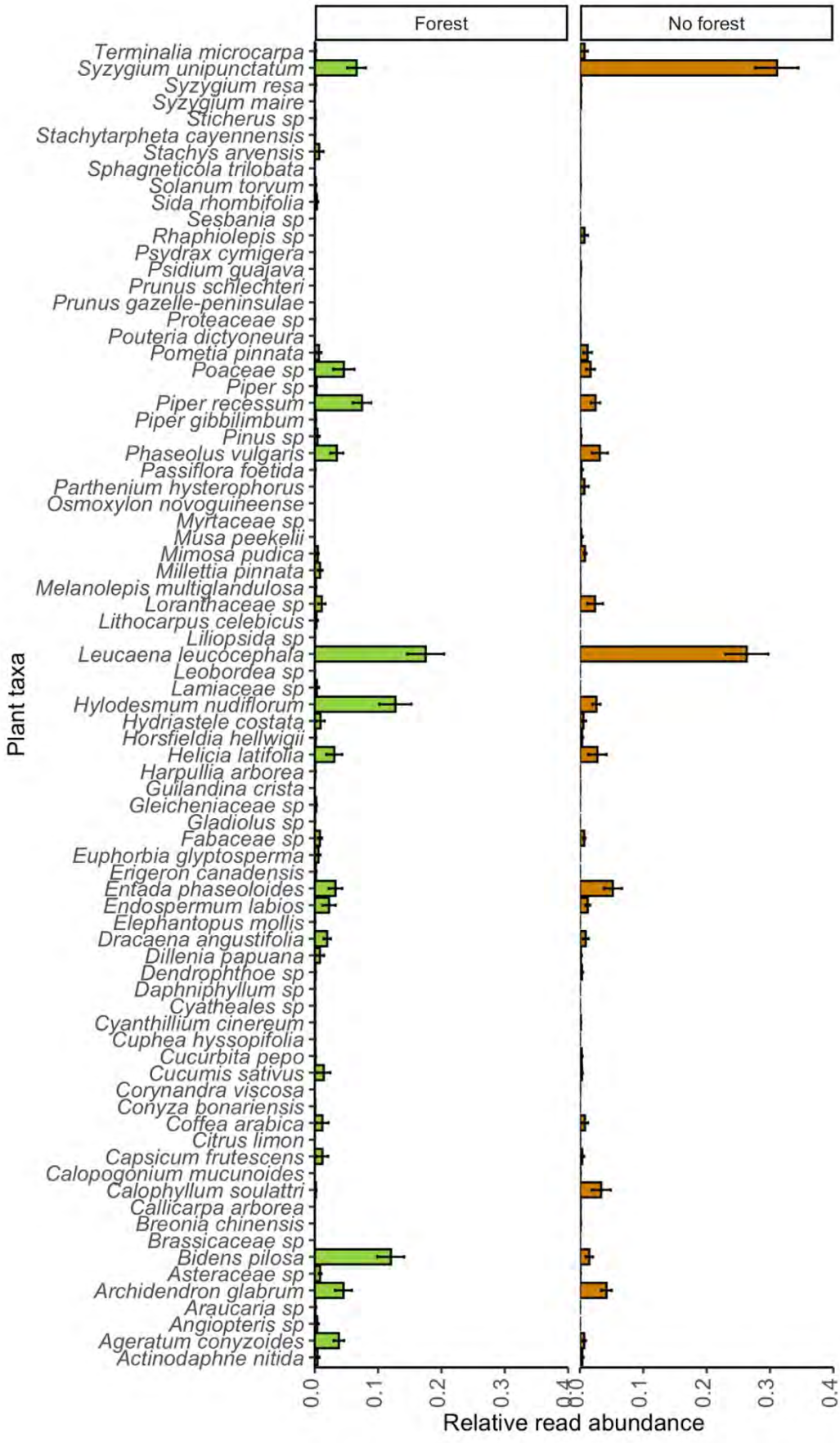


Figure 8. Mean relative read abundances for plant taxa identified in bee bread samples between Agriculture and Forest landscapes. Bar plots show mean values and error bars of relative read abundance from OTU's of plant taxa.

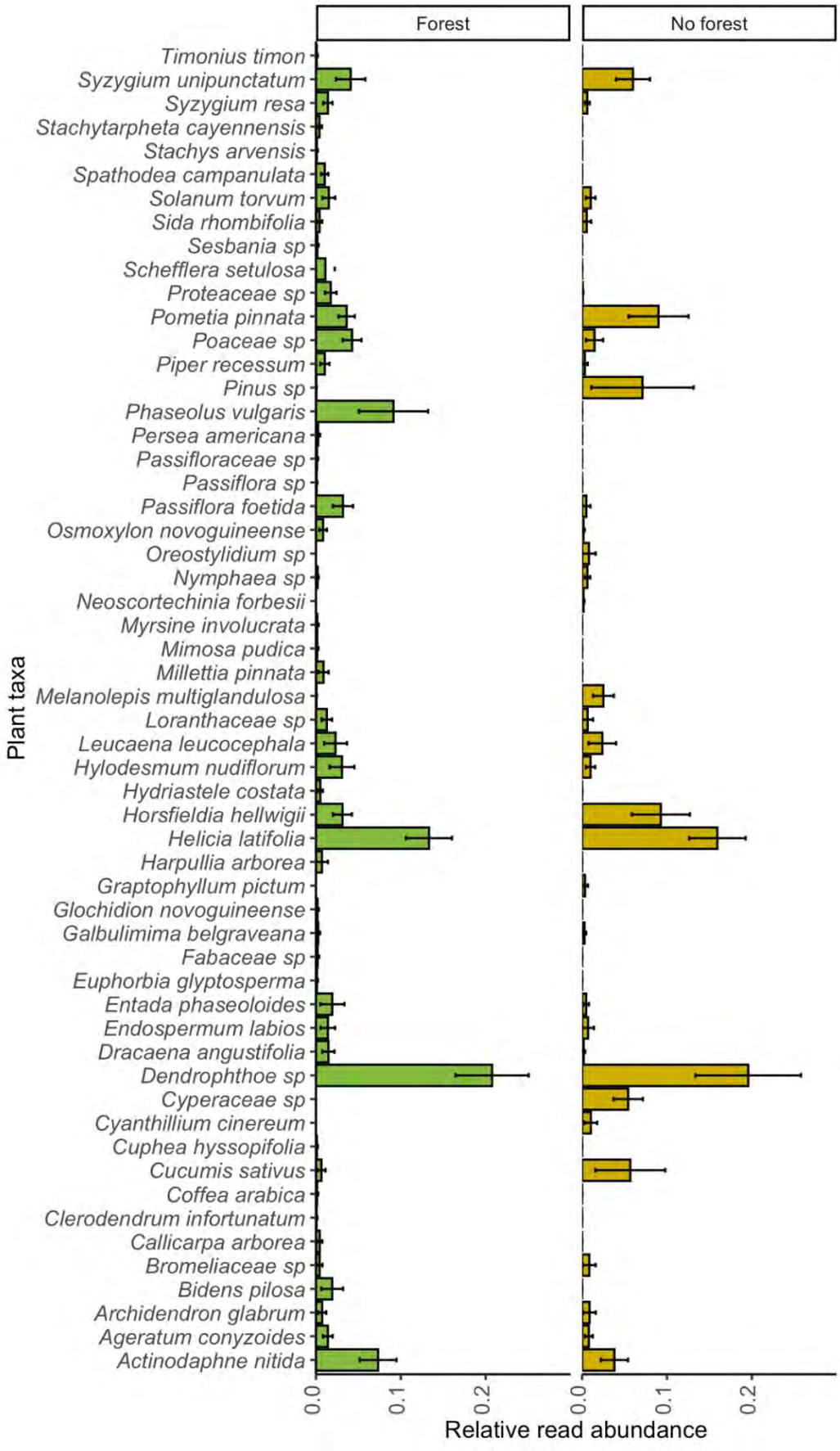


Figure 9. Mean relative read abundances for plant taxa identified in honey samples between forest and No Forest landscapes. Bar plots show mean values and error bars of relative read abundance from OTU's of plant taxa.

Chemical analysis of bee bread samples revealed the lipid content of pollen is affected by the presence of forest cover surrounding hives. We were able to show some important fats found in bee bread are available in higher amounts when bees have access to forest cover (Figure 11). Fatty acids are important for honeybee health and help honeybees with hygiene, immunity against pest and disease and supports good queen production, so this relationship between forest access and healthy honeybees will be helpful for beekeepers.

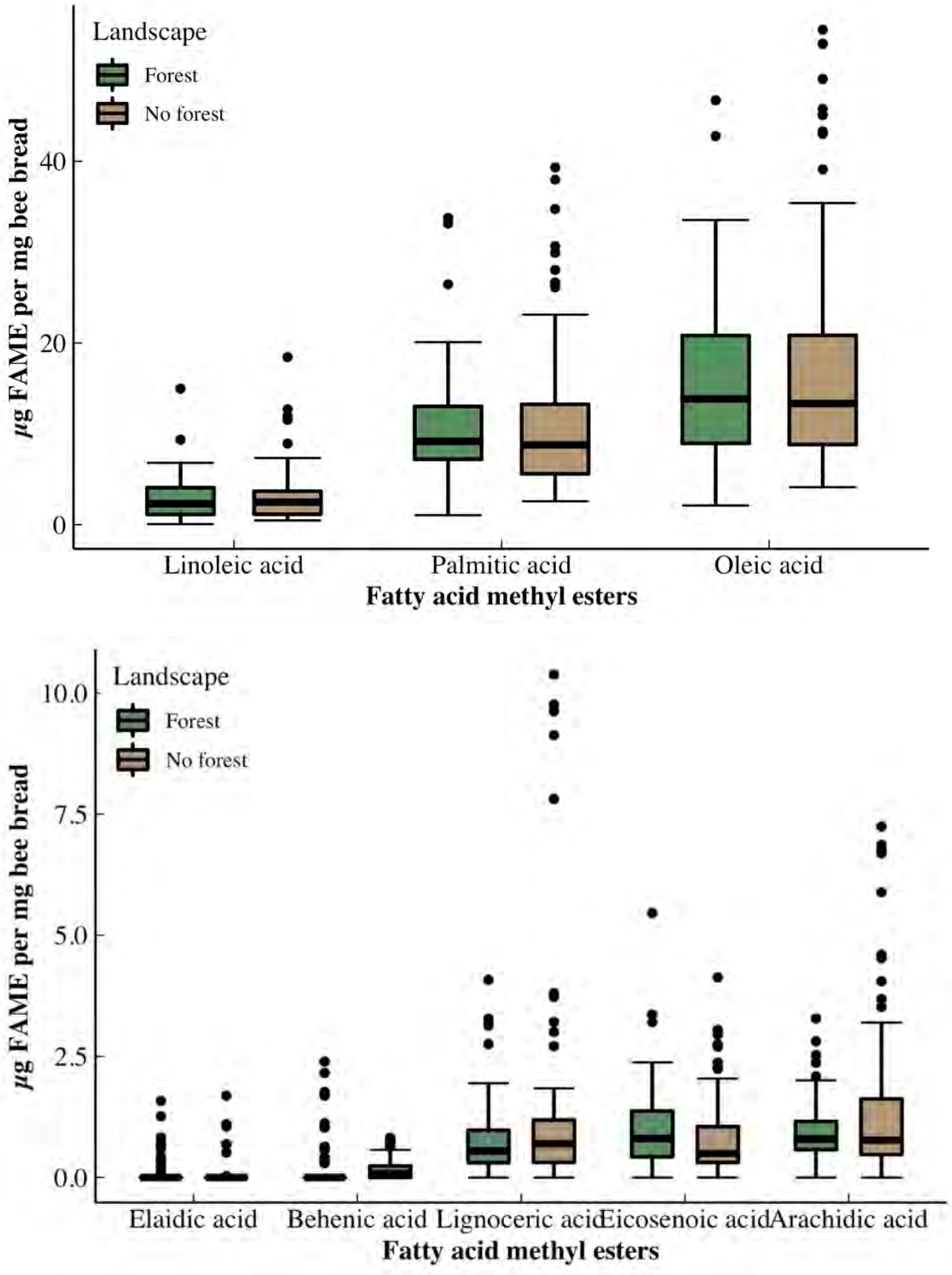


Figure 10. a) Major and b) minor sources of FAMEs from bee bread in agriculture and forest landscapes that were not significantly different between landscapes.

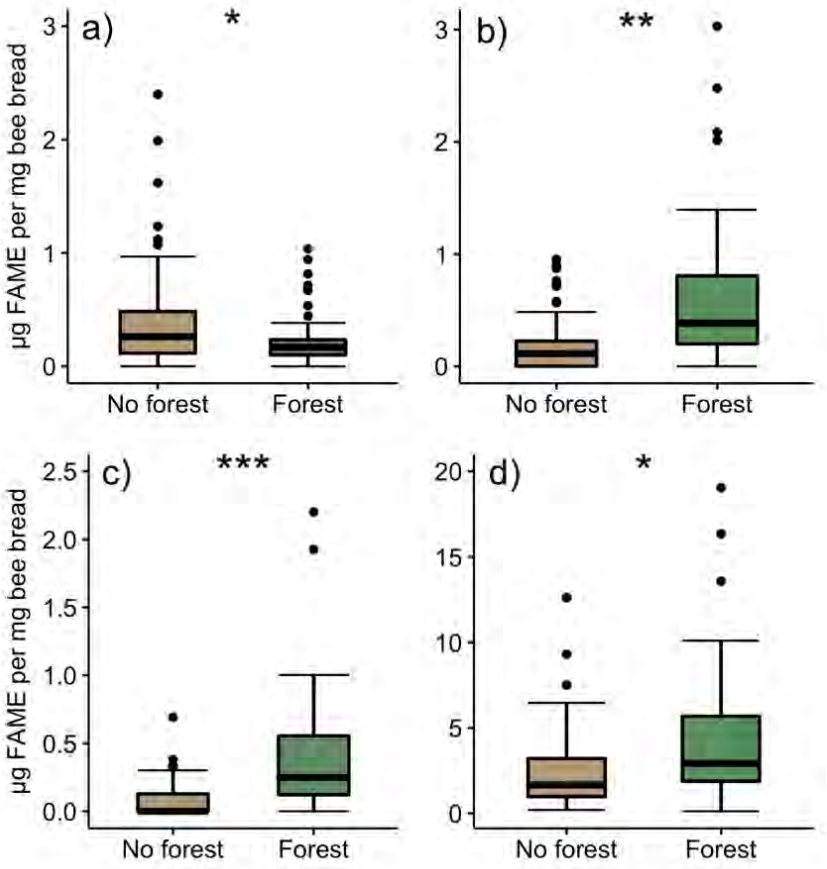


Figure 11. Boxplots comparing micrograms of (a) Lauric acid, (b) Myristic acid, (c) Palmitoleic acid and (d) Stearic acid per milligram of beebread in agriculture and forest landscapes obtained from tweedie (a, b and c) or gaussian (d) GLMMs. Asterisks indicate significant differences between landscapes according to maximum likelihood (Adaptive Gauss-Hermite Quadrature) ratio tests, significance levels as follows: * P < 0.05, ** P < 0.01, *** P < 0.001.

Our results highlight the importance of trees for honeybees in PNG where they constitute a large portion of pollen diets even in landscapes absent of forest where they must travel further to collect tree resources. This research demonstrates that honeybees collect pollen and nectar from agroforestry timber species and crop species, presenting potential for the integration of beekeeping with agroforestry practices in PNG. Furthermore, forests provide diverse fatty acids that help to maintain bee health. This research shows that beekeeping in PNG would benefit from preserving remaining forest cover and incorporating more trees to existing, open landscapes to optimize the diversity in honeybee diets.

2.3 Identify opportunities, incentives and barriers that enable adoption of value-adding

The literature review (Appendix 11.8) identified that women are often underrepresented in value-adding in Melanesian countries. Social-cultural factors such as access to resources and land, financial services and markets, education, and serious time constraints for household and parenting duties reduces participation. Women's involvement in micro-enterprise and employment is however increasing. Addressing the factors listed above can help to create employment opportunities for women in value adding.

The project also explored opportunities for increasing incentives and linking with the tourist industry using incentives such as payment for environmental services. In Fiji, negotiations between Shangri-La and Nadroumai women's group for supply of seedlings and catchment revegetation progressed through Terms of Reference and Concept note stage before management decisions within Shangri-La placed the catchment regeneration project on hold. In Vanuatu, increased tourism linkages also focused on tourism operators seeking sustainable certification in line with the new tourism policy. In addition to the initial discussion paper, a report on the lessons learnt from working with tourist operators to facilitate catchment regeneration was produced. Despite significant engagement and positive feedback, Shangri-La did not feel they were in a position to lead with establishing a catchment working group that could take the concept and seek funding to promote catchment regeneration.

Our research found that processors and financial institutions need confidence that there is a strong business case for investing in value-adding of agroforestry products. To assist a small size Micronesian business expansion, a cost benefit analysis was undertaken. This economic analysis assessed a range of challenges and opportunities and investigated current production against four expansion opportunities. These models were: 1) business as usual, 2) business with a moderate expansion, 3) business with additional equipment and 4) business with a larger expansion allowing for a new factory to permit HACCP certification.

Suggestions such as diversification of locations and suppliers and have been used to assist the owner with decision making and future directions for this family-owned business. Information contained in the report has enabled the owners to commence obtaining finance to build a HACCP certified production facility. Unfortunately, these plans are on hold following the downturn in the economic environment following the Covid-19 pandemic and decline in tourism.

Objective 3. Enable smallholder and gender equitable participation in agroforestry crop production (VAN, Fiji)

3.1 Identify opportunities, incentives and barriers that enable participation in agroforestry crop production

The SWOT analysis (Appendix 11.7) identified opportunities and barriers for tree planting by female small holders. Land tenure is a serious barrier to women's involvement in planting trees as that activity constitutes a land claim. An opportunity was identified for women to participate in nursery production. Subsequently, nurseries were established in Fiji and Vanuatu. Details are provided under Objective 5 and the impacts detailed under Economic Capacity.

The literature review (Appendix 11.8) recognised significant gender differentiation within agroforestry value chains (Purnomo et al. 2014; Sunderland et al. 2014) but revealed a bias to Africa and Latin America and a limited information about Melanesia. There is a movement in developing nations to question globalisation which has created some of the greatest levels of inequality for rural smallholders (Sader 2009). Secure tenure on land is the single most important condition for economic empowerment (FAO 2010). Social-cultural factors such as: access to resources and land; access to extensions and financial services and markets; the physical nature of value chain activities and cultural norms; customary and formal regulatory arrangements; and the limited benefit seen from agricultural research and development efforts all influence women's disadvantage in agroforestry value chains (Addinsall 2017).

Women are predominately segregated into low-technology occupations and concentrated into certain phases of the supply chain such as packaging, post processing which can limit the opportunities to gain new skills and capabilities (FAO 2011). Once systems are formalised, they are owned and controlled by men (Addinsall et al. 2018). Economic and political institutions need to work within communal structures and enhance resource ownership and access for women. Developing countries need to develop innovative cash economy activities to supplement traditional activities, while maintaining customary land ownership and the sustainable use of resources (Addinsall et al. 2015b).

To increase women's participation in agroforestry, the project worked with women through Participatory Women's Groups. In Fiji, the project established a community tree crop nursery with the Nadroumai Women's Club (NWC). Prior to the nursery the NWC made around $500 Fijian a year, with members of the NWC earning on average $300 Fijian a month from catching and selling prawns and picking coffee.

Over the 3 years that the project engaged with the NWC, the nursery was established and produced over 1500 plants. The nursery is financially viable (detailed under 8.3.1 Community Economic Impacts).

In Vanuatu, the project trained women in grafting techniques for cocoa for a socially responsible business owned by ACTIV Association and engaging female farmers through a farmer-to-farmer exchange program looking at growing and harvesting Nangai (*Canarium*) for a local owned business Lapita Café. Through these engagements, the project team disseminated information about planting the best materials, ensuring quality products and how to access markets to the women.

A major constraint to the uptake of agroforestry is the traditional land tenure in Vanuatu and Fiji (Appendix 11.6). In Fiji 87.9% of land is under iTaukei (indigenous or customary) title, 7.947% is freehold land and 0.25% is state owned land. In Vanuatu 99% of land is held under custom tenure. Leasing of land in Vanuatu is more complicated than Fiji as custom boundaries and identification of owners has not been formally documented. Through the project key insights into opportunities for increased uptake of agroforestry systems have emerged. Supporting agroforestry projects should occur in a targeted way, identifying incentives and opportunities that can help drive land use change to this sustainable, long term use. Some of the opportunities include:

- Introducing agroforestry systems into long term existing leased land (>50 years) or, aggregating custom landowning groups to increase tree crop production from many small plots and sell produce in a coordinated way
- Introducing more tree crops within a mixed agroforestry system
- Engaging women through collective charitable activities or micro-enterprise activities within the agroforestry value chain that don't require land tenure e.g., collection of seed for growing seedlings in community managed nurseries, collection of nuts for selling in local markets and local agribusiness, training in value-adding for local markets (honey, jams, nuts etc.)
- Strengthening linkages between the tourism sector and smallholders to build a long-term market This could be achieved through policies such as "Payment for Environmental services" levy
- Encouraging tree planting in buffer zones where regulations require tree cover for ecological protection but also where access to water is more secure
- Utilising finance for catchment regeneration to plant productive tree species that can provide erosion control but also livelihood opportunities for farmers

There is a largely unrealised market for local produce to the tourism market, however quality, consistency of supply and securing local produce was challenging as there is little co-ordination of supply. Motivation to strengthen linkages between producers and the tourism sector is recognised at the national levels. In Vanuatu, the project team were involved in national efforts to encourage increased local produce within the tourism market

through the development of the Vanuatu Sustainable Tourism Policy (2019-2030) which was approved by the Council of Ministers in November 2019. Policy objectives support an increase in local produce, much of which could come from agroforestry systems and supports benefits from tourism to a broader range of stakeholders.

Other opportunities that were explored include “Payment for environmental services” and development of corporate social responsibility among businesses such as tourism operators in addition to the introduction of a Visitors Arrival Levy which could fund the establishment of agroforestry community managed nurseries and catchment regeneration through agroforestry replanting of productive species.

3.2 Identify which gender may benefit at which stage of the value chain, and determine whether women can be drawn into those activities that add the most value

The slow uptake of agroforestry systems can be attributed to complex social, economic and environmental issues. Customary land tenure in the Pacific adds a level of complexity to all land use decisions. Addinsall et al., (in review) publication based on findings from this project found that while customary land tenure is a major constraint to the uptake of agroforestry, it is important in a Melanesian context to not reduce the value of land as an economic asset to be sold, mortgaged or as investment in the formal economy. In response to this, addressing land tenure constraints and particularly rights for women to access land should not be confused with the push for reform of customary ownership of land (with the replacement of freehold or individual title) from neo-classical economists who see customary ownership as a critical barrier to economic growth. Therefore, the project sought to explore ‘preferable methods’ that can support agroforestry uptake and increase access for women without displacing or eroding customary tenure.

The literature review and interviews revealed that women’s participation in agroforestry was usually limited to low value occupations and factors such as access to resources, finance and markets and cultural expectations increase women’s disadvantage in agroforestry value chains (Appendix 11.8). Through the project key insights into opportunities for increased uptake of agroforestry systems have emerged. For example, harvesting wild coffee is women’s work while planting coffee trees is viewed as staking a land claim and invokes the complexity of land tenure. Similarly developing large scale agroforestry plantation is a challenge involving negotiations between family groups. Short term leases fail to provide legal protection and confidence to farmers planting long term agroforestry crops.

Women are increasingly engaging in micro-enterprise and employment in rural and urban areas. In Vanuatu and Fiji, agroforestry systems (containing local nuts, spices, cocoa, copra and coffee) are more supportive of women’s livelihoods than formalised monoculture cash cropping. Women in Nadroumai community were participating in the coffee value chain through Bula coffee and this project has worked with Bula Coffee to increase their supply chain and assist women from an additional 82 villages (Appendix 11.9).

3.3 Address issues surrounding women’s involvement in income generating activities and disseminate information from project down to women

We identified the supply of high-quality seedlings as a major barrier to upscaling tree crop production in Fiji and Vanuatu. Although women cannot plant trees, they can collect seeds and grow seedlings without land tenure. Nurseries also do not require a large time commitment for women in addition to their household duties. This project has established nurseries in Nadroumai (Fiji) and Port Vila (Vanuatu) to create employment opportunities for women in value-adding and agroforestry and avoid some of the major problems. A journal article “Applying an intersectional lens to addressing gender disparities and

disadvantage in rural Melanesia; Case study Nadroumai", has been submitted to the Journal for International Development.

Although there is a market pull from tourist operators to use local products and reduce high cost imported foods, issues with quality and consistent quantity were challenging. Small scale agroforestry output does not always generate the volume and consistency required. Also, the uncoordinated supply and geographical dispersal make it a challenge for buyers.

Working through Women's groups have also provided an opportunity to disseminate information directly to the women.

Fiji

Women in Nadroumai community have increased their participation in the coffee value chain. Collecting wild harvested coffee and selling through Bula coffee have provided direct economic benefit. Improving coffee production by planting trees, thinning, and pruning would change the coffee from being a wild harvest and become a community asset where the women would lose the direct benefit.

Work with Bula also included providing advice and resources to improve postharvest drying (e.g., large sealable plastic bags for storing dry coffee), support for improved pulping and drying and sharing of information with growers and roasters in Australia and Vanuatu.

Discussions with the women's group in Nadroumai who were involved in harvesting coffee also led the establishment of a nursery for women. Training programs on basic nursery practice, business management and improvements to the nursery were undertaken. Sandalwood with a citrus host, vegetables and flower production were use as part of the training. Training issues for the village women include time constraints due to family and community obligations as well as a serious lack of financial resources.

Due to the scarcity of seedlings in Fiji for revegetation work and the project's interest in promoting catchment revegetation, the project team have found the Nadroumai nursery to be economically viable and encouraging agroforestry within the community. The land tenure system is a major impediment for individuals and even clans within the community to invest time and effort into planting because of uncertainty of returns from communal ownership. Impacts from this project in Fiji are demonstrated in the video under Community Economic Impacts (8.3.1).

Vanuatu

Women were engaged through ACTIV Association (food and handicrafts production) and Lapita Cafe (farmers supplying raw nuts). The project has collaborated with ACTIV Association and Lapita Café to support women's economic empowerment through training in value-adding and specialised nursery and grafting training for cocoa.

The ACTIV Cooperatives work with women and men selling handicrafts, cocoa, coconuts, herbs and tourism directly or through tourist outlets and more recently Oxfam outlets. Supply of raw materials rather than market opportunities is the major problem for ACTIV in contrast to many situations where there is product with limited market. Taking cocoa for chocolate, the islands have unique flavour characteristics from naturalised cocoa and ACTIV produces single origin chocolate. At a chocolate expose' in Paris, single origin chocolate from three islands in Vanuatu performed well.

To increase supply of known quality of beans, propagation of the best available material through grafting and cutting was addressed through nursery training programs. Farmers from two islands have now successfully grafted their own trees.

Objective 4. Develop and pilot testing of catchment revegetation systems linked to markets (VAN, Fiji)

The project established trial agroforestry sites in Fiji and Vanuatu to demonstrate food, non-timber forest products and timber production. Traditional/ indigenous tree crops (fruits, oils and nuts), including sandalwood, which have shown market potential, were included in the establishment design. These sites also demonstrate ecological services such as improved biodiversity and soil protection. In Fiji both Nadroumai and Korotari sites were clearly identified as urgently in need of improved catchment revegetation, for biodiversity conservation to improve water quality, and to reduce the impact of flooding.

The project established three trial agroforestry sites in Fiji and Vanuatu. These sites were at Nadroumai Village near Sigatoka (Fiji; Figure 12), Korubua community at Korotari near Labasa (Fiji; Figure 13) and Jubilee Farms on Santo Island (Vanuatu). At each site there has been between 1 and 2 hectares of tree planting plantings established, with additional cash crops integrated. Tree crops take several years to produce marketable products and as such, short term crops (taro, pineapples, banana and sweet potatoes) were interplanted with the tree crops to provide cash flow.

Figure 12. a) Nadroumai site b) Inspection of flood damage at Nadroumai with Project scientists and SPC collaborators

- At Nadroumai Community, a mid-catchment site, planting of 1 hectare began in 2016/17 with approximately 350 trees. 200 seedlings across 8 key species including tavola (*Terminalia*), ivi (*Inocarpus*), vutu (*Barringtonia*), vesi (*Intsia*), sandalwood, citrus, breadfruit and cocoa. Flooding in 2018 damaged the site which was replanted with over 120 trees (Figure 12). Coffee seedlings and other cash crops were also planted. Total area developed over the project was 3.4ha with an area of approximately 1ha fenced to reduce browsing pressure from livestock and wild pigs. 38 members were involved with this site.
- At Korubua community, a mid to upper catchment site, was located on ex-sugar cane farmland adjacent to a forest reserve and river buffer zone and provides ecological remediation advantages. Planting commenced in 2018 with 500 fruit, timber and traditional nut trees, and 500 pineapples. Trees included Sandalwood (yasi), citrus, tavola (*Terminalia catappa*), ivi (*Inocarpus fagifer*), vutu (*Barringtonia edulis*), Calliandra, vesi (*Intsia bijuga*), cinnamon, kavika, soursop and avocado. Cash crops include pineapples, passionfruit, kava, vegetables (tomatoes, eggplant, chillies), cocoa and coffee. In 2019, additional trees were planted. The total area under production was 3.4 hectares. the focus has been on engaging with youth as a part of the collaboration with the 14 members of the Korobua Youth

Group. During September 2020, 32 youth were trained in farm management, seed selection, propagation, grafting, marcotting and nursery management.

Figure 13. a) Koratari site b) Nursery

- At Mackenzie's farm at Jubilee farms, a mid-catchment site, 1 hectare was planted in 2017/8 with 400 trees including *Terminalia catappa* (Natapoa), *Canarium indicum* (Nangai), *Inocarpus fagifer* (Namambi) and smaller trees such as *Cacao* and *Flueggea flexuosa (*Namamou*)*. *C. indicum* was a focus, due to the importance of the crop to the landowners (Lapita Café). Additional plantings were undertaken late 2018 to replace losses due to the dry conditions. Cash crops included manioc, kava, vegetables, tropical fruits (bananas, pawpaw), coffee and cocoa.

Figure 14. a) Agroforestry gardens at Lapita farm b) *Terminalia* tree planted 2017.

An additional three sites listed below were investigated with some initial trees planted, however issues with land ownership, partner participation and ongoing maintenance prevented continuation of these sites.

- *Pilot Site 4- Fiji – Viti Levu – Sigatoka* - Farmer Jone PGS Tomato farmer- (PGS) Planting started in June 2017- Plants secured and on site but only established perimeter planting around tomatoes.
- *Pilot site 5 – Vanuatu – Port Vila* - Taouma George (landowner) and ACTIV (industry partner) 2 ha have been planted with more than 250 trees. These include

Barringtonia (25); *Terminalia* (50); *Canarium* (50); *Inocarpus* (50); Cocoa (50); Coffee (25).

- *Pilot site 6 – Vanuatu – Santo. Jubilee Farms* –Bradley Wood (landholder) and Vanuatu Fresh (industry partner). 1 ha soil testing completed and site preparation underway- site was planted with some trees in September 2017.

4.1 Recommend species for planting in Fiji and Vanuatu at upper, mid and lower catchments

The recommended species for each country are:

Fiji: *Inocarpus fagifer* (Tahitian Chestnuts (Ivi)), *Tectona grandis* (Teak), *Santalum* (Sandalwood), *Artocarpus altilis* (Breadfruit), *Terminalia* (Tropical almond, Tarvola), *Barringtonia edulis* (Cutnut, Vutu), Avocado, Coconuts, Mango, Coffee, Cocoa, Flowers.

Results from the work by the postgraduate student (Dean Wotlolan) determined suitable areas to establish agroforestry systems containing cutnut (*Barringtonia procera*), breadfruit (*Artocarpus altilus*), lemon (*Citrus limon*), sandalwood (*Santalum yasi*), tropical almond (*Terminalia catappa*), Tahitian chestnut (*Inocarpus fagifer*), and vesi (*Intsia bijua*) in the Sigatoka Valley (Fiji).

Food Benefit were considered the most important need, with a criterion weight of 0.447, suggesting that benefits from food crops is more than twice as important as Economic benefit (0.180). Other benefit rankings in the Pacific region were 0.126 for Medicine, 0.154 for Maintenance (low labour requirements), and 0.092 for Other (construction material and crafts) (Wotlolan et al. 2021). These weights do not suggest that all agroforestry initiatives in the Pacific region should focus on food production. While this study relied on expert opinions and did not include social considerations from local stakeholders, it provides an initial step in the planning process and a more qualitative analysis for future planning (Wotlolan et al. 2021).

Vanuatu: *Santalum* (Sandalwood), *Canarium*, *Inocarpus fagifer* (Tahitian Chestnuts (Ivi)), *Barringtonia procera* (Navele), *Terminalia* (Tropical Almond, Natapoa), *Artocarpus altilis* (Breadfruit), *Morinda citrifolia* (Noni), *Calophyllum inophyllum* (Tamanu), Coconuts, Fruits (Mango, Pineapples, Lemons, Cocoa, Coffee, Spices (Vanilla, Pepper), Kava.

4.2 Support pilot planting of agroforestry crops with other projects such as FAO/ GEF

The project found that tree planting projects in the Pacific region are challenged by a lack of planting materials. Nurseries and training were identified early in the project as an opportunity to support other projects and for women to engage with agroforestry. Nurseries established in Nadroumai (Fiji) and ACTIV (Vanuatu) to support tree revegetation plantings provided training of women's groups in basic nursery skills, grafting and nursery management.

Through this project, the nursery at Nadroumai has played a significant role in supplying 3,966 seedlings for the Global Environmental Fund Ridge to Reef reforestation project.10,000 eucalyptus seedlings and 30,000 pine seedlings are currently being raised for the Ministry of Forestry to reafforest the catchment areas in Fiji (8.3 Economic Impacts).

4.3 Monitor growth and yield of produce from demonstration plots

Due to the time constraints involved in obtaining yield data from tree production, delays caused by land tenure issues and planting failure it was not possible to monitor growth and yield from the demonstration sites. As a result, the emphasis of the project was changed to

monitoring the yield from the Nadroumai women's nursery. Tree seedling sold by Nadroumai nursery was as follows: 90 seedlings, (2018), 910 seedlings, (2019), 1000 seedlings, (2020) and 1966 seedlings, (2021) and is currently producing an additional 10,000 eucalyptus and 30,000 pine seedlings.

4.4 Monitor sediment and nutrient status of the pilot sites. Provide information on erosion and nutrient status to modelling efforts at the catchment scale

Baseline assessments of soil undertaken in Fiji and Vanuatu in 2017/18 showed that soil pH ranged from being slightly acidic to neutral (ranging from 6.2-6.8). Soils measured across all sites were relatively fertile within most key chemical variables, namely C%, N%, and exchangeable Ca, Mg and K. This indicates that inherent soil fertility or replenishment is broadly adequate in these agroforestry and fallow treatments. However, all treatments / sites were inherently low in readily and slowly available forms of phosphorous, whilst high in more recalcitrant forms of phosphorous. Further, bulk density was suboptimal in most soils, particularly those in pasture treatments, indicating the potential for inhibition of plant root growth, at least in surface soils.

At the site level, only marginal differences in soil fertility were observed between agroforestry treatments containing different stocking rates and species composition. Any significant differences between treatments observed are attributed primarily to the inherent variation in soils and or differences in historical land uses at the site level prior to the establishment of trees. The influence of agroforestry systems on soil fertility may be more discernible in the later stages of tree growth when litter accumulation and turnover is more advanced.

At this stage of establishment, soil fertility under agroforestry trials are comparable to more traditional fallows of similar age. It is expected that the uptake of different agroforestry and managed fallow prescriptions by smallholders and land managers will be driven primarily by livelihood opportunities over soil amelioration. This study supports the feasibility of agroforestry strategies that combine short-term cropping and forestry activities, whilst encouraging the maturation of trees and concomitant replenishment of soils at a level comparable to traditional fallow systems (Appendix 11.10).

As shown in the Fiji video (8.3.1 Community Economic Impacts), recent floods combined with extensive logging in the catchment upstream from the pilot site resulted in major sediment flow impacting downstream from the pilot site. Consequently, it was impossible to measure sediment and water quality in the reef areas and downstream from the pilot site. There is however interest in large donor-funded reforestation and catchment revegetation.

4.5 Explore mechanisms to facilitate funding of catchment revegetation by tourism operators

In Vanuatu and Fiji, there is a growing understanding within the tourism industry of the negative impacts of degradation of the landscape. Fiji and Vanuatu have identified watershed protection and conservation as major priorities. However, there are few examples of systems that can help to protect vulnerable areas in key catchments from the impacts of severe climatic events (particularly flooding) and threats to water quality (nutrients and sediment). This project explored the potential to obtain collaborative funding from major tourism operators for revegetation of catchments in the areas close to their facilities.

Findings from the participatory action group and discussion paper were integrated into the Vanuatu Sustainable Tourism Policy (2019-2030) which was endorsed by the Council of Ministers in 2019. The Vanuatu Sustainable Policy identifies the need for catchment protection and requests that the tourism sector adopts conservation management to protect key biodiversity areas. Active catchment revegetation is one way that tourism operators can

protect the environment. Project personnel worked with the Vanuatu Sustainable Tourism Policy to develop standards for sustainable tourism and methods to fund investment in conservation.

Opportunities for increasing incentives and linking with the tourist industry were explored. In Vanuatu, negotiations took place with tourism industry stakeholders and cruise company representatives to explore the introduction of "Payment for Environmental Services" programs and the introduction of a "Visitor Arrival Levy" for conservation activities. The project team supported the inclusion of these activities within the Vanuatu Sustainable Tourism Policy (2019-2030) and the Vanuatu Crises Response and Recovery Plan (2020-2030). In Fiji, tree clearing upstream from the pilot site at Nadroumai has created erosion problems for landholders in Nadroumai village and sedimentation of the reef affects the Shangri-La resort downstream. Catchment revegetation is urgently needed, but there are land tenure issues associated with planting trees. Negotiations between Shangri-La and Nadroumai women's group for supply of seedlings and catchment revegetation progressed through Terms of Reference and Concept note stage before management decisions within Shangri-La placed the catchment regeneration project on hold.

The pilot sites and workshops in Fiji and Vanuatu have raised awareness of the environmental benefits of integrating trees and crops. Agroforestry reduces the demand on forest reserves and conservation areas and provides opportunities of ecotourism.

4.6 Identify current constraints to supplying the tourism industry with locally grown produce and strengthen linkages between producers and tourism industry stakeholders

A largely unrealised market exists in supplying local produce to the tourism market. Tourism operators often operates around local communities and are generally keen to promote local foods as a point of difference in their products and to reduce high cost imported food. Major barriers to implementing increased market supply into the tourism sector are consistent quality and reliable supply. Small scale agroforestry output does not always generate the volume and consistency required. Geographically dispersed source of supply is difficult for buyers to access the goods. Some of the major constraints to supplying the tourism industry with locally grown produce are the following:

- Quality – Improving local varieties to suit the sector's needs requires support and extension services not always available to smallholders. Improving options for transport of fruits is a challenge.
- Consistency – Discussions with operators such as Shangri-La Resort in Fiji indicated that seasonality was not a concern but the reliability of supply when crops were in season was.
- Coordination – As described by the Head Chef at Shangri-La Resort, sourcing local produce was a priority, but a challenge given poor coordination by middlemen who could deliver the produce. Where farmers' cooperatives or coordination between multiple farms exists, buyers would prefer to go direct to the farmers. However, the project has worked with ethical intermediaries who provided a key service in quality control, supply assurance, training and extension services and overall coordination of supply. Such actors heighten opportunities for long term beneficial relationships between producers and the industry.
- As a result of activity by members of this project, motivation to strengthen linkages between the productive sectors and tourism sectors is also being demonstrated at the national level in Fiji and Vanuatu and presents opportunities to direct financing to support such linkages
- The project has made a very large impact in supporting Government action towards encouraging demand for local supply of produce to the tourism industry in Vanuatu through the development of the Agritourism Diversification Strategy which

meets key criteria in the Vanuatu Sustainable Tourism Policy (2019-2030). The project team supported the Vanuatu Government in the development of the Agritourism Diversification Strategy as part of the Vanuatu Crises Response and Recovery Plan (2020-2030) (Figure 15).

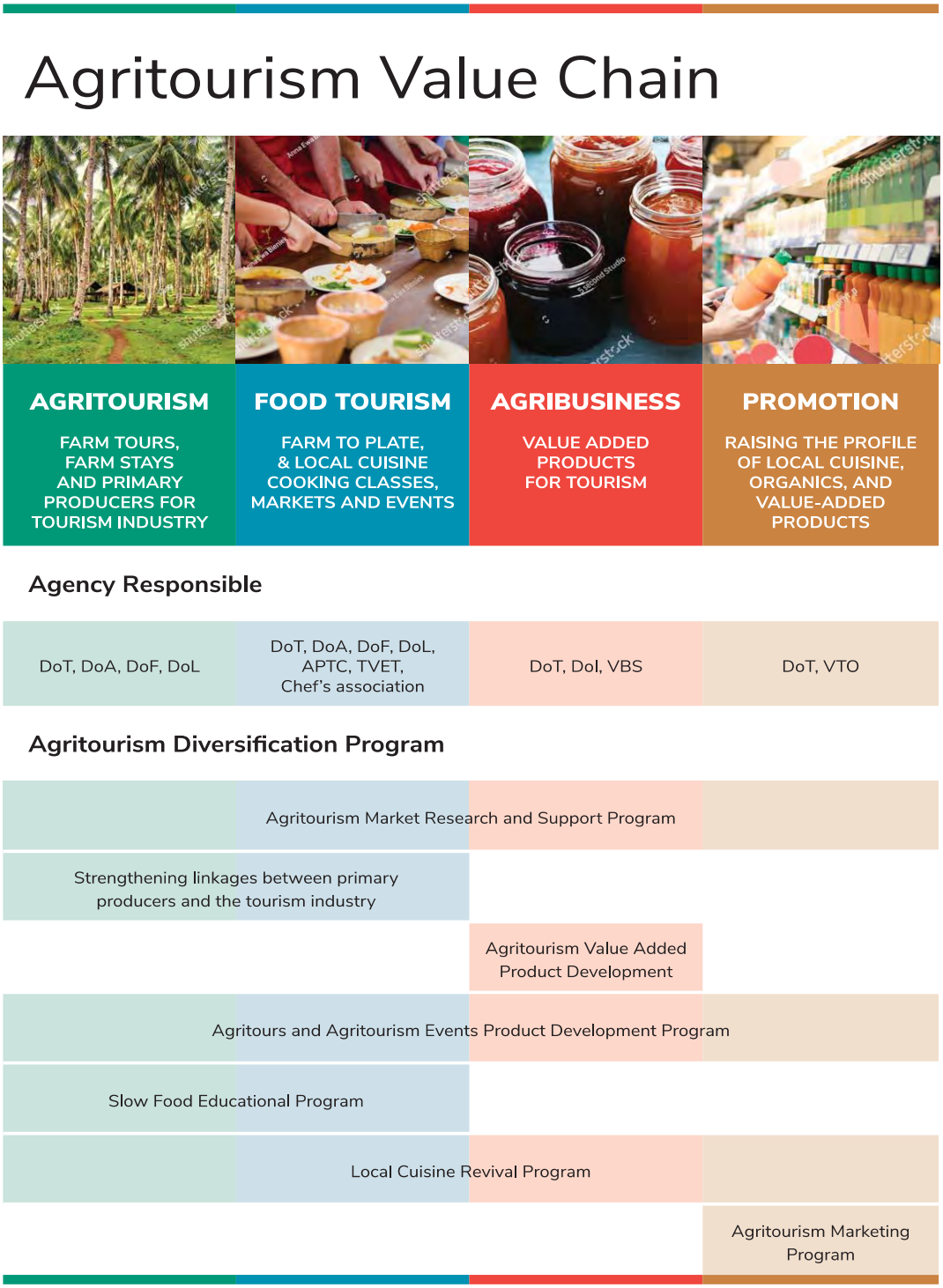


Figure 15. Components of the Agri-tourism Value Chain in Vanuatu, showing key Government Departments and linkages to the programs

Objective 5. Build capacity and disseminate research findings

5.1 Conduct a training needs analysis, an impact pathway analysis and a monitoring and evaluation plan

Responses from the training needs analysis by Ni Vanuatu women recommended the following:

- Content should be practical and address Ni Vanuatu women's priorities
- More time in the farmer-to-farmer information exchange sessions, particularly with the household budgeting which was particularly relevant
- Recipients suggested all content should be delivered in Bislama with summary handouts in Bislama and delivered by Ni Vanuatu farming women
- During storian sessions, there was an overwhelming sentiment that training duration should still allow women to attend their other livelihood duties.
- The structure of all female training received a lot of positive feedback. Participants suggested that due to custom obligations and an overall shyness to talk in public places with men present, having all women training enabled greater participation by the women.
- Training must be undertaken at times suitable for the participants to enable them to fulfill other family obligations.

Monitoring and evaluation questions were generated (Table 4). Links to videos demonstrating these impacts are also provided (8.3.1 Community Economic Impacts).

Table 4. FST/2014/067 Monitoring and evaluation indicators and outcomes.

Objective	**Monitoring question**	**Indicator**	**Outcome/ Impact**
Objective 1	How and to what extent have the value chains for priority species in the four countries been improved (qualitative and quantitative)?	Market volumes and processor sales of agroforestry products, case studies of impacts	Market volumes and sales of value-added agroforestry products have increased in several countries. New products developed include 3 types of nuts (*Canarium*, *Terminalia* and *Barringtonia*), muesli, dried bananas, dried pineapple and dried paw paws (Solomon Islands), chutneys, jams, manioc flour and dried banana (Vanuatu) and chutneys and jams (Fiji). In Vanuatu, ACTIV was assisted to export to Australia. As a result of intervention by this project, sales made by ACTIV to Oxfam in 2018 were AUD17,490. In Vanuatu during the project, production of value-added products by Lapita Café has increased (8.3.1 Economic Impacts). Purchases of Nangai nut kernel increased from 1 to 2 tonnes, however tropical cyclones and disruption of tourism due to Covid-19 has negatively impacted supply and demand. In the Solomon Islands, volumes of sales increased from limited sales of small volumes in 2014 to over 500kg, (all nuts combined) prior to covid-19 causing closure of the markets in 2020.The impact of the project on producers in Solomon Islands and Fiji is demonstrated in the videos (8.3.1 Community Economic Impacts).

Objective 2	How and to what extent has the research on constraints to value-adding and value-added processing techniques generated enhanced economic impact in each country (qualitative and quantitative)?	What additional income has been generated for smallholders and processors?	Numbers of smallholders and processors involved in value-adding of agroforestry products has increased due to this project. Income figures are commercially and culturally sensitive and hence we have used numbers of suppliers as a proxy. In Vanuatu, Lapita Café have increased the numbers of suppliers from 100 farmers at project commencement in 2015 to approximately 700 farmers at project completion, providing economic benefit to their community. In Fiji, Bula Coffee have expanded sourcing wild harvested coffee from just one village at project commencement to working with women from 82 villages. In the Solomon Islands, 41 suppliers including one new women's group have commenced processing and industry partners have improved quality (8.3.1 Community Economic Impacts).
Objective 3	How and to what extent has gender equitable participation in agroforestry crop production been enhanced in Fiji and Vanuatu (qualitative and quantitative)?	How many women and men participated in agroforestry crop production as a result of the project	Nurseries were identified as constraints to agroforestry production. Establishing the nursery at Nadroumai (Fiji) has provided financial benefits by selling seedlings worth >4,000 FJD and demonstrated the viability of this nursery. The impact of developing this nursery is demonstrated in the video (8.3.1 Community Economic Impacts). Nursery training has been conducted in Port Vila (Vanuatu) and Nadroumai (Fiji). Demonstration days have been held at and Malo (Vanuatu) and Nadroumai (Fiji). These nursery and agroforestry field day training has been provided to more than 280 participants (including more than 200 women).
Objective 4 (tourism)	In what ways are the tourism industry and smallholders collaborating to enable land re-vegetation and what are the remaining constraints (qualitative)?		This project has guided formation of the Vanuatu Sustainable Tourism Policy (2019-2030). The Vanuatu Sustainable Policy identifies the need for catchment protection and promotes conservation protection of key biodiversity areas by the tourism sector.
Objective 4 (revegetation)	How can selected agroforestry systems encourage revegetation, reduce soil loss and increase livelihoods (qualitative and quantitative)?	What sites were planted? What new information have we learnt about constraints and opportunities for agroforestry planting? What alternative	Sites were established at Nadroumai Village near Lautoka (Fiji), Korubua community at Korotari near Labasa (Fiji) and Jubilee Farms on Santo Island (Vanuatu). Floods, maintenance and cyclones were issues that arose while establishing these sites. An additional 3 sites that were also investigated, raised issues of land tenure and willingness to participate. Nurseries to supply quality seedlings were identified as an opportunity, Training and

		opportunities exist for agroforestry plantings and how much income can they generate? (Nadroumai nursery)	assistance to establish the nursery at Nadroumai has been extremely successful. The impact of developing the nursery at Nadroumai is demonstrated in the Fiji video (8.3.1 Community Economic Impacts).
Objective 5	How has capacity in agroforestry crop production, value chain analysis and value-added processing been enhanced in each country and to what extent have these capabilities led to improved outcomes (qualitative and quantitative)	How many participants were trained and what evidence is there for the use of the information?	Value-adding food training has been provided to 701 participants. Details are provided under impacts section below. The impacts of the project are highlighted in Solomon Islands and Fiji videos (8.3.1 Community Economic Impacts). Nursery training has been provided to 195 participants (Fiji 146 participants, Vanuatu 49 participants). 20 beekeepers in Lake Kutuba (Gesege and Tugiri communities) and 20 women farmers in Daga community in PNG. Beekeeper and value-adding for root crop production has been provided to 42 participants in Vanuatu.

5.2 Conduct a training workshop on a range of value chain techniques

5.3 Build capacity in business management value-adding and processing techniques with training workshops, especially for female participants

A series of workshops were designed and delivered to share knowledge on small business management, food safety, value-adding and food preservation (Table 5). These included the following:

A training program for women in the market who sell fresh produce and could benefit from value-adding to grow their business was developed in a collaboration between University of Adelaide and Griffith University. Women were trained in value-adding techniques to extend the shelf life of products, sell to alternative markets and increase the unit price of products, thus increasing income and allowing women to diversify their microenterprises. This training was delivered initially in the Solomon Islands by the project team but then further developed with a Fijian company “Food Inspired”.

Training of women market vendors was conducted in collaboration with UN Women “Markets for Change Business Fair”, a UNDP & UN Women initiative. Initially, 12 workshops were conducted in Fiji and were attended by 401 participants. These workshops were so well attended, and the workshops were valued so highly by UN Women that they sponsored additional training workshops in Vanuatu and the Solomon Islands. In total, 529 women and 87 men received training through this program.

Food inspired training was well received and generated much positive feedback. Feedback was that the initial training didn’t contain enough hands-on experience and insufficient time to build skills, confidence and experience. Consequently, Food Inspired, were commissioned to provide more in-depth training and mentoring to a smaller group of women from Lautoka social housing project. This new training was conducted as multiple training workshops with small groups to build the skills and confidence to produce a consistent quality product.

The training covered food safety, Fiji food legislation, practical food preparation, packaging, skills for starting and managing a microbusiness and sales and marketing. Multiple training workshops were successfully delivered with small groups who gave extremely positive feedback on the training. Participants had opportunities to sell their products through market days. 42 participants completed the training, from the 48 women who commenced the training. Monitoring and evaluation of the project was incorporated into the design of the training and the economic impacts were captured by interviews and video productions. Several women have made steps towards creating microbusinesses of their own. Three follow up visits have been conducted to provide further assistance to those who have commenced selling value-added products. The impacts from this training is demonstrated on the Fiji video (8.3.1 Community Economic Impacts).

Figure 16. Participants at value-adding training workshops (Fiji)

Figure 17. Participants at the subsequent training in 2020 in Hart Village (Fiji) conducted by “Food Inspired”.

Table 5. Value-adding training

Date	Location	Participants	Training
Nov 2017	Jedom food ltd. Honiara, (Solomon Is.)	27 female, 3 male	Training farmers and processors in Food Safety, preservation and developing products
June 2018	Suva Market (Fiji)	27 female, 4 male	Hygiene and Food Safety
June 2018	Suva Market (Fiji)	46 female, 4 male	Value-adding and food preservation
June 2018	Nausori Market (Fiji)	29 female	Hygiene and Food Safety
June 2018	Nausori Market (Fiji)	21 female, 2 male	Value-adding and food preservation
July 2018	Lautoka Market (Fiji)	44 female, 1 male	Hygiene and Food Safety
July 2018	Lautoka Market (Fiji)	40 female	Value-adding and food preservation
August 2018	Labasa Market (Fiji)	27 female, 2 male	Hygiene and Food Safety
August 2018	Labasa Market (Fiji)	20 female, 2 male	Value-adding and food preservation
August 2018	Labasa Ministry of Youth (Fiji)	30 female, 12 male	Value-adding and food preservation
August 2018	Vunikura Village (Fiji)	23 female, 20 male	Hygiene and Food Safety
August 2018	Savusavu (Fiji)	25 female, 1 male	Value-adding and food preservation
August 2018	Savusavu (Fiji)	20 female, 1 male	Value-adding and food preservation
September 2018	Auki Market, Malaita (Solomon Is.)	17 female, 22 male	Value-adding and food preservation
September 2018	Auki Market, Malaita (Solomon Is.)	28 female, 13 male	Value-adding and food preservation
September 2018	Port Vila (Vanuatu)	48 female,1 male	Value-adding and food preservation
September 2018	Port Vila (Vanuatu)	35 female	Value-adding and food preservation
September 2018	Luganville (Vanuatu)	30 female, 2 male	Value-adding and food preservation
September 2018	Luganville (Vanuatu)	29 female	Value-adding and food preservation
July to August 2020	Lovu (Fiji)	48 female participants commenced: 42 completed the course	Six-week workshops on food safety legislation, quality control and processing methods, making jams and chutneys, finance and marketing. Several post workshops were then conducted to assist those starting businesses

5.4 Connect private sector SME participants with mentors, especially female entrepreneurs

The project supported business networking and mentoring of industry partners and women processers. Business networking and mentoring meetings to and between industry partners Votausi Mackenzie-Reur (Lapita Café - Vanuatu) and Doni and Jenny Kelly (Farm Fresh Foods - Solomon Islands) has generated a flow on effect of mentoring and training to women from Kolupa village (Solomon Islands). The impact of this mentoring has resulted in ongoing benefits that are detailed under community impacts (Section 8.3) below.

An inaugural meeting of Melanesian nut processors was held in Papua New Guinea to facilitate networking of value-adders and food businesses working on indigenous nuts throughout the Pacific. This was attended by Helen Wallace, Votausi Mackenzie-Reur and representative processors from Papua New Guinea. Participants from Papua New Guinea and Vanuatu shared their experiences and common problems of sourcing raw materials and consumables, establishing a sustainable pricing policy, maintaining quality and monitoring moisture content to minimize microbial contamination, maximize shelf life and storage.

Figure 18. Photo Dalsie Hannet and Votausi Mackenzie-Reur at the inaugural meeting of Melanesian nut processors

5.5 Build capacity in agroforestry crop production especially for female smallholders by running field demonstration days

A series of workshops were designed and delivered to share knowledge on nursery training and nursery/small business management. Demonstration days have also been conducted to help build capacity of smallholders participating in integrated agroforestry production systems and encourage replanting of catchments with agroforestry crops that can provide an income. Depth of training needs to be enough to allow development of skills and increased confidence of participants. The number of participants at each training workshop is shown in Table 6.

Table 6. Nursery training

Date	Location	Participants	Training
Oct 2016	Shangrila Nursery (Fiji)	10 Participants: 6 staff Shangrila, 2 rangers Sigatoka Sand Dunes NP, 2 youth Nadroumai.	Basic nursery training (potting media, watering, aeration and drainage, nutrients, transplanting)
Oct 2016	Nadroumai Village (Fiji)	5 female (Nadroumai women's group)	Nursery training and coffee pruning.
March 2017	Nadroumai Village (Fiji)	17 female (Nadroumai women's group)	Nursery Training. Propagate seed traditional nut trees.
June 2017	Nadroumai village (Fiji)	4 female (Nadroumai women's group)	Participatory women's group to design training to their needs.
June 2017	Nadroumai village (Fiji)	16 female (Nadroumai women's group)	Nursery training, potting up Sandalwood.
July 2017	ACTIV Port Vila (Vanuatu)	2 female	Specialised nursery training, grafting cocoa.
Sept 2017	Nadroumai village (Fiji)	Women's PAR	Rapid Assessment of Perceptions and Aspirations to aid establishment of nursery business.
Nov 2017	ACTIV Port Vila (Vanuatu)	1 female, 1 male	Specialised nursery training, grafting cocoa.
Dec 2017	ACTIV Port Vila (Vanuatu)	1 female,1 male	Specialised nursery training, grafting cocoa.
Dec 2017	Nadroumai village (Fiji)	16 female	Specialised nursery and vegetable seedling training
March 2018	ACTIV Port Vila (Vanuatu)	1 female, 1 male	Grafting
April 2018	Nadroumai village (Fiji)	13 female, 4 male	Small Business Nursery management training
Oct 2018	Malo, (Vanuatu)	6 female, Santo; 14 female, Malo	Developed a gender-sensitive farmer-farmer training programme
Oct 2018	Malo (Vanuatu)	19 female, 8 male	Farmer to Farmer information exchange, harvesting and seed collection, improving soil quality, growing seedlings, pruning, and bookkeeping
Oct 2018	Port Vila (Vanuatu)	41 participants	Nursery training and grafting
Nov 2018	Korotari (Fiji)		Planting and agroforestry design
Nov 2018	Nadroumai village (Fiji)	26 female, 5 male	Nursery training, collecting seed, potting mix, potting up, planting seedlings, nursery management
Feb 2019	Malo (Vanuatu)	4 female, 7 male Santo; 3 female Malo	Farmer to Farmer information exchange
April 2019	Malo (Vanuatu)	18 female farmers, 4 male	Farmer to Farmer information exchange
2019	Nadroumai village (Fiji)	20 Women; 10 Men	Farm management
Sept 2020	Korobua	32 Youth	Farm and nursery management

Training was provided to beekeepers in Goroka (PNG) (Table 7). Personal safety equipment (head veils and smokers) and refractometers to measure water content have been supplied to beekeepers. This training and the equipment supplied has increased safety of beekeepers and harvesting efficiency. This project has successfully identified important honeybee flora of the Eastern highlands of PNG and is detailed under capacity impacts.

Table 7. Beekeeper training, PNG

Date	Location	Participants	Training
March 2021	PNG	20 beekeepers in Lake Kutuba (Gesege and Tugiri communities) and 20 women farmers in Daga community	Apiary Management skills

This project partnered with the Department of Industries (Vanuatu) to undertake two activities aligned with the project objectives. These projects assisted with bee keeping training and post-harvest training for the cassava industry (Table 8). Satellite Food Processing training was undertaken on Efate Island (Vanuatu) to increase food security. The training focused on post-harvest handling of cassava (harvesting, sorting, grading, treatment, packaging, transportation, handling during transportation, peeling, washing, storage and finally export) and farmers' business management training (commercial farm management, bookkeeping, season costing cycle, planning and budgeting) (Figure 19). The Epule farmers also agreed to formally establish a Cassava Producer Cooperative.

Table 8. Beekeeping and cassava training, Vanuatu

Date	Location	Participants	Training
September 2020	Tanna Is. (Vanuatu)	24 farmers	Bee keeping skills
September 2020	Tanna Is. (Vanuatu)	18 farmers	Post-harvest handling of cassava for export

Figure 19. Farmers receiving value-added training

8 Impacts

8.1 Scientific impacts – now and in 5 years

This project has built scientific capacity within Fiji, Vanuatu, The Solomon Islands and Papua New Guinea by undertaking research in partnership with Pacific Island researchers. This has led to a series of joint publications with Pacific researchers (Appendix 10.2).

The research findings from Addinsall's published work on agritourism has resulted in policy changes in Vanuatu.This report informed the national efforts to encourage increased local produce within the tourism market through the development of the Vanuatu Sustainable Tourism Policy (2019-2030).

The project has made a very large impact in supporting Government action towards encouraging demand for local supply of produce to the tourism industry in Vanuatu through the development of the Agritourism Diversification Strategy which meets key criteria in the Vanuatu Sustainable Tourism Policy (2019-2030). The project team supported the Vanuatu Government in the development of the Agritourism Diversification Strategy as part of the Vanuatu Crises Response and Recovery Plan (2020-2030).

This project has built research capacity by supporting two Pacific Island Master's students. Jimmy Rantes, Vanuatu Director of Trade, undertook a Master's degree entitled "Integrating Sustainable Development in Public Policy: An evaluation of existing agriculture, trade and land-use policies and laws of Vanuatu". He conducted fieldwork on the diversity of crops grown in three Vanuatu communities. He found food insecurity has developed when households concentrate on planting kava instead of food crops to sustain their livelihoods in his native Wintua Village of South West Bay Malekula. His research received prominence and media attention at a public event with the Minister of Agriculture Matai Seremaiah. https://www.facebook.com/milroy.cainton/videos/1575399972503994/

Dean Wotlolan, at the University of the South Pacific (Fiji) was also supported during his postgraduate study to conduct an analysis of land suitability for agroforestry systems in the Sigatoka Valley (Fiji). Multi-criteria decision analysis and geographic information systems were used to model areas suitable for cutnut (*Barringtonia edulis*), breadfruit (*Artocarpus altilus*), lemon (Citrus limon), sandalwood (*Santalum yasi*), tropical almond (*Terminalia catappa*), Tahitian chestnut (*Inocarpus fagifer*), and vesi (*Intsia bijua*) agroforestry systems. His study relied on expert opinions but did not include local social considerations. It found the food benefits were the most important and more than twice as important as economic benefits. This methodology provides a more qualitative analysis for initial future planning.

The project pioneered the use of DNA metabarcoding to examine honeybee pollen and nectar sources in the Eastern Highlands of PNG. This is the first study of its kind in the tropics and one of only a handful of studies using the technique for honeybees globally. We anticipate this technique will be increasingly used more widely to identify different types of honey and to understand bee behavior globally.

8.2 Capacity impacts – now and in 5 years

8.2.1 Change in knowledge and skills of individuals (and businesses)

Value-adding training and nursery training have been described under results Activity 5 (Table 5 and 6). This section will focus on the impacts from that training.

Fiji

Training has had the following impacts:

- 449 participants received training in value-adding techniques (Results section, Activity 5.2, Table 5). From an intensive training of 48 women in HART village (Fiji), at least 4 participants immediately commenced trading and an additional 20 women followed when they witnessed their peer's success. A follow-up questionnaire revealed that 70.9 % of respondents made value-added product in the 30 days post-workshop and 54.8 % of respondents made product and are engaged in commercial sales.
- The nursery training and business development training (Results, Activity 5.5, Table 6) provided to the Nadroumai Women's Group (NWC) has resulted in establishing the Nadroumai Women's Nursery as a new successful business (8.3.1 Economic Impacts). Prior to this project, the NWC received finance through member donation of $1 per meeting, now the NWC receives regular income from seedling sales and has money in their bank account for community infrastructure projects (Appendix 11.9). Women are also benefiting through increased interest in vegetable seedling and cut flower production.
- Youth at Korotari (Results Activity 4) have been engaged in tree planting to improve catchment revegetation to improve water quality and reduce the impact of flooding.


Figure 20. Nadroumai women's club members in the nursery.

Figure 21. Koratari Youth Group Meeting

Vanuatu

The impacts in Vanuatu are as follows:

- Lapita café has developed several new products. These include chutneys, jams, manioc flour and dried banana. Nutritional analysis has been undertaken and used to improve the packaging of these new products (Figure 22). The project has assisted with business mentoring, research on drying, nutritional analysis, microbial analysis, packaging and labelling.
- A cost benefit analysis (Results Activity 2.3), has assisted with decision making and has increased capacity to obtain funding for expansion. The business is developing a HACCP certified factory. The factory will be cyclone proof, have solar power and its own water supply to cater for natural disasters.
- The post-harvest value-added training conducted by the Department of Industries (Vanuatu) has assisted small holder farmers to reduce crop losses and enable farmers to export root crops especially Cassava to New Zealand and other potential markets.
- This project assisted the formation of the Vanuatu Sustainable Tourism Policy (2019-2030). This policy increases national efforts to increased use of local produce within the tourism market. Goal 4 of the policy targets sustainable and responsible tourism to attract responsible high-value tourists, support sustainable, ethical, local agricultural products and experiences. By increasing linkages between the agriculture, handicrafts and tourism sectors, the benefits from tourism will be shared between a broader range of stakeholders. The project has made a very large impact in supporting government action and has increased the skills of the government employees involved (Results Activity 4.5).
- Training in nursery management and grafting techniques provided to ACTIV nursery, (Results Activity 5, Table 6) have increased capacity in nursery production and grafting for participants.

Figure 22. Votausi Mackenzie-Ruer with value-added products

Solomon Islands

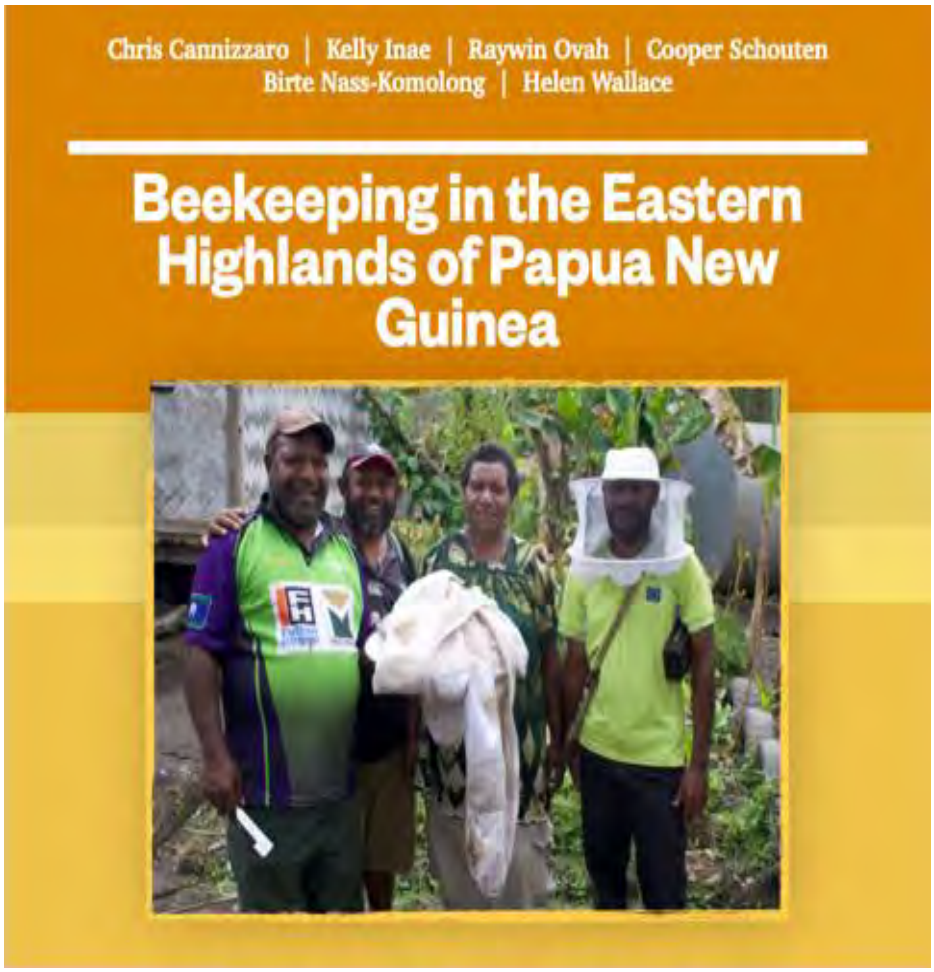
110 participants received training in value-adding techniques (Results Activity 5.2, Table 4). As a result, women from Kolupa village have commenced producing value-added *Terminalia* and *Barringtonia* products (8.3.1 Community Economic impacts).

Drying research (Results, Activity 2) was utilised by Jedom trading to develop several new products. These include dried *Terminalia* (Island crunchy), dried *Barringtonia* (Island milky) and dried *Canarium* (Island soft), dried pawpaw, pineapple and banana, and muesli. The project also increased capacity for Jedom trading by providing information on storage, nutritional analysis, microbial testing, product label design and packaging (Figure 23).Jedom Trading purchase nuts and fruit from over 41 farmers, who they have trained in post-harvest handling.

Figure 23. Doni Kelly and Bruce Randall drying nuts; Packaging of dried nuts

Papua New Guinea

This project has successfully identified important honeybee flora of the Eastern highlands of PNG. The findings have been used to construct a floral guide to beekeeping that is being distributed throughout PNG. The book is a 68-page, full colour visual guide with important instructions and information on pest management, honeybee flora identification for pollen and honey and other helpful notes for beginner beekeepers. The book has been translated to Tok Pisin through NARI. Printed copies of the book are being distributed to farmers throughout PNG in workshops facilitated by Kelly Inae, who is a master beekeeper and is well known for holding beekeeper, training events as well as supplying locally made hive equipment. Pages from the book are shown in Figure 24. In addition, 40 participants received beekeeper training (Results Activity 5.5, Table 7). This has increased efficiency of harvesting honey and safety for beekeepers.



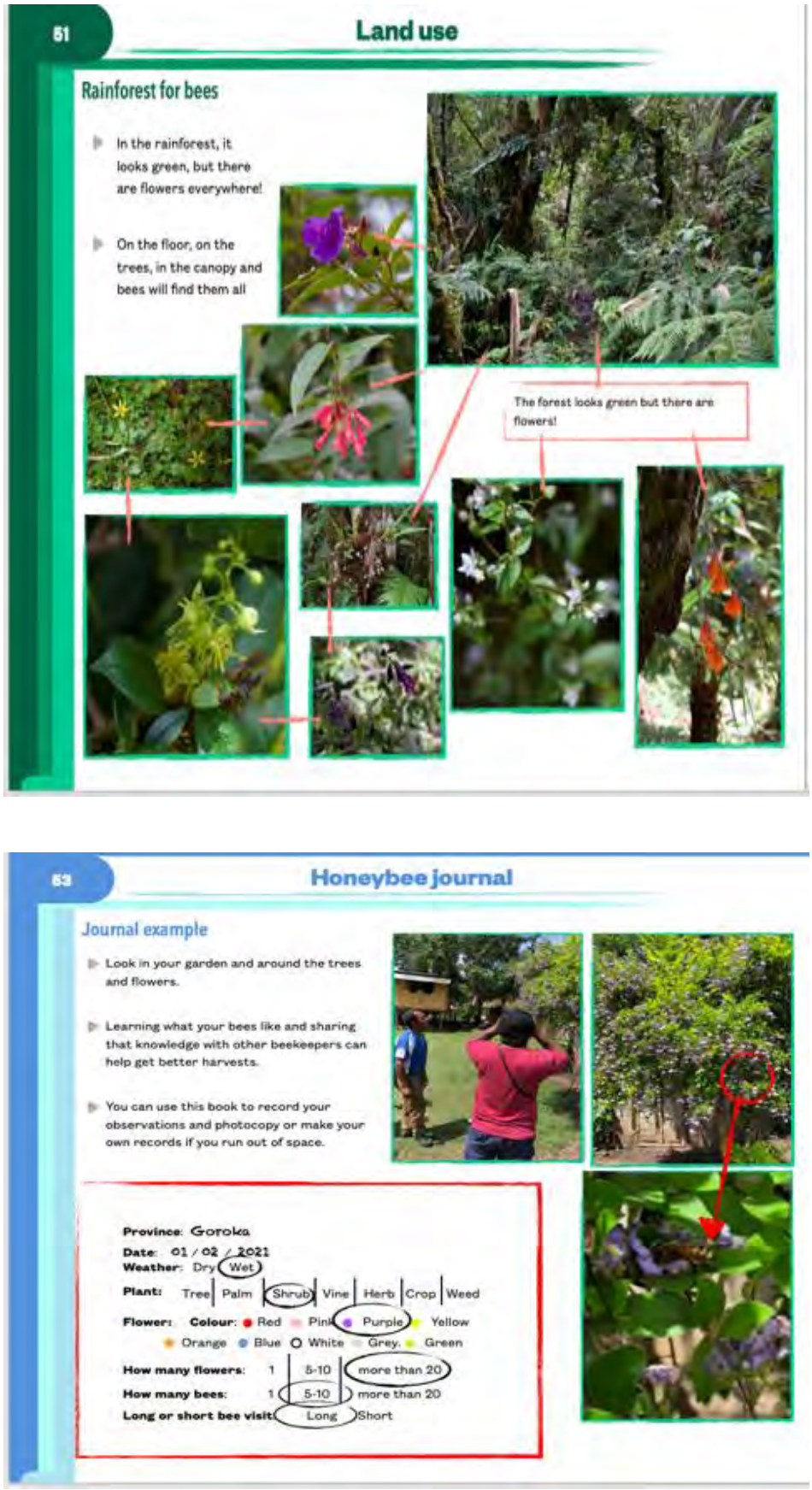


Figure 24. Examples of pages from beekeeping guide to flora of Papua New Guinea

8.2.2 Change in equipment and infrastructure

Fiji

The project team provided Bula coffee with drying advice and developing new packaging. Large sealable plastic bags for storing dry coffee were supplied to enable more efficient postharvest drying and storage of coffee. Bula Coffee has credited this intervention with enabling them to maintain the quality of their beans, expand their operations and create export markets. This was especially important as they were able to export to New Zealand when the tourist market collapsed during the Covid-19 shutdowns. As a result of this, they were able to keep their employees and increase their source of coffee beans. Initially Bula Coffee was sourcing coffee from only one village, now they are sourcing coffee from eighty-three villages with 1,200 people picking coffee.

Nadroumai Women's' group received potting equipment, materials and training to establish their nursery. This has resulted in a financially viable business.

Figure 25. Bula Coffee

Solomon Islands

Three small processers in the Solomon Islands (Marghoto Holdings, SolArgo Pty Ltd and Jedom Trading) were provided with food processing and food packaging equipment and packaging materials. This equipment and materials were purchased in Australia and sent to the Solomon Islands as they are difficult to procure in that country. This equipment and materials (food processors, food dehydrators, vacuum sealers, food grade buckets for storing raw material and glass jars and plastic pouches for selling value-added products), have increased their processing capacity.

Jedom trading received assistance with construction of a solar dryer (Figure 26) to reduce reliance on electricity and reduce associated production costs. Jedom Trading also received assistance to develop new packaging and labels.

Figure 26. Doni Kelly with solar dryer

Vanuatu

Lapita Café received assistance to develop over 1-hectare agroforestry plot at Mackenzie's farm (Santo Island). This farm with more than 400 nut trees (*Terminalia catappa* and *Canarium indicum*) as well as cash crops (manioc, kava, tropical fruits, coffee and cocoa) will assist Lapita café with sourcing raw materials for Lapita Cafe. Assistance was also provided to Lapita Café to develop new packaging and labels with the nutritional information included to improve sales and their export potential.

The Department of Industries established new hives to support honey producers on Tanna Island (Figure 27). Sixteen new hives were established with another 20 hives under construction. 62 queen bees were reared to increase the honey industry and 20 potential beekeepers were trained on Tanna Island. During the past year, honey production has increased by 80 kg. The Department of Industry will use this strong industry on Tanna Island to introduced honeybees into existing agroforestry systems on Efate Island and re-establish the entire Vanuatu honey industry.

Figure 27. Training beekeepers and rearing queen bees on Tanna Island (Vanuatu) (left photo). Transferring queen-bee larvae to new brood cells (middle and right photo)

Papua New Guinea

The project provided equipment for Kelly Inae (Helping Hands Honey) in Goroka, Eastern Highlands. Kelly provides training, equipment, processing honey for sale and distribution of honey for over 200 local farmers. Kelly Inae was supplied with a new computer tablet to collect information on beekeepers, record the health status of clients hives throughout the highlands and record videos for training workshops.

Beekeeping equipment (protective clothing, head veils and smokers and refractometers) has been supplied to beekeepers in the Eastern Highlands of PNG (Figure 28). This has increased efficiency of harvesting honey and safety for beekeepers. Refractometers are particularly important to ensure that honey is harvested when the moisture content is optimum for storage (around 20%). These refractometers have proven useful in training beekeepers and demonstrating how to harvest honey correctly.


Figure 28. Farmer Samiya of Pandayompa region and his wife receiving a full body beekeeping suit to help with honey harvesting of their large apiary holding over 50 hives. Chris Cannizzaro and Helen Wallace sampling honey from hives in Goroka


Figure 29. Kelly Inae, Raywin Ovah and Chris Cannizzaro with new smokers for field work and training sessions for local beekeepers. Kelly Inae demonstrating safe and effective use of smoker to calm bees for observing hive and maintenance.

8.3 Community impacts – now and in 5 years

8.3.1 Economic impacts

Overview

The project has had a range of economic impacts, especially for female smallholders, especially in Fiji, Vanuatu and the Solomon Islands. Project activities have allowed both smallholders and processors to access new markets, and increased income and sales as a result, up until the Covid-19 pandemic in March 2020.

The disruptions to the economy caused by the Covid-19 pandemic highlighted the need for and created opportunities for more value- added local food in Pacific countries. Food security emerged as a major concern and processing local food to increase its shelf life and add value is seen as a way to improve livelihoods, produce income and substitute for imported food which is no longer affordable or available. In Fiji Food Inspired provided further training in value adding to market women as a way to improve livelihoods when many people are out of work and food trading and bartering are flourishing. In Vanuatu "satellite food processing" training on outer islands was delivered as a part of the project in response to the Covid-19 crisis and Tropical Cyclone Harold.

The impacts of the project on industry partners, small holders, and new producers who have commenced producing value-added products are highlighted in three videos:

- A video reporting outcomes from the work at Nadroumai (Fiji) working with Nadroumai women's group, Shangri-La resort and Bula Coffee is available at: https://vimeo.com/389910080/eefd3ed6ac
- A video reporting outcomes working with Jedom trading and the women from Kolupa village (Solomon Islands) is available at: https://vimeo.com/423068750/c6c4431839
- A video report detailing value-added training at HART village (Fiji) is available at: https://www.youtube.com/watch?v=BMEvO4-H8go

Fiji

The Nadroumai women's nursery was established as a part of the project activities. At the conclusion of the project, the nursery is fully functioning without the ACIAR project team's support. Income from the nursery is shown in Table 9. The nursery also has 10,000 eucalyptus seedlings for Nabou Green Energy (value FJD 3,000) and 30,000 pine seedlings for Ministry of Forests in stock. The nursery has doubled in size and has over 30 women now engaged in the day to day running of the nursery. This has assisted the community at a time when many people in Nadroumai have lost their employment in the neighbouring Shangrila Resort as an outcome of Covid-19 border closures. Women have also been given 1.5 acres to cultivate coffee and grow vegetables. Prior to this Agroforestry project, women were not able to cultivate coffee in Nadroumai, due to a lack of support in addressing key problems with land access. Impacts from the work in Fiji including the Nadroumai nursery is demonstrated in the Fiji Video (8.3.1 Community Economic Impacts).

Table 9. Income from Nadroumai Nursery

	2018	2019	2020	2021
Number of seedlings	90	910	1000	1966
Value FJD$	300	2600	>3,000	5,898

Figure 30. Nursery at Nadroumai

The training by Food Inspired at the Hart Village (Fiji) has already provided positive economic impacts for the female participants of this training as shown in the Fiji – Hart village video (8.3.1 Community Economic Impacts). These impacts include:

- More than 50% of participants producing value-added products
- Participants are excited about be able to produce jams and chutneys and earn money
- One participant's first batch was made in only one day and completely sold out
- Another participant made $90 in the first week and $60 in the second week
- Another participant made $45 on the first day then $46 on the second day
- There is growing interest from shops and resorts to purchase from local markets

Vanuatu

Lapita Café has developed several new products 2018-2021. These have included Nangai oil, Gluten free Nangai and coffee bean cookies and chilli and pawpaw chutney. Prior to the Covid-19 pandemic, Lapita café reported increased sales of gluten free cookies and nut products through the supermarkets and hotels. Between 2018 and 2020, production of value-added products by Lapita Café has increased (Taro chips 130%, Tamarind products 16% and mango products 105%, dried Nangai products 17%). Sales for gluten free flour remained stable but were hampered by a shortage of manioc. In 2019, Nangai nut purchases had increased from 1 to 2 tonnes of processed kernels, however tropical cyclone Harold destroyed many of the Nangai trees on Malo resulting in Lapita Café sourcing more nuts from Malekula, Tongoa, Paama and Epi islands. Following the disruption to tourism in Vanuatu (Lapita's largest market for value-added products) by the Covid-19 pandemic, sales from January to July 2020 were severely impacted to just 0.6 ton. The purchase of Nangai nuts and other raw materials provides economic benefits to 400 to 700 farmers at the end of the project (compared with 100 farmers at project commencement in 2015).

Prior to Cyclone Harold, this project assisted Lapita Café to develop an agroforestry plot growing raw materials for their business. This vertical integration will assist long term productivity by ensuring supply of raw material particularly manioc which has been in short supply.

This project has facilitated new export markets for processors in Vanuatu. Through negotiations with Oxfam during 2018, ACTIV achieved AUD$17,490 in total sales of chocolates and coconut oil. Trade Aid (NZ) expressed interest flour, chips dried fruit chutneys, jams, relish sauces, desiccated coconut, coconut oil and tea from the Pacific Islands. Samples of these products from Lapita Café (Vanuatu), ACTIV (Vanuatu) and Friends (Fiji) have been sent are awaiting review by Trade Aid.

Solomon Islands

The industry partners, Jedom Trading in Solomon Islands has increased production of processed *Barringtonia* and *Terminalia* value-added nut products during the life of this project (Table 10). Using methods for commercial production of *Barringtonia* and *Terminalia* dried nuts, Jedom Trading now have developed a new product range and were purchasing almost 1 tonne of nut products prior to the Covid-19 pandemic (Table 10). Jedom Trading have increased their skills and capacity to enter into new export contracts with better packaging and labelling suitable for export markets.

Value-added training by Jedom Trading, to a women's group at Kolupa village has resulted in the group value-adding to *Barringtonia* and *Terminalia* nuts. The women's group from Kolupa village are sourcing their own *Barringtonia* and *Terminalia* nuts, are now producing value-added products and selling them to local consumers. Instead of selling fresh nuts for $2, dried nuts sell for $5-6. (Video report - Solomon Islands (Community Economic Impacts 8.3.1). Business networking and mentoring by Votausi Mackenzie-Reur (Vanuatu) to Doni and Jenny Kelly (Solomon Islands) resulted in mentoring by Doni and Jenny Kelly to women from Kolupa village. This village was previously only providing raw materials to Jedom Trading.


Figure 31. Women from Kolupa village (Solomon Islands) with their dried value-added produce

Cyclone Harold impacted supply of nuts, and the Covid-19 pandemic has seriously impacted tourism in the Solomon Islands, closing most of the hotel and market sales outlets that sell dried nuts. Prior to 2018, Jedom trading were purchasing raw material from more than 20 farmers each year, but since COVID has only purchased from five farmers. This has impacted the livelihood of those farmers.

Table 10. Volume of Ngali, Alite and Cut nuts purchased by Jedom Trading each year

Year	*Canarium* (Ngali nut)	*Terminalia* (Alite nut)	*Barringtonia* (Cut nut)
2016	Not available	Nil	Nil
2019	500kg	270kg	220kg
2020	279kg	190kg	146kg
2021	20kg	11kg	Nil

Processing of *Barringtonia* and *Terminalia* nuts has the potential to increase output/ income for processors who are currently producing value-added canarium nut products. This industry is currently a cottage industry servicing domestic market demand. Sales of indigenous nut products in Solomon Islands and Vanuatu have been strong with supply unable to meet consistent repeat demand. This unmet demand in the domestic market for nut products indicates that this sector will continue to expand and provide opportunities for export opportunities. Several processors have already been experimenting with the export market.

8.3.2 Social impacts

Providing new sources of income to rural families has provided positive social impacts for smallholder farmers, particularly women. However, Covid-19 has disrupted markets and had impacts on demand for products. Increased opportunities for greater involvement will provide improved social impacts such as sending children to school and university and alleviating stress due to lack of cash.

Development of women's groups in Vanuatu and Fiji has already begun to improve social inclusion of women in the community nurseries. As stated in elsewhere (Results, Objective 3 and Economic impacts), the Nadroumai Woman's Group are currently clearing an area of land near the Village where they can cultivate coffee and grow vegetables near the nursery.

Prior to this Agroforestry project, women were not able to cultivate coffee in Nadroumai, due to a lack of support in addressing key problems with land access.

The pilot site at Korotari, near Labasa (Fiji), has provided positive impacts for the Korobua Community Youth Group. Young people have been involved in planning, selecting species, sourcing the planting materials and planting. These young traditional owners have attended workshops and participated in demonstration activities. Pilot sites provide support of women and youth group programs to help them learn new skills and to make planting materials available (trees and crops) that may assist them to gain experience and produce income from crop sales.

In addition to the economic benefits listed above, the training by Food Inspired at the Hart Village (Fiji) has also had positive social benefits. Women have reported that their self-confidence has improved (Fiji – Hart village video (8.3.1 Community Economic Impacts).

Figure 32. Young people from Korotari planting pilot site

8.3.3 Environmental impacts

The pilot sites and workshops have raised awareness of the environmental benefits of integrating trees and crops. In both pilot sites in Fiji and the site on Santo sustainable use of forest reserves and conservation areas was included. Exploration of ecotourism opportunities, wild harvest of coffee and other local fruits, seeds and nuts have contributed to livelihoods. Biodiverse reforestation systems that will produce both food and timber demonstrate strategies that reduce pressure on natural forest reserves and provide resources and timber in the future.

The Vanuatu Sustainable Tourism Policy (2019-2030), discussed in Scientific impacts, promotes national efforts to protect catchments and encourages the tourism sector to adopt conservation management to protect key biodiversity areas. Policy objectives support an increase in local produce and encourages increased local produce within the tourism market. We anticipate that the increased market opportunities for agroforestry products and research combined with increasing agroforestry tourism will promote the value of trees in the landscape. This will stimulate more investment in planting indigenous tree crops and result in more carbon sequestered.

Clear-felling of trees for power generation upstream from the Nadroumai site and subsequent rainfall events resulted in severe erosion and sedimentation of the reef and impacted on the project activities. Erosion is a huge problem for landholders in Nadroumai village and the Shangri-La resort downstream. Catchment revegetation is urgently needed, but there are land tenure issues associated with tree planting for women. A video report Fiji – Nadroumai (Achievements, Activity 5.1) highlights the impacts of tree clearing in the catchment, flooding and erosion at the demonstration site.

8.4 Communication and dissemination activities

Three videos have been produced by the team to highlight the project activities and impacts from this project in Fiji and Solomon Islands.

A video reporting outcomes from the work at Nadroumai (Fiji) demonstrates work with Nadroumai women's group, Shangri-La resort and Bula Coffee is available at: https://vimeo.com/389910080/eefd3ed6ac

The video highlights the following points:

- Erosion is a huge problem for landholders in Nadroumai village and for the Shangri-La resort downstream. Catchment revegetation is urgently needed, but there are land tenure issues associated with tree planting for women.
- To solve land tenure issues the Nadroumai women's club nursery was established and nursery training was conducted. This has given women a new source of income and there is demand for their trees from many sources.
- Agroforestry demonstration sites have been established
- The partnership with Bula coffee has helped Bula increase its supply base of ethically and sustainably sourced coffee from the Nadroumai women.

A video report outcomes from the work with Jedom trading and the women from Kolupa village (Solomon Islands) is available at: https://vimeo.com/423068750/c6c4431839

The video highlights the following points:

- Women from Kolupa village are drying *Canarium*, *Barringtonia* and *Terminalia* nuts
- They developed their own markets for value-added nuts and sell to local consumers
- The dried nuts sell for $5-6 instead of $2 so they have increased the value of their agroforestry products by processing
- Value-adding preserves produce that may otherwise be wasted and is financially beneficial to the village

A video report detailing in-depth training and mentoring to 48 women from Hart Village a social housing village in Lautoka (Fiji) is available at: https://www.youtube.com/watch?v=BMEvO4-H8go

Training covered food safety, processing methods, quality control and how to manage a microbusiness and marketing was provided to build the skills and confidence to produce a consistent quality product. The video highlights the following:

- Since the training more than 70% of participants have made value-added products
- More than 50% are engaged in selling their products.

The training and value-adding production have received media coverage in Fiji Times and the FBC news. The work with women at the Hart village in Fiji was also highlighted in a Fijian women's magazine.

https://www.yumpu.com/en/document/read/65181830/i-am-woman-magazine-fiji-issue-14

9 Conclusions and recommendations

9.1 Conclusions

This project demonstrated the potential of value-added agroforestry products to improve livelihoods of rural villagers in PNG, the Solomon Islands, Vanuatu and Fiji. The research identified opportunities in the fruit, nut, honey and tree nursery industries and then focussed on appropriate value-adding, small scale processing and drying techniques as key enablers of industry development. The project also established pilot sites in Fiji and Vanuatu to demonstrate agroforestry services and determine crops with best market potential.

This project resulted in many new value-added products and produced livelihood benefits for many stakeholders. These new products and benefits included

- new nut products (Solomon Islands),
- linking processers to export markets (Vanuatu),
- new processed products (Vanuatu),
- women's nurseries to support tree planting (Fiji)
- improvements to coffee production (Fiji),
- training for smallholders in value adding and up chain marketing (Fiji, Vanuatu and Solomon Islands)
- adoption of new policies on agritourism by key stakeholders (Vanuatu)
- resources to help smallholders produce honey (Papua New Guinea).

The project has had a range of economic impacts, especially for female smallholders in Fiji, Vanuatu and the Solomon Islands. Project activities have allowed both smallholders and processors to access new markets, and increased income and sales as a result, up until the Covid-19 pandemic in March 2020.

The disruptions to the economy caused by the Covid-19 pandemic highlighted the need for more value-added local food in Pacific countries. Food security emerged as a major concern. In Fiji, food trading and bartering of processed local food was used when many people were out of work. In Vanuatu "satellite food processing" training on outer islands was delivered in response to the Covid-19 crisis and Tropical Cyclone Harold.

A major strength of this project was the training in value-adding and nursery production to the women participants. This has demonstrated to other donors the importance of quality training and designing training that is appropriate for the participants to ensure lasting impacts at the conclusion of the project.

9.2 Recommendations

Value-adding of agroforestry products has the potential to improve the lives of smallholders, particularly women, in Pacific Island countries. Pacific Island countries have a significant opportunity to strengthen the emerging small-scale food processing sector using their unique agroforestry products. Products can target both the domestic, tourist and export markets and will increase incomes and improve local food security. To take advantage of this opportunity, donors, processors, and governments need to harness the momentum built by the current research. Further investment and interventions are needed especially due to the impacts of Covid-19 on the tourism market in the Pacific.

Some critical emerging issues that require further research and intervention are:

1. *Women's issues*. This project had a strong emphasis on improving the livelihoods of female smallholders and entrepreneurs. However, formalising traditional agricultural knowledge and rights is complicated. Understanding traditional barriers, such as

land tenure, to women's use of resources and cultural expectations, is important to increase women's involvement in agroforestry systems. For example, formal approval to manage tree production indicates a land claim and as such prevents women from planting coffee trees, while they can harvest coffee from the wild. Addressing these issues will support the emerging industry and produce substantial benefits to smallholders, SMEs and private sector investors.

2. *Further training in value-adding for smallholders*. Training on value-adding, food safety, business management provided many benefits to smallholders and should be ongoing and more widely provided. As demonstrated in the training needs analysis, content and delivery must be practical and address the participants' priorities.

3. *Product consistency and quality for domestic and export markets*: Although tourist operators would like to use local products and reduce their reliance on high-cost imported foods, issues with quality and consistent quantity are challenging. Barriers that prevent tourism operators from purchasing local produce such as quality, consistent quantity and uncoordinated supply need to be addressed. Methods that maintain product quality when agroforest products are processed on-farm need to be developed. Food safety and quality control from the farmgate to markets needs to be improved. Manufacturing and storage protocols are needed to minimise rancidity and microbial contamination in the final products by strict adherence to food safety standards. Standards required for export markets such as HAACP requirements need to be promoted. Training in techniques and processing skills and support for infrastructure will be required to address these issues.

4. *Strengthen policy*. The Vanuatu Sustainable Tourism Policy (2019-2030) developed form this project identifies the need for catchment protection and requires conservation management by the tourism sector to protect key biodiversity areas. Methods to fund investment in conservation such as "Payment for Environmental Services" programs and a "Visitor Arrival Levy" may be implemented. Strengthening of government policy has improved linkages between the production sectors and tourism sectors to promote local produce and provide environmental protection. More work is required in this area.

5. *More support for women's seedling nurseries*. One major barrier to upscaling tree crop production in Melanesia is the supply of high-quality seedlings. Nurseries may not necessarily require formal land tenure access. This project demonstrated that establishing nurseries with community women's groups can provide a worthwhile livelihood opportunity for women within the agroforestry value chain. A significant amount of nursery and business management training over an extended period to facilitate quality products as well as market pull for products is needed. Working through women's groups also provides an opportunity to disseminate information directly to the women.

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Shahla Hosseini Bai, Bruce Randall, Repson Gama, Basil Gua, Doni Keli, Paitia Negalevu, John Oakeshott, Kim Jones, Peter Brooks and Helen M Wallace. Physical and chemical characteristics of *Barringtonia* species nuts in three Pacific Island countries.

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11 Appendixes

11.1 Multipurpose agroforestry crops with market potential to be value-added

Objectives 1 and 4

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Executive summary

The project explored opportunities for new value-added agroforestry products to improve livelihoods and environmental benefits in PNG, Vanuatu, Fiji and the Solomon Islands. The research used a value chain framework to identify key crops in each country with the greatest potential in these areas with an additional focus of planting trial sites in Fiji and Vanuatu. The research investigated appropriate processing methods to meet market requirements such as drying, packaging, and quality standards. Opportunities, incentives and barriers that enable smallholder participation in agroforestry crop production were identified, with a focus on the involvement of women and the private sector. This Report primarily addresses Objective 1: *Identify multipurpose agroforestry crops with market potential to be value-added in all four countries*, but also informs other objectives.

Previous and existing agroforestry programs being run by ACIAR, other international funders, government, NGO's and private sector players were researched (desk-based) in all four countries. The recommendations and outcomes of a range of final and interim reports prepared by ACIAR were studied and documented. Where required, project team members from these projects were approached and spoken with to verify report recommendations with a view to focussing the scope of this research.

Key informant interviews and workshops were undertaken 'in-country' with a range of donor, government, NGO and private personnel with a view to analysing the recommendations and outcomes of previous research. These interviews and workshops were also conducted for the purpose of establishing project partners for this research and to focus the research on agroforestry crops that had the greatest potential for value-adding and environmental benefits in each of the four countries.

Interviews were conducted by the entire project team, who bought a wide range of skills and expertise to the discussions. This ensured that a wider scope of opportunities and their potential impacts were considered in each country and was especially important in Fiji and Vanuatu where trial sites were also established.

The research, both desk-based and interviews / workshops (in-country) concluded that the following agroforestry crops and 'sites' have the greatest potential for value-adding (i.e. they are the 'best bets') in each country, noting that 'potential' has been considered in terms of economic (market), social (cultural) and environmental impact. It should also be noted that some of the 'best bets' outlined in the country matrix section are being addressed in other ACIAR project activities, so while we'll look to collaborate where appropriate, this report focuses on the specific activities within this project.

Before looking at each country individually there was an overarching opportunity to look at Pacific wide opportunities to export into countries like Australia. One example of a suitable market channel focussing on ethically conscious Australian consumers is Oxfam Australia. Oxfam Australia agreed to allow us access to their 55,000 strong membership database to undertake a significant consumer survey to better understand this market and their purchasing behaviour towards Pacific products. While Oxfam Trading Australia is experiencing its own retailing issues at the moment, these consumer insights with be valuable to our Pacific stakeholders interested in Australia as a target market and we have

also shared these insights with other potential retailers looking to link Pacific value adders to Australian consumers to promote further trade between the two countries.

Best bet species:

Vanuatu

- Crops including *Canarium, Terminalia, Barringtonia*, Tahitian chestnut (ivi), Breadfruit, Mango, Pineapple, Tamanu, Coffee and Cocoa
- Project partners included: The Department of Industry in Vanuatu, Lapita Café and ACTIV.
- 'Drying' was used as a technique for value adding to enhance stabilisation of the product (crop) to avoid issues relating to cold chain logistics.
- Research on value adding included:
    - Drying techniques for both the nuts and fruit.
    - New product development

Fiji

- Crops including nuts (*Terminalia, Barringtonia)* fruit and coffee
- Project partners were Bula Coffee and SPC.
    - Opportunities to utilise existing wild coffee with women collection through villages like Nadroumai with Bula Coffee
- Research included:
    - Helping to solve any processing issues
    - Training and extension - particularly on plant propagation and nursery management.
    - Link in with consumer research with Oxfam
- Research on value adding included:
    - 'drying' as a technique for value adding enables stabilisation of the product (crop) to avoid issues relating to cold chain logistics. There is crossover with work being done on 'drying' techniques in PNG, Vanuatu and the Solomon Islands.

Solomon Islands

- Crops included nuts (*Canarium*, *Terminalia* and *Barringtonia*)
- Project partners included: Ministry of Commerce, Industry, Labour and Immigration and Jedom Organic Fruits Ltd.
- Research included:
    - Cracking and drying techniques for nuts.
    - Investigating certification requirements for export.
    - New product development.

Papua New Guinea

- Crops included honey
- Project partners were NARI and Mountain Honey
- Research included:
    - Understanding which flowers the bees are feeding on through nectar DNA analysis.
    - Understanding taste and medicinal properties for consumer marketing.

Trial sites:

Vanuatu

- **Trial Site 1 – Santo**
  - Project partners were the Department of Industry, the Department of Forestry in Vanuatu, VaRTC, ACTIV and Lapita Cafe.
  - Focus was on developing an integrated system of crops including *Canarium*, *Terminalia*, *Barringtonia*, Tahitian chestnut (ivi), Breadfruit, Mango, Pineapple, Tamanu, Coffee and Cocoa

Fiji

- **Trial Site 1 – Nadroumai Village (Shangri-La)**
  - Project partners were SPC, Shangri-La Resort and the Nadroumai Village.
    - Priority was working with Shangri-La and Nadroumai on environmental and product connections.
- **Trial Site 2 – Nadi, Labasa**
  - The second trial site focused on an agroforestry system better suited to a drier and more degraded site in the upper catchment area. Species included Sandalwood, *Terminalia* and Mango.

Background

Approximately 80% of people in PNG and the Pacific live in rural areas. More than 90% of them are semi-subsistence smallholder farmers, who earn their livelihoods from agriculture, forestry and fishing. Rural farmers in countries such as PNG, Fiji, Vanuatu and the Solomon Islands generally have limited access to distant markets for their crops. Value-adding can enhance market access, especially if products can be dried or semi-processed locally and transported to distant markets. Industries based on value-added products can also create employment and enhance opportunities for small- to medium- enterprises (SME's) to strengthen local economies.

There is great potential to value-add to a variety of agroforestry crops in the four countries, but targeted research was needed to identify the best opportunities for investment and to build capacity in value-added processing of these products in both the government and private sectors in the four countries. Industries based on value-added agroforestry crops are at different phases of development in each of the countries. Previous ACIAR projects in the Pacific have demonstrated that value-added products from agroforestry crops can enhance livelihoods.

This research was driven from Pacific stakeholders in the government and private sector and Australian researchers collaborating on the ACIAR PARDI (PC/2008/044) projects on canarium, tamarind and cocoa, and on canarium research in PNG (FST/2010/013). In PNG and the Pacific Island countries, private sector processing of agroforestry crop products is under-developed. ACIAR's project (FST/2010/013) has shown the potential for new small and medium scale enterprises to be developed around value-added processing of canarium nuts. This project undertook research on existing and potential products and processes in conjunction with the private sector. This project also created opportunities throughout the value chain for new processors and marketers with a range of locally produced value-added products.

The emphasis on a need for further agroforestry research was discussed in a series of ACIAR stakeholder workshops (PC/2013/016) over the past two years (with grower, government, processor and community representatives) in Nadi and Suva. A broad range of stakeholders strongly endorsed the need for development of agroforestry cropping systems that provide demonstrated livelihood benefits and that are specifically targeted to the needs of smallholders in degraded catchments, such as the Nadi Basin.

The 2014-2015 ACIAR Annual Operational Plan chapter on PNG identified “smallholder forestry and agroforestry systems and value-adding in wood and non-wood products” as one of seven country priorities. The Pacific Islands chapter identified improving food and nutritional security through new, market-driven opportunities, integrated and sustainable forestry resource management and development, underpinning the competitiveness of value chains as regional priorities. Further, the Department of Industry in Vanuatu has initiated the value chain framework approach of this project and identified value-adding of fruit and nut products as a key need for investment.

This research aligned with the Australian Government’s aid policies, including enhancing opportunities for women and engaging with the private sector. Women have a central role in household food gardening, growing and tending to agroforestry crops and marketing of horticultural and agroforestry crop products. In partner countries, improving opportunities for value-adding is a critical part of the national development strategies.

Objectives

This Report addresses aspects of Objective 1, in particular the following:

1. Identify multipurpose agroforestry crops with market potential to be value-added in all four countries

1.1 Inventory and review donor, government, NGO and private programs promoting agroforestry value chains in all four countries
1.2 Conduct key informant interviews and desk studies to analyse existing evaluations of projects and policies identified in activity 1.1
1.3 Establish criteria and process for selecting the high value agroforestry crops
1.4 Surveys of smallholder farmers (males and females) and review of the literature at the start of the project to establish a baseline and understand the value chain, adoption behaviour, practices on the farm, labour trade-offs (addressed in part)

This report provides key information used in the other aspects of the project. Some of the information contained within this report provides background for/ is relevant to or partly addresses the following objectives for the project. Reports for outcomes of specific activities are detailed in additional appendices.

2. Enhance small to medium enterprises ability to participate in value-adding

2.1 Identify key research gaps in value-adding for each crop in each country

3. Enable smallholder and gender equitable participation in agroforestry crop production

3.1 Identify opportunities, incentives and barriers that enable participation in agroforestry crop production

4. Develop and pilot testing of catchment revegetation systems linked to markets

4.1 Recommend species for planting in Fiji and Vanuatu at upper, mid and lower catchments
4.2 Support pilot planting of agroforestry crops with other projects such as FAO/GEF

5. Build capacity and disseminate research findings

5.1 Conduct a training needs analysis, an impact pathway analysis and a monitoring and evaluation plan
5.2 Conduct a training workshop on a range of value chain techniques

Methodology

For the purposes of this Report, the 'methodology' is explained broadly for the entire project and then with a focus on Objective 1 and the activities that have contributed to the achievement of this Objective.

The overall project used a value chain framework to identify key crops in each country with the greatest potential for value-adding. The project has taken a transdisciplinary approach to the research. Interviews were conducted by the entire project team, who bought a wide range of skills and expertise to the discussions.

The research investigated appropriate processing methods to meet market requirements such as drying, packaging, and quality standards. Opportunities, incentives and barriers that enable smallholder participation in agroforestry crop production were identified, with a focus on the involvement of women and the private sector. A review of the literature along with surveys and interviews with value chain members and stakeholders provided a better understanding of the opportunities, adoption behaviour, farm practices and decision making at both the private and public sector level.

This project addressed both the "market pull" and the biophysical, economic and social needs of agroforestry systems. The "market pull" approach ensures that markets exist for products and that the species that are promoted for planting will increase smallholder livelihoods. The biophysical, economic and social aspects of agroforestry crop production in tandem with the market pull, to give smallholders confidence that plantings will produce an income in an integrated system with a variety of crops.

This report is the basis of the project and informs all other objectives of the project, especially Objective 2, 3 and 4. The catchment revegetation pilot projects (Objective 4) were conducted only in Fiji and Vanuatu, where there has been a clearly identified urgent need to improve catchment revegetation to improve water quality and reduce the impact of flooding. In addition, the research examined the agri-tourism value chain by facilitating discussions between smallholders and the tourism industry. The project also identified possible beneficiaries of market mechanisms such as PES or CSR and engaged in discussions and negotiations to define suitable payment mechanisms to provide incentives to encourage smallholder participation in agroforestry crop production. The project team also conducted training days, workshops and field demonstrations, especially for female entrepreneurs and smallholders on value-adding and agroforestry crop production.

Objective 1. Identify multipurpose agroforestry crops with market potential to be value-added in all four countries (PNG, SI, VAN, Fiji)

1.1 Inventory and review donor, government, NGO and private programs promoting agroforestry value chains in all four countries

Previous and existing agroforestry programs being run by ACIAR, other international funders, government, NGO and private sector players were researched (desk-based) in all four countries. The recommendations and outcomes of a range of final and interim reports prepared by ACIAR were studied and documented. Where required, project team members from these projects were approached and spoken with to verify report recommendations with a view to focussing the scope of this research. ACIAR research projects that were targeted in this desk-based study were:

- ACIAR PARDI (PC/2008/044) program in Vanuatu and the Solomon Islands
- ACIAR Projects FST/2010/013 and FST/2006/048 focusing on canarium in PNG
- ACIAR Projects FST/2005/089 and FST/2012/020 focusing on multi-species agroforestry systems
- ACIAR Whitewood project FST/2012/042

- ACIAR Project ADP 2014/012 - Improving livelihoods and economic progress through rehabilitation of degraded catchments in Fiji and Vanuatu
- ACIAR ADP/2014/013 - Promoting sustainable agriculture and agroforestry to replace unproductive land-use in Fiji and Vanuatu

Government programs relating to agroforestry were reviewed (desk-based) in each of the four countries. The economic and social objectives of these programs were noted and documented. These programs were investigated further 'in-country' (details of 'in-country visits are documented in the methodology specific to objective 1.2) with appropriate personnel from government.

International funders, NGO and private programs promoting agroforestry value chains in all four countries were also reviewed. This provided the project team with several 'leads' on potential partner organisations for the research. These 'leads' were followed up 'in-country' (details of 'in-country visits are documented in the methodology specific to objective 1.2) where appropriate.

1.2 Conduct key informant interviews and desk studies to analyse existing evaluations of projects and policies identified in activity 1.1

Key informant interviews and workshops were undertaken 'in-country' with a range of donor, government, NGO and private personnel with a view to analysing the recommendations and outcomes of previous research. These interviews and workshops were also conducted for the purpose of establishing project partners for this research and to focus the research on agroforestry crops that had the greatest potential for value-adding in each of the four countries.

As stated above, interviews were conducted by the entire project team, who bought a wide range of skills and expertise to the discussions. This ensured that a wider scope of opportunities and their potential impacts were considered in each country and was especially important in Fiji and Vanuatu where trial sites were also a consideration.

The following 'In-country' visits were undertaken by project staff to present workshops and conduct interviews:

- PNG (February 2016)
- Solomon Islands (May 2016)
- Vanuatu (May 2016)
- Fiji (June 2016)
- Fiji (July 2016)
- PNG (August 2016)
- Vanuatu (October 2016)
- Solomon Islands (October 2016)
- PNG (January and February 2017)

An inventory of workshops and interviews conducted on these visits is provided in the results section.

1.3 Establish criteria and process for selecting the high value agroforestry crops

Establishing the criteria and selecting the priority agroforestry value chains was a collaborative process involving relevant project partners and stakeholders. The criteria were established by the project team using the information gathered from the desk-based research and the interviews and workshops that were conducted. The criteria considered the economic, social (specifically the impact on smallholder farms and women) and environmental benefits of each of the potential agroforestry value chains. Each criterion was

given a weighting (percentage) to quantify 'priority' and to enable comparison between potential agroforestry crops.

Each potential agroforestry crop in all four countries were graded against the weighted criteria that had been established. A simple grading system was used:

- 'No' compliance with a criterion resulted in a grade of 1
- 'Little' compliance with a criterion resulted in a grade of 2
- Compliance with a criterion resulted in a grade of 3
- 'Good' compliance with a criterion resulted in a grade of 4
- 'Maximum' compliance with a criterion resulted in a grade of 5

Grading was undertaken by the project team in collaboration with relevant project partners and stakeholders. A matrix of each of the crops and how they were graded against each of the criteria was developed.

The matrix was given strong consideration by the project team and project partners and stakeholders when selecting the agroforestry crops with the most potential for value adding. The results of the matrix were verified through anecdotal sources (interview and workshops) with stakeholders.

1.3 Surveys of smallholder farmers (males and females) and review of the literature at the start of the project to establish a baseline and understand the value chain, adoption behaviour, practices on the farm, labour trade offs

This data was collected for previous projects and where possible it has been summarized and included in appendix 11.1. As discussed previously, the methodology and thus information gathered when addressing Objective 1 of the project has in-part initiated activities that are detailed in other objectives for the project. Further, it was very important that the exercise of scoping the best opportunities for value-added crops in each country didn't hold-up other key aspects of the project, particularly species and site selection (the trial sites) for planting in Vanuatu and Fiji.

Key results and discussion

Key Findings from Previous Research

Overview

Previous ACIAR projects in the Pacific have demonstrated that value-added products from agroforestry crops can enhance livelihoods. For example, tree species such as canarium provide shade for cocoa, can be integrated into cropping systems with fruits, vegetables and root crops and also provide a nut crop which can be value-added, stored and sold to distant markets. Additionally, the canarium tree can also be used a source of timber.

Key results from previous studies are as follows:

- In partner countries (PNG and Fiji), improving opportunities for value-adding is a critical part of the national development strategies.
- ACIAR projects (FST/2010/013, PC/2013/016 ADP 2014/012 ADP 2014/013) have demonstrated the opportunities for value adding and have highlighted the barriers for farmers and producers including: need for short term cash flow to provide a return on investment, lack of good quality germplasm and the need for market integration with the producers, and training to ensure quality produce.
- Need for socially acceptable solutions.
- Smallholders need the confidence that plantings will produce an income in an integrated system with a variety of crops.

The Selection of 'Trial Sites' in Fiji and Vanuatu:

- In Fiji and Vanuatu there has been a clearly identified and urgent need to improve catchment revegetation. This is needed to improve water quality, reduce the impact of flooding and erosion and maintain the pristine environment for key industries such as tourism.
- The catchment revegetation pilot projects will be conducted only in Fiji and Vanuatu. Both nations have identified watershed protection and conservation as major priorities. However, there are few examples of systems that can help to protect vulnerable areas in key catchments from the impacts of severe climatic events (particularly flooding) and threats to water quality (nutrients and sediment).
- Agroforestry has been shown to enhance food security, but farmers need to have short term cash flow or other incentives while tree crops are growing.
- Species selection for pilot sites has been predicated on consultations with local community in both Fiji and Vanuatu, as well as experts (Dr Lex Thomson). The sourcing of planting material has presented a challenge as many of the preferred species are difficult to obtain in nurseries, particularly in Fiji.
- The preferred species for traditional tree crops are *Inocarpus*, *Terminalia*, *Barringtonia*, Breadfruit, Sandalwood, Citrus, Coffee, Cocoa and Mango. Planting material has been obtained for the pilot sites but follow up will be required to obtain additional varieties of the most promising agroforestry species.
- Linkages to the ACIAR Tropical Fruit programs have also provided superior pineapple and citrus varieties for the deployment in pilot sites.

Agroforestry crops identified for value adding potential:

Previous research and program activities conducted by the donor, government, NGO's and the private sector have suggested possible agroforestry crops for value adding. This information has been captured below for each country and has been considered along with the key informant interviews when concluding and making recommendations in this Report.

<u>PNG</u>

- In PNG, the pilot canarium processing NARI factory at NARI (ACIAR projects FST/2010/013 and FST/2006/048) has demonstrated the potential for value-added canarium nuts.

<u>Fiji</u>

- A survey of 1000 urban households, 600 producers and 8 retail outlets has been analysed to understand food shopping consumption and the value chain from producers to consumers. Results are detailed in Appendix 11.3.
- Discussions with tourism have examined barriers to increase the sales of local vegetables into the food service tourism industry.

<u>Vanuatu</u>

- Previous research under the ACIAR PARDI (PC/2008/044) program in Vanuatu and the Solomon Islands has resulted in growth of industries and establishment of new markets for smallholder farmers' products such as canarium, cocoa, tamarind, tamanu oil for cosmetics and noni juice.

<u>Solomon Islands</u>

- The domestic market for value adding of indigenous nuts is growing.

Key Findings from Interviews and Workshops

Establishing the criteria and selecting the priority agroforestry value chains was a collaborative process involving relevant project partners and stakeholders. The criteria were established by the project team using the information gathered from the desk-based research and the interviews and workshops that were conducted. The criteria considered the economic, social (specifically the impact on smallholder farms and women) and environmental benefits of each of the potential agroforestry value chains. Each criterion was given a weighting (percentage) to quantify 'priority' and to enable comparison between potential agroforestry crops (Figure 1).

1st Tier	Is there a sustainable / growing market?
1st Tier	Will the chain be able to sustainably supply the market?
1st Tier	Will it lead to livelihood benefits to smallholders?
	environmental benefits; revegetation, reduced erosion
1st Tier comb	environmental benefits; improved water quality
	environmental benefits; reduced flooding risk
1st Tier	involvement of the private sector
1st Tier	govt support
1st Tier	Gender equitable participation / opportunities for women
2nd Tier	resilience to environmental hazards (floods, cyclones etc)
2nd Tier	value adding opportunities / links to tourism
2nd Tier	enhancing food security
2nd Tier	Intervention replicable / potential to scale up
3rd Tier	ability to integrate with other crops
3rd Tier	fit in with social structures and conditions
3rd Tier	Potential for export / import sub / PES or CSR
3rd Tier	Nutritional benefits, if food / Village use if timber?
3rd Tier	Researchable issues that fit with ACIAR's mandate

Figure 1. Criteria for prioritising the potential of each crop

When considering each of the agroforestry crops it was very important to not only focus on those crops that had the biggest market potential but also to understand the cultural aspects of each of the value chains, especially in relation to the supply capabilities of the smallholder farmers. Further, the opportunities that were prioritised needed to have impacts along the entire chain as the outcomes of this research are not purely of a commercial focus. In considering the potential livelihood and environmental benefits of this research, different goals and timelines will ensue. In addition to this we are looking at site specific options in Vanuatu and Fiji which is one of the reasons why the broader project team has been involved in these decisions from the start.

Each potential agroforestry crop in all four countries were graded against the weighted criteria that had been established. A simple grading system was used:

- 'No' compliance with a criterion resulted in a grade of 1
- 'Little' compliance with a criterion resulted in a grade of 2

- Compliance with a criterion resulted in a grade of 3
- 'Good' compliance with a criterion resulted in a grade of 4
- 'Maximum' compliance with a criterion resulted in a grade of 5

Grading was undertaken by the project team in collaboration with relevant project partners and stakeholders. A matrix of each of the crops and how they were graded against each of the criteria was developed. The matrix was given strong consideration by the project team and project partners and stakeholders when selecting the agroforestry crops with the most potential for value adding. The results of the matrix were verified through anecdotal sources (interview and workshops) with stakeholders and other ACIAR project activities were considered when 'best bets' were assessed.

In all country's stakeholder interviews were targeted based upon the findings of the desk-based research and the relationships that had been established between the project team and personnel 'in-country' from other research activities. In many cases the interviews were the initial step in developing project partners for the research moving forward.

Papua New Guinea

Figure three is the completed Agroforestry Criteria Matrix for Papua New Guinea. The matrix has been completed based on the information gathered and summarised above in the desk-based review and the interviews that have been conducted in-country. Note that some of the 'best bets' outlined in the country matrix section are being addressed in other ACIAR project activities, so while we will look to collaborate where appropriate, this report will focus on the specific activities within this agroforestry project.

Fiji

Figure four is the completed Agroforestry Criteria Matrix for Fiji. The matrix has been completed based on the information gathered and summarised above in the desk-based review and the interviews that have been conducted in-country. Note that some of the 'best bets' outlined in the country matrix section are being addressed in other ACIAR project activities, so while we will look to collaborate where appropriate, this report will focus on the specific activities within this agroforestry project.

Vanuatu

Figure five is the completed Agroforestry Criteria Matrix for Vanuatu. The matrix has been completed based on the information gathered and summarised above in the desk-based review and the interviews that have been conducted in-country. Note that some of the 'best bets' outlined in the country matrix section are being addressed in other ACIAR project activities, so while we will look to collaborate where appropriate, this report will focus on the specific activities within this agroforestry project.

Solomon Islands

The Solomon Islands won the right to host the Pacific games in 2023. This will provide a big boost for the economy with construction and the use of timber to significantly increase in the lead up to the event (both private and public sector spending).

There is a new Ministry of Agriculture project named Rural Development Program 2 (RDP2). It is focussed on rehabilitation of cocoa and coconuts. It is supposed to have started mid last year but funding hasn't begun flowing yet.

Figure six is the completed Agroforestry Criteria Matrix for the Solomon Islands. The matrix has been completed based on the information gathered and summarised above in the desk-based review and the interviews that have been conducted in-country. Note that some of the 'best bets' outlined in the country matrix section are being addressed in other ACIAR project activities, so while we will look to collaborate where appropriate, this report focuses on the specific activities within this agroforestry project.

Papua New Guinea - Pacific Agroforestry Product Criteria Matrix													
Criteria	**Weighting**	**Agroforestry Options**											
		Coffee	**Cocoa**	**Coconuts (VCO)**	**Canarium**	**Honey**	**Vanilla**	**Spices (Pepper, Chilli etc.)**	**Pineapple / Banana**	**Mango**	**Citrus**	**Avocado**	**Sago**
Sustainable / growing market	**10%**	4	4	3	4	4	2	3	4	3	3	3	2
Livelihood benefits / employment creation	**10%**	4	4	3	4	4	3	3	4	3	3	3	2
Sustainable Supply (existing or potential)	**10%**	3	3	3	3	3	3	3	3	3	2	3	2
Environmental benefits	**10%**	3	3	3	3	5	3	3	3	3	3	3	3
Private sector involvement along the chain	**10%**	4	4	3	3	4	4	2	5	3	3	3	2
Govt support / National priorities	**10%**	5	5	3	5	3	3	3	4	3	3	3	2
Opportunities for Women	**10%**	3	3	3	3	3	3	3	3	3	3	3	3
First Tier	**70%**	**52**	**52**	**42**	**50**	**52**	**42**	**40**	**52**	**42**	**40**	**42**	**32**
Resilience to disasters	**5%**	3	3	4	4	3	3	3	3	3	3	3	3
Value adding opportunities / capacity building	**5%**	3	4	4	4	4	3	3	4	3	3	3	3
Enhancing food security (via product or income)	**5%**	3	3	3	3	3	3	3	3	3	3	3	3
Intervention replicable / potential to scale up	**5%**	3	3	3	3	3	3	3	3	3	3	3	3
Second Tier	**20%**	**12**	**13**	**14**	**14**	**13**	**12**	**12**	**13**	**12**	**12**	**12**	**12**
Ability to integrate with other crops	**2%**	3	3	3	3	4	3	3	3	3	3	2	3
Fit in with local structures and conditions	**2%**	3	3	4	3	3	3	3	3	3	2	2	3
Potential for export / import sub / PES or CSR	**2%**	4	4	3	3	3	4	3	3	3	3	2	3
Nutritional benefits, if food / Village use if timber?	**2%**	2	3	4	3	4	2	3	4	4	4	4	3
Researchable issues that fit with ACIAR's mandate	**2%**	3	3	3	4	3	3	3	4	3	2	2	3
Third Tier	**10%**	**6**	**6.4**	**6.8**	**6.4**	**6.8**	**6**	**6**	**6.8**	**6.4**	**5.6**	**4.8**	**6**
Total Score out of 100 (Scale x Weight) x100	**100%**	**70**	**71.4**	**62.6**	**70.4**	**71.8**	**60**	**58**	**71.8**	**60.4**	**57.6**	**58.8**	**50**

Figure 2. Papua New Guinea – Pacific Agroforestry Product Criteria Matrix

	Fiji - Pacific Agroforestry Product Criteria Matrix														
Criteria	**Weighting**	**Agroforestry Options**													
		Coffee	**Cocoa**	**Coconuts (VCO)**	**Tahitian Chestnut / Ivi**	**Vutu**	**Teak**	**Sandalwood**	**Breadfruit**	***Terminalia***	**Mango**	**Pineapple**	***Barringtonia***	**Avocado**	**Flowers**
Sustainable / growing market	**10%**	5	3	3	4	4	4	3	3	3	3	3	3	3	3
Livelihood benefits / employment creation	**10%**	4	3	3	4	4	4	3	3	3	3	3	3	3	3
Sustainable Supply (existing or potential)	**10%**	4	2	3	3	3	3	3	3	3	3	2	3	3	3
Environmental benefits	**10%**	3	3	3	4	3	3	3	3	4	3	3	3	3	3
Private sector involvement along the chain	**10%**	5	3	3	3	3	3	3	4	2	3	3	2	3	3
Govt support / National priorities	**10%**	3	2	4	3	3	3	3	3	3	3	3	3	2	2
Opportunities for Women	**10%**	4	3	3	3	3	2	2	3	3	3	3	3	3	4
First Tier	**70%**	**56**	**38**	**44**	**48**	**46**	**44**	**40**	**44**	**42**	**42**	**40**	**40**	**40**	**42**
Resilience to disasters	**5%**	3	3	4	4	3	3	3	3	4	3	3	4	3	2
Value adding opportunities / capacity building	**5%**	3	4	4	3	3	2	2	4	3	3	3	3	3	2
Enhancing food security (via product or income)	**5%**	3	3	3	3	3	2	2	4	3	3	3	3	3	2
Intervention replicable / potential to scale up	**5%**	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Second Tier	**20%**	**13**	**13**	**14**	**13**	**12**	**10**	**10**	**14**	**13**	**12**	**12**	**13**	**12**	**9**
Ability to integrate with other crops	**2%**	3	3	3	3	3	3	3	3	3	3	3	3	2	3
Fit in with local structures and conditions	**2%**	4	3	4	3	3	3	3	3	3	3	3	3	2	2
Potential for export / import sub / PES or CSR	**2%**	4	4	3	3	3	4	4	4	3	3	3	3	2	3
Nutritional benefits, if food / Village use if timber?	**2%**	2	3	4	3	3	2	2	4	4	4	4	4	4	2
Researchable issues that fit with ACIAR's mandate	**2%**	4	3	3	3	3	3	3	3	3	3	3	3	2	2
Third Tier	**10%**	**6.8**	**6**	**6.8**	**6**	**6**	**6**	**6**	**6.8**	**6.4**	**6.4**	**6.4**	**6.4**	**4.8**	**4.8**
Total Score out of 100 (Scale x Weight) x100	**100%**	**75.4**	**57.4**	**64.8**	**67**	**64**	**60**	**56**	**64.8**	**61.4**	**60.4**	**58.4**	**59.4**	**56.8**	**55.8**

Figure 3. Fiji – Pacific Agroforestry Product Criteria Matrix

Vanuatu - Pacific Agroforestry Product Criteria Matrix																
Criteria	**Weighting**	**Agroforestry Options**														
		Sandalwood	**Canarium**	**Cocoa**	**Coconuts (VCO)**	***Terminalia* / Natapoa**	**Noni**	**Tamanu**	**Spices (Vanilla, Pepper)**	**Fruits (Mango, Pineapples, Lemons etc.)**	**Handicrafts (Natangora etc.)**	***Barringtonia***	**Tahitian Chestnut (ivi)**	**Breadfruit**	**Coffee**	**Kava**
Sustainable / growing market	**10%**	3	4	4	3	3	3	4	3	3	4	3	4	3	4	4
Livelihood benefits / employment creation	**10%**	3	4	4	3	3	3	3	3	3	4	3	3	3	4	4
Sustainable Supply (existing or potential)	**10%**	3	4	4	4	3	3	4	3	3	3	3	3	4	4	4
Environmental benefits	**10%**	3	3	3	3	4	3	4	3	3	2	4	4	3	3	3
Private sector involvement along the chain	**10%**	4	5	5	4	3	4	5	3	4	3	3	4	4	4	5
Govt support / National priorities	**10%**	3	5	5	5	4	4	4	3	4	4	4	4	3	3	3
Opportunities for Women	**10%**	3	5	5	4	3	3	3	3	4	5	3	3	3	4	4
First Tier	**70%**	**44**	**60**	**60**	**52**	**46**	**46**	**54**	**42**	**48**	**50**	**46**	**50**	**46**	**52**	**54**
Resilience to disasters	**5%**	3	4	3	4	4	3	4	3	3	3	4	4	3	3	3
Value adding opportunities / capacity building	**5%**	3	5	4	4	4	3	3	3	4	4	4	3	3	3	4
Enhancing food security (via product or income)	**5%**	2	4	4	3	3	3	3	3	4	4	3	3	4	3	3
Intervention replicable / potential to scale up	**5%**	3	4	4	3	3	3	3	3	4	3	3	3	3	3	3
Second Tier	**20%**	**11**	**17**	**15**	**14**	**14**	**12**	**13**	**12**	**15**	**14**	**14**	**13**	**13**	**12**	**13**
Ability to integrate with other crops	**2%**	3	4	4	4	4	3	4	3	4	3	4	4	3	3	3
Fit in with local structures and conditions	**2%**	3	4	4	4	4	3	3	3	4	4	4	3	4	3	4
Potential for export / import sub / PES or CSR	**2%**	4	4	5	3	3	4	4	3	4	3	3	4	3	3	4
Nutritional benefits, if food / Village use if timber?	**2%**	2	3	3	4	3	2	2	3	4	2	3	3	4	2	2
Researchable issues that fit with ACIAR's mandate	**2%**	3	4	3	3	3	3	3	3	4	3	3	4	3	3	2
Third Tier	**10%**	**6**	**7.6**	**7.6**	**7.2**	**6.8**	**6**	**6.4**	**6**	**8**	**6**	**6.8**	**7.2**	**6.8**	**5.6**	**6**
Total Score out of 100 (Scale x Weight) x100	**100%**	**61**	**84.6**	**82.6**	**73.2**	**66.8**	**64**	**73.4**	**60**	**71**	**70**	**66.8**	**70.2**	**65.8**	**69.6**	**73**

Figure 4. Vanuatu – Pacific Agroforestry Product Criteria Matrix

Criteria	Weighting									
		Canarium	**Cocoa**	**Coconuts (VCO)**	***Terminalia* / Natapoa**	***Barringtonia***	**Teak**	**Coffee**	**Breadfruit**	**Chilli**
Sustainable / growing market	**10%**	4	4	3	3	3	4	4	3	3
Livelihood benefits / employment creation	**10%**	4	4	4	3	3	4	4	3	3
Sustainable Supply (existing or potential)	**10%**	4	4	4	4	4	4	3	3	3
Environmental benefits	**10%**	3	3	3	4	4	4	4	3	3
Private sector involvement along the chain	**10%**	4	4	4	4	4	4	4	3	3
Govt support / National priorities	**10%**	5	5	4	5	5	4	3	2	3
Opportunities for Women	**10%**	4	4	4	4	4	3	3	3	3
First Tier	**70%**	**56**	**56**	**52**	**54**	**54**	**54**	**48**	**40**	**42**
Resilience to disasters	**5%**	4	3	4	4	4	3	3	3	3
Value adding opportunities / capacity building	**5%**	4	4	4	4	4	3	4	3	3
Enhancing food security (via product or income)	**5%**	4	4	4	4	4	2	3	4	3
Intervention replicable / potential to scale up	**5%**	4	4	3	4	4	4	3	3	3
Second Tier	**20%**	**16**	**15**	**15**	**16**	**16**	**12**	**13**	**13**	**12**
Ability to integrate with other crops	**2%**	4	4	4	4	4	3	3	3	3
Fit in with local structures and conditions	**2%**	4	4	4	4	4	3	3	3	3
Potential for export / import sub / PES or CSR	**2%**	4	4	3	4	4	4	3	3	3
Nutritional benefits, if food / Village use if timber?	**2%**	3	3	4	4	4	2	2	4	3
Researchable issues that fit with ACIAR's mandate	**2%**	4	3	3	4	4	4	3	3	3
Third Tier	**10%**	**7.6**	**7.2**	**7.2**	**8**	**8**	**6.4**	**5.6**	**6**	**6**
Total Score out of 100 (Scale x Weight) x100	**100%**	**79.6**	**78.2**	**74.2**	**78**	**78**	**72.4**	**66.6**	**59.4**	**60**

Figure 5. Solomon Islands – Pacific Agroforestry Product Criteria Matrix

Conclusions and recommendations

The research, both desk-based and interviews / workshops (in-country) concluded that the following agroforestry crops and 'sites' have the greatest potential for value-adding (i.e., they are the 'best bets') in each country, noting that 'potential' has been considered in terms of economic (market), social (cultural) and environmental impact. It should also be noted that some of the 'best bets' outlined in the country matrix section are being addressed in other ACIAR project activities, so while we'll look to collaborate where appropriate, this report will focus on the specific activities within this project.

Before, looking at each country individually there was also an overarching opportunity to look at Pacific wide opportunities to export into countries like Australia. One example of a suitable market channel focussing on ethically conscious Australian consumers is Oxfam Australia. Oxfam Australia agreed to allow us access to their 55,000 strong membership database to do a significant consumer survey to better understand this market and their purchasing behaviour towards Pacific products. While Oxfam Trading Australia is experiencing its own retailing issues at the moment, these consumer insights are valuable and have been shared with our Pacific stakeholders interested in Australia as a target market and other potential retailers looking to promote further trade between the two countries.

Best bet species:

Vanuatu

- Crops including *Canarium, Terminalia, Barringtonia*, Tahitian chestnut (ivi), Breadfruit, Mango, Pineapple, Tamanu, Coffee and Cocoa
- Project partners included: The Department of Industry in Vanuatu, Lapita Café and ACTIV.
- 'Drying' was used as a technique for value adding to enhance stabilization of the product (crop) to avoid issues relating to cold chain logistics.
- Research on value adding included:
    - Drying techniques for both the nuts and fruit.
    - New product development

Fiji

- Crops including nuts (*Terminalia, Barringtonia)*, fruit and coffee:
- Project partners were Bula Coffee and SPC.
    - Opportunities to utilise existing wild coffee with women collection through villages like Nadroumai with Bula Coffee
- Research included:
    - Helping to solve any processing issues
    - Training and extension - particularly on plant propagation and nursery management.
    - Link in with consumer research with Oxfam
    - Research on value adding included 'drying' as a technique for value adding enables stabilisation of the product (crop) to avoid issues relating to cold chain logistics.
    - There is cross over with work being done on 'drying' techniques in PNG, Vanuatu and the Solomon Islands.

Solomon Islands

- Crops included Nuts (*Canarium*, *Terminalia* and *Barringtonia*):
- Project partners included: Ministry of Commerce, Industry, Labour and Immigration and Jedom Organic Fruits Ltd.
- Research included:
    - Cracking and drying techniques for nuts.
    - Investigating certification requirements for export.
    - New product development

Papua New Guinea

- Crops included honey
- Project partners were NARI and Mountain Honey
- Research included:
    - Understanding which flowers the bees are feeding on through nectar DNA analysis.
    - Understanding taste and medicinal properties for consumer marketing.

Trial sites

Vanuatu:

- **Trial Site 1 – Santo**
    - Project partners included: The Department of Industry and Department of Forestry in Vanuatu, VaRTC, ACTIV and Lapita Cafe.
    - Focus was on developing an integrated system of crops including *Canarium*, *Terminalia*, *Barringtonia*, Tahitian chestnut (ivi), Breadfruit, Mango, Pineapple, Tamanu, Coffee and Cocoa

Fiji:

- **Trial Site 1 – Nadroumai Village (Shangri-La):**
    - Project partner were SPC, Shangri-La Resort and the Nadroumai Village. Priority was working with Shangri-La and Nadroumai on environmental and product connections.
- **Trial Site 2** – Nadi, Labasa
    - The second trial site focused on an agroforestry system better suited to a drier and more degraded site in the upper catchment area. Species included Sandalwood, *Terminalia* and Mango.

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Abbreviations

ACTIV	Alternative Communities' Trade in Vanuatu Association
CePaCT	Centre for Pacific Crops and Trees
CIC	Coffee Industry Corporation
DAF	Queensland Department of Agriculture and Fisheries
DAL	Department of Agriculture and Livestock
DFAT	Department of Foreign Affairs and Trade (Australia)
FAO	Food and Agriculture Organisation
FFV	Fresh Fruit and Vegetables
JCU	James Cook University
MDF	Market Development Facility
NGFC	New Guinea Fruit Company
NGO	Non-government Organisation
PAG	PARDI Advisory Group
PAPP	Pacific Agriculture Policy Project
PARDI	Pacific Agribusiness Research for Development Initiative
PGS	Participatory guarantee scheme
PHAMA	Pacific Horticultural and Agricultural Market Access program
PIC	Pacific island country
PIFON	Pacific Island Farmers Organisation Network
PNG	Papua New Guinea
POM	Port Moresby
PRA	PARDI Research Activity
R&D	Research and development
RPM	Research program manager (ACIAR)
SI	Solomon Islands
SME's	Small to Medium Businesses
SPC	Secretariat of the Pacific Community
UoA	University of Adelaide
UQ	University of Queensland
USC	University of the Sunshine Coast
USP	University of the South Pacific
VCO	Virgin Coconut Oil

11.2 Baseline agroforestry analysis for each country

Objective 1

Author: Mr. Craig Johns (UoA)

Overview of Agriculture

Fiji

According to the FAO Gender Assessment report, the agriculture accounts for 44% of all employment in Fiji. Tourism contributes around 38% of GDP, with agriculture just 11%. Agriculture has been negatively impacted by weather events in recent years. While the total value of the agriculture sector grew by 6% between 2011 and 2016, its contribution to GDP fell from 8.2% in 2011 to 7.5% in 2016. Until recently, sugarcane production, which employed about 3000 people directly and sustained the livelihoods of approximately 200,000 and subsistence farming formed the backbone of the agricultural sector. Today they contribute approximately 2.2% of Fiji's GDP (Asian Development Bank, 2014; Ministry of Economy, 2017).

Vanuatu

According to the FAO report, Vanuatu is a predominantly agricultural society in which 75% of the total population lives in rural areas and depends largely on subsistence agriculture and fishing for daily sustenance and livelihoods (Vanuatu National Statistics Office (VNSO), 2016). The 2016 Mini-Census found that 88% of households engage in some form of vegetable crop production, 57% in cash crop production, 69% in livestock production and 49% in fishing.

Solomon Islands

According to the Solomon Islands 2012/13 Household Income and Expenditure Survey (HIES), 19% of the population resides in urban areas and 81% in rural areas (National Statistics Office, 2015). Solomon Islands is rich in natural resources, including native forests, fresh water, marine and fishery resources, minerals and agricultural land, though they are distributed unevenly across the country's nine provinces. According to the Solomon Islands 2012/13 HIES, nationally, around 76% of households derive their cash incomes from active participation in four main subsistence-based activities: agriculture (including forestry), fisheries (including gathering/harvesting), livestock and handicrafts (including home processing of food). This share is even higher in rural areas, where 85% of households derive their cash incomes from these subsistence-based activities, compared to less than a third (31%) of urban households (National Statistics Office, 2015). Agriculture and Hunting accounted for 14.5% of the Solomon Islands' GDP in 2015, according to the Solomon Islands Government. The Department of Agriculture and Livestock reported in its most recent Corporate Plan (2011 - 2014) that agricultural production has been declining over the past two decades. The sector faces negative impacts from a lack of improved production technologies in farming systems, lack of inputs for production, increasing pest and diseases, natural disasters, soil degradation, lack of production incentives, declining export prices, limited market opportunities, limited access to land and poor private and public investment in the sector. Political and economic instability, along with the impacts of climate change add further barriers to agricultural development.

Papua New Guinea

According to the FAO, over 85% of the total population of Papua New Guinea (PNG) live in rural villages with an average of 5.1 person per household. Around 45% of PNG is mountainous, adding further pressure on arable land available for farming. According to The

National Agricultural Research Institute (NARI), the agriculture sector plays a significant role by providing broad based income and employment to the vast majority of the population in the country, most of which still lives in the rural areas and engaged in subsistence, semi-subsistence and commercial farming. According to the FAO's Nutrition Country Profile 2020, the agriculture sector contributes 19% of total exports and accounts for 25% of the gross domestic product (GDP.) In recent years, the estimated growth has been well below expectations, and often around 1%, compared to a population growth of 2.7%. This has naturally affected the rural population that depends exclusively on agriculture for livelihoods (PNG National Agricultural Development Plan, 2007, p8) and has an effect of issues like nutrition and increasing cases of malnourishment (FAO, Nutrition Country Profile, 2020).

Establishment of Agroforestry systems

Fiji

Forests cover about one million hectares of land in Fiji, which is over half of the total land area and 2.5 times the agricultural area (FAO 2017; Reserve Bank of Fiji, 2017).

Vanuatu

Forests in Vanuatu occupy 74% of the country's total land area, of which productive forests occupy 36% (Department of Forests, 2011). Apart from timber production, forests and forest products play a significant role in providing and supporting basic livelihood needs for the Ni-Vanuatu (ethnic group of peoples native to Vanuatu), including food, clean water, fuel, medicine and income. Forests provide a broad range of non-wood forest products such as tubers, fruits (e.g., breadfruit), nuts, fibres, grass and leaves for thatch, other construction materials and game (e.g., wild pigs). Forests are also used to house at least 44% of the population by providing bamboo and thatch (VNSO, 2016). Forests play an important spiritual role in Vanuatu's traditional societies, as well, providing materials for ceremonies and traditional medicines (Department of Forests, 2011).

Solomon Islands

It would appear from the literature review that agriculture tends to include forestry in the reporting of figures. While this implies close links, it would appear there is no recognised, commercial 'agroforestry' production system.

Papua New Guinea

Forests and forestry are very important to PNG. Forestry is one of the major industries in the country, contributing to the national economy and to formal employment. PNG's predominantly agricultural society practices agroforestry widely. In the lowlands one of the most common practices is from betel nuts to coconuts and cacao whereas in the highlands is coffee and banana with some understory greens and vegetables. This approach is effective in supporting food security and conservation and similar practices are followed by many communities in PNG decreasing the need for some to open untouched forest areas.

Integrating honeybee and coffee to improve coffee yield is one such example of establishing such system which is currently being practiced by coffee farmers (Coffee Industry Corporation Ltd Website, n.d.) According to the FAO, PNG's Forestry sector also makes a significant contribution of 5% to the overall economy of PNG mainly through employment creation. There are 30-50 different species of commercial timber available in PNG and because of this, only 15% is used domestically while the remaining is exported. At the subsistence level, the

challenge involved in generating income from the sales of specific species of timber as a cash crop would be the prolonged production time before harvest.

Main agricultural products/crops produced

Fiji

Sugar is a major agricultural commodity, with livestock production contributing to the GDP, along with traditional food crops (e.g., dalo and cassava, which are the main root crops produced in Fiji), tropical fruits, vegetables, spices, cocoa, coconut products, beef, dairy, pork, poultry and goat (Ministry of Agriculture, 2014; Ministry of Economy, 2017).

Vanuatu

According to the FAO report, in rural areas, 97% of households are engaged in vegetable crop production, 85.6% manage livestock, 73.9% are engaged in cash cropping, and of these, 6–9% grow spices. The main agricultural staples for subsistence farming are root crops, including taro, yam, cassava and sweet potato. These are grown for consumption and cultural purposes. The four main commercial food crops include cocoa, coconut, kava and coffee. Twenty-four percent of Ni-Vanuatu households are engaged in cocoa production, 69% in coconut production, 50% in kava production and 2% in coffee production (Department of Agriculture and Rural Development, 2015). Semi-commercial crops include varieties of cabbage and other leafy greens, corn, tomatoes, capsicum and eggplant (Department of Agriculture and Rural Development, 2015).

Solomon Islands

The most common subsistence food crops in the Solomon Islands are sweet potato, cassava and banana, followed by taro and yams, as well as edible leaves such as slippery cabbage. In the smaller outer islands of Solomon Islands, subsistence food crops include breadfruit, nuts (e.g., canarium) and edible leaves. Agricultural livestock rearing consists mostly of pigs, poultry, cattle and honeybees, although cattle and pigs are on the decline due to depletion of existing stocks, lack of new breeding stock and subsequent inbreeding (Evans, 2006). Cash cropping is an important feature of the Solomon Islands Agriculture and Livestock Policy 2015–2019. Cash cropping typically utilises large amounts of fertile land to plant a single crop that families sell rather than consume.

Papua New Guinea

The main agricultural products or crops produced in PNG are oil palm, coffee, cocoa, copra, rubber, tea, sweet potato, banana, sago, taro, Chinese taro, yams, cassava, sugarcane, fresh vegetables and betelnut. Imported rice, meat and wheat supplement these domestically produced crops (Piesse, 2019). The important food crops are sweet potato, banana, sago, taro, Chinese taro, yams, cassava and sugarcane. Cash crops include oil palm, coffee, cocoa, copra, fresh vegetables and betel nut.

Main agricultural products/crops exported

Fiji

Sugar, fish, crude coconut oil, root crops, horticultural crops

Vanuatu

According to the FAO report in 2017 Vanuatu's highest-value export commodities were copra, kava, coconut oil, sawn timber, beef and cocoa.

Solomon Islands

Prominent cash crops, apart from copra, include cocoa and spices such as vanilla, cardamom, ginger and turmeric, which, while relatively minor, have generated interest over the years given overseas market demands.

Papua New Guinea

The main agricultural exports are oil palm, coffee, cocoa, copra, rubber and tea.

Imports

Fiji

A range of different foods are imported into Fiji, including processed food as well as fresh produce from Australia and New Zealand. Tourists into Fiji drive some of this demand but local consumer preferences are also changing over recent years.

Vanuatu

Basic domestic food requirements are not met, necessitating food importation (Ministry of Agriculture, 2014). According to Australian research institute, Future Directions International, while all Pacific Island nations have high food imports and are tackling nutrition related health issues that include malnutrition, obesity and a high rate of non-communicable diseases, Vanuatu is faring better than many. It does still produce traditional food crops for domestic consumption, which is a positive, and while obesity is an issue, it is not as high as neighbouring Pacific Island countries.

Solomon Islands

Rice is a major food import into the Solomon Islands, in fact it is a major import across all categories. Wheat is also imported as are flour products. The FAO reports that malnourishment is on the rise in the Solomon Islands.

Papua New Guinea

The main crops imported are rice, sheep meat/ goat meat, wheat and meslin and other food preparations and water containing sugars (Piesse, Future Directions, 2019). Note that the rural populations have limited access to imported goods due to poor infrastructure and rely more on their own subsistence crop production.

Subsistence v Commercial Agriculture

Fiji

Agriculture is a significant part of the Fijian economy and involves a large percentage of the rural population whose unpaid, in-kind and subsistence economic contributions are difficult to measure. Such work contributes to poverty alleviation in a variety of ways, including through provision of economic, food and nutrition safety nets for rural families. Commercial agriculture

has seen some growth while the value of the subsistence sector has decreased (Fiji Bureau of Statistics, 2017).

Vanuatu

Although agriculture is the primary activity for the majority of the population in Vanuatu, only about one-third of production is commercial, resulting in the sector's relatively low share of GDP, while the majority of economic activity is in the services sector, largely driven by tourism. The agricultural sector's contribution to GDP was severely impacted by tropical cyclone Pam in 2015, with a decrease in the value of agricultural sector output by 16% and a decrease in the constant price value of animal production by 58% in from 2014 to 2015. Likewise, commodity exports decreased. According to the FAO report, 57.8% of households are engaged in the fishing industry, 55.8% are engaged in forestry activities and 51.3% are involved in value-adding activities.

Solomon Islands

According to the Solomon Islands 2012/13 Household Income and Expenditure (HIES) report, nationally, around 76% of households derive their cash incomes from active participation in the following four main subsistence-based activities: agriculture (including forestry), fisheries (including gathering/harvesting), livestock and handicrafts (including home processing of food). Incomes are generated in various ways, including small-scale marketing of vegetables and fish, market gardening for sale in larger centres, commercial harvesting of fish and invertebrates, cash cropping and leasing land for forestry and mining rights. In heavily populated areas, there may be strong competition among clans and extended families, and/or between women and men, for use rights to particularly fertile or resource-rich land.

Papua New Guinea

A study conducted found that subsistence agriculture was the main driver of deforestation between 1972 and 2002, accounting for 45.6% of net forest change recorded across the country. An estimated 3.6 million hectares, 11% of the areas of intact forest in 1972, had been cleared as a result of garden expansion or subsistence farming related activity by 2002. The same study also recorded there was a total area of 149,402 hectares under palm oil and rubber plantations in PNG, with around 90% for palm oil, mostly in the areas of West New Britain, Milne Bay, Oro and New Ireland (Shearman et al., 2008). Palm oil is the largest agricultural export but is generally produced by large-scale commercial farms and not smallholders.

Land tenure

Fiji

Land and marine tenure arrangements are complex and support customary ownership of 85% of the land base by indigenous (i-Taukei) clan groups called mataqali. In addition to customary ownership, other tenure arrangements include freehold leases and leases of crown land.

Vanuatu

Most land, sea and related resources are under the customary tenure system. Customary land cannot be leased; land does not belong to an individual but to a clan. This system can present some challenges with the development of infrastructure and the private sector. However, land is much more than a commodity. For the Ni-Vanuatu, land is intrinsically part of their identity and culture. As member of a clan, all individuals, male or female, "have the right to use a piece

of land within the clan's territory" (Simo J., 2005). Both patrilineal and matrilineal systems exist in Vanuatu, in which the land is passed on through the father' or mother's lineage.

Solomon Islands

Both patrilineal and matrilineal inheritance systems exist in different areas of the Solomon Islands. These systems can influence where couples settle after marriage, responsibilities related to children's' custody and guardianship, and land-use rights. In matrilineal systems, women's decision-making power within the home and extended family may be higher, but in general, decision making made in the public sphere is men's domain, and men are signatories to agreements linked to cash cropping, forestry, mining and infrastructure development. Women's legal rights to clan proceeds from land or foreshore leased for agricultural or fisheries development are unclear (ADB, 2015). Land held by clans is generally divided up for use among individuals and families. As women are key agricultural producers, they have users' rights for farming and gathering. Given that agricultural land is rotated and fallowed, individuals or families do not have permanent rights to a given piece of land. However, semi-permanent uses of land for cash crops such as coffee, cocoa or coconut plantations are common, and both men and women contribute labour to farming, harvesting and processing in family businesses. Unfortunately, disputes over land are common. The first level of resolution is the village court system, and if no solution is reached, disputes are moved to the land court system.

Papua New Guinea

The land tenure system in PNG is considered very complex because much of the land is under customary ownership and the land administrative system is very inefficient and ineffective. The various legislations covering land provides for registration of customary land and recognizes ownership of title. However, the process of land tenure can be quite cumbersome, and the high numbers of cases tend to overwhelm the system. The uncertainty and often disputed ownership of customarily owned land precludes most lending for agriculture development on traditionally owned land since such land cannot be used as collateral. Attempts by the government to enable registration of customary land have been met with widespread opposition over the years. Confidence in the mediation and land court system has diminished because the system has been inactive due to lack of funding and inconsistent government support. Combined with a general deterioration in the law and order situation, there is widespread tendency to disregard the established process of land dispute settlement.

Known on–farm practices

Fiji

Men typically take responsibility for the 'on farm' activities of clearing land, construction and cash crop planning, planting and harvesting (taro, cassava, kava, coffee, cocoa, tree fruits & coconuts). Women typically take responsibility for subsistence market gardens, cash crop post-harvest processing, market sales, raising poultry and small livestock like pigs and sheep. Post-harvest activities for cash crops tends to be typically shared between men and women.

Vanuatu

Production is labour-intensive and rain dependent, based on the use of rudimentary implements. Many farmers use organic farming practices (Department of Agriculture and Rural Development, 2015). According to the FAO report, a notable level of risk and uncertainty exists

regarding potential yield loss at any given time, which gives rise to food insecurity and vulnerability to shocks (Department of Agriculture and Rural Development, 2015).

Solomon Islands

Men tend to undertake the more strenuous work of clearing gardens, heavy planting and harvesting tasks and construction work, whereas women tend to do more ongoing and labour-intensive tasks such as maintenance of seedlings and gardens and post-harvest processing. Both rural women and men are engaged in small-scale marketing in the Solomon Islands, selling fruit, vegetables, fish and handicrafts.

Papua New Guinea

According to the FAO, due to the complexity of customary land tenure system in PNG, land ownership tends to be by groups made up of several family members, and the land in question is usually as small as 150m^2. Families farm these small plots of land for their livelihoods and food produced is for both income generation and consumption. Many smallholder farmers in PNG derive their income from the production of coffee, fresh foods, betel nut and cocoa. According to the FAO's PNG Country Profile, subsistence food production is the source of 83% of food energy and 76% of protein in PNG.

Gender and youth roles in labour in ag and agroforestry

Fiji

'Persons under the age of 24 make up 46% of the total Fijian population. Gendered differences in labour force participation were more pronounced in rural areas for both adults and youth (Fiji Bureau of Statistics, 2018). For rural women, the primary reason for being outside of the labour force was household work (76.1%, compared to only 5.2% for men), whereas rural men indicated full-time study as the primary reason (41.6%, compared to 14.6% for women) (Fiji Bureau of Statistics, 2018).

Vanuatu

Vanuatu has as a typically ‘young’ population structure with 39% of the total population aged under 15 years and with a median age of 20 years (in rural areas, the median age is slightly lower at 19 years). Youth (15–29 years) make up 26% of Vanuatu’s population (23.8% in rural areas and 31.3% in urban areas). From 1999 to 2009, the urban population grew two to three times faster than the rural population, suggesting a pattern of rural-urban migration. The urban drift, particularly for young people, has prompted some concern about the younger generations declining interest in agriculture. Women and men participate in almost equal numbers in the agricultural sectors, although they may grow different crops and use different levels of technology. Women have a heavier workload than men due to expectations that in addition to agricultural work they are responsible for small-scale marketing, handicraft production for sale and/or household use, caregiving, housework and a considerable amount of voluntary community work.

Solomon Islands

The Solomon Islands has a young population, with 41% of Solomon Islanders being under 15 years of age. Women and men are active in subsistence work in nearly equal numbers, yet a gendered division of tasks, responsibilities, equipment use and knowledge is prevalent. In land disputes, women are often disadvantaged in both constitutional and customary court settings due to social norms and traditional gender roles as well as lack of literacy, lack of

financial means for travel to courts or seeking legal advice, and lack of confidence to represent themselves or present arguments in a male-dominated environment.

Papua New Guinea

According to the FAO's, although women play a key role in food production in PNG, implementing most of the daily activities such as the gardening, rearing of livestock, and marketing of cash crops at the local urban markets, it is the head of the household (men) that are typically the decision-makers.

Value Chain Maturity

Fiji

There are active value chains in some niche markets such as coffee and agritourism.

Vanuatu

The FAO Gender Assessment reports that 51.3% of households are engaged in value adding activities (VNSO, 2016). Figures in one of the quoted references (Mini Census, 2016) are: Household engaged in value-adding activities for sale include 15.3% making flour, chips or bread and 16% producing beverages including kava, 3.7% in beauty product production, 23% making handicrafts, 5% sewing/ painting and 1.8% in building furniture.

Solomon Islands

The FAO report suggests that only limited and small-scale value-adding is being undertaken in agriculture across the Solomon Islands and is often done without the engagement of women. Because of the remoteness of many communities, rural women are less likely to travel to larger markets as often as men, with poor infrastructure in the markets, a lack of proper sanitation, security and transparent governance systems.

Papua New Guinea

There appears to be limited formal value chain development in PNG.

Products/ chains with most potential - market, cultural and environmental

Fiji

Fiji's main crops supporting nutrition, import substitution and commercial opportunities are: 1) market garden crops (e.g., leafy greens, beans, tomatoes); 2) root crops such as taro, kumala, and cassava; 3) tree fruits; 4) spice crops, including ginger and turmeric and; 5) coconuts (Ministry of Agriculture, 2015). Additionally, kava is a highly favoured high-value crop that produces faster yields on newly cleared forest land. However, consultations with Ministry of Agriculture and CSOs highlighted that the increasing price of kava is currently driving damaging rates of deforestation. Deforestation undermines Fiji's climate change mitigation efforts, reduces availability of non-timber forest products such as medicinal plants and increases risks of flooding during increasingly common extreme weather events. Coffee continues to have potential for market growth with private sector engagement already in place. A number of CSOs are also working with rural communities in Fiji to develop a selection of niche crops for women producers. These crops include spices, honey and flowers. There are niche opportunities to explore with fruit and nuts, well suited to value-adding.

Vanuatu

There are already coffee manufacturers in operation in Vanuatu, making coffee a sector of interest for development to benefit smallholders. So too fruit (Pineapple, Mango, Breadfruit) and nuts (*Canarium*, *Terminalia*, *Barringtonia*, Tahitian Chestnut) that are very suitable for value-adding techniques such as drying and cracking. Cocoa also has potential.

Solomon Islands

Nuts (*Canarium*, *Terminalia* and *Barringtonia*) present market and development opportunities, with significant engagement across government departments, NGOs and private sector players. Nuts are very suitable for value-adding activities so have potential for small-holders.

Papua New Guinea

Fruit, namely pineapple and banana for drying. Honey.

Existence of agricultural co-operatives

Fiji

Agricultural cooperatives are not a common model in the Pacific, and there are only few examples in Fiji of successful cooperatives that have operated over an extended period. There is a related lack of information about rural women's engagement in cooperatives. Women working in groups tend to do so through models facilitated by NGOs that support some combination of small business capacity development, quality control and branding.

Vanuatu

The FAO report outlines that there is a long tradition of agricultural cooperatives in Vanuatu. Formalized during the Condominium, (British-French rule of Vanuatu), agricultural cooperatives comprising groupings of small-scale family producers were the second largest source of copra exports after large-scale 'estate' commercial plantations. The cooperatives were historically based on the commercial sale of surplus from the prevalent family-type farming systems, and women were actively involved. To some extent, post-independence development policies and programmes neglected to utilise and build upon the existing cooperative system, and the sector received little support until development priorities shifted to the rural sector. The 2001 Co-operative Development Fund introduced rules and regulations that excluded many of the existing cooperatives, with the exception of those with strong development partner support, particularly those producing cash crops, including cocoa, coffee and spices. The Government of Vanuatu began to rebuild the cooperative sector with the Priorities and Action Agenda 2006–2015, which mobilised resources and fostered an enabling environment for small-scale farmers to organise in cooperatives or other associations to reach the minimum scale needed for efficient processing.

Solomon Islands

None reported.

Papua New Guinea

Co-operatives have historically struggled to thrive in PNG due to issues around abuse of process, mismanagement and mistrust. "While cooperatives may be desirable for linking semi-subsistence farmers to profitable markets, given their previous history in PNG, new systems need to be found to ensure their sustainability" (Murray-Prior et al., 'Overcoming Constraints

to the Establishment of Collaborative Marketing Groups for Coffee Growers in the Highlands of PNG', International Symposium on Horticultural Economics and Management). Co-operatives remain a priority of the PNG government and have potential to benefit smallholder farmers, but in PNG they need to overcome a somewhat negative history.

Private sector engagement

Fiji

As evidenced in other ACIAR projects, there is positive private sector engagement in the food sector in Fiji. Notably, there has been small scale success with linkages between tourism and resort operators and food producers and manufacturers. This is sometimes more evident through the lens of agritourism but bodes well for ongoing relationship development.

Vanuatu

According to Vanuatu's Agriculture Sector Policy, 2015 - 2030, 'Low level of contribution and participation by private sector and civil society for empowering the agriculture sector results in loss of popular confidence in the sector'.

Solomon Islands

According to the FAO report, commercial private sector engagement in agriculture is limited.

Papua New Guinea

The Australian High Commission reports that Papua New Guinea has one of the most difficult environments for business and addressing those challenges is at the core of all Australia's aid activities in the PNG.

Potential barriers to value adding development

Among the barriers faced by all Pacific Islands nations when it comes to agribusiness development are the challenges of each nations' vulnerability to extreme weather and natural hazards, small domestic markets, the shortage of development capital, complicated land use and land ownership arrangements and inadequate infrastructure facilities. Barriers also exist due to a lack of technical expertise of, and training for, farmers, lack of knowledge of market and marketing opportunities and instability of product supply, with consistency expected by customers. Other nation specific barriers include:

Fiji

For women in particular, women who want to use i-Taukei land to undertake agricultural or inland fishery farming rely on their mataqali to enable them to access and use land. In some cases, the size of their mataqali works in their favour. However, as research reveals, land tenure systems around i-Taukei land are often a barrier for women who want to use land for economic purposes. Inheritance patterns for land rights vary from area to area, and while women can legally inherit land, their brothers or husbands often dominate decision making on land use.

Solomon Islands

The FAO Gender Assessment report confirms that poor infrastructure is a critical barrier to growth acceleration and poverty reduction in Solomon Islands, including development in

agricultural value chains. More specifically, rural electrification is still a major challenge, with only 0.22 percent of rural households connected to the national electrification grid. The road network is not of a high standard and as rural roads and other infrastructure connect main towns in some areas, the key means of transportation for most interisland travel is by outboard motorboat. For example, farmers on outer lagoons need an outboard motor to get to and from Western Province's main town of Gizo to transport produce. Safe and accessible water transport is therefore another necessity for rural women and men.

Papua New Guinea

There are several barriers to agricultural development in PNG: poor transport and storage infrastructure and high transport costs; a lack of access to affordable finance; law and order issues in some rural areas; the emphasis on subsistence agricultural production; variable product standards; overcrowded local markets; limited trust among supply chain actors; and lack of timely market information.

Fit with Government policy

Fiji

In the Agriculture Sector Policy Agenda 2020, the following objectives were set a) To build modern agriculture in Fiji as an organized system of producing, processing, and marketing crops, livestock, and aquaculture products, b) To develop integrated production, processing, energy, and transport infrastructure support system for agriculture, c) To improve delivery of agriculture support services, d) To enhance capabilities to generate fund and secure investment through foreign investment, private public partnership, and other innovative business arrangements, and e) To improve project implementation and policy formulation capability within the Ministry of Agriculture (MOA) and its partner institutions.

Vanuatu

In Vanuatu Agriculture Sector Policy 2015 - 2030, states that the themes of Research and Development and Production and Market Access in agriculture underpin all efforts of sustainable development in the sector. The overarching goal of the policy direction is: The nation's agricultural resources are managed in an integrated and sustainable manner to provide food and improved incomes as well as contribute to environmental and social services to enhance wellbeing of all people in Vanuatu.

Solomon Islands

The Solomon Islands Agriculture and Livestock Sector Policy 2015-2019 has four clear key goals: 1) To achieve food sovereignty; 2) To improve rural livelihoods; 3) To promote agriculture for import substitution; and 4) To increase trade. (No more recent policy documents were found)

Papua New Guinea

In Papua New Guinea's National Food Security Policy 2016-2025, the following is stated: The National Food Security Policy will strengthen the platform for joint planning and guide coherent programs and actions from all key stakeholders to build and sustain food security in Papua New Guinea.

The Government recognizes the vital role the private sector has in driving the food economy and developing the efficient food value chains necessary to supply quality food throughout the country. A primary aim of the policy will, therefore, be to foster strong public-private partnerships to leverage agriculture's potential to promote improved nutrition and health by bringing profitable smallholder farming, efficient food value chains, small and medium enterprise development, women's income and child nutrition together.

11.3 Analysis of data from Fiji producers survey

Activity 1.4

Author: Craig Johns (UoA)

Introduction

The survey was undertaken by the University of Adelaide in collaboration with the University of South Pacific and the Ministry of Agriculture Fiji. This research was funded by a grant from the Australian Centre for International Agricultural Research (ACIAR).

The purpose of the survey was to improve the understanding of the patterns, determinants, and effects of participation of farmers in evolving horticultural value chains in Fiji. The objective of this descriptive report is to provide a baseline to understand the value chain, adoption behaviour, practices on the farm, labour trade-offs and the role of women.

Methodology

The survey was undertaken in March 2014 with the help of local enumerators and supervisors using paper-based questionnaires. The survey was split into two questionnaires – one household questionnaire and one female horticultural producer questionnaire. In total, 511 farms participated in the survey.

The household questionnaire was predominantly answered by the household member that was primarily responsible for agricultural/horticultural production (usually the husband/ father in the household). Details of all household members were also recorded. The female horticultural producer questionnaire was answered by the main female in the household, who was primarily responsible for agricultural/ horticultural production (usually the wife/ mother in the household).

The interviews were carried out privately (no neighbours, company representatives or government officials present) and male and females were interviewed in separate rooms at the same time (where possible).

Farms were identified as either a family farm (n=505) or a corporate farm (n=6). A corporate farm is a business enterprise with a corporate structure and usually the farmer is a contracted employee rather than the owner of the farm.

Descriptive survey data results

Characteristics of members of the household

Households

Number of households	511
Number of household members	2,438
Average household size	4.8

Gender

	Freq.	Percent
Male	1,291	53.11%
Female	1,140	46.89%
Total	**2,431**	**100%**

Just over half of the household members (53%) are male and 47% are female.

Ethnicity

	Freq.	Percent
Indo Fijian	1,687	69.88%
Itauke	717	29.70%
Chinese	10	0.41%
Total	**2,414**	**100%**

With 29.7% Itauke is underrepresented in this sample (compared to 56.8% in the 2007 Census) and Indo Fijian (and Hindu religion) are overrepresented.

Religion

	Freq.	Percent
Hindu	1,481	61.71%
Christian	776	32.33%
Muslim	128	5.33%
Other	15	0.63%
Total	**2,400**	**100%**

Corporate Farms

The sample includes 6 corporate farms with on average 2.7 full-time employees, 3.5 part-time employees and 2 employees involved in crop selling and marketing. No further results are presented here, because of the low sample size.

Farm and household assets

The objective of this section is to obtain general information on housing characteristics and ownership of assets.

Access to water *(more than one type of water source may be used)*

	Percent
Rainfall only	73.5%
Creek	45.8%
Piped water	19.7%
Irrigation channels	19.2%
Rain Tank	8.1%
Other	7.1%
Dam	3.5%

Rainfall only is the main source of water (73.5%) for farmers' crops and livestock.

Access to forest land for materials

This section was asking if the farmer can access the following items from the wild. There may be more than one yes answer.

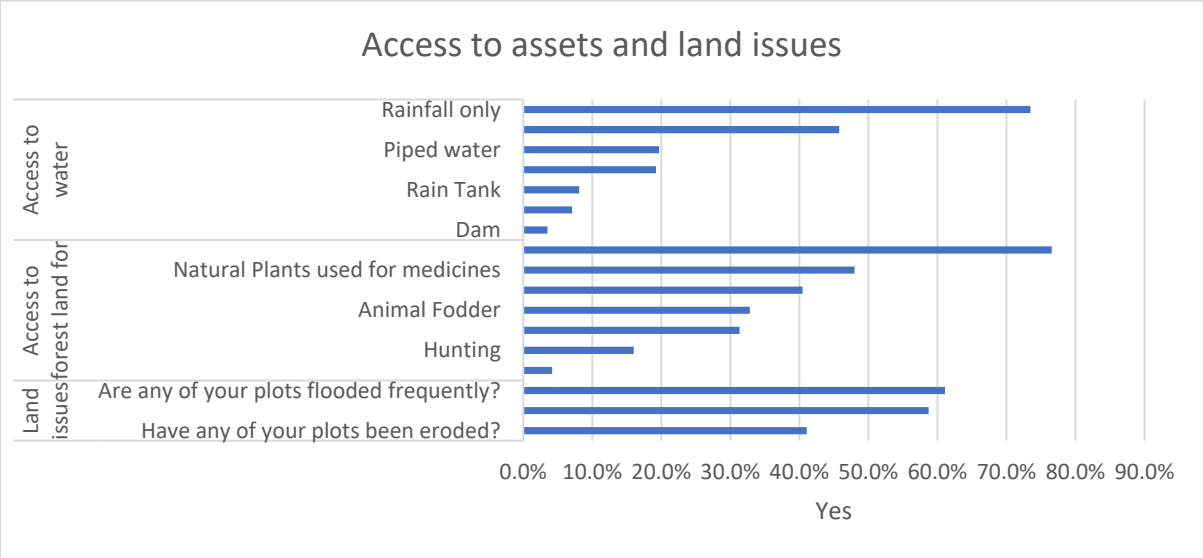
	Percent
Firewood	76.6%
Natural Plants used for medicines	48.0%
Fruits	40.5%
Animal Fodder	32.8%
Building Material	31.3%
Hunting	16.0%
Honey	4.2%

Most of the farmers (76.6%) have access to forest land for the purpose of firewood.

Land issues

	Percent
Are any of your plots flooded frequently?	61.1%
Do any of your plots fail to produce due to lack of water?	58.7%
Have any of your plots been eroded?	41.1%

The majority of farmers have experienced frequent (often, most seasons etc.) flooding (61.1%) and a failure to produce due to a lack of water during the dry season (58.7%) on their plots. Also, 41.1% have experienced erosion on their plots in the last five years.



Agricultural land

The purpose of this section is to ascertain changes in farmland, land being used for horticulture and land tenure.

Land area

	Mean	Observations
Plot land area (ha)	1.60	484
Plot land area under horticulture (ha)	0.79	485
Percentage of plot land area under horticulture	49.3%	

How was the land acquired?

	Freq.	Percent
Lease	151	31.13%
Inherited	143	29.48%
Purchased	126	25.98%
Gift	42	8.66%
Allocated by government	23	4.74%
Total	**485**	**100%**

This question asked how farmers received or came to own/live on the land. Land was primarily leased (31.1%), inherited (29.5%) and purchased 26.0%. A further 13.4% was acquired by gift or allocated by the government.

Land tenure

	Freq.	Percent
Freehold	135	28.18
NTLB lease (short term)	124	25.89
Mataqali	104	21.71
Crown lease	78	16.28
Share farming	21	4.38
Other	17	3.55
Total	**479**	**100.00**

The majority of the tenure over the plot land is freehold (28.2%), short-term NTLB lease crown lease (25.9%), Mataqali (21.7%), crown lease (16.3%), and share farming (4.4%).

Agricultural production

The purpose of this section is to find out what types of crops are most important to farmers in Fiji.

Top 10 temporary crops (any volume)

		Freq.	Percent
1	Eggplant	268	10.07%
2	Tomatoes	251	9.43%
3	Okra (Bhindi)	220	8.26%
4	Long Beans	209	7.85%
5	Chinese Cabbage	192	7.21%
6	Cucumber	192	7.21%
7	English Cabbage	141	5.3%
8	Bora Beans	131	4.92%
9	French Beans	121	4.55%
10	Watermelon	119	4.47%

Note: Most common temporary crops (not considering the order in terms of volume grown)

All crops with an under one year growing cycle, which must be newly sown or planted for further production after harvest. Crops remaining in the field more than one year are also considered temporary crops if harvesting destroys the plant (e.g. cassava and yams).

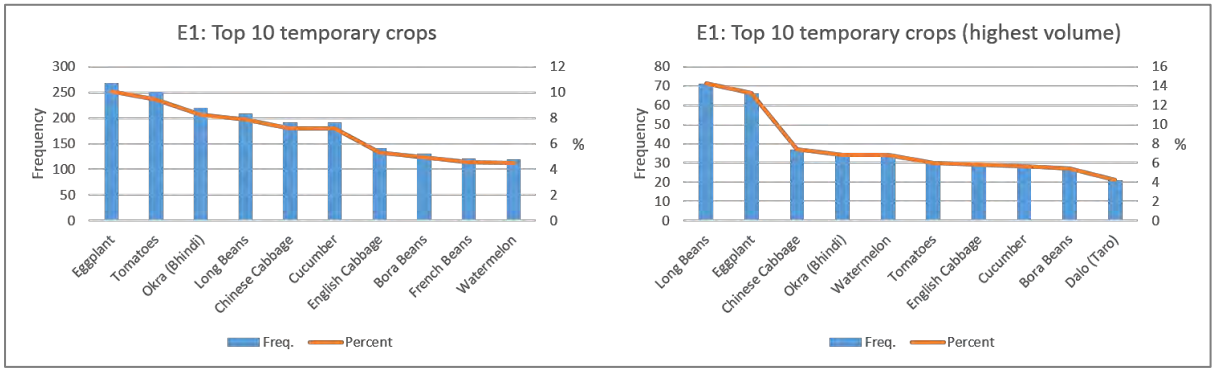
The top 10 temporary crops grown in the last 12 months are the following: eggplant, tomatoes, okra, long beans, Chinese cabbage, cucumber, English cabbage, bora beans, French beans, and watermelon.

Top 10 temporary crops (highest volume)

		Freq.	Percent
1	Long Beans	71	14.26%
2	Eggplant	66	13.25%
3	Chinese Cabbage	37	7.43%
4	Okra (Bhindi)	34	6.83%
5	Watermelon	34	6.83%
6	Tomatoes	30	6.02%
7	English Cabbage	29	5.82%
8	Cucumber	28	5.62%
9	Bora Beans	27	5.42%
10	Dalo (Taro)	21	4.22%

Note: Temporary crops with the highest volume for the farm (listed in first place)

In terms of (highest) volume grown, the top 10 temporary crops grown in the last 12 months are the following: long beans, eggplant, Chinese cabbage, okra, watermelon, tomatoes, English cabbage, cucumber, bora beans, and dalo.



Top 13 permanent crops (any volume)

		Freq.	Percent
1	Chillies	118	19.67%
2	Pawpaw	104	17.33%
3	Banana	58	9.67%
4	Bele	58	9.67%
5	Plaintain	33	5.5%
6	Dhania	24	4%
7	Duruka	18	3%
8	Pineapple	18	3%
9	Cassava	17	2.83%
10	Coconut (Copra) Nuts	14	2.33%
11	Dalo (Taro)	14	2.33%
12	Sugarcane	12	2%
13	Yaqona	12	2%

Note: Most common permanent crops (not considering the order in terms of volume grown)

Includes long term crops which do not have to be replanted for several years after each harvest.

The top 13 permanent crops grown in the last 12 months are the following: chillies, pawpaw, banana, bele, plaintain, dhania, duruka, pineapple, cassava, coconuts, dalo, sugarcane, and yaqona (Kava).

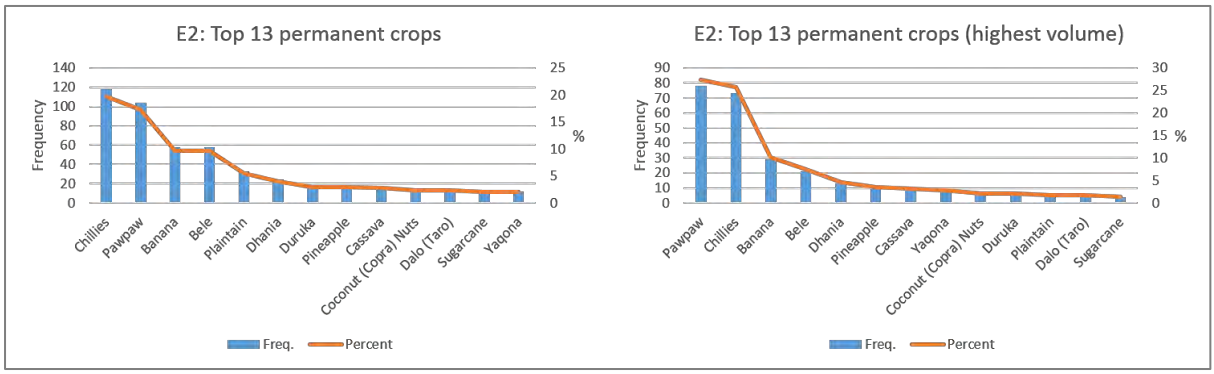
Top 13 permanent crops (highest volume)

		Freq.	Percent
1	Pawpaw	78	27.46%
2	Chillies	73	25.7%
3	Banana	29	10.21%
4	Bele	21	7.39%
5	Dhania	13	4.58%

6	Pineapple	10	3.52%
7	Cassava	9	3.17%
8	Yaqona	8	2.82%
9	Coconut (Copra) Nuts	6	2.11%
10	Duruka	6	2.11%
11	Plaintain	5	1.76%
12	Dalo (Taro)	5	1.76%
13	Sugarcane	4	1.41%

Note: Permanent crops with the highest volume for the farm (listed in first place)

In terms of (highest) volume grown, the top 13 permanent crops grown in the last 12 months are the following: pawpaw, chillies, banana, bele, dhania, pineapple, cassava, yaqona (Kava), coconuts, duruka, plaintain, dalo, and sugarcane.



Top 10 commercial crops (any revenue)

		Freq.	**Percent**
1	Eggplant	235	10.69
2	Tomatoes	213	9.69
3	Okra (Bhindi)	193	8.78
4	Long Beans	166	7.55
5	Chinese Cabbage	156	7.1
6	Cucumber	142	6.46
7	English Cabbage	110	5
8	Watermelon	100	4.55
9	Bora Beans	99	4.5
10	Pawpaw	75	3.41

Note: Most common commercial crops (not considering the order in terms of revenue)

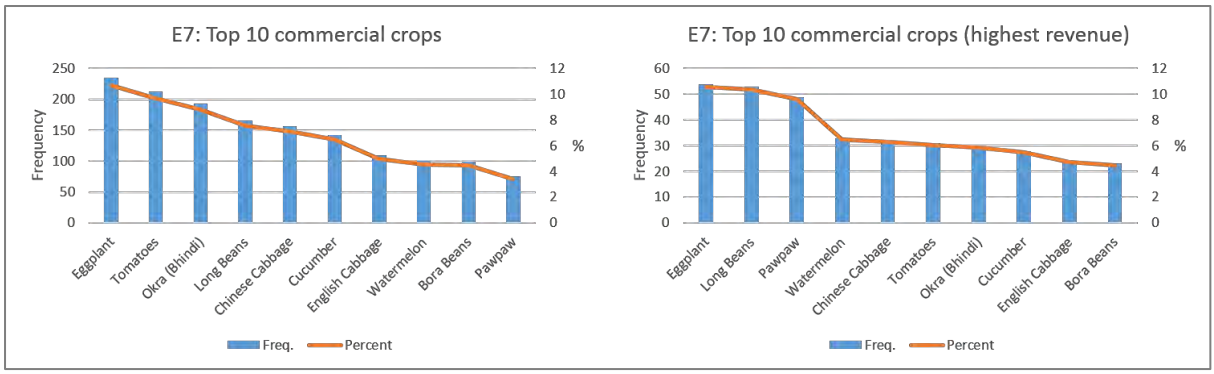
In terms of revenue, the top 10 main commercial crops farmers grow are the following (similar to the top 10 temporary crops): eggplant, tomatoes, okra, long beans, Chinese cabbage, cucumber, English cabbage, watermelon, bora beans, and pawpaw.

Top 10 commercial crops (highest revenue)

		Freq.	Percent
1	Eggplant	54	10.57
2	Long Beans	53	10.37
3	Pawpaw	49	9.59
4	Watermelon	33	6.46
5	Chinese Cabbage	32	6.26
6	Tomatoes	31	6.07
7	Okra (Bhindi)	30	5.87
8	Cucumber	28	5.48
9	English Cabbage	24	4.7
10	Bora Beans	23	4.5

Note: Commercial crops with the highest revenue for the farm (listed in first place)

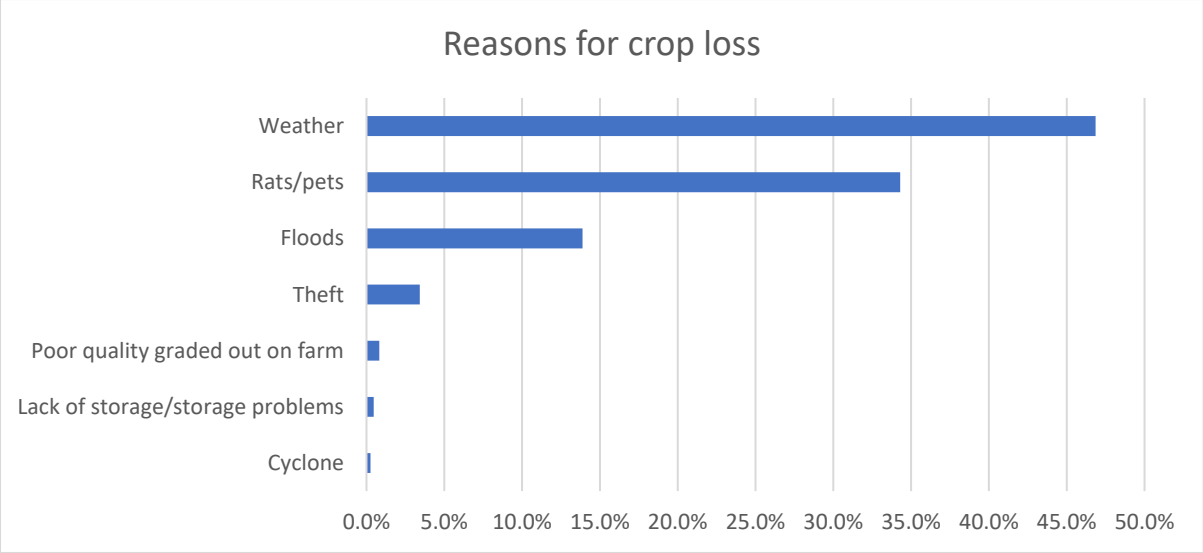
In terms of (highest) revenue, the top 10 main commercial crops farmers grow are the following (similar to the top 10 temporary crops): eggplant, long beans, pawpaw, watermelon, Chinese cabbage, tomatoes, okra, cucumber, English cabbage, and bora beans.



Reasons for crop loss

	Freq.	**Percent**
Weather	918	46.9%
Rats/pets	672	34.3%
Floods	272	13.9%
Theft	67	3.4%
Poor quality graded out on farm	16	0.8%
Lack of storage/storage problems	9	0.5%
Cyclone	5	0.3%
Total	**1,959**	**100%**

The main reasons for most of the crop loss was weather (46.9%) and rats/pets (34.3%).



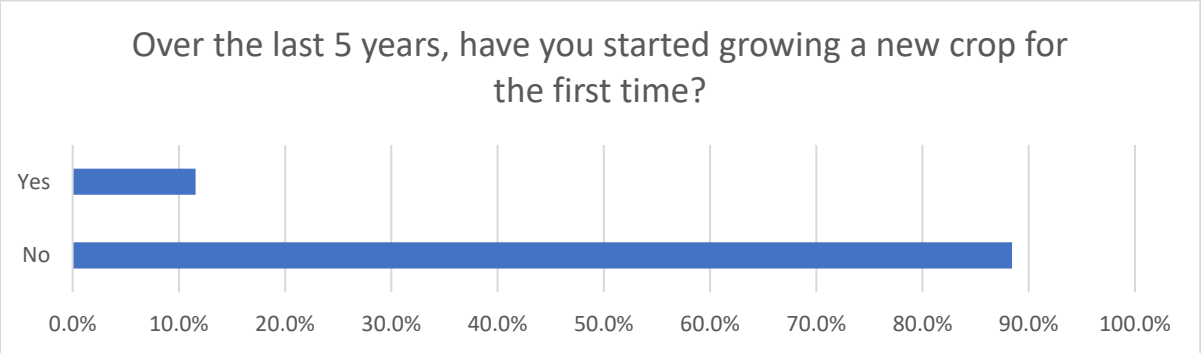
Adoption

The purpose of this section is to see whether farmers have adopted any new crops or production technologies in the last five years.

Growing a new crop

	Freq.	**Percent**
Yes	61	11.57%
No	466	88.43%
Total	**527**	**100%**

Over the last 5 years, only 11.6% have started growing a new crop for the first time (farmers still did not need to be growing this crop currently).



Most important new commodities

	Freq.	Percent
Zucchini	9	15%
Capsicum	6	10%
Ginger	6	10%
Watermelon	6	10%
English Cabbage	4	6.67%
Dalo (Taro)	3	5%

The most important new commodities (crops) farmers have started growing in the last five years are the following: zucchini, capsicum, ginger, watermelon, English cabbage, and dalo.

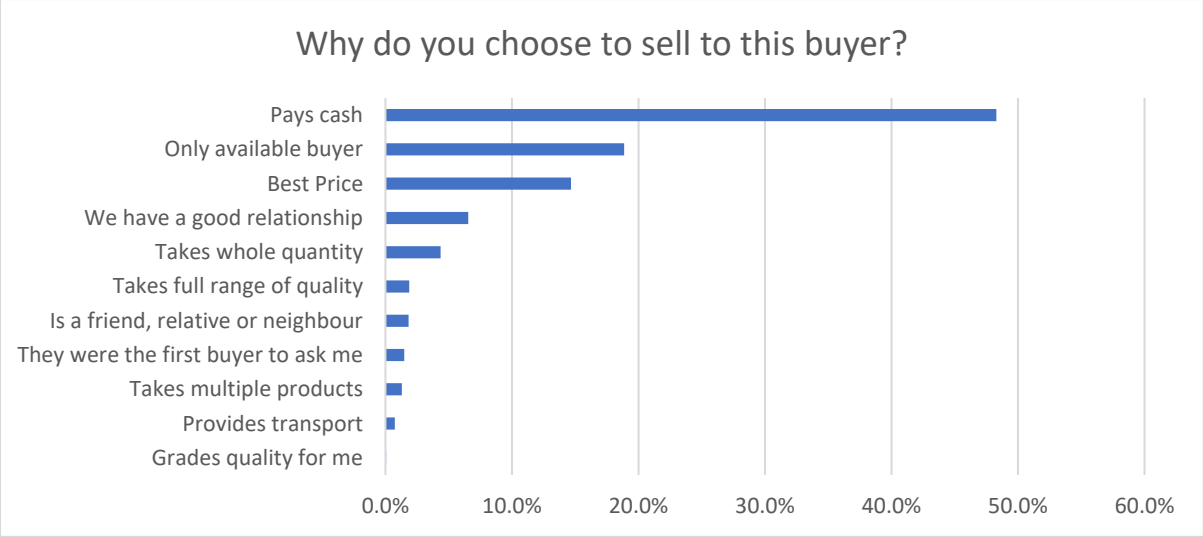
Relationship with buyer

The purpose of this section is to find out what type of arrangements farmers have with their crop buyers.

Reasons for selling to buyer

	Freq.	Percent
Pays cash	975	48.3%
Only available buyer	381	18.9%
Best Price	296	14.7%
We have a good relationship	132	6.5%
Takes whole quantity	88	4.4%
Takes full range of quality	38	1.9%
Is a friend, relative or neighbour	37	1.8%
They were the first buyer to ask me	30	1.5%
Takes multiple products	26	1.3%
Provides transport	15	0.7%
Grades quality for me	1	0.1%
Total	**2,019**	**100%**

Farmers choose to sell to their buyer for their 5 main commercial crops primarily because the buyer paid cash (48.3%), was the ‘only available buyer’ (18.9%) and paid the ‘best price’ (14.7%).



Main problems with buyer

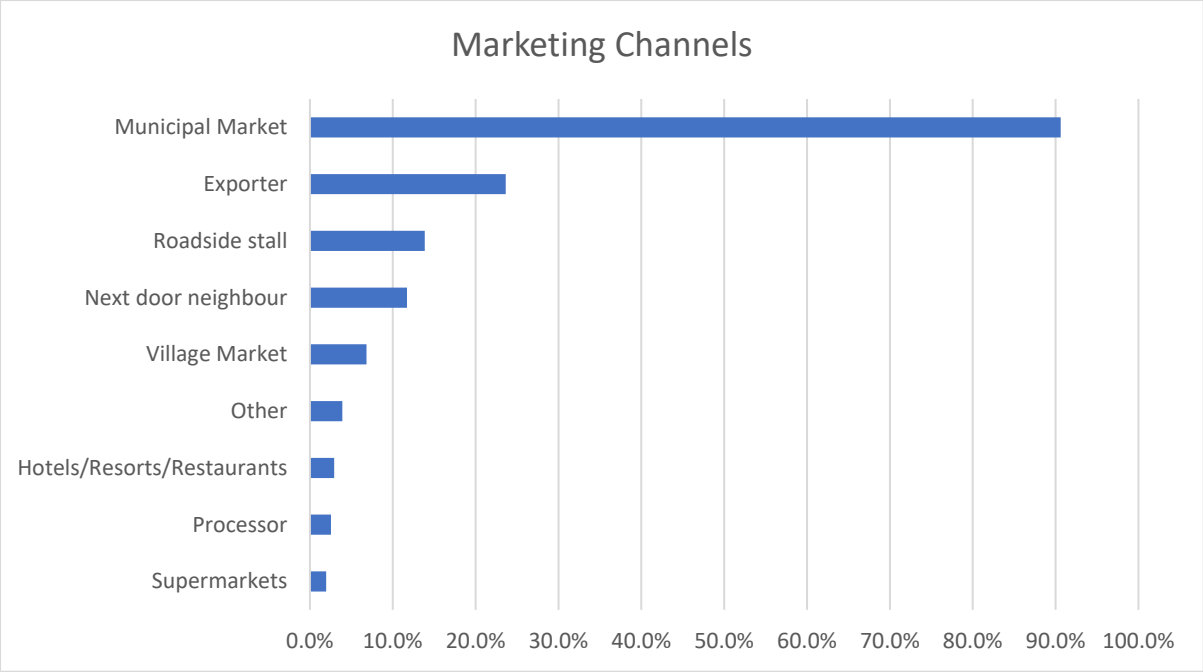
	Freq.	**Percent**
Buyer did not give promised price	15	40.54%
Change in price	9	24.32%
Change in requirements	7	18.92%
Issues with inputs provided by buyer	5	13.51%
Delay in paying for harvest	1	2.7%
Total	**37**	**100%**

Only 1.8% (37 farmers) had problems with crop buyers. The first most important problem was that the 'Buyer did not give promised price' (40.5%), the second most important problem was a 'Change in price' (24.3%), the third most important problem was a 'Change in requirements' (18.9%), and the fourth most important problem were 'Issues with inputs provided by buyer' (13.5%).

Market channels

	Observations	Percent
Municipal Market	512	90.6%
Exporter	512	23.6%
Roadside stall	512	13.9%
Next door neighbour	512	11.7%
Village Market	512	6.8%
Other	512	3.9%
Hotels/Resorts/Restaurants	512	2.9%
Processor	512	2.5%
Supermarkets	512	2.0%

The majority of farmers' products mainly go to municipal markets (90.6%). Other market channels used are exporters (23.6%), roadside stall (13.9%), and next door neighbour (11.7%).



Production and marketing information

The purpose of this section is to find out what the main sources of information are for production and marketing.

Group memberships

	Yes	**No**	**Total**
Farmer group	8	71	79
Village group	5	72	77
Cooperative/Association	1	78	79
Women farmer's group	0	72	72
Total	**14**	**293**	**307**

Around 4.6% of the responding farmers, or any of the family members, belonged to a farmer group, a cooperative or association, or a village group. Most of those farmers belonged to a farmer or village group.

Perception of change

The purpose of this section is to find out how the standard of living has changed over the last five years and the reasons behind any changes. Standard of living is the level of material comfort experienced by the household, which is measured by their access to goods, services, necessities and luxuries.

Standard of living

	Freq.	Percent
Improved significantly (>30%)	180	35.50%
Improved somewhat (10-20%)	197	38.86%
No Change (-10% to 10%)	110	21.70%
Deteriorated somewhat (-10-30%)	20	3.94%
Total	**507**	**100%**

In the last five years, 74.4% of the farmers experienced a significantly or somewhat improved standard of living in their household. Around 3.9% experienced a somewhat deteriorated standard of living.

Main reason for an improved change in living standard

	Freq.	Percent
Change in crop prices	138	38.33%
Growing horticulture crops	98	27.22%
Change in health of family members	50	13.89%
Change in crops grown	41	11.39%
Change in crop yields	19	5.28%
Change in non-farm income	8	2.22%
Change of crop buyer	3	0.83%
Other	2	0.56%
Change in livestock income	1	0.28%
Total	**360**	**100%**

If the household standard of living had improved in the last 5 years, the primary reason was ‘Change in crop prices’ (38.3%) followed by ‘Growing horticulture crops’ (27.2%).

Main reason for a deteriorated change in living standard

	Freq.	Percent
Change in health of family members	17	85.00%
Change in crop prices	1	5.00%
Change in crop yields	1	5.00%
Change in level of crime in area	1	5.00%
Total	**20**	**100%**

If the household standard of living had deteriorated in the last 5 years, the primary reason was ‘Change in health of family members’ (85%).

Survey of female horticultural producers

Role in decision making

The aim of this section is to find out what type of contribution the woman of the household has in household decision making. In other words, how much of a say or input she has into decisions.

Decisions about which commodities/crops to grow

	Freq.	Percent
Decision made by my spouse & I	334	70.17%
No contribution	109	22.90%
Decision made by myself	20	4.20%
Decision made by someone else	13	2.73%
Total	**476**	**100%**

Decisions of what commodities/crops to grow are primarily made by the wife and husband together (70.2%). Around 22.9% of the female respondents make no contribution to the decision on what crop to grow and 4.2% make the decision by herself.

Decisions about who to sell to

	Freq.	Percent
Decision made by my spouse & I	326	68.49%
No contribution	115	24.16%
Decision made by myself	20	4.20%
Decision made by someone else	15	3.15%
Total	**476**	**100%**

Decisions about who to sell their produce/crops to are primarily made by the wife and husband together (68.5%). Around 24.2% of the female respondents make no contribution to the decision on where to sell to and 4.2% make the decision by herself.

Decisions about household livelihood strategies

	Freq.	Percent
Decision made by my spouse & I	365	76.84%
No contribution	69	14.53%
Decision made by myself	30	6.32%
Decision made by someone else	11	2.32%
Total	**475**	**100%**

Household livelihood strategies are the activities the household undertakes to make an income and survive. Decisions about household livelihood strategies are primarily made by the wife and husband together (76.8%). Around 14.5% of the female respondents make no contribution to the decision on livelihood strategies and 6.3% make the decision by herself.

Decisions about the health and education of the children

	Freq.	**Percent**
Decision made by my spouse & I	380	80.17%
No contribution	47	9.92%
Decision made by myself	40	8.44%
Decision made by someone else	7	1.48%
Total	**474**	**100%**

Conclusions

Decisions about the health and education of the children of the household are primarily made by the wife and husband together (80.2%). Around 9.9% of the female respondents make no contribution to the decision on the children's health and education and 8.4% make the decision by herself.

In summary, most of the decision-making is undertaken by the wife and husband together. Female respondents were primarily deciding herself on decisions about the children's health and education and the household's livelihood strategies.

11.4 Oxfam consumer report

Activity 1.5 and 3.1

Author: Mr Craig Johns (UoA) and Ms Larissa Pagliuca (UoA)

Acknowledgments

We would like to sincerely thank the management staff at Oxfam Trading Australia. Even with the day-to-day pressures of running a challenging business, they were able to able to devote their time and energy into helping us develop the survey and then arranging access to their substantial subscriber database. Thanks also go to the customers of Oxfam, who generously gave up their time to fill in the survey. In addition to Oxfam Trading Australia, we've been privileged to be part of a collaborative partnership utilising skills and expertise from the University of Adelaide, Griffith University, Southern Cross University, the Secretariat of the Pacific Community, Department of Industry, Vanuatu, and the National Agricultural Research Institute, PNG. The dedication and support of project staff from these agencies is genuinely appreciated. And finally, we would like to especially acknowledge the generous amount of time and industry input provided by our Pacific islands private sector partners, who make our research not only possible but meaningful.

Acronyms

ACIAR - Australian Centre for International Agricultural Research

PNG - Papua New Guinea

SME - Small to medium enterprise

SPC - The Pacific Community

Background

Key Issues: Approximately 80% of people in Papua New Guinea (PNG) and the Pacific Islands live in rural areas. More than 90% of them are semi-subsistence smallholder farmers who earn their livelihoods from agriculture, forestry, and fishing. Rural farmers in countries such as PNG, Fiji, Vanuatu, and the Solomon Islands generally have limited access to distant markets for their crops. Value-adding can enhance market access, especially if products can be dried or semi-processed locally and transported to distant markets. Industries based on value-added products can also create employment and enhance opportunities for small to medium enterprises (SME's) to strengthen local economies. There is a great potential for value-adding to a variety of agroforestry crops, but targeted research is needed to identify the best opportunities for investment and to build capacity in value-added processing in both the government and private sectors in the four countries. To achieve this goal, this wider project proposes to enhance small to medium enterprises' ability to participate in value-adding by identifying barriers to development, along with incentives and opportunities that enable adoption of value-adding.

Project justification: The Australian Centre for International Agricultural Research (ACIAR) funded project is focused on improving food and nutritional security and environmental benefits across the Pacific through the development of more competitive value chains focusing on new market driven opportunities. Oxfam International is a not-for-profit confederation of 20 independent charitable organisation focusing on addressing global poverty. It has varied operations and bases around the globe. At the time of this study, the Australian organisation, Oxfam Australia, had a subsidiary organisation, Oxfam Australia Trading, who operated 13 retail stores across the country and an online shop trading under the name Oxfam Shop.

Oxfam Australia Trading also supplied coffee, tea and chocolate products to Australian supermarkets on a wholesale basis through their Oxfam fair brand. Oxfam Shop offered customers a range of ethically sourced products from around the globe and promoted fair trade as a way to support sustainable communities and equitable employment opportunities. The philosophy lies in the idea that when customers purchase Oxfam's handmade products, the customer is helping to lift artisans and farmers from all over the globe out of poverty.

This project included a survey of Oxfam Australia Trading's database of customers. This Oxfam Australia Trading customer survey will help to better define the market opportunity for value-added products from the Pacific by gaining a better understanding of ethically conscious Australian consumers. It is envisioned that these insights will potentially benefit both Australian consumers and Pacific communities that can produce products for this market channel.

Objectives

The Oxfam Australia Trading survey aims to better understand Oxfam customers, particularly in regard to opportunities for Pacific Island products. The wider ACIAR project explores opportunities for new value-added agroforestry products to improve livelihoods and environmental benefits in Papua New Guinea, Vanuatu, Fiji, and the Solomon Islands. The proposed cross-sectional online questionnaire aims to better understand the purchasing patterns of Oxfam Australia Trading customers and get some insight into consumer behaviour towards Pacific Island products and the drivers behind ethical purchases. Overall, the results will provide valuable insights for stakeholders in these countries and Oxfam Australia Trading to help identify the most effective market channels and promotion to this consumer base. In particular, the findings will help us to better understand market opportunities and 'scale up' activities outside of Oxfam Australia Trading and identify the best opportunities for capacity building and investment in value-added processing of Pacific Islands' products. Consequently, this report will be presented to ACIAR, Oxfam Australia Trading, and our relevant stakeholder partners across the four countries in the Pacific.

Values and benefits to participants: The findings will provide valuable insight into how stakeholders from the Pacific Region can better understand the consumer behaviour of Australian customers towards Pacific products. While participants in the survey will not be immediately or directly benefited, this research is expected to provide useful information to retailers like Oxfam Australia Trading about the purchase patterns of their customers to allow their needs to be better serviced. The research will also give a clearer understanding of the potential for product and value chain development for specific products from the Pacific Islands. It is hoped these findings will lead to enhanced self-reliance and ultimately help reduce poverty in the Pacific region.

Methodology

An online questionnaire was considered the most practical and efficient method of collecting quantitative data to better understand the customers` demographic profiles and purchasing behaviour from a large and national sample of Oxfam Australia Trading consumers. The survey was undertaken using an online platform called "Qualtrics" and was administered under the Oxfam Australia banner to existing members of the Oxfam Australia Trading database Australia wide. The respondents' data was collected anonymously with data only tagged to a random identification number. Therefore, survey data returned to the University of Adelaide researchers from the online platform contained no form of personal identification, such as names or other contact information. The only demographic information collected was general in nature, such as gender, age, state, household income, etc. Survey respondents were recruited through the Oxfam Australia Trading database of 55,000 account holders. Each account holder was invited to participate by email and the cover letter used for this initial interaction is included Appendix 1. Once they agreed to be part of the study, they were directed

to the online survey on the Qualtrics platform. Prior to commencing the survey, participants were presented with the Participant Information Sheet (see Appendix 2). The only eligibility criteria was that Oxfam Australia Trading customers, the respondents, needed to be aged 18 years and over. There was no time limit to complete the 30 questions (see Appendix 3) and when the survey was closed, only fully completed surveys were analysed.

The survey covered four key topic areas:

1. Demographics: To provide a profile of Oxfam Australia Trading customers and potential consumers of Pacific products in Australia.
2. Consumer segmentation: To extend the profile of Oxfam Australia Trading customers and provide insight into some of their beliefs and behaviours.
3. Purchasing from Oxfam Australia Trading: To better understand purchasing patterns of ethically conscious Australian consumers.
4. Pacific Products: To provide insights on the demand for Pacific products from each of the target countries (Fiji, Papua New Guinea, Solomon Islands and Vanuatu).

The survey was conducted between 20/08/18 to 04/09/2018 (16 days). Once the data was collected it was analysed using a statistic software package called “Stata” to provide insights into this report.

The key personnel involved in the survey included:

- Craig Johns, Associate Director of Agribusiness Innovation at the Centre of Global Food and Resources (CGFAR). Craig managed the initial negotiation and research design; implementation with the survey project team; data analysis; and preparation of the report and subsequent publications.
- Ms. Larissa Gui Pagliuca, Research Assistant at CGFAR. Larissa contributed to the research design, data analysis, and preparation of the report and subsequent publications.
- Sara Allan, National Marketing Manager at Oxfam Trading. Sara contributed to the survey design and liaised with Oxfam Australia Trading’s eCommerce Manager to implement distribution of the survey to Oxfam Australia Trading subscribers.

Achievements against activities and outputs/milestones

Objective 1: Better understand the consumer behaviour towards Pacific products, the drivers behind it and hence the most effective market channels and promotion to this consumer base, targeting Oxfam Australia Trading customers and other potential clients, in support of the Pacific producers.

no.	Activity	Outputs/ milestone	Due	Comment
1.1	Design the Oxfam Australia survey; ethics approval and pre-test.	Approval through the University of Adelaide ethics department. Finalisation of the survey on the Qualtrics platform	July 2018	Input from Oxfam and our Pacific partners were collected during the design of the survey
1.2	Data collection.	Email out to Oxfam`s subscribers	Aug 2018	The survey was monitored and some technical support was given to respondents regarding the Qualtrics platform.
1.3	Data analysis.	Report produced	June 2019	Present the report with the main results to ACIAR, Oxfam and other stakeholders from the Pacific Region.

Results

The following insights can be used to drive stakeholders from the Pacific Region that want to use Oxfam Shops or similar types of retailers as a channel to reach the Australian market. From the 55,000 Oxfam Australia Trading subscribers, 1030 people consented to take the survey and from these, there were 930 completed surveys that were used in the analysis below.

1. Demographics

The 930 completed surveys were distributed across Australia in a similar way to the last Australian Census1 (07/ 2018). The other key characteristics of the respondents are described below in Table 1.

2. Consumer Segmentation

Oxfam Australia Trading customers expressed that giving back to communities in need is important to them (90% agree/strongly agree) but they are not so engaged in charity activities or socialising with other people as they are with living simply, spending time with friends and family (Figure 1). They also try to combine their “fraternity” with the consumption of unique and high-quality products. So, they are willing to help but they also want to receive good products in return.

Table 1. Demographic characteristics from the sample, Oxfam customers (n=930)

Demographic characteristics		% of respondents (N=930)
Gender	Male	10
	Female	90
Age	18 - 24	4.2
	25 - 34	15.7
	35 - 44	23.8
	45 - 54	21.2
	55 - 64	21.8
	65 - 74	11.5
	75 - 84	1.7
	85 or older	0.1
State	ACT	2.7
	QLD	14.2
	NSW	25.6
	NT	1.5
	SA	14.4
	TAS	3.1
	VIC	25.5
	WA	12.7
	Outside Australia	0.3
Arrangement	Single, separated, divorced or widowed	36.6
	Married, living with partner or De facto	63.4
Education	Finished before year 12	4.9
	Finished year 12	7.8
	Trade Qualification	2.2

[1] Source: http://www.abs.gov.au/ausstats/abs@.nsf/mf/3101.0

	Graduate Certificate or Diploma	19
	Bachelor Degree	34.4
	Postgraduate Degree	31.6
Job position	Working full time	36.3
	Working part-time / casual	30
	A full-time student	2.4
	A part-time student	0.5
	Both working and studying	3.5
	Retired	14.7
	Engaged in full-time home duties	5.8
	Not in paid work but looking	3.3
	On a pension (other than age pension)	3.3
	None of the above	0
Household Income during the past 12 months	Less than $24,999	8
	$25,000 - $49,999	14.1
	$50,000 - $99,999	25.9
	$100,000 - $149,999	15.7
	$150,000 - $199,999	8.3
	$200,000 - $249,999	2.8
	More than $250,000	2
	Not sure / Rather not say	23.2

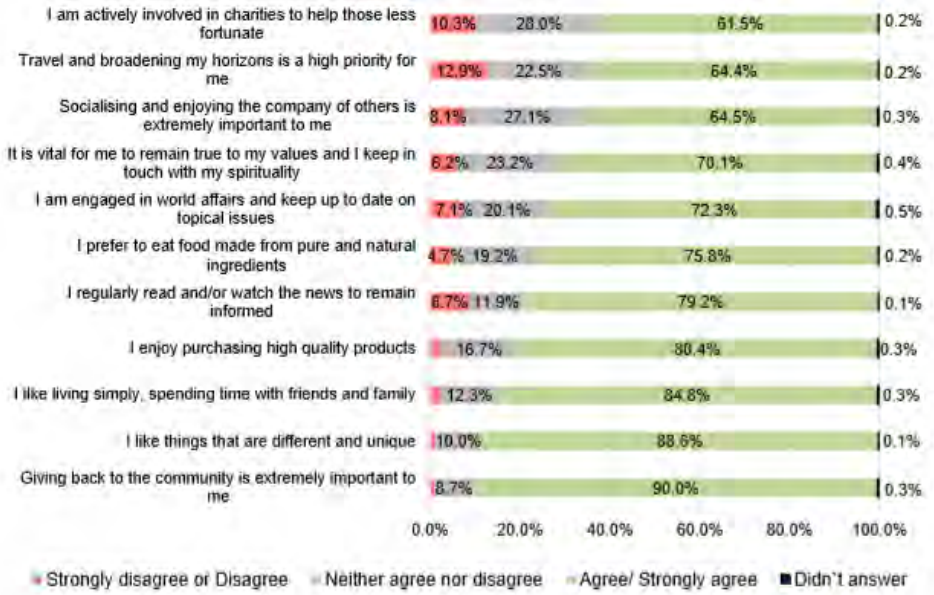


Figure 1. Level of agreement/disagreement with the following statements (n=930).

3. Purchasing from Oxfam

This topic will guide producers and value adders in the Pacific to better understand the consumer purchasing patterns of ethically conscious Australian customers and how they can be better serviced. From 930 respondents, 98.9% purchased something from Oxfam (either in-store, from the supermarket or online) in the past few years. So, the following analysis focus on these 920 people. 62.8% of the respondents purchased some food products in the past 2 years and 82% go shopping once every few months or once a year. The frequency for purchasing beverages is higher than purchasing food, with 15% of the customers buying beverages weekly/monthly and 8.3% buying food weekly/monthly. Also, as expected, the high-income group buy more frequently compared to the low-income group. After the Oxfam shops, online sales are the second most dominant channel for buying Oxfam products (including food), with around 40% of the respondents using this channel and 74.3% visiting the website either monthly or every few months. Also, the share of sales through both channels increases with income. The main motivations that guide the consumption of products from Oxfam, including food, is **"The story behind the product"** (Figure 2). The priority reasons are the same across income groups. Regarding food products, quality is the second most important reason, followed by uniqueness. Price is not so important (6%), even for the low-income group. This is quite significant when you consider that respondents could choose more than one option.

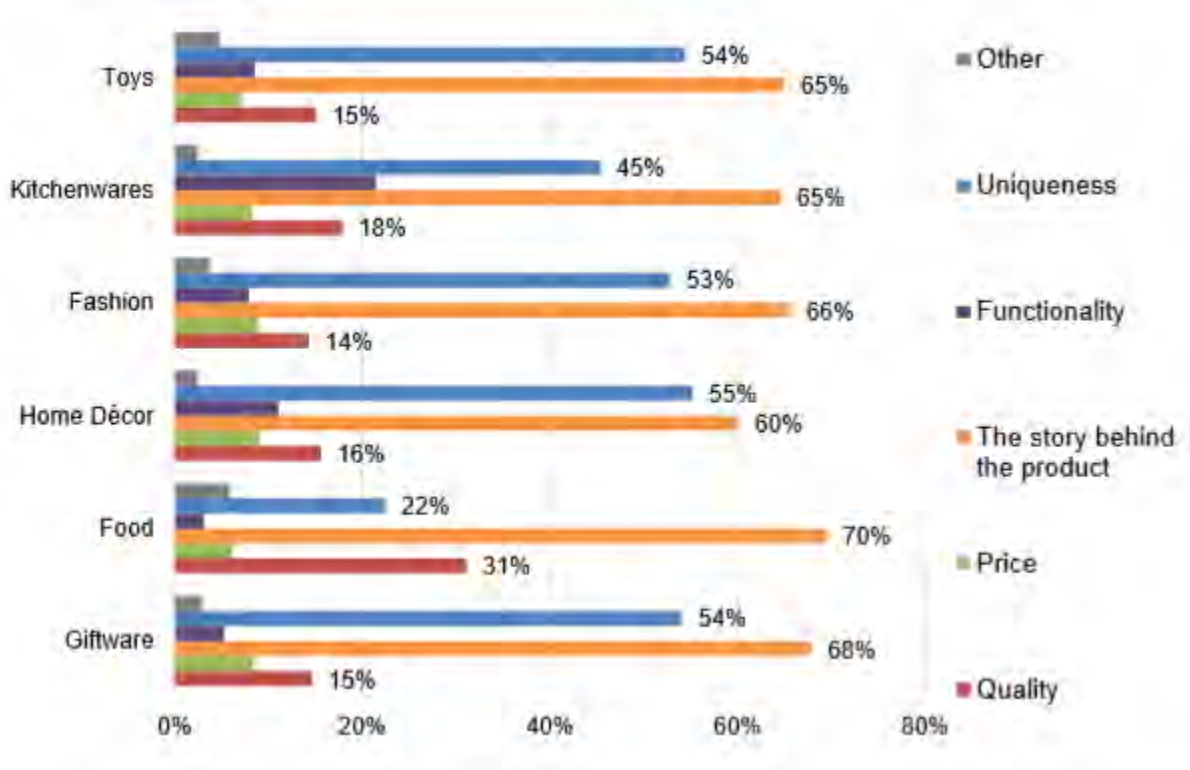


Figure 2. Reasons that best describes the consumption of products from Oxfam (n=920)

When buying Food products from Oxfam, the most important attribute is "Company is responsible and ethical", followed by "Certified Fairtrade" (Figure 3). And the attribute "Having experiences in product`s country of origin" isn't considered very important at all. Once again, "price" was not as relevant compared to the other attributes.

Attributes	Not at all/ not very important *	Somewhat important	Very/Extremely important
Company is responsible and ethical	0.9%	4.8%	94.3%
Certified Fair Trade	1.6%	7.4%	91.0%
Taste / flavour	2.1%	9.3%	88.6%
The product specifies that buying it helps local producers	2.1%	8.5%	89.4%
Knowing the exact origin of the product	6.6%	23.4%	70.1%
The product is produced and owned locally	19.9%	29.8%	50.3%
Certified organic	22.5%	35.1%	42.4%
Nutritional characteristics	19.4%	41.5%	39.1%
Certified HACCP	27.3%	35.6%	37.0%
Price	12.6%	55.9%	31.5%
The product specifies it is produced using traditional methods	29.8%	39.3%	31.0%
Appearance	22.8%	49.0%	28.2%
Having an emotional connection to the shops you buy from	37.9%	34.3%	27.9%
Packaging and Labelling	33.4%	42.9%	23.7%
Having experiences in the product's country of origin	59.5%	26.6%	13.8%
Brand	58.8%	27.9%	13.3%
Size	39.1%	48.8%	12.1%

Figure 3. Level of importance for certain attributes when buying food products (n=578).

The percentage is in relation to the number of respondents that purchased food from Oxfam (Qu5), n= 578 * It also included the respondents that didn't answer for some attributes

4. Pacific Products - from Fiji, PNG, Salomon Island, and Vanuatu

This topic aims to understand the demand for Pacific products from Oxfam customers in Australia. It investigates their level of interest for different types of Pacific products, their knowledge of some indigenous products and their understanding of relevant certification logos.

67.5% of the respondents have an interest in buying products from at least one of these countries - Fiji, Papua New Guinea, Solomon Islands or Vanuatu (Figure 4, in blue) with no clear preference for a specific country and no significant trend as incomes increase. Interestingly, these respondents have similar characteristics (response rate for gender, age, state, education, work, and income) when comparing them to the entire sample.

Just 10.22% of the respondents have visited at least one of these four countries (Fiji, Papua New Guinea, Solomon Islands, and Vanuatu) in the last two years. Yet, Fiji is the most visited country out of the four but still represents only 5.9% of the respondents. Also, as expected, from that 10.22 % of the customers that have visited some of these countries before, 80% have interest in purchasing Pacific products (Figure 4, in orange).

Figure 4. Percentage of respondents that have interest in purchasing products from Pacific, by countries (n= 930) and the percentage from those who have visited at least one country before (n=95).

Figure 5 presents the level of interest from Oxfam customers to purchase some Pacific products. Handicrafts tops the list for “extremely or very interested” followed by clothing, chocolate and coffee. Kava and flour were at the other end of the spectrum with a high percentage of respondents “not at all or not very interested” in purchasing these products. It is interesting that even products like chocolate and coffee that have just under a third of respondents very interested or extremely interested in purchasing, also have just over a third, who are not that interested at all, which shows a real divergence in consumer preferences across different food products. If you compare these results against the respondents that had visited the country before, then the level of interest to purchase is still topped by handicraft, but chocolate moves up to second (replacing clothing), then coffee and indigenous nuts, which suggests that these food categories benefit from the experience tourists have had in those countries. If all 3 groups of “somewhat interested”, “very interested” and “extremely interested” are combined then chocolate is the most desired food product - 66% of the respondents have some interest in purchase it.

Options	Extremely/ very interested	Somewhat interested	Not at all / Not very interested
Handicraft items made with local materials	44.0%	34.1%	22.0%
Clothing made with local materials	32.2%	38.0%	29.8%
Chocolate	31.0%	35.1%	33.9%
Coffee	28.7%	32.6%	38.7%
Pearls and Pearl Handicraft	22.0%	31.0%	47.0%
Virgin Coconut Oil	17.9%	29.5%	52.6%
Cosmetic products	8.0%	25.0%	67.0%
Spices	24.6%	36.5%	38.9%
Tea	24.5%	33.0%	42.5%
Vanilla	23.3%	32.9%	43.8%
Indigenous nuts	18.5%	33.0%	48.5%
Ginger	17.3%	30.7%	52.0%
Sauces, syrups, jams and spreads	17.1%	34.2%	48.7%
Dried local fruit	13.0%	30.8%	56.2%
Honey	10.5%	25.2%	64.3%
Oil	9.2%	28.6%	62.2%
Kava (traditional Pacific drink)	9.1%	18.8%	72.1%
Flour	4.0%	21.2%	74.8%

Figure 5. Level of interested in purchasing any of the following products from Pacific Region. It was considered the total of respondents that answered this question of each of the four countries (Qu 21, 22, 23, 24), n=3622.

When making the decision to buy chocolate from the Pacific Region, “taste”, “benefits to local communities”, “Fairtrade certified” and “Quality” are considered the main attributes (Figure 6). The same was observed for each individual country. However, if the respondents had visited some of the countries before, “benefits to local communities” became more important than “taste” and also “story behind the product” gained more importance. Once again, “price” did not feature prominently against the other attributes and this was constant across all four countries.

Options	Extremely/ very important	Somewhat important	Not at all / Not very important/ didn't answer
Taste	90.8%	7.9%	1.4%
Benefits to local communities	90.1%	8.9%	1.0%
Fair trade certified	89.2%	9.2%	1.6%
Quality	88.6%	10.4%	1.0%
Story behind the product	66.8%	29.8%	3.3%
Organic certified	51.6%	32.2%	16.2%
HACCP certified	50.5%	33.6%	15.9%
Price	35.0%	57.1%	7.9%
Island of origin	24.7%	38.9%	36.4%
Packaging	18.7%	43.2%	38.1%
Other chocolates being sold	17.8%	50.3%	31.9%

* It was considered the answers from Qu 25, 25.2, 25.4, 25.6. **There are 690 respondents from Fiji, 391 from PNG, 655 from Solomon Islands and 657 from Vanuatu that have some interested in buying chocolate..

Figure 6. Level of importance for certain attributes when making the decision to buy chocolate from the Pacific Region

Kava, tamarind, sago, coconut oil and breadfruit flour are the most known Pacific products from Oxfam customers (Figure 7). Yet, if they had visited some of the four countries before their knowledge increases for almost all products (i.e. *Canarium* nuts, Tavula nuts increased by more than threefold).

However, this does not necessarily imply an interest in buying these products. For instance, kava is known but just 9% of the respondents are extremely or very interested in to buy it. The same is with coconut oil and indigenous nuts when the response rate is only 18% (Figure 5).

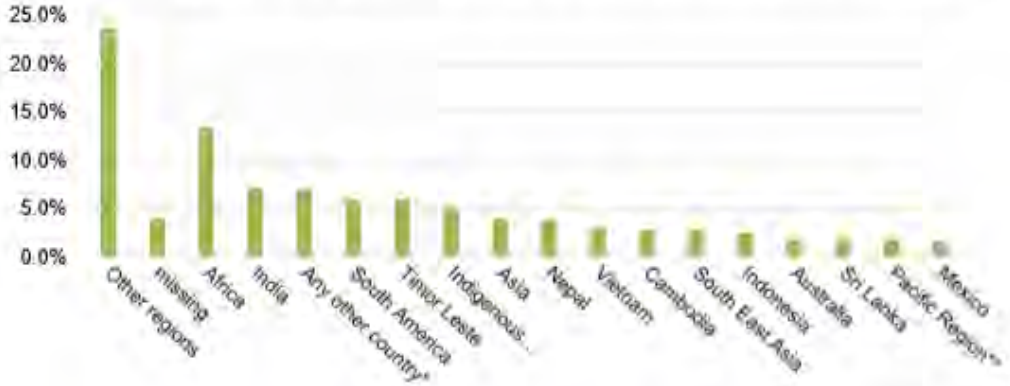
Figure 7. Percentage of respondents that have heard about these Pacific products before.

Products	In general*	Have visited before**
Kava	72.8%	87.4%
Tamarind	73.4%	74.7%
Sago	70.9%	68.4%
Virgin Coconut Oil	70.0%	75.8%
Breadfruit flour	24.5%	29.5%
Noni	15.5%	27.4%
Tavula nuts	10.0%	16.8%
Tamanu oil	8.4%	10.5%
None of them	7.5%	3.2%
Tahitian chestnut / Ivi	3.9%	4.2%
Canarium nuts (Ngali, Nangai, Galip)	2.9%	9.5%
Vutu nuts	3.1%	6.3%
Tuluk	1.9%	2.1%
Island Cabbage Bele	0.9%	2.1%
Barringtonia	0.8%	1.1%
Terminalia / Natapoa	0.6%	1.1%
Laplap	0.0%	0.0%

*N= 930 **It was considered the respondents that visited Fiji, PNG, Solomon Island or Vanuatu in the last 2 years (N=95).

36% of the respondents have a particular interest in products from other regions/ countries. From 84 regions/ countries mentioned, Africa shows the highest amount of interest, followed by India and “any other country in need” (Figure 8). Just 1.8% mentioned another place in the Pacific Region, such as Samoa, Tonga, Torres Strait Islands and the Marshall Islands.

Figure 8. Please specify the region/country that you have a particular interest in products from.



*The places mentioned were Samoa, Tonga, Torres Strait Islands and the Marshall Islands. "Other regions" are the sum of all the other places mentioned.

To investigate the level of consumer understanding of certification logos, five common logos were chosen to be included in the survey, these are:

Fairtrade certification


HACCP (Hazard Analysis and Critical Control Point) is a food safety methodology applied in the food industry.


Pasifika org is an organic certification in the Pacific Region.

NASAA (The National Association for Sustainable Agriculture Australia) is organic certification.

OXFAM is a confederation of 20 independent charitable organisations, a major non-profit group.

The Fairtrade and the Oxfam logo are the most familiar, seen by 96% of the respondents, followed by NASAA (49%), HACCP (22%) and Pasifika org (9%). From those first two, more than 80% of respondents said they had previously purchased food products with these logos. The response rate for those who purchased NASAA products is 37%, HACCP is 11% and Pasifika org is only 5%.

When verifying if the consumers have an idea of the meaning of each logo it is interesting to note that most of the statements chosen about Fairtrade are very similar to Oxfam (Figure 9). Both logos were strongly related to “supporting communities”, “ethically sourced”, “trustworthy source”, “do something good/charity”.

However, most of the respondents don`t know or don`t believe that Pasifika certification is organic certification, as the responses rate for “products are certified organic” is 55%. They also don`t know or don`t believe that HACCP certification is a healthier choice. Probably those logos are not transmitting clear information about the product.

Figure 9. Percentage of respondents who believe that the statement applies to the logos.

Statements	FairTrade	HACCP	NASAA	Pasifika	Oxfam
Better value for money	14%	9%	7%	14%	16%
Guaranteed to be better quality	21%	33%	29%	28%	21%
From a more trustworthy source	79%	63%	60%	52%	74%
A healthier choice	11%	29%	45%	38%	9%
Allowing me to do something good/ charity	76%	27%	28%	36%	88%
Allowing me to support Oxfam Australia	29%	17%	11%	15%	91%
A unique product	27%	12%	13%	32%	47%
Allowing me to remember a holiday experience	5%	4%	3%	11%	8%
Allowing me to supporting communities	80%	28%	26%	45%	84%
The product has been FairTrade certified	91%	13%	14%	22%	34%
Products are ethically sourced	84%	28%	29%	39%	77%
Products are certified organic	14%	18%	79%	55%	13%
No different than others (i.e. marketing gimmick)	2%	3%	0%	5%	2%
Don't know	3%	12%	6%	13%	3%
None of the statements apply	1%	7%	4%	9%	1%

* It was considered the respondents that answered "yes" in Qu 28. There are 890 respondents from Fair Trade, 205 from HACCP, 458 from NASAA, 85 from Pasifika and 897 from Oxfam.

Conclusions and Recommendations

It is unfortunate that recently the decision has been made to close the Oxfam Australia Trading operations. This includes all their retail stores and online shop, but they are currently in negotiations to distribute the Oxfam fair brand through a third party and will be prepared to make an announcement on the outcomes of these negotiations closer to July 2019. The Oxfam Australia Board that made the decision cited the tough retail environment in Australia and ongoing commercial pressures as the reasons for the close. Those pressures have seen a large number of retailers close their doors recently around the country. The most pleasing result in this survey is that there is definitely demand for Pacific products from ethically conscious Australian consumers, with 67.5% of Oxfam Australia Trading respondents registering an interest in purchasing products from Fiji, Vanuatu, Solomon Islands or PNG.

Oxfam are not the only retailer interested in the socially and ethically responsible space and have generously given their consent to share the broad insights from this project to investigate alternative market channels for Pacific products into Australia. While the Australian retail scene undergoes some significant changes, it is still very encouraging that there appears to be consumers still motivated to buy high quality, socially responsible and ethically sourced products. For this target market, price is low on the list of motivations too, which is encouraging for enterprises and producers hoping to deliver products to these consumers. The challenge going forward may well be less around whether there is a market for Pacific products, but more around how best to connect the producers and their products to its target market.

When trying to better understand who are purchasing products through the Oxfam Trading Australia channels (stores, online or through other retailers), it is interesting to note a clear profile emerges. The target market tends to be mainly women, who have a high level of education, are more mature in age, are either working or retired and belong to a middle to high income group. While they are subscribers to Oxfam Australia Trading, they might only purchase products every few months or once a year.

In light of Oxfam Australia's recent announcement that they are closing their stores, it may be interesting to explore in more depth why this target market shopped infrequently with Oxfam, despite their considerable interest in the products and support of the organisation's ethos. Oxfam closing its stores is a timely and important consideration in the potential for products from the Pacific. It could well be that the now expected trend for convenience in both shopping experience and product attributes, suggests that even products with a the aim of benefitting

impoverished people need to be made available to the market through lower costs, convenient and more mainstream channels such as Amazon and supermarkets. This is certainly worthy of further investigation in identifying pathways to market. This consumer group described above are willing to give back to communities in need, but they also desire to buy something unique with a high level of quality, as well as food made from pure and natural ingredients. They also identify strongly with the Oxfam brand and associate it with all the same attributes as the Fairtrade brand including “supporting communities”, “ethically sourced”, “trustworthy source” and “do something good/charity”.

When questioned about their motivation for purchasing from Oxfam, the key message was that they wanted to hear about the “story behind the products” and know that the “company is responsible and ethical”. This contrasts quite strongly with the low importance given to price, where only 6% of respondents rated this as a motivation.

Chocolate was identified as one of the key products of interest for Australian consumers who considered “taste”, “benefits to local communities” and “Fairtrade certified” as the most important attributes when making a purchasing decision. Once again price was not important. At the other end of the spectrum, products like kava and virgin coconut oil are known by consumers but the interest in purchasing them from the Pacific is low. More research is required on these individual products before we can gain a better understanding on the reasons behind these results.

When considering what recommendations can be made from a study such as this one, it is useful to look at the different stakeholder groups.

From the perspective of the producers and value adders in the Pacific there are several useful insights on which they can act upon:

- If the Pacific based enterprises believe ethically conscious Australians are a good target market for their products, then it is valuable to try and understand who this consumer group is made up of. In the case of Oxfam consumers, this survey identified a reasonably clear Oxfam consumer profile. The next step for Pacific based enterprises might be to test their particular products on this specific target market to gather more insights into what appeals to the Oxfam Australia market.
- While price is always going to be important right along the value chain, enterprises in the Pacific need to keep in mind that it ranks very low in important attributes with this consumer group, so how they communicate the important attributes (physical and nonphysical) of their product becomes a lot more important.
- Considering the importance that ethically conscious consumers put on the ‘story’ of the product and the ‘brand’ of the retailer, it is important that Pacific based exporters don’t just pick the first market channel that offers to buy their product to sell into the Australian market. A better strategy would be to do some homework and assess the suitability of that buyer to not only meet their price, quality and service needs, but also consider whether they will be able to service the targeted market and continue to sell the ‘story’ of their product to a consumer group that trusts the whole value chain to fulfil their needs.
- Online sales have been a key market channel for Oxfam Australia Trading which is highlighted by the high frequency of engagement when compared to consumers visiting the stores. Engagement and sales through an online platform will no doubt grow more in a range of similar business models as consumer shopping patterns continually evolve. Once again, companies will need to keep this in mind when they are developing their own online strategies as well as when assessing the retailers they may be looking to partner with.

From the perspective of other stakeholders such as ACIAR, other funding agencies and relevant government departments across the Pacific, it is important that this type of market opportunity is better understood so an appropriate enabling environment can be created to

help support Pacific enterprises wanting to export their products. Some of the key insights to note include:

- The country of origin within the Pacific doesn't seem to matter much to this consumer group, so marketing efforts could be based on the broader Pacific angle. This is a significant marketing insight, as a collective or umbrella brand could be a way of networking Pacific producers and reducing the financial and general business risk and cost for smaller producers, while having a greater cut-through with the target market.
- There is a strong willingness to purchase Pacific products even if Australian customers haven't visited the Pacific before which gives some hope to countries like PNG and the Solomon Islands that don't have the larger tourist industry that Fiji and Vanuatu do. However, if Australian consumers have visited the Pacific, then they are more aware of the local products which raises their willingness to purchase even more (80%). This is especially the case for chocolate, coffee and indigenous nuts that seemed to enjoy a substantial increase in demand from respondents who had visited the Pacific before. This highlights the need to work closely with the tourist industry when looking to promote the export of local products.
- Certification can be an important driver of consumer purchasing behaviour, but it is important to understand what this means from a consumer perspective. The study of the five logos in this project has shown that the retailer brand can be just as strong in communicating some of the values of the certification schemes. Companies will need to make individual choices around what best suits their needs and the value chains and markets they are looking to sell into, but aid funders and policy makers need to keep this in mind when recommending and delivering larger projects.

11.5 Opportunities, incentives and barriers to uptake of agroforestry in Fiji and Vanuatu

Activity 3.1 and Activity 4.6

Authors: Anjali Nelson, Dr Cherise Addinsall, Dr Wayne Hancock, Dr Kevin Glencross

Opportunities, Incentives and Barriers to the Uptake of Agroforestry;

Key findings from Fiji and Vanuatu

Overview

While the benefits of agroforestry are increasingly well known, the uptake of agroforestry systems in Fiji and Vanuatu remain limited. This slow uptake can be attributed to complex social, economic and environmental issues. Therefore, a multidisciplinary lens is crucial in identifying the opportunities, incentives and barriers that currently exist. This report seeks to provide some key insights from research undertaken in Fiji and Vanuatu which incorporates economic, legal (land tenure), social and biophysical considerations. This report uses case studies to highlight potential scenarios where agroforestry uptake may be most successful and identify existing opportunities where rural communities could be supported further.

Key findings will be outlined from the Participatory Action Research groups that were formed by ACIAR Project FST/2014/067 under activity 4.6 (to identify current constraints to supplying the tourism industry with locally grown produce and strengthen linkages between producers and tourism industry stakeholders), activity 3.1 (identify opportunities incentives and barriers to agroforestry crop production) and activity 3.3 (to address issues surrounding women's involvement in income generating activities and disseminate information from project down to women). These findings are brought together with other activities in Objective 3 and 4 to identify incentives, barriers and uptake of agroforestry in Fiji and Vanuatu.

Introduction

Efforts to increase uptake of agroforestry systems in Melanesia are made with the intention of generating a range of environmental, economic and social benefits. A greater understanding of the opportunities, incentives and barriers to agroforestry for smallholders must come before the benefits of such systems can be fully realised.

A project titled: Enhancing value added products and environmental benefits from agroforestry systems in the Pacific (the project), funded by the Australian Centre for International Agricultural Research (ACIAR), is researching how trees can form a more prevalent part of an integrated cropping system; providing food, income, shade and environmental benefits such as preventing soil erosion, sequestering carbon and habitat for wildlife.

Key observations have been collected from field research and through feedback from Participatory Action Research groups formed as part of the project. These groups provided key insights into motivations for altering existing practices to incorporate agroforestry and the production of local tree crops. A central focus of the project has been the engagement of smallholder women and the circumstances that they find themselves in.

Examples of work undertaken by the project in training and capacity building support the key findings and are described throughout the report.

Market Pull

What does the market want and can it support agroforestry?

The majority of farmers the project has worked with to date have sold their produce to local fruit and vegetable markets in nearby urban centres. There is limited opportunity to scale up tree crops in this market as generally women, who predominantly sell their produce at these markets, sell what small amounts of tree crops they can from their home gardens or wild harvest. Small quantities of fruit and nuts, not consumed by the family, provides sufficient supply to local markets. Increasing observations have also found that in Fiji and Vanuatu, in urban and increasingly rural areas, consumers are moving towards purchasing processed food rather than growing their own. Generating the market pull from other markets to enable uptake of agroforestry products is therefore important in incentivising agroforestry.

A largely unrealised market exists in supplying local produce to the tourism market. Often tourism operators are operating in or around local communities. Tourism operators are generally keen to promote local foods as a point of difference in their products and to be able to reduce high-cost imported food. In discussions with tourism operators, the project identified some of the major barriers to developing this market pull from the tourism sector:

Quality – Improving local varieties to suit the sector's needs requires support and extension services not always available to smallholders. Improving options for transport of fruits is a particular challenge.

Consistency – Discussions with operators such as Shangri-La Resort in Fiji indicated that seasonality was not a concern but the reliability of supply when crops were in season was.

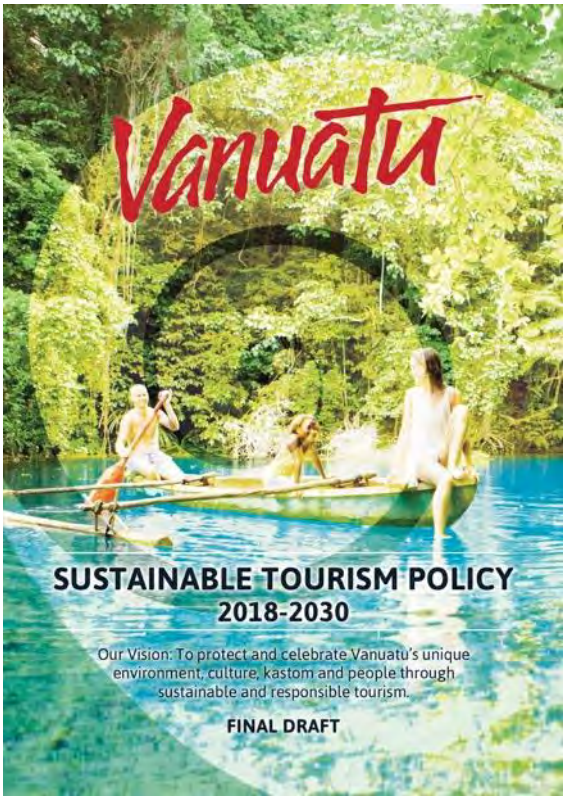
Coordination – As described by the Head Chef at Shangri-La Resort, sourcing local produce was a priority, but a challenge given poor coordination by middlemen who could deliver the produce. Where farmers' cooperatives or coordination between multiple farms exists, buyers would prefer to go direct to the farmers. Having said that, the project has worked with ethical intermediaries (see text box below) who provide a key service in quality control, supply assurance, training and extension services and overall coordination of supply. **Such actors heighten opportunities for long term beneficial relationships between producers and the industry.**

Motivation to strengthen linkages between the productive sectors and tourism sectors is also being demonstrated at the national level and presents opportunities to direct financing to support such linkages. In Fiji, the project has connected with the CEO of the Fiji Hotels and Resorts Association who is on a newly established Agritourism Working Group. The current focus of this group is to increase the proportion of local produce in resorts and hotels in Fiji.

In Vanuatu, the project team were involved in national efforts to encourage increased local produce within the tourism market through the development of the National Sustainable Tourism Policy. Within the policy are objectives that seek to support an increase in local produce, much of which could come from agroforestry systems. For example, Goal 4 of the policy talks about Sustainable and responsible tourism products and services developed, supported, and marketed to attract responsible high value tourists;

The tourism industry in Vanuatu provides and supports sustainable, ethical, local products, experiences and agricultural produce.

Increase the linkages between the agriculture, handicrafts and tourism sectors to increase the benefits of tourism to a broader range of stakeholders.[1]



[1] *Objectives from Goal 4 of NSTDP*

Agritourism Promoting Agroforestry at ACTIV Association and Lapita Cafe

ACTIV Association, a French NGO and project partner in Vanuatu is making real gains in promoting local produce to tourists. ACTIV Association is also playing a pivotal role in supporting nearby farmers to adopt agroforestry systems. Produce is sold back to ACTIV where local female contractors of ACTIV value add the products. ACTIV sells produce to tourists at various markets within the country but has taken the link between agroforestry and tourism further. ACTIV is now establishing an agritourism tour where tourists visit local agroforestry farms before returning to ACTIV's centre to purchase local herbs and spices, handicrafts, coffee and chocolate.

Lapita Café is another key intermediary in promoting local tree crops. The organisation supplies local produce to resorts, hotels, national airports and supermarkets. Lapita is looking to develop an agritourism tour educating tourists on traditional foods and how the purchasing of these products is supporting livelihoods, in particular for women.

Both ACTIV and Lapita are key organisations strengthening linkages between the tourism industry and agroforestry producers. Currently neither organisation can access the supply required to meet local and international demand. Supporting such organisations, presents a sound opportunity to increase the market pull for agroforestry products.

The project is working with ACTIV to increase access to the cruise industry and to increase suppliers for both organisations.

Land Tenure

Can land tenure enable sufficient scale of agroforestry uptake to support markets?

Underlying all land use decisions in the Pacific is a complex architecture of customary land tenure. In Fiji approximately 88% of land is, iTaukei, or owned by the indigenous Fijian clans. In Vanuatu custom land comprises 99% of the land. The rules governing custom land are highly decentralised and can differ even across small islands. Secondary or usufruct rights, communal rights and rights that spread across different levels of custom governance are common; making clarification of a sole landowner for western-style leasing a challenge. Even without formal leasing, decisions about land use must adhere to highly localised custom laws.

Feedback from tourism operators and local markets in Fiji and Vanuatu explained that small scale agroforestry output does not always generate the volume and consistency required. Further, these geographically dispersed and not coordinated suppliers make it a challenge for buyers to access the goods. Bringing multiple agroforestry producers together in a geographical and organisational unit would therefore be one way to respond to market needs.

Developing medium to large scale agroforestry plantations is a challenge, however, where a lease would need to be created to formally aggregate land. In Vanuatu and Fiji many indigenous people are resistant to leasing their land. This is partly due to a historical loss of customary title where the nature of land leasing makes it very hard for the indigenous owners

to reclaim their land once leases expire. Aggregating custom land through leasing to develop commercial agroforestry in therefore a challenge. There is at least one example in Fiji of multiple landowning groups developing a single lease and leasing this back to themselves through a landowning cooperative in order to manage their land for long-term economic gain however this is a long and costly process.[2]

Land in most cases is divided within clan groups to specific farmers and families. On these small parcels of land, decision making around tree planting is informal and can be readily made by the landowner farming his land. At the level of the family 'garden' is where an opportunity to increase agroforestry uptake by custom landowning farmers exists. In Nadroumai village, for example, mature agroforestry systems exist on small quarter hectare plots. Planting productive trees at this scale is not uncommon in Fiji or Vanuatu. These plots, however, rarely return a significant enough income to encourage greater uptake of agroforestry as the produce is sold in a piece meal way at the local market or just consumed by the family. So, while working at this level of land use decision making can enable greater uptake of agroforestry, strengthening the supply chain to enable farmers to generate an income from such plots must occur.

Women play a key role in small family plots as they grow crops to feed the family and to sell at market. In most cases the decision to plant an agroforestry system will fall to senior males in the family however supporting women to manage, maintain and understand the benefits of agroforestry is crucial.

Incentivising Agroforestry through PES

An example of incentivising small scale agroforestry uptake with individual farmers has been developed through the project in Fiji. Working with Shangri-La Yanuca Resort, the project is designing a Payment for Ecosystems Services project whereby farmers engage in catchment remediation through establishing agroforestry plots in buffer zones alongside the river.

Shangri-La is assessing opportunities to provide financial and technical support in establishing these plots and will assist the farmers to aggregate their produce from the tree crops to sell back to the resort. The resort benefits from reduced sediment flows damaging the resort's reef while also improving its access to local produce and supporting local communities.

One other aspect of land tenure, short term leases, also present both opportunities and barriers to agroforestry. The situation differs here between Fiji and Vanuatu. In Fiji, short term leases of about 30 years have been provided largely for sugarcane production. These lease holds are already established for commercial agricultural production. Targeting them for agroforestry could be seen as an opportunity to quickly move away from unsustainable land uses to agroforestry systems where much of the commercial systems are already in place. These lease holds, however, are too short to give leasees the confidence to plant long term crops such as trees.

In Vanuatu even more insecure land use opportunities are seen through short term informal leases that occur across all major islands near urban centres. Parcels of land are farmed by non-custom landowners who provide an annual payment in the form of produce, to landowners. These 'rents' do not afford the sort of legal protection required for farmers to confidently plant long term agroforestry crops. A further complication is the perception that planting trees is a form of staking ones' claim to the land and that doing so may create land disputes in the future. Targeting agroforestry systems in these informal rental farms could provide key opportunities for economic development and ecosystem-based resilience for marginal, vulnerable communities in Vanuatu. Their proximity to markets would also support the economic argument for increasing uptake in these areas. Incentivising agroforestry in

[2] *Drawa Forest Carbon Project.* See www.nakau.org

these areas would, however, require benefits to reach both landowners and tenants with some form of formalised agreement being reached to engender trust and cooperation between all parties. Shorter term crops with known economic value such as coffee, cocoa and kava, ginger and turmeric would help as economic incentives to provide nearer term income while longer term tree crops grow.

In Vanuatu, longer term leases, of 50 years are being used around Port Vila to establish agroforestry plots. The project has been working with ACTIV association which is providing extension support to nearby leasees to plant grafted cocoa in mixed agroforestry systems. Leasees here have stated their confidence to plant cocoa given the time frame for producing crops and the support and market provided through ACTIV. Here the market pull is sufficient to give farmers on leased land the confidence to plant tree crops and the timeframe short enough to see a return in the foreseeable future.

A final opportunity for uptake of agroforestry exists in expired leases around Vanuatu. The majority of these colonial lease holds are degraded coconut plantations. Their access to transportation is relatively good for nuts and longer shelf life produce given these sites were established for copra production and export. It has been suggested that the Government of Vanuatu purchase these expired leases, which the landowners cannot afford to buy back, and develop a scheme to support smallholder farmers to manage agroforestry plots within the leases.[3] This option would have the advantage of aggregating supply and targeted extension support to improve the quality of crops produced.

Livelihood Preferences

Do farmers want to do agroforestry?

Agroforestry is far from a new concept in Fiji and Vanuatu. Mixed plantings have long been a part of traditional farming systems in the Pacific and farmers, especially women, still rely on sales from multiple food crops as their main income source.

Where female farmers have continued their focus on the family 'gardens', male farming has moved further towards monocropping. Increasing agroforestry systems into these monocropped areas requires nothing less than a convincing economic argument demonstrating significant market pull to justify the increased labour inputs required. Creating linkages between the tourism market and farmers provides a key opportunity to increase agroforestry uptake where the opportunity to sell tree crops exists. Generating the market pull is not sufficient in itself. Sustained extension and support services are required to develop the supply side and continue strengthening linkages to market.

Raising tree crops at scale sufficient for it to be a main livelihood opportunity requires time and labour inputs that are not always available. This is especially the case for women who in rural Vanuatu and Fiji are responsible for household chores, food preparation, child minding as well as tending to family food gardens. In Nadroumai, women stated that they had one or two half days free per week at varying times which they could commit to additional work. The time required to manage a young agroforestry plot may not, therefore, be an option for many women.

Engaging existing women's groups in revenue raising activities is one way to incentivise agroforestry for women where the activity is seen as contributing to the community and forms part of an expectation for women in a community to commit to charitable work. Micro-finance

[3] *Carodenuto. S., et al* 2017, *Analytical Studies for Reducing Emissions from Deforestation and Forest Degradation (REDD+) in Vanuatu; Final report* Unique Forestry and Land Use

schemes have often engaged women's groups and helped individual women to establish micro-enterprise through this medium.

Lower input crops and seasonal crops such as trees that have a specific fruiting period are useful from a livelihood perspective. Enhancement of currently grown tree crops with improved varieties and value adding these crops through women's groups provide a key avenue for engaging women in agroforestry.

Women are increasingly engaging in micro enterprise and employment in rural and urban areas. Creating employment opportunities for women in value adding and agroforestry is an avenue to encourage agroforestry uptake that can avoid some of the major constraints existing

A key question for farmers is about what kind of farmers they would like to be. Many smallholders already produce a multitude of crops. Becoming solely a tree crop producer carries significant risks, a major one of which is the lead time for trees to start producing a crop. Rather than promoting tree crops alone, increasing the production of tree crops in and amongst other crops may provide a more significant opportunity as it sits more comfortably with existing farming systems. The Loru Forest Project in Vanuatu has demonstrated that women can be engaged in weeding and tree maintenance when young tree seedlings are intercropped with vegetables and other short-term crops. The additional labour required to manage the young trees is reduced where these women are already working that piece of land. In most cases families have various plots they can use and therefore once the trees are mature enough, the women simply move their vegetable gardens to other plots leaving the site for mature tree crop production ongoing.

Biophysical Conditions

Will agroforestry systems work and support the local ecology?

The project has developed pilot plantings that are designed to enhance livelihoods and are well adapted to biophysical characteristics of catchments. In both Fiji and Vanuatu pilot sites will demonstrate, particularly in the longer term, how agroforestry systems may provide a multitude of benefits to the environments in the surrounding area. The pilot sites have included cropping, fruit, coffee and cocoa to enhance the income from systems in the short to medium term.

Wild Coffee in Nadroumai

The agroforestry project has been working with the Nadroumai Women's Club which currently coordinates the sale for wild coffee beans harvested by the women in the community for sale to Bula Coffee. Currently the women work for three months of the year to harvest wild coffee beans from trees in the nearby forest as time permits. The wild trees do not produce as efficiently as a manage tree would and require significant time and labour to access.

The project was keen to find opportunities to improve the economic gains for the women through coffee. Suggestions were made to plant formal coffee sites where the plants could be managed and pruned for the greatest quality and production. The women explained that various barriers existed for this to occur. Firstly, the women would need formal approval by traditional decision makers to plant coffee and an appropriate site for this would not be easy to find. Secondly, the women explained that the current system suited their livelihood choices. Rather than having to manage a coffee plantation full time, the women could focus on coffee for just three months a year providing them with a good income for the family.

Formal production systems may not fit the livelihood context within communities especially for women in the community setting.

In Vanuatu, cyclones and drought pose risks to young agroforestry systems. Although careful design of the plots and choosing resilient local varieties can ameliorate these risks to a certain extent. In the period since the pilot site establishment, in late 2016 and 2017, Vanuatu has experienced dry and hot conditions. Species such as *Inocarpus* (Tahitian chestnut), *Flueggea* and *Santalum* (Sandalwood) planted through the project responded better to the challenging conditions than *Canarium* and *Terminalia* during the 2017 dry season on Efate.

Along the Coral Coast of Fiji trial plantings by the Fijian Department of Forests have found that fire is a major risk and farmers are less willing to invest where fire is a risk from sugar cane, cultural burns or escaped fire into grasslands surrounding agroforestry systems. Some areas of Vanuatu and Fiji may create the conditions that encourage farmers to feel confident in planting trees where others may not.

In general, the soils in both countries are reasonable for a range of agroforestry species and intercrops provided rainfall is sufficient and reliable. Interestingly, Sandalwood is a preferred plant in all sites covered by the project due to its perceived value. This is despite it having a long lead time to harvest and it not being suited to wetter, heavier areas where it is being planted. **Decisions about plant choice are often made primarily on perceived value.**

Competition from tree crops is another obstacle in some farmers' minds and invasive species such as African tulip in Fiji present a problem for farmers even with small areas to maintain, especially where a shifting fallow is used.

One major barrier to upscaling tree crop production in Fiji and Vanuatu is the supply of high-quality seedlings with known desirable traits. In Vanuatu the project is working with ACTIV to establish a nursery maintaining high quality cocoa as a starting point for other species. In Fiji, the project has been working with the Nadroumai Women's Club to establish a nursery business. Nursery establishment in both countries is greatly needed and can provide a worthwhile livelihood opportunity within the value chain. However, a significant training input in nursery practice and business management is needed over a period of time to facilitate quality products as well as market pull for products.

Cocoa Grafting in Vanuatu

In 2017 the project provided training to a group of women working with ACTIV Association in grafting cocoa. ACTIV's plan is to have trained grafters and nursery managers to set up the only commercial-sized nursery in Vanuatu where improved genetic material, starting with cocoa, will be grafted. ACTIV is seeking funding to employ these women to work at the nursery doing grafting long term.

The materials grafted will go out to farmers who sign an agreement with ACTIV to allow the organisation to graft material from their trees once they are fully grown. The objective is to establish improved genetic cocoa material from each cocoa-growing island.

Wayne Hancock providing cocoa grafting training in Vanuatu.
Photo courtesy of C. Addinsall

Nadroumai Women's Club – Nursery Training

In order to meet targets for community infrastructure needs, the Nadroumai Women's Club agreed to trial the establishment of a tree nursery. The project has strengthened the link between the NWC and Shangri-La Resort who are keen to purchase seedlings from the nursery to support catchment regeneration and to see an increase in local tree crops available for the resort to purchase.

With support from the Department of Agriculture, the project worked with the women to establish a nursery nearby the local school. The project has also run training on establishing and maintaining a nursery. Topics covered have included:

- making potting mix,
- seed collection from useful trees,
- raising sandalwood seedlings,
- support to get a basic nursery structure in place.

In early 2018 the project has organised business training, provided by Live & Learn Fiji, for the NWC to help them design the running of the nursery. A first order for seedlings has also been made by Shangri-La Resort. The Resort has placed an order for 1000 seedlings with a mix of Breadfruit, Iwi, Bush Lemon and Mandarin. The project is supporting the women to have the order ready for planting in November 2018 to coincide with the start of the wet season.

Nursery and Business Training in Nadroumai. Photo courtesy of C. Addinsall

Conclusion

Through the project key insights into opportunities for increased uptake of agroforestry systems have emerged. Supporting agroforestry projects should occur in a targeted way, identifying incentives and opportunities that can help drive land use change to this sustainable, long term use.

Some of the opportunities occur around:

- Introducing agroforestry systems into long term existing leased land (>50 years) or, where benefits are targeted at smallholders, seeking to aggregate custom landowning groups by increasing tree crop production in many small plots and selling produce in a coordinated way.
- Introducing more tree crops within a mixed system rather than farmers being encouraged to rely solely on tree crops for their livelihood opportunities.
- Engaging women through collective charitable activities or micro enterprise activities in value adding and agroforestry rather than working with individual women to plant trees in circumstances where the local governance systems create a barrier to this.
- Aggregating smallholders together in order to deliver extension services and in order to develop enough supply to meet market demands.
- Strengthening linkages between the tourism sector and smallholders to build a long-term market.
- Encouraging tree planting in buffer zones where regulations require tree cover for ecological protection but also where access to water is more secure.
- Utilising finance for catchment regeneration to plant productive tree species that can provide erosion control but also livelihood opportunities for farmers. Ensuring these projects address market pull by engaging with the tourism sector or other key sectors to develop long term financing mechanisms.

In both Fiji and Vanuatu, there are pre-existing circumstances that can help drive agroforestry uptake. These can be seen through:

- Current demand from the tourism sector for more local produce.
- Interest from the tourism sector in value added produce that can be sold to international tourists or exported (locally derived handicrafts, coffee, chocolate, Tamanu oil are examples).
- Existing capacity and understanding of productive tree species within traditional farming communities for selection of better plants with a range of desired characteristics; and
- High quality local varieties of tree crops.

Further trials that directly link smallholder agroforestry producers to the tourism market are recommended to enhance learning and demonstrate to others the opportunities that currently exist.

11.6 Identify land tenure constraints to revegetation in Fiji and Vanuatu land tenure

Activity 3.1

Author: Dr Cherise Addinsall

Fiji

- Land falls into three main categories in Fiji – iTaukei (indigenous or customary) land (87.9%), freehold land (7.947%) and State land (0.25%). When considering land tenure in relation to smallholder agroforestry, there needs to be a distinction between iTaukei land that has been leased to smallholder farmers or commercial growers and iTaukei land that is registered but unleased (i.e., is managed directly by the landowners).
- Around the Fiji pilot site of Nadroumai, smallholder farmers on leased land are largely sugarcane producers. Given their leases in many cases must be renewed every 30 years, the impetus to plant trees is greatly reduced. While Fijian law allows the planter of the tree to be the owner (i.e., the leasee), insecure tenure for leasees remains a barrier to uptake of agroforestry.
- On unleased or unlicensed iTaukei land, the mataqali, (sub-clam) is considered the central proprietary group when it comes to land tenure decisions and tends to be identified as the leasor. In addition to this though, additional levels of custom governance also play a role in decisions about land use and land management such as at the vanua (tribe), yavusa (clan) and itokatoka (extended family unit) levels. Therefore, decisions about increasing uptake of agroforestry is often a decision that is required to go through many formal custom governance channels.
- The scale of uptake of agroforestry has important implications for tenure decisions:
    - Often a family group or even a senior male will identify a specific parcel of land as theirs to farm. Decisions by the male landowner here to plant trees for his own purpose (and to sell in local markets) can be relatively straightforward and require no formal legislative agreement. This is small scale and piece meal uptake however so is often not an effective channel for large scale catchment regeneration projects or for developing a strong supply for market. There is potential here where farmers aggregate their crops for sale.
    - Where planting occurs at a large scale within the mataqali, agreement must be reached at the various levels of custom ownership including clarification of who will manage and sell what is produced. While this scale offers a greater impact for catchment revegetation and greater opportunities for supplying produce to markets, it requires a high level of organisation and business development within the mataqali which can be a barrier where there is insufficient labour and resources to invest.
    - Large scale commercial planting which could support demand from nearby markets is likely to trigger the need for leasing or licencing as it will more than likely mean the involvement of a third party. While leases are common in Fiji, they are complex to establish and often remove control of the agroforestry production from the mataqali thereby removing many opportunities for benefits at the community level.
- Land is predominantly owned and passed through paternal lines in Fiji. This poses significant challenges for engaging women in agroforestry planting. For example, in Nadroumai, women are allowed to harvest wild coffee beans and sell them. If the women were to develop a stronger and more consistent supply of coffee by planting their own trees, they would need permission from multiple levels of custom governance to do so. Often this intentional planting would then remove control over the crop from the women, including the benefits derived from their sale.
- Women play a significant role in vegetable farming and sales to local markets. There is an opportunity to encourage agroforestry systems to be integrated with current short term crop planting systems however given the long-term nature of agroforestry, any decision to plant trees would require agreement within the family and therefore decision-making power is taken out of the hands of women.

Vanuatu

- 99% of land in Vanuatu is held under custom tenure. Unlike Fiji, only a very small proportion of this has been registered and therefore leasing of land in Vanuatu is a complicated process as custom boundaries and identification of owners has not been formally documented residing in custom knowledge alone.
- There are no legal tenure impediments to uptake of agroforestry systems by custom landowners on their own land. Conflict over parcels of custom land often occur though if successful farming delivers benefits perceived as unfair by others. Jealousy therefore often leads to reduced productivity of farm sites as once a conflict has occurred over a piece of land it cannot be farmed until the conflict is resolved.
- Much of the land on Efate and near urban centres is informally leased. These informal leases (or informal settlements) enable non-custom landowners to farm a small piece of land (< 1 ha). Payment is made by a gift of goods produced to the custom landowner. There is a significant opportunity to increase agroforestry in these informal settlements as they have good access to markets and there is often an availability of labour given those living in settlements have come from outer islands looking for work. The informal nature of the lease is, however, also a major barrier to the uptake of agroforestry in these sites. This is because any tree planting is seen as an attempt to improve the value of the land. There is an understanding that improvements made by the lease can be recompensed by the leasor when the lease is returned to the landowner. Planting trees is seen therefore as something you cannot do without permission of the leaser. Further to this it can be seen as a claim to the land long term. There are therefore significant social barriers to agroforestry uptake in informal settlements.
- Urban centres in Vanuatu are fringed by expired leased land. The majority of this land is degraded coconut plantations and there is an opportunity to revegetate these sites with productive agroforestry systems. Their market access would be significant via land and sea given these sites were chosen for copra production. It has been suggested that the Government of Vanuatu purchase these expired leases (which the landowners cannot afford to buy back) and develop a scheme to support smallholder farmers to manage agroforestry plots within the leases. This would have the advantage of aggregating supply and targeted extension support to improve the quality of crops produced.
- The project site is working with a lease who has purchased a 50-year lease near ACTIV association. He states he is comfortable planting trees given the length of this formal lease.

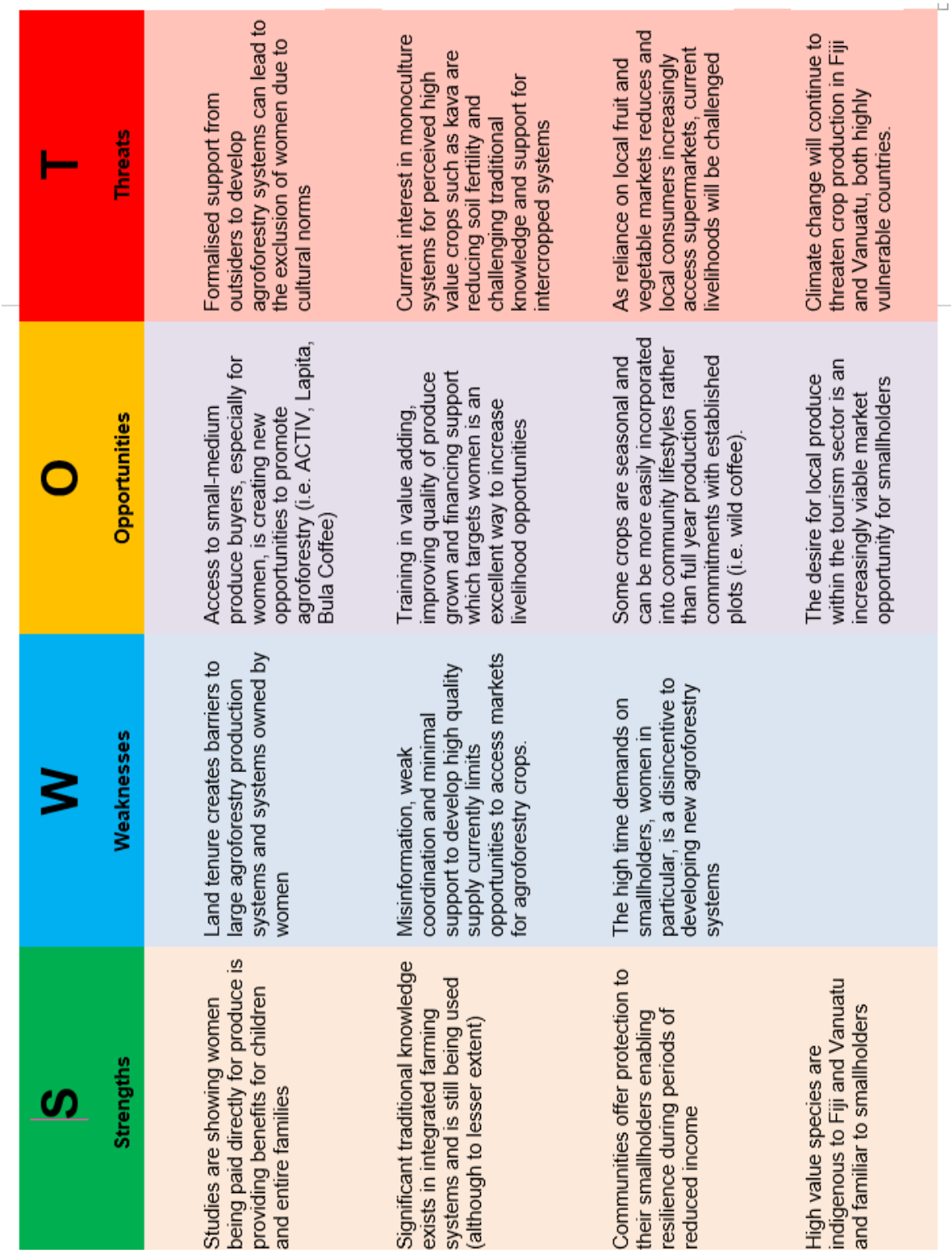
Conclusion

We found form our data collection in Vanuatu and Fiji that agroforestry systems (with a mixture of local nuts, spices, cocoa, copra, coffee) are more supportive of women's livelihoods then formalised monoculture cash cropping. Forestry, kava, cocoa, copra and cattle are referred to as male farming activities while ACTIV, Lapita Café and Bula Coffee are mainly working with female suppliers of nuts, coffee and spices. As soon as a farming system is formalised this falls under a lease or customary land agreement is in therefore predominately the domain of men. Therefore, we advise for the promotion of agroforestry systems that meet both male and female livelihood objectives and enable greater access to women.

11.7 SWOT Analysis small holder participation in agroforestry production

Activities 2.3 and 3.1

Author: Dr Cherise Addinsall



S Strengths	W Weaknesses	O Opportunities	T Threats
Studies are showing women being paid directly for produce is providing benefits for children and entire families	Land tenure creates barriers to large agroforestry production systems and systems owned by women	Access to small-medium produce buyers, especially for women, is creating new opportunities to promote agroforestry (i.e. ACTIV, Lapita, Bula Coffee)	Formalised support from outsiders to develop agroforestry systems can lead to the exclusion of women due to cultural norms
Significant traditional knowledge exists in integrated farming systems and is still being used (although to lesser extent)	Misinformation, weak coordination and minimal support to develop high quality supply currently limits opportunities to access markets for agroforestry crops.	Training in value adding, improving quality of produce grown and financing support which targets women is an excellent way to increase livelihood opportunities	Current interest in monoculture systems for perceived high value crops such as kava are reducing soil fertility and challenging traditional knowledge and support for intercropped systems
Communities offer protection to their smallholders enabling resilience during periods of reduced income	The high time demands on smallholders, women in particular, is a disincentive to developing new agroforestry systems	Some crops are seasonal and can be more easily incorporated into community lifestyles rather than full year production commitments with established plots (i.e. wild coffee).	As reliance on local fruit and vegetable markets reduces and local consumers increasingly access supermarkets, current livelihoods will be challenged
High value species are indigenous to Fiji and Vanuatu and familiar to smallholders		The desire for local produce within the tourism sector is an increasingly viable market opportunity for smallholders	Climate change will continue to threaten crop production in Fiji and Vanuatu, both highly vulnerable countries.

Detailed Observations

SWOT Matrix	Competitive Advantages	Institutional Challenges
Internal Factors	**Strengths**	**Weaknesses**
	Women appear to be providing the household with increased resilience and lower vulnerability through their roles in informal institutions and increased access to employment and formal institutions (although still limited).	Government stakeholders in both Fiji and Vanuatu brought attention to the difficulty of implementing long term land use changes within the current land tenure arrangements. Customary land tenure arrangements prevail in the Pacific islands which do not easily allow for commercial land use. • Leasing often removes ownership and control of resources from the traditional owners whose economic development may be a core justification for any interventions. • Contracting arrangements and decision-making processes can become very challenging when seeking to achieve sufficient scale of productive output through formal agroforestry systems required to meet market demands. • Leasing in itself can be a barrier to agroforestry systems as many short term and informal leasing arrangements discourage long term crops. Land tenure as an institutional barrier to long term land use change was a common theme throughout participatory discussions with stakeholders and requires further in-depth investigation.
	In most cases women who are earning income from agroforestry systems are paid directly for produce e.g. Market sales, Bula coffee, Lapita Café and ACTIV. Studies in Fiji by MDF have shown this model offers the best direct benefits to women and children.	Due to land tenure systems women often only have access to informal agroforestry systems (wild or home garden) to generate their personal income. In most cases it was noted that once systems are formalised, they are owned by men. The wild coffee at Nadroumai and the wild local nuts in Santo are good examples of where the women can harvest the produce if it remains wild. Attempts to support women to improve productivity through in situ pruning or fertilising, or the provision of improved material may result in control of this resource being removed from women by the male leadership in their community. anymore.

	Traditional agricultural systems often exhibit high levels of diversity, as communities rely on a broad range of integrated systems to provide them with food, water, fuel and medicine. These systems are inspired by cultural practices and the interaction between people and their environments which have taken place over generations and are still often relied on. Information collected in this project demonstrates that many rural people in Vanuatu and Fiji are still reliant on the products and services derived from these traditional gardening systems and that significant capacity to manage such systems exists.	If women want to improve and formalise agroforestry systems, they encounter barriers to finance, time constraints, negotiating lease/tenure arrangements and understanding labour management. Women have noted they are careful to not be too successful as jealousy within the community can damage their livelihood significantly.
	Lower input agroforestry crops such as trees that have specific fruiting periods and have value beyond the community are useful (such as nuts, coffee, cocoa) as this fits better with available time resources. For example ,women in Nadroumai pick coffee intensively for three months of the year, out of coffee season they focus on other income generating activities such as embroidery.	A major barrier is time for people beyond meeting basic food requirements. Particularly for women and children with socio/cultural and family/village responsibilities which are not conducive to formal high input activities such as flowers and vegetables.
	Participatory discussions with rural smallholders in Vanuatu showed rural communities with the most diverse livelihood opportunities were those with good access to land, services (such as roads, regional and international markets, medical centres and education) and social support networks. Informal community and culturally based social protection systems can provide supportive environments for successful smallholder-based agroforestry enterprise development activities by acting as a buffer for times of crises or need.	Access to funds, training and support are major constraints to the establishment and scaling up of agroforestry systems. The connections to private enterprise and often perceived conflict between the returns to individuals and processors is misunderstood by most communities and requires trusting, transparent and informed relationships. Women are especially vulnerable in this given they may not be involved directly in negotiations with external stakeholders or be given the opportunity to be represented adequately.
	The cocoa in Vanuatu is a good example where the different islands have unique cocoa that is a valuable product if processed well and marketed (as ACTIV have demonstrated). Coffee, wild as in	Agroforestry systems have a long lead time to harvest and cannot be promoted without sufficient design to support livelihoods through short term

	Nadroumai is a similar story although the quality is not great and as outlined earlier it may be difficult to improve because of community issues. However, wild harvested coffee is an economic driver for the women in the community and eventually could be built into a coffee production system for better quality with dedicated production more commercially based that would still fit within an agroforestry system due to scale and rotations.	economic gain (e.g. intercropping with vegetables)
	The cocoa in Vanuatu is a good example where the different islands have unique cocoa that is a valuable product if processed well and marketed (as ACTIV have demonstrated). Coffee, wild as in Nadroumai is a similar story although the quality is not great and as outlined earlier it may be difficult to improve because of community issues. However, wild harvested coffee is an economic driver for the women in the community and eventually could be built into a coffee production system for better quality with dedicated production more commercially based that would still fit within an agroforestry system due to scale and rotations.	Despite interest in new and improved systems such as agroforestry, participation is limited where the economic driver is not obvious. Given time and resource constraints, new enterprise is generally unsuccessful without external resources and support being provided for an extended period of time.
		Land disputes are a major concern among many of the stakeholders engaged in Vanuatu. The more remote the communities are from the urban centre, the fewer land disputes. In the most remote communities, the majority of disputes were resolved at the village court level without requiring external assistance. The more accessible communities experienced a number of land disputes with most cases still waiting to be resolved in the high courts. The high level of land disputes in these areas may be attributed to the land becoming increasingly valuable because of proximity to markets, particularly tourism development
	Opportunities	**Threats**
External Factors	Small market opportunities are establishing that pay better prices than global markets for quality products and support women's involvement in income generation e.g. Vanuatu- ACTIV and Lapita Cafe (local nuts, coconut oil, cocoa, coffee)	Supply to markets is an issue, with many small processors suggesting they are undersupplied. Systems need to be improved for smallholders to grow and access the markets easily such as better coordination of producers at the community level, improved quality seen through extension and support services to producers etc.

	Through participatory discussions with households and government stakeholders it was found that programs of support for agroforestry were seen favourably. These were initiatives that supported smallholders to establish micro-finance, co-operatives, community associations or PES schemes that addressed supply barriers to market. Corporate Social Responsibility was also described as a potentially effective way to provide financial incentives for land use change. CSR may be easier to sell to private industry especially industries that rely on the environment such as tourism.	The high value and demand for kava is moving smallholder farmers away from traditional agroforestry farming systems to monoculture kava plantations. This also threatens food security and leaves the farmer vulnerable to market variations and natural disasters. Monoculture production impacts on the many essential ecosystem services that forests can provide such as water allocation and purification, carbon sequestration, suppression of pests, and eradication of diseases and toxic compounds.
	Smaller local markets are easier for local farmers to access than export markets and are more considerate of the context that these farmers are operating in. They are also more likely to buy a variety of produce from farmers (over export markets which usually demand high production single crop, monoculture systems) which supports the agroforestry concept.	The vast majority of smallholder farmers sell into traditional market channels (municipal markets, roadside stalls etc.) A study of Fijian urban consumers has shown the switch to more modernised market channels (i.e., 54% of all urban food expenditure is through supermarkets). If this trend continues, particularly into fresh produce then this will have implications for smallholders and the women selling through these channels.
	Ancillary services such as improving post-harvest and marketing of value adding at the local level could provide enhanced income. These activities are particularly conducive with women as they do not require access to land and the women work in a group and collectively mange the kids, social cohesion etc.	Designing agroforestry systems that can give the highest return could impact negatively on access to land and resources, especially for women.
	Further input in training into higher value trees including grafted trees of known quality and types to enhance local plantings and for sale could provide increased income for smallholders and opportunities for women to run specialised nurseries. This project sees the value in this and has been administering specialised training to smallholders and women in nursery management and grafting. Training also	Accessing reliable and affordable transport is a major logistical constraint in new activities and scaling up. Produce is often damaged due to lack of capacity in post handling techniques, not having proper refrigeration, safe and clean holding area, and a regular timetable for delivery.

	provides a conducive environment to conduct participatory research.	
	Nurseries can provide a number of products useful within the community and local markets such as vegetable seedlings for sale and planting, some trees for similar uses and could support some cut flowers directly or by providing a focal point for activity such as heliconia, gingers and orchids, low maintenance crops that do not require a high labour input. These will support and agroforestry system by providing trees to plant and other intercrops, something currently lacking in Fiji and Vanuatu.	Continued pressure on the environment and resources from the combinations of market forces, the impacts of climate change and population growth reduce the resilience of smallholders and their capacity to conserve traditional farming systems. Increased population is leading to “consumption of the environment” on many islands. Continued and intensifying cropping leads to declining soil fertility compounding this issue. The same is happening with water resources.
	Access to credit and microfinance can protect households and empower women to establish small businesses, and cope with economic stress and shocks. The access to financial resources can also help to get the best economic return from agricultural or agroforestry production by avoiding selling at low-price points such as when payment of school fees are due.	The need for cash to service cash economy fluctuates throughout the year such as when school fees are due. This is not ideal for buyers who require a reliable year-round supply.
	One way to reinforce traditional knowledge is to develop strategies to transfer knowledge to the younger generations by integrating it within the curricula of formal education. However, education programmes need to be supported by economic activities, that demonstrate the livelihood benefits from interpreting this knowledge.	Factors such as increased population and the shift to the cash economy have changed agroforestry systems from shifting systems with long fallow periods to regenerate soil fertility to more permanent household gardens and less rotation with increased land clearing. Similarly, historical exploitation of large land areas from colonialization for export including sugar and timber without subsequent replanting and regeneration have led to degradation in most of Fiji and large parts of Vanuatu. This is very costly to regenerate with conventional techniques and without economic drivers for local people and confused land ownership, it does not happen as can be seen readily. The abject failure of the EU reforest Fiji program shows this sadly where a lack of planting material, cane farmers with little incentive or spare income to be involved and unrealistic timeframes for a top down solution did not work.

	One way to reinforce traditional knowledge is to develop strategies to transfer knowledge to the younger generations by integrating it within the curricula of formal education. However, education programmes need to be supported by economic activities, that demonstrate the livelihood benefits from interpreting this knowledge.	Urbanisation has seen an exodus of younger people from rural areas as Western influenced education influences the pursuit of more lucrative employment than farming. This leads to the questioning of traditional knowledge and practices leading young people to distance themselves from traditional ways of living.
		As urban migration continues to rise, female internal participants in particular suggested that traditional knowledge and skills such as weaving, broom making, tree and crop planting, food roasting and medicine production skills are not being passed on. Even in relatively strong traditionally focused communities, there was concern for preservation of these key livelihood skills. Concerns were raised that the loss of skills to value-add forest and marine resources into useful assets could leave future generations in a vulnerable position particularly after extreme weather events, therefore relying on the volatile global economy for their livelihoods.
		Access to high quality seedlings is a challenge where nurseries do not exist in country. Often this results in wildlings or variable quality being planted.

11.8 Literature review considering gender issues in value adding and agroforestry crop production: Vanuatu, Fiji, Solomon Islands and PNG

Activities 2.3 and 3.2

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Abstract

This literature review considers gender issues in value adding and agroforestry crop production in the South Pacific, with a focus on the four independent countries of Melanesia (Fiji, Vanuatu, PNG, and Solomon Islands). Research and development in agroforestry is only recently starting to investigate the critical link between gender and agroforestry with recognition of the significant gender differentiation within agroforestry value chains (Purnomo et al., 2014; Sunderland et al., 2014; Shackleton, 2011; Ruiz Perez et al., 2002; Ingram et al., 2016). However, there is still little information on the role of gender in agroforestry value chains and a bias towards Latin America and Africa. To address this shortfall this literature review considers unpublished reports and case studies from research and development projects operating in Melanesia in addition to peer reviewed papers.

This review is influenced by a variety of critical theories such as post-colonialism, feminism, and globalisation. This approach enables an improved understanding of rural people's livelihoods in Melanesia addressing factors such as inequality, gender, governance, farming systems, land tenure, culture, vulnerability, and resilience (Addinsall, 2017). Findings from this literature review show distinct gender differences in the role of men and women in agroforestry value chains, with men often positioned more favourably than women. Social-cultural factors such as: access to resources and land; access to extensions and financial services and markets; the physical nature of value chain activities and cultural norms; customary and formal regulatory arrangements; and the limited benefit seen from agricultural research and development efforts all influence women's disadvantage in agroforestry value chains. Goal 5 of the Sustainable Development Goals: Achieving gender equality and empowering women can only be realised from gaining an increased understanding of gender relations and dynamics to uncover the complexity in which rural women operate (CARE, 2002). However, a lack of data alongside the influence of gender biased perceptions have resulted in limited awareness and appreciation of the role of women in food security and rural development. Therefore, it is vital that research and development projects operating in Melanesia raise awareness of gender biases and support gender inclusive value chain development. Otherwise, projects operating in this space risk continuing to disempower women and, undermine food and nutritional security.

Introduction

Using feminist and post colonialism theory this review attempts to understand gender disadvantage in rural areas of Melanesia (a subregion of Oceania extending from the western end of the Pacific Ocean to the Arafura Sea, and eastward to Fiji) and the multiple ontologies and world views that exist in this space. Feminist theory, in particular, highlights the marginalisation of females, while post colonialism takes this a step further highlighting the significant influence colonial administrators (guided by their own (male) gender values) demonstrated prejudices on rural farming women (Boserup, 1965). In the past 30 years there have been many conceptual shifts in the feminist development literature, incorporating feminist approaches such as Gender and Development (GAD) (Oakley, 1972; Rubin, 1975), which seeks to understand how society assigns roles, responsibilities, and expectations to gender. Alternative feminist approaches have also been recognised in the gender and development literature such as the capabilities approach (Nussbaum, 2011) and ecofeminism (Adams & Gruen, 2014). The capabilities approach is resolutely 'pluralist about value'; it contradicts capitalism and the free market as it recognises that people may require different quantities of resources and support depending on their position in society. It is deeply concerned with entrenched social injustice and inequality, particularly those that result from discrimination and marginalisation (Nussbaum, 2011). Ecofeminism directly links colonialism and capitalism to the increasing human impact on the environment from the perspective of gender and sustainable development.

Understanding world views and ontologies are crucial in this space as rural development in the sense is a definitive concept of the colonial era that was used to justify imperial intervention to adapt or marginalise colonial subjects. Feminist and Postcolonial theory critique positivist sociology and acknowledge that the study of people, gender, and culture can make no claim to objectivity (Krieken et al., 2000). It is in this space that 'post neoliberalism' has gained traction in many developing countries as we see more rural smallholders and governments begin to question globalisation processes which have created some of the greatest levels of inequality (Sader, 2009).

The International Assessment of Agricultural Knowledge, Science and Technology for Development (IAASTD) report (McIntyre et al., 2009, p. 44), describes "the many iterative processes caused from globalisation that have significantly impacted on rural populations such as: rising input costs, low levels of investment, and lack of credit leading to deterioration in economic and social conditions for rural areas". Boserup (1965) suggested that the modernisation of farming that came as a consequence of colonialism and globalisation severely disadvantages women as men were given the training, cash crops and equipment. Sen and Grown (1987) have moved Boserup's theories further beyond the goal of gender equality (by articulating the words of scholars and activists from developing countries) to question the influence of capitalism and the dominance from the West over developing countries. This led to the Development Alternatives for Women for a New Era (DAWN) to emphasise the need for policy to support the most disadvantaged groups, with a particular focus on rural farming women (Sen & Grown, 1987).

FAO (2010, p. 19) documented in their report on gender gaps in agriculture that "access to land in conditions that ensure security of tenure is the single most important condition for economic empowerment". This is based on the realisation that constraints to productive resources such as credit, inputs and access to extension services is conditional on land ownership. FAO (2010) concluded "if women had the same access to productive resources as men, they could increase yields on their farms by 20-30 percent. This could raise total agricultural output in developing countries by 2.5-4 percent, which could in turn reduce the number of hungry people in the world by 12-17 percent (FAO, 2010, p. 40).

A large majority of Melanesian people have to this day access to land that has remained under customary title, which is controlled by clans and families (Anderson & Lee, 2010). Vanuatu, Papua New Guinea and Solomon Islands are among the last remaining countries in the world where the traditional economy outweighs the cash economy in terms of providing for livelihoods (Regenvanu, 2010). Unlike many countries that have shared a colonial history, the scale of dispossession of traditional landowners from lands in Melanesia was radically less than that in countries such as Australia and Canada which experienced nearly complete dispossession from their lands and culture (Fingleton, 2005). Yet colonialism has influenced customary and formal systems of land tenure in Melanesia with concepts and definitions from English Law. Traditional Melanesian societies appear to have consisted of scattered groups practicing shifting cultivation and led by various people responsible for different activities (such as warfare, sorcery, rituals, food production, hunting) that weren't necessarily gendered. The chief's role was more focused on social organisation than land management. Yet the colonial administration organised groups of people into villages and appointed a chief largely responsible for assigning ownership of land. While the concept of chief is a traditional one, through colonisation, the roles of the chief were influenced by a patriarchal society which sought to move land from a communally owned asset to one administered by patriarchs (Haccius, 2011).

This 'ideology of chieftainship' conceals the way in which the position of chief has been transformed, and even strengthened, through missionary and colonial influences. Furthermore, like any ideology, powerful actors can manipulate discourses of kastom and claims to 'chiefly title' for personal gain. So kastom is not a straightforward articulation of autochthony or indigeneity against alien loa [Western Law]. Rather, each concept is able to take on aspects of the other according to the contexts and purposes of its deployment (Smith, 2017, 11).

While there are some cases of matrilineal systems of land inheritance, society in Melanesia is generally patriarchal with gender biases existing in every sphere. This process has further disadvantaged Melanesian women by supporting inequitable and exclusionary provisions limiting their access to key resources such as land and credit. In countries such as Vanuatu their constitution outlaws discrimination against women, yet actual enforcement of this when it intersects custom is unclear (Bowan et al., 2009). Reforms of the legal frameworks in place could work to ensure gender equality are required with distinction made between formal and customary law (Bowan et al., 2009).

Smith (2017) discusses the land tenure reform in Vanuatu and the new requirement of gaining consent of the whole community for registration and leasing. Yet studies show that customary practices and cultural norms continue to inhibit women's ability to exert authority of land use (Napua, 2017). Smith (2017, 11) challenges these cultural norms and highlights that kastom signifies "inclusive, consensual, peaceful and relational ethics against exclusionary or individualising processes in shifting political contexts", and therefore suggests the potential for kastom to adapt to incorporate social inclusion, increasing community participation and therefore make space for gender equitable decision making (Napua, 2017). Napua (2017, 10) found that the "framing of social inclusion, rather than just a women's issue tied advocacy efforts closer to culturally respected and valued principles relating to communal livelihoods, which helped to gain credibility for advocacy efforts and also earned women a seat at the negotiating table for land reform".

Gender patterns of control over income are largely influenced by land tenure systems, the type of crops and characteristics of households. Within some households in Melanesia cash income 'belongs' to whoever produces the goods for sale, particularly in Fijian households, while in other households men control all household income. There is also evidence that increasing women's access to land and assets has been found to significantly reduce the level of domestic violence (Agarwal & Panda, 2007). This is attributed to the fact that women who have property feel that they can leave marital violence (Friedemann-Sánchez 2006; International Centre for Research on Women [ICRW] 2006, p. 12).

It is important in a Melanesian context to not reduce the value of land as an economic asset to be sold, mortgaged or as investment in the formal economy. Anderson (2011, p. 86) identifies traditional Melanesian land systems as "vehicles for food security, housing, widespread employment, social security, biodiversity protection and ecological stability; they are also a store of natural medicines, as well as a source of social cohesion, inclusion and cultural reproduction". Land rights for women "are not primarily marketable assets but rather a secure foundation for sheltering and nurturing their families and making a living" (Meinzen-Dick et al., 1997). Tenure security for women not only enhances their role in household decision making, but it enhances their self-confidence and self-esteem and participation in rural institutions (Lastarria-Cornhiel, 2007). In response to this, addressing land rights for women should not be confused with the push for reform of customary ownership of land (with the replacement of freehold or individual title) from neo-classical economists who see customary ownership as a critical barrier to economic growth (Hughes, 2003). Development literature in Melanesia is emphasising neoliberal discourses of 'growth', 'efficiency', 'reform', and 'governance', while only a handful of publications from NGO's and researchers are challenging current economic and trade policy (Addinsall et al., 2015a; Addinsall et al., 2015b; Addinsall et al., 2017; Anderson and Lee 2010; Lightfoot, 2005; Simo, 2010; Regenvanu, 2009).

These viewpoints fail to recognise the reality in PNG, Solomon Islands and Vanuatu, where the vast majority of people reside in rural areas and have vibrant smallholder subsistence and cash-cropping economies (Allen, 2008). Anderson (2011) suggests many Western 'growth' strategies favour formal economies and private businesses, in particular export industries, while devaluing and often displacing more traditional 'hybrid' livelihoods which combine formal, informal and subsistence economies. It is these 'hybrid' traditional where rural women in Melanesia play a significant role (Addinsall et al., 2015a).

Strategies focused on growth notoriously exclude environmental benefits and costs in their analyses whereas traditional economic activities are often centred on sustaining the resource base and therefore are more often based on sustainability (Anderson, 2011). Allen (2008) suggests "the introduction of a system of freehold or individual title could also lead to sharp socio-economic differentiation and, in the long term, the emergence of a landless peasantry. There are other preferable methods of increasing agricultural productivity, which are more likely to yield sustainable increases in community living standards without entailing serious social disruption". Therefore, work is needed to explore these 'preferable methods' that can enhance access for women without displacing or eroding customary tenure and the traditional economy which constitutes the political, economic and social foundation of contemporary Vanuatu society (Regenvanu, 2009). This would require new ways of integrating the cash economy and political institutions to work within communal structures and enhance resource ownership and access for women (Westoby, 2010). This needs to be one in which men and women gradually develop innovative cash economy activities that

supplement traditional activities, while maintaining customary land ownership and a sustainable use of the resource base (Addinsall et al., 2015b).

The reports of the IAASTD put forward the idea of the 'feminisation of agriculture' that has shown women now constitute over 43% of the global agricultural labour force in developing countries, yet women only have accesses to 13% of agricultural land. These figures mask considerable variation and due to the overall labour burden of rural women (which often exceeds that of men) and in reality, the percentage of unpaid agricultural related duties undertaken by women makes it impossible to verify empirically (FAO, 2011). Mikhailovich et al., (2016) also found that the distribution of labour between women and men was not equal with women having a much greater share of responsibilities and greater working hours.

Gender differs to one's sex as it is not biologically determined, it is rather a result of socialisation into a male or female role. Gender differences in developing countries become clearer when you look at women's overall workloads, particularly in rural areas (Lanjouw & Lanjouw, 2001). Rural women often pursue multiple livelihood strategies which are quite complex. While these activities such as: producing agricultural crop for subsistence and markets; processing and preparing food; collecting fuel and water; caring for family members; maintaining houses etc. are not defined as economically active employment activities, they are regarded as essential to the well-being of households.

For governments in Melanesia to keep to their commitments of meeting the UN Sustainable Development Goals there will need to be more emphasis on developing policy and programs to end all forms of discrimination against women enabling equal rights to economic resources, addressing nutritional needs, offering qualification opportunities, extension services and agricultural training to women, to own land, to have access to water, livestock, and machinery, to self-organise and take part in community decision making. Yet given the gender variability in agricultural roles, policy should be based on studies that are specific to a geographical and cultural context. Many see policy as a powerful instrument to create long term impact on gender biases. Agricultural and forestry policies have inherently excluded women because the social role of the farmer is seen as male resulting in rural women being significantly behind in most social and economic criteria, which further confirms Boserup's (1965) conclusions from decades ago. What is particularly concerning is that little improvement in the economic or social status of rural women in Melanesia has occurred since these conclusions were drawn.

Agroforestry in Melanesia

Agroforestry is defined as an integrated system of trees, crops and/or livestock within a managed farm or agricultural landscape (Zomer et al., 2009). Agroforestry systems can play a key part in reaching sustainable development goals, particularly those related to poverty eradication, food security and environmental sustainability through the production of both local commodities (such as fuelwood, timber, fruit and fodder) and global ones (such as coconut, copra, coffee, cocoa, spices, and nuts). When designed properly, agroforestry systems (with the combination of trees, crops and livestock) can also bring a wide range of environmental benefits such as soil cover against erosion, flood mitigation, water storage, nutrients from deeper soil layers and nitrogen fixation and fertilizer through leaf litter. FAO (2013) suggest that with the correct species selection "effective agroforestry systems make the most of positive interactions between their various components, so that the final product is more valuable than in the absence of trees, while the risks of failed harvests and dependence on chemical inputs are reduced" (FAO, 2013, p. 3).

FAO (2013, p. 2) outlines the benefits of agroforestry as:

- helps protect and sustain agricultural productive capacity
- ensures food diversity and seasonal nutritional security
- diversifies rural incomes
- strengthens resilience to climatic fluctuations
- helps perpetuate local knowledge and social and cultural values

Agriculture (including crops, livestock, forestry and fisheries) and tourism are the largest contributors to the economies of Melanesian countries, yet the contribution of the subsistence economy to the livelihoods and resilience of these countries is often underestimated. Majority of people in Melanesia live in rural areas and secure their subsistence and cash income from traditional farming and fishing systems (PIFON, 2015). These traditional farming systems act as safety nets providing resilience against external shocks as well as safeguarding food security and maintaining economic stability. Traditional gardening systems in Melanesia are defined as 'sets of interconnected customary practices of producing crops and animals for food, socio-cultural uses and export which conserve resources, protect the environment and are passed down from generation to generation' (Tofinga, 2001, p. 34), playing a key role in achieving food security and sustainability. Anderson (2011, p. 11) identifies traditional gardening systems as "vehicles for food security, housing, widespread employment, social security, biodiversity protection and ecological stability; they are also a store of natural medicines, as well as a source of social cohesion, inclusion and cultural reproduction". Traditional gardening systems in Melanesia have predominately consisted of agroforestry gardens that exhibit high levels of diversity and maximise food production by intercropping multipurpose trees with short-term crops. These systems are inspired by cultural practices and the interaction between people and their environments which have taken place over generations.

Increased engagement in the cash economy (through monoculture cash cropping) is seeing a departure from traditional agroforestry farming systems. Population growth also stimulates the move to the cash economy as pressure increases on limited land resources and inputs, often entrenching the poverty of women through continual child rearing and limiting access to shrinking land resources for subsistence. Niche horticultural crops are becoming the fastest growing part of Melanesia's agricultural sector, with over 200 crops being exported to 20 countries (FAO, 2010). Yet the Solomon Islands is still characterised by largely undercapitalised rural sectors with fishing and unsustainable logging accounting for 80% of the economic output. FAO (2010) recommend for countries such as the Solomon Islands, developing agriculture to stimulate rural economic economies is essential to achieve poverty alleviation, manage rural urban migration and maintain social stability. Caution is placed on growth of the agricultural sector at the expense of rural livelihoods and the environment. A key challenge for Melanesia is developing pathways for commercialisation of traditional farming systems over monoculture high input farming techniques, which allows for increased income while continuing to support social support networks, reciprocal networks of exchange, environmental sustainability and food security (Addinsall et al., 2016).

Incorporating high-value native tree species with subsistence gardens and cash cropping presents an alternative that is compatible with traditional knowledge, can be inclusive of both male and female smallholders and, can enhance sustainable livelihoods and wellbeing over the long term (Addinsall et al., 2015b). Addinsall et al., (2015a, p. 17) research highlights: "the importance of supporting smallholder individual and household-based agroforestry enterprise development activities operating within informal community and culturally based social protection systems in a rural Melanesian context. With the absence of formal safety nets, there is potential, particularly for women, to be adversely affected and more vulnerable to macro-economic shocks. Therefore, strategies should be put in place to support economic development in communities and empowerment of women while complementing traditional social support networks and activities."

While the concept of agroforestry challenges conventional and industrial approaches to land management, with a focus on environmental concerns, it lacks consideration of the social-cultural and political concerns impacting on rural smallholders in Melanesia, particularly women.

Gender and Agroforestry value chains

Agroforestry value chains concern the activities (such as harvesting, cleaning, transport, design, processing, production, transformation, packaging, marketing, distribution and support services) involved in bringing timber, Non Timber Forest Products (NTFP), agricultural commodities and livestock through processing, production and final delivery to consumers. These activities are implemented by various stakeholders termed 'actors' (such as harvesters, processors, traders, retailers and service providers) and generally add value to the product along every step of the value chain. The relationships between the various actors, is known as 'chain governance' (Helmsing &

Vellema, 2011). Haverhals et al., (2014), distinguishes agroforestry value chains from agricultural value chains in that collection is often wild sourced making sustainability of harvesting a core aspect.

A growing body of research is exploring the role of gender in agroforestry value chains with a focus on where the differences are concentrated within value chains, the factors influencing these differences, and developing gender equitable value chains (Mai et al., 2011; Haverhals et al., 2014). Yet much of the peer reviewed literature is based in Africa, Asia and Latin America, highlighting a desperate need for research and development into the role of gender in agroforestry value chains in the South Pacific.

A wide range of literature outside of Melanesia sees socio-cultural factors determining gender participation in agroforestry value chains and how value chains are governed. Governance institutions can exhibit gender-differentiated access rights and responsibilities to land, tree species, agroforestry products, labour, technology, credit, information, and product markets. These socio-cultural factors further influence the work performed, division of labour within each step of the value chain and other household and economic responsibilities. The general sentiment emerging from literature on gender and agroforestry value chains is that women are severely disadvantaged in every step of the value chain (Gumucio et al., 2018).

FAO (2011) associate the underperformance of the agricultural sector in many developing countries to the severe constraints women face in access to productive resources which in turn reduces their productivity. This is fuelled by the recognition of women's involvement in agroforestry which sees women as: being the majority of all farmers in developing countries; having a longer work day then men, with many reaching their limits; harbouring specialised knowledge representing a highly skilled pool of labour in agriculture; contributing the most income to their household expenses and communities; productivity is severely constrained by the fragmentation of their time from competing responsibilities; becoming more responsible for households in rural areas as men leave for remunerated work. Similarly, for the health issues for both men and women. The impact of the Ebola out outbreak in Sierra Leone and Ivory Coast was a major reduction in cocoa production from the loss of labour, often child labour and the inability to pick and process at the household level, usually by women. The fear and superstition generated meant access to resources and field was disrupted and the value chain collapsed, field were abandoned and then time and effort is needed to bring these back into production. On the local level, this has a massive impact on women and families (Hancock, 2018).

In most developing countries, women are predominately segregated into low-technology occupations and concentrated into certain phases of the supply chain such as packaging, post processing which can limit the opportunities to gain new skills and capabilities (FAO, 2011). Women are also overrepresented in lower wage jobs and experience generally poorer labour standards. The combination of limited decision making within the household and lower access to resources and household income can lead women to accept lower wages and conditions. While these pay segregations are common in the developing world, there are new forms of organisation in agricultural supply chains for export-orientated crops and agri-processing which have wages that are typically higher and better working conditions than traditional agricultural employment (FAO, 2011).

Across Melanesia women are critical in achieving food security through their various roles throughout the agroforestry value chain, "from production on the family plot, to food preparation, to distribution within the household" in addition to supply of produce to local markets (ADB, 2013, p. 8). Yet while women make up the bulk of labour in agroforestry value chains their roles are generally undervalued and constrained by a number of factors largely influenced by social norms and practices that determine the gendered division of labour. Gender inequality in PNG is significant with female smallholders facing a number of constraints to generating income from participating in the agroforestry value chain. PNG has a gender inequality index of 133 out of 149 countries (which represents gender-based inequalities in three dimensions of the Human Development Index (HDI) reproductive health; empowerment; and economic activity). The Inequality-adjusted HDI (which is basically the HDI adjusted to take into account inequality) for the Pacific showed an average loss of 19.3 percent (United Nations Development Program, UNDP, 2014). Women in PNG experience limited access to productive resources and the business knowledge and acumen to improve access (Chambers et al., 2012). Yet Chambers et al., (2012) found empowering female smallholders in PNG as being one of the most effective ways to improve household livelihoods as women are more likely to invest additional resources (such as income and food) back into their families and communities.

Catacutan and Naz (2015) highlight the integral role of women in agroforestry at the early stages of establishment such as domestication of indigenous fruit trees. It has been suggested that participation of women in these early stages of the agroforestry value chain are largely influenced by access to land, distances to processing sites; the physical nature of the activity, and access to credit and technology. Leakey (2012) proposes adopting 'Participatory Domestication of indigenous trees can empower women while maintaining culture and tradition. By producing marketable products from indigenous species new locally important cash crops can be developed that are also food for domestic use that is rich in micro-nutrients (Cooper et al., 1996; Sanchez & Leakey, 1997). Promoting entrepreneurism and developing value-adding and processing technologies for indigenous tree crops (that are suitable for a rural Melanesian context and meet the needs of women) can supply quality nutritious food for their household while gaining employment opportunities to increase their disposable income.

A case study of female smallholders in PNG (Mikhailovich et al., 2016) sought to respond to the differences in the literature concerning gendered nature of work in agricultural production (Cahn & Liu, 2008; Bourke & Harwood, 2009). Mikhailovich et al., (2016) sought to understand the agricultural context that women in PNG operate in by gaining information on financial and business knowledge, practices and issues; and how culture, gender, family and regional factors impact on their economic development. PNG has highly defined gender roles (typical of Melanesian countries), therefore Mikhailovich et al., (2016) considered gender relationships carefully taking a gender-inclusive approach to their study seeking to promote gender-equitable relationships and the importance of asset sharing. They found that while women smallholders in PNG are key to food production the clearly defined gender roles has led to a long tradition of agricultural extension/training benefiting men, while creating an 'invisible barrier' to women (Peters, 1986; Saito & Spurling, 1992).

Davies et al., (2014) found that monetization of resources can increase gender inequalities and adversely impact women. In their study of households in Kahua in the Solomon Islands they found that current development activities focused on cash crops were unlikely to benefit the poor or marginalised, particularly women who have limited access to land. They also found the shift of land from subsistence to economic was eroding social cohesion and increasing conflict, which is an increasing issue in Melanesia (Addinsall et al., 2015a; 2016; Bonnemaison, 1984; Foale & Manele, 2004; Fazey et al., 2011).

The evolution of new challenges to food security in Melanesia bring to the fore the necessity of engaging women more directly during interventions into food production. Research conducted by Live & Learn International on climate change adaptation for food security in the Solomon Islands and Vanuatu identified a decline in food production at the household level due to climate variability and exacerbated by the onset of the cash economy and resource extraction (Live & Learn, 2010, p. 37, 41). Women in Sanma Province, Vanuatu noted that increased pressure for store-bought goods such as rice and flour meant that the higher quality garden produce was being sold at markets for cash leaving little fresh food available for families (Live & Learn 2010, p.44). This decline in food production was perceived to be affecting family health, an area of most concern to women as the providers of household nutrition (Live & Learn, 2010, p.8). Despite the involvement of women in household food security, the research by Live & Learn International also found that:

In all communities women held far fewer opportunities than men to participate in agricultural decisions. Compounding this was the inequitable gender division of formal natural resource leadership roles, restricting women's ability to control resources beyond deciding what to grow in small food gardens (2010, p.9)

The research identified that deliberate efforts were required to up-skill women on gardening techniques as they have intimate knowledge of the small garden systems.

In Melanesia, women conduct the majority of farming and trading of agricultural crops (with exception of kava, copra and cocoa). Addinsall et al., (2015a) and Nelson (2015) both found that men were predominately responsible for the planting and harvesting of trees in agroforestry systems in Vanuatu, while the women were more often focused on garden crop selection and harvesting of indigenous nuts. Nelson et al., (2018) found that women play a key role in small family plots as they grow crops to feed the family and to sell at market. In most cases the decision to plant an agroforestry system will fall to senior males in the family, yet there is evidence of male smallholders shifting their focus to the monoculture cropping of kava (Carodenuto et al., 2017). Therefore, supporting women

to manage, maintain and understand the benefits of agroforestry is crucial. Evidence from Fiji and Vanuatu is showing that in most cases women who are earning income from agroforestry systems are paid directly for produce from local processors e.g. Bula coffee, Lapita Café and ACTIV (Addinsall et al., 2018). Studies in Fiji by MDF have shown this model offers the best direct benefits to women and children (MDF, 2013).

Time poverty experienced by many rural women in Melanesia diminishes their capacity to exploit educational or income earning opportunities to enhance participation in agroforestry value chains. Raising tree crops at scale sufficient for it to be a main livelihood opportunity requires time and labour inputs that are not always available. This is especially the case for women who in rural Vanuatu and Fiji are responsible for household chores, food preparation, child minding as well as tending to family food gardens. Female smallholders in Fiji and Vanuatu stated that they had one or two half days free per week at varying times which they could commit to additional work (Nelson et al., 2018). Other studies have shown that women have between 1 – 2 hours of free time per day as opposed to young men who stated they had around 8 hours free per day when not engaged in studies (Nelson et al., 2015). The time required to manage a young agroforestry plot may not, therefore, be an option for many women (Nelson et al., 2018).

The time poverty of women to move exclusively to agroforestry production was addressed by the Nakau Programme who have worked with a community in Sanma Province, Vanuatu to establish community agroforestry plots. Women were given the opportunity to plant vegetables for market and home consumption alongside young fruit, nut and timber trees. The women tended the vegetables and trees simultaneously increasing the productivity and financial returns from the site. This work was undertaken on a communal plot, but the concept could be mimicked in individual gardens. The women are able to consume or sell the vegetable crops, however the sale of timber, fruit or nuts would be negotiated with the men whose role it was to manage fencing for the agroforestry plot (to keep out livestock) and to clear new land for further plots (Nelson et al., 2015). Education of men is critical to ensuring success in research and development projects, particularly in rural areas, overcoming the inherent bias and traditional exploitation of women in relatively fixed gender roles and male dominated attitudes to sex.

The underreporting of women's activities in agroforestry is causing disagreements among scholars as to the extent of the feminization of agriculture (de Brauw et al., 2008; de Brauw et al., 2012; Chang, MacPhail, & Do, 2011; Mu, & van de Walle, 2011). This is due to the fact that women's activities are largely within the informal economy (traditional economy). To address this there needs to be recognition of women's contribution to the 'traditional economy'. Addinsall et al., (2015a) found that rural women in Vanuatu play a key role in maintaining traditional economic systems that were vital in reducing vulnerability, providing resilience (to disasters such as cyclones, droughts etc.) and supporting livelihoods, which is in line with research undertaken in Vanuatu and Solomon Islands by Feeny et al., (2013).

Research and development intervention in agroforestry systems in Melanesia should be approached with caution as findings are starting to emerge from participatory discussions with rural women in Fiji and Vanuatu which suggest that women's access to tree crops is restricted if there is any attempt to improve the trees such as pruning and fertilising or if the plantings are formalised in any way (e.g. improved germplasm, the development of plantations) as most produce picked by women in Melanesia is from wild tree crops or within their household gardens (Addinsall et al., 2018). Again, this leads back to the issue of policy, customary land laws and patrilineal and matrilineal systems. Through patrilineal succession property devolves through the male line where with matrilineal systems, property is traced through the mother's line, therefore often giving women greater rights than patrilineal systems (yet even through matrilineal system's land is still generally owned and controlled by men) (Cotula, 2006). Further where community agreement to support women in the agroforestry value chain is agreed to within the community, adequate business training and extension services must continue for women to maintain a position within the value chain.

Access to credit and microfinance can protect households and empower women to establish small businesses, and cope with economic stress and shocks (Feeny et al., 2013). The access to financial resources can also help to get the best economic return from agricultural or agroforestry production by avoiding selling at low-price points such as when payment of school fees are due (Addinsall et al., 2015a). Addinsall et al., (2015a) found in their study in agroforestry systems in Vanuatu that many female respondents engaged in micro finance schemes to provide an avenue for increased

involvement in agroforestry value chains. However, not all of the feedback on microfinance institutions was positive. Some participants suggested the interest payments on their loans were too high.

Haverhals et al., (2014, p. 4) found in their literature review on gender and agroforestry value chains that there is an "absence of gender disaggregated data on male and female activities" and a lack of monitoring of gender focused chain interventions with minimal baseline studies. Haverhals et al., (2014) put forward recommendations for future studies on gender and agroforestry value chains to not just focus on women's involvement but to consider the impacts of interventions on both women and men and how they interact.

The literature is particularly scarce on identifying the structural barriers to the equitable participation of women in agroforestry value chains and strategies to overcome these barriers. As a matter of priority, further research is needed that provides empirical evidence on women's and men's roles and responsibilities in agroforestry value chains where sex-disaggregated data in participation and benefit distribution is scarce.

Examples of Women's involvement in agroforestry value chains in Melanesia

Canarium value chain in Vanuatu

Agricultural products such as Canarium nuts are traded by Ni Vanuatu women either on the roadside or village markets. The trade in Canarium nuts are predominately based on wild and garden tree populations. Women could gain a greater source of income from Canarium nuts if they participated in processing and value adding, yet at present these parts of the value chain are not well developed (ACIAR, 2016).

ACIAR FST/2010/013: *Developing markets and products for the Pacific Island and PNG Canarium nut industry,* worked with local female entrepreneurs in Vanuatu to train female suppliers to meet processing specifications. The project addressed some key processing challenges and explored new processing systems such as kernel and solar drying which has led to substantial growth of the Canarium industry in Vanuatu. This has been a successful capacity building exercise that is strengthening the Canarium value chain which at present is dominated by women.

The industry has grown in Vanuatu from one processor to five processors and value adders which has increased the capacity to supply value added product to the domestic market and tourist markets. ACIAR FST/2010/013 have found that large gains can be made in the processing and production of Canarium by tree selection. Having access to the best trees can result in a doubling of growers return for efforts for activities such as harvesting and cracking. Recommendations were made for a clonal propagation program to capture the best germplasm and develop a seedling distribution program to realise these gains to the industry. However, what needs further investigation is how will efforts to scale out industries such as Canarium impact on the livelihoods of women? Particularly as there are already signs of the exclusion of women once commodities move from small to medium domestic supply to large domestic and export.

In Khole Village, Vanuatu, women commonly harvested wild Canarium for sale to a nearby intermediary. Nine kilos of raw nut sold to local markets by the women of Khole was fetching 1900vt and requiring a full week of work. A project by Live & Learn sought to support the women of the village to solar dry the nuts, package them and sell them to tourists at the nearby Cruise Ship port of Champagne Beach. It was calculated that the women could make approximately 18,000 vatu, or ten times the amount per kilo, by value adding the nut themselves. With the assistance of Live & Learn Vanuatu and TVET, solar driers were purchased and training provided in producing solar dried, packaged nuts. Despite the women of Khole undertaking training and receiving the initial supply of materials required for value adding, ongoing promised funding to support the initiative did not occur. It was crucial for the women to receive ongoing support in managing the enterprise in order to make it a success.

Canarium Value Chain in the Solomon Islands

Canarium processing in the Solomon Islands occurs along clearly defined gender roles, often being described as 'women's business' with all stages of the value chain predominately being carried out by women (Grant, 2012). The Canarium industry is seen as fundamentally important to the traditional economy and is characterised by reciprocal labour exchange, communal resource, trading and gifting (Hviding & Bayliss-Smith, 2000). While Canarium plays an important role in maintaining food security and community cohesion, it is also becoming a highly sought-after commodity in urban markets. Grant (2012) found that growing the Canarium industry presents new opportunities for women to generate income as the industry begins to have more presence in the formal economy. Yet Grant (2012, p. 52) also highlighted the tensions that are resulting from "the increasing prominence of the Canarium industry"…. as values change and "people begin to individually claim once commonly owned Canarium trees".

These value changes alongside population growth, increasing demand for Canarium in the marketplace, and natural disasters etc. is diminishing access to Canarium resources and potentially privileging some people but not others in their participation in the industry. This will result in those with less access to the once communally owned resource having less agency within the Canarium value chain. Therefore, when considering strategies for enhancing opportunities for women in the Canarium industry there must be consideration of the transition of this industry to a hybrid economy "where social relationships are grounded in non-market exchange but draw on the introduced market economy" (Grant, 2012, p. 61). It is particularly important that any attempts to move this industry further into the formal economy doesn't impact on the important role Canarium plays in community cohesion and food security.

Coffee Value Chain in Fiji

The Nadroumai Women's Club in Fiji coordinates the sale for wild coffee beans harvested by the women in the community for sale to Bula Coffee. Currently the women work for three months of the year to harvest wild coffee beans from trees in the nearby forest as time permits. The wild trees do not produce as efficiently as formalised systems.

ACIAR Project FST/2014/067 *Enhancing value-added products and environmental benefits from agroforestry systems in the Pacific,* was keen to find opportunities to improve the economic gains for the women through coffee. Suggestions were made to plant formal coffee agroforestry sites where the plants could be managed and pruned for the greatest quality and production. The women explained that various barriers existed for this to occur. Firstly, the women would need formal approval by traditional decision makers to plant coffee and an appropriate site for this would not be easy to find. Secondly, the women explained that the current system suited their livelihood choices. Rather than having to manage a coffee plantation full time, the women could focus on coffee for just three months a year providing them with a good income for the family. Formal production systems may not fit the livelihood context within communities especially for women as there are no restrictions to access of products collected from wild systems.

Coffee Value Chain in PNG

Coffee in PNG is a major export commodity with women providing over 60% of the labour in the coffee value chain. Yet while women work longer hours in the coffee value chain, they receive less than a third of the income of their male counterparts. To address this discrepancy, CARE has developed a Coffee Industry Support Project that works with key coffee stakeholders to implement gender strategies that influence their approach to business. CARE's mandate is to build the business case that gender equality leads to better results for the private sector, households and communities in the Eastern Highlands of PNG. CARE has provided Gender Equity and Diversity (GED) to 6 of the major coffee companies operating in PNG with several now adopting gender strategies into their own training and HR processes to start investing in women. CARE encouraged coffee companies to invest in women to enable them to adopt practices to create higher value coffee. As a result, women's participation in extension related activities in the coffee value chain have risen from less than 5% to 55%, with changes between men and women's roles beginning to emerge. http://www.care.org/work/world-hunger/coffee-industry-support-project

Tree crops Value Chain in PNG

Cahn and Liu (2008) suggested that women in PNG are beginning to play an important role in commercial tree-crop agriculture, although men were still the major decision makers and controlling the marketing of these 'formal sector' crops (such as coffee, cocoa and oil palm). As many policy makers and agricultural development projects do not recognise the importance of the subsistence and informal sectors, much of the capacity building and training is targeted to the formal commercial sector where men dominate. Household prioritises also inhibit women from attending agricultural extension and training. These constraints for women to participate in capacity building limits their potential as economic agents (Koczberski, 2007; Manchón & Macleod, 2010; Live and Learn, 2010). To respond to these constraints the Integrated Agriculture Training Program (IATP) was initiated as a gender-sensitive training programme to improve the livelihoods of rural women. A key outcome from the training was the importance of arranging training at the village level rather than district level as rural women find it difficult to travel long distances taking them away from their household commitments. Also, Cahn and Liu (2008) found that women engaged in the training have considerable confidence in tree-crop agriculture. Building on this confidence through appropriately designed training that responds to both community and women's needs was considered paramount in increasing women's participation in tree crop agriculture.

Cocoa Value Chain in Solomon Islands

Cocoa is one of Solomon Islands biggest agricultural export earners, generating around USD 15 million in exports per year. Men largely control the cocoa value chain, yet more than 50% of producers and processors of cocoa are women. Women are also typically quite heavily involved in the growing and harvesting stages in addition to fermenting and drying the cocoa beans.

The Pacific Horticultural and Agricultural Market Access (PHAMA) program commissioned a gender analysis of the cocoa value chain and found an immediate entry point for women was through the involvement of women in solar drier trials for cocoa.

Lucy Kasimwane participated in the solar drier trials and training in growing, harvesting and fermenting conducted by PHAMA. She now owns and operates the Lukasko Group which employs 8 women who assist in cocoa harvesting, removing beans from pods and keeping the cocoa farms clean. Lucy suggested that while it was a bit challenging at first entering the cocoa value chain as it is such a male dominated field it didn't take long for her to grow the confidence to manage her own cocoa farm. PHAMA has also connected Lucy to boutique chocolatiers in Australia. http://pacificwomeninbusiness.com.au/blog/snapshot/lucy-kasimwane-owner-lukasko-group-solomon-islands/

Commercial nurseries for agroforestry catchment revegetation in Fiji

Engaging existing women's groups in revenue raising activities is one way to incentivise agroforestry for women where the activity is seen as contributing to the community and forms part of an expectation for women in a community to commit to charitable work. This has also been evidenced in Fiji in the ACIAR FST/2014/067 project where the women's group in Nadroumai donate a percentage of their income earned from picking wild coffee from agroforestry systems within their village to their women's group. This group has been responsible for key infrastructure upgrades in the community. This is supported by research undertaken by AusAID (2009) which highlighted that support for women's economic empowerment has focused more on the informal cash-generating activities, such as selling food and handicrafts, at markets rather than supporting access to formal, male-dominated areas of livelihood generation such as employment in both private and government sectors that predominately generate higher incomes.

The ACIAR FST/2014/067 project is designing a Payment for Ecosystems Services project whereby farmers engage in catchment remediation through establishing agroforestry plots in buffer zones alongside the river. Yet the project found a significant shortage of good quality seedlings to plant out agroforestry systems. To respond to this shortage the project is now working with the Nadroumai Women's Club who have agreed to trial the establishment of an agroforestry tree nursery. The project is now liaising with resorts within the Nadroumai catchment to gain support for large scale

catchment regeneration and to see an increase in local tree crops available for these resorts to purchase.

With support from the Department of Agriculture, the project worked with the women to establish a nursery nearby the local school. The project has also run training on establishing and maintaining a nursery. Topics covered have included:

- making potting mix,
- seed collection from useful trees,
- raising seedlings,
- support to get a basic nursery structure in place.

In early 2018 the project also organised business training, provided by Live & Learn Fiji, for the Nadroumai women's group to help them design the running of the nursery. A first order for seedlings for the nursery has also been made by with a mix of Breadfruit, Evi, Bush Lemon and Mandarin. The project is supporting the women to have the order ready for planting in November 2018 to coincide with the start of the wet season.

Microenterprise Nurseries in Vanuatu Post Disaster

In Vanuatu census data in 1999 revealed that up to 30% of businesses were owned by women, with women being increasingly involved in the private sector (Bowan et al., 2009). However, in many cases, women in Vanuatu are effectively operating their businesses within a framework that discriminates against them. While the country's constitution outlaws discrimination, there needs to be a clear distinction between customary and formal law to outlaw discrimination (Bowan et al., 2009).

As part of the response to Tropical Cyclone Pam, the Recovery to Resilience project targeted women in peri urban parts of Efate Island, Vanuatu to establish vegetable nursery microenterprise. These women were not working on land they owned but within informal communities and on leased land. They were able to establish three small nurseries which provided 174,000 vegetable seedlings to 1300 families in the 6 months after the cyclone (Live & Learn, 2015).

The project recognised that women play a key role in generating food and income from small-scale farming. 61% of recipients of seedlings were women. 1848 women and 3442 children lived in the households receiving seedlings. Some of the women went on, after the project to run their nurseries as small businesses.

The Kava Value Chain in Vanuatu

Women are becoming more active in the Kava value chain in Vanuatu as the customary barriers to participation are changing. Historically, in some provinces women were forbidden (and still are) from growing, selling, making, serving or drinking kava. The Vanuatu Kava strategy has put forward some key recommendations on planting material and cropping methods such as: planting kava in intercropping systems not monoculture; only buying noble variety planting material from reliable sources; and leaving areas to fallow for up to 3 years after harvesting by planting nitrogen fixing plants.

In response to the recommendations Dr Vincent Lebot has recommended that women could play a key role in setting up kava nurseries for noble varieties. He suggests women have been seen to be more careful with propagation and seedling production than men and therefore stand a better chance of producing healthy, quality kava seedlings compared to the current male dominated nurseries. http://dailypost.vu/news/kava-nurseries-should-be-owned-by-women-dr-lebot/article_99d1cf89-363a-53ec-86b9-0d0310e725ba.html

PHAMA (2018) recommend these nurseries be strategically located in villages where women can receive specialised training on the practicalities of nurseries and small business management and support to establish nurseries to propagate and sell noble variety kava seedlings to farmers. An increasing number of women are also entering the value kava chain through the operation of nakamals and selling of food. The concept was introduced from New Caledonia and rapidly caught on with most nakamals now serving 'wash mouth' refreshments (PHAMA, 2018).

Incorporating agritourism into the agroforestry value chain in Vanuatu

ACTIV Association, a French NGO and project partner in Vanuatu is making real gains in promoting local produce from agroforestry systems to tourists. ACTIV Association is also playing a pivotal role in supporting nearby farmers to adopt agroforestry systems. Produce is sold back to ACTIV where local female contractors of ACTIV value add the products. ACTIV sells produce to tourists at various markets within the country but has taken the link between agroforestry and tourism further. ACTIV is now establishing an agritourism tour where tourists visit local agroforestry farms before returning to ACTIV's centre to purchase local herbs and spices, handicrafts, coffee and chocolate (Nelson et al., 2018).

In 2017 the ACIAR FST/2014/067 project provided training to a group of women working with ACTIV Association in grafting cocoa. ACTIV's plan is to have trained grafters and nursery managers to set up the only commercial-sized nursery in Vanuatu where improved genetic material, starting with cocoa, will be grafted. The materials grafted will go out to farmers who sign an agreement with ACTIV to allow the organisation to graft material from their trees once they are fully grown. The objective is to establish improved genetic cocoa material from each cocoa-growing island. ACTIV is seeking funding to employ these women to work at the nursery doing grafting long term.

Lapita Café is another key intermediary in promoting local tree crops. The organisation supplies local produce to resorts, hotels, national airports and supermarkets. Lapita is looking to develop an agritourism tour educating tourists on traditional foods and how the purchasing of these products is supporting livelihoods, in particular for women.

Both ACTIV and Lapita are key organisations strengthening linkages between the tourism industry and agroforestry producers. Currently neither organisation can access the supply required to meet local and international demand. Supporting such organisations, presents a sound opportunity to increase the market pull for agroforestry products.

Strategies to further engage women in agroforestry value chains in Melanesia

Agroecology as a tool to mainstream gender in agroforestry

The rapidly emerging field of Agroecology is starting to be explored as an alternative development method in rural areas of Melanesia (Addinsall et al., 2015a; Addinsall et al., 2015b; Addinsall et al., 2016a; Addinsall et al., 2016b; Addinsall et al., 2017) with its focus on 'the ecological foundations of the traditional farming systems in developing countries' (Gliessman, 2015, p. 29). The Nyéléni Declaration (Anderson et al., 2015, p. 1) sees agroecology as 'a key form of resistance to an economic system that puts profit before life,' in other words, an economic approach that recognises and values the non-commodity outputs of agriculture such as agrobiodiversity, ecosystem services, climate change resilience, traditional knowledge systems and biodiversity (Silici, 2014). To underpin this, it supports and nurtures local knowledge and culture, seeks to promote social justice and equality, and aims to strengthen the economic viability of rural areas sustainably (Anderson et al., 2015).

The concept of agroecology is continually expanding its disciplinary boundaries becoming an interdisciplinary holistic perspective combining disciplines such as sociology, economics, agronomy and ecology. Agroecology is now being approached as tool to improve rural livelihoods while combining the stable and high production of food with nature conservation (Altieri, 2002; Altieri, Funes-Monzote, & Peterson, 2011; Gliessman, 2007; Vandermeer, 2009). While Agroecology as a discipline is starting to be accepted in the public domain, there are criticisms surrounding the co-optation of Agroecology to fine tune the industrial food system, (under various names such as "climate-smart agriculture", "sustainable-" or "ecological-intensification", industrial monoculture production of "organic" food, etc.) while the existing power structures remain unchallenged (Declaration of the International Forum for Agroecology, Nyeleni, Mali, 2015).

In response to these criticisms emerging literature surrounding agroecology is incorporating and strengthening the focus on political ecology, social (encompassing gender, race, ethnic, age and disability discrimination) and environmental concerns. As such agroecology is now being described as not just a scientific discipline but political in that it requires us to challenge and transform structures of power in society and see's minority groups (such as women and youth) and their knowledge,

values, vision and leadership as critical for moving forward. The International Forum for Agroecology, Nyeleni (2015, p. 163) highlighted the impacts of “migration and globalization mean that women’s work is increasing, yet women have far less access to resources than men. All too often, their work is neither recognized nor valued. For Agroecology to achieve its full potential, there must be equal distribution of power, tasks, decision-making and remuneration”.

Agroecology recognition as a social movement for sovereignty, access to land and autonomy of rural populations (Caporal & Costabeber, 2000) is particularly important for Melanesia as “strengthening the traditional economy and sustaining and enhancing the natural resource base is central to enhancing livelihoods of rural traditional landholders” (Addinsall et al., 2015a, p. 7). Rural development and research in Melanesia often fails to recognise the structural biases of dominant policies and institutions. Taking an agroecological approach to research and development in Melanesia addresses macro level issues such as measuring national well-being using Gross Domestic Product (GDP) per capita, as GDP measures only the cash value of activities and does not recognise then many tangible social and economic benefits delivered by the traditional economy (Regenvanu 2010). This is particularly important for Melanesia as many small holder farmers have been unable to compete against the consequences of neo-liberal policies and globalisation, such as stagnating world food prices, declining government support and increasing household expenses (Rapley, 2006). Declining commodity prices has had a major impact on wellbeing for both genders, with women especially impacted because of the loss of seasonal labour for specific sectors of the value chain, e.g., chill and paprika where women do most of the drying and sorting at household or first processing level, and peanuts, coconut oil, copra etc.

These powerful factors are influencing agroecology to see the small farm sector as livelihood systems, which incorporate food security and income-generating strategies rather than just focusing on cropping or farming systems (Reardon et al., 2000). One of the failings of the farming systems approach is the inability to address power from structural, policy, financial etc. and this limits effectiveness and is further compounded by the cash imperative economy forced on households, increasing the disadvantage of women. Addressing these power structures has led to the integration of sustainable livelihoods perspectives with agroecology (Addinsall et al., 2017). Developing agroecology models through the lens of sustainable livelihoods perspectives can enhance synergies between subsistence agriculture, agroforestry, agroecosystems and the wider food network, creating interlinked products that meet the capacity requirements of the landholders, while also providing for opportunities in agri-ecotourism and the sale of produce straight from the farm to the tourism industry (Addinsall et al., 2016a; Addinsall et al., 2016b).

Integrating agroecology and sustainable livelihoods offers a framework for research and development projects operating in Melanesia to truly recognise the importance of the smallholder household, including both men and women equally at all stages of the research from earliest formulation through to planning, application and decision making.

The Declaration of the International Forum for Agroecology, Nyeleni, Mali, (2015, pg 166) puts forward evolving strategies for agroecology such as:

I. Promotion of agroecological production through policies that:

- Are territorial and holistic in their approach to social, economic and natural resources issues.
- Secure access to land and resources in order to encourage long-term investment by small-scale food producers.
- Ensure an inclusive and accountable approach to the stewardship of resources, food production, public procurement policies, urban and rural infrastructure, and urban planning
- Promote truly democratized planning processes in conjunction with relevant local governments and authorities.
- Promote appropriate health and sanitation regulations that do not discriminate against small-scale food producers and processors who practice Agroecology.
- Promote policy to integrate the health and nutrition aspects of Agroecology and of traditional medicines.

- Ensure pastoralists' access to and control over pastures, migration routes and sources of water as well as mobile services such as health, education and veterinary services that are based on and compatible with traditional practice.
- Ensure customary rights to the Commons. Ensure seed policies that guarantee the collective rights of peasants to use, exchange, breed, select and sell their own seeds.
- Attract and support young people to join agroecological food production through strengthening access to land and natural resources, ensuring fair income, knowledge exchange and transmission.
- Support urban and peri-urban agroecological production.
- Protect the rights of communities that practice wild capture, hunting and gathering in their traditional areas – and encourage the ecological and cultural restoration of territories to their former abundance.
- Implement policies that ensure the rights of fishing communities.
- Implement the Voluntary Guidelines on the Tenure of Land, Fisheries and Forests of the Committee on World Food Security and the Voluntary Guidelines on Securing Small-scale Fisheries of the FAO.
- Develop and implement policies and programs that guarantee the right to a dignified life for rural workers, including true agrarian reform, and Agroecology training.

II. Knowledge sharing

- Horizontal exchanges (peasant-to-peasant, fisher-to-fisher, pastoralist-to-pastoralist, consumer-and-producer, etc.) and intergenerational exchanges between generations and across different traditions, including new ideas. Women and youth must be prioritised.
- Peoples' control of the research agenda, objectives and methodology.
- Systemize experience to learn from and build on historical memory.

III. Recognition of the central role of women

- Fight for equal women's' rights in every sphere of Agroecology, including workers' and labour rights, access to the Commons, direct access to markets, and control of income.
- Programs and projects must fully include women at all stages, from the earliest formulation through planning and application, with decision-making roles.

IV. Build local economies

- Promote local markets for local products.
- Support the development of alternative financial infrastructure, institutions and mechanisms to support both producers and consumers.
- Reshape food markets through new relationships of solidarity between producers and consumers.
- Develop links with the experience of solidarity economy and participatory guarantee systems, when appropriate.

V. Further develop and disseminate our vision of Agroecology

- Develop a communications plan for our vision of Agroecology
- Promote the health care and nutritional aspects of Agroecology
- Promote the territorial approach of Agroecology
- Promote practices that allows youth to carry forward the permanent regeneration of our agroecological vision
- Promote Agroecology as a key tool to reduce food waste and loss across the food system

VI. Build alliances

- Consolidate and strengthen existing alliances such as with the International Planning Committee for Food Sovereignty (IPC)
- Expand our alliance to other social movements and public research organizations and institutions

VII. Protect biodiversity and genetic resources

- Protect, respect and ensure the stewardship of biodiversity
- Take back control of seeds and reproductive material and implement producers' rights to use, sell and exchange their own seeds and animal breeds
- Ensure that fishing communities play the most central role in controlling marine and inland waterways

VIII. Cool the planet and adapt to climate change

- Ensure international institutions and governments recognize Agroecology as defined in this document as a primary solution for tackling and adapting to climate change, and not "climate-smart agriculture" or other false versions of Agroecology
- Identify, document and share good experiences of local initiatives on Agroecology that address climate change.
- Denounce and fight corporate and institutional capture of Agroecology
- Fight corporate and institutional attempts to grab Agroecology as a means to promote GMOs and other false solutions and dangerous new technologies.
- Expose the corporate vested interests behind technical fixes such as climate-smart agriculture, sustainable intensification and "fine-tuning" of industrial aquaculture.
- Fight the commodification and financialization of the ecological benefits of Agroecology.

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- Fight the commodification and financialization of the ecological benefits of Agroecology

These strategies put forward by the Declaration of the International Forum for Agroecology, Nyeleni, Mali, 2015, aligns closely with the traditional economy and the political, economic and social foundations of Melanesia. Yet these strategies take it a step further by recognising the central role of women in rural development. These strategies are in contrast to the way capitalist systems organise themselves and challenges the ways of knowing and approaches that many research and development projects (funded by Western counties) currently take.

Gender responsive agroforestry research, development and extension services

IAASTD suggested back in 2008 that supporting women in agriculture has the biggest potential to raise total agricultural output while meeting sustainable development goals and sustaining resources. While majority of agricultural extension is still largely ignoring the major concerns of rural women such as: storage and small-scale processing; household food security; and access to finance and small business management (Stephens, 2004), there is a growing movement occurring in some agricultural research and development agencies, NGO's and governments to mainstream gender issues in their programs and activities (ACIAR, World Bank, FAO). This can be demonstrated through actions such as the ACIAR Gender Guidelines for Project Proposals (ACIAR, 2016)

There are a number of factors attributing to the lack of engagement of women in rural research and development projects and the predominate failure of extension services to empower rural women.

Firstly, globally there is a striking underrepresentation of female extension service agents and agricultural and forestry scientists (De Shutter, 2010). Also, in some contexts women may be excluded from attending extension services run by men due to religious, social or cultural rules or they can just feel intimidated or uncomfortable to a group of male trainers and participants.

Secondly many research and development projects automatically assume that men are the only producers in the household and the sole decision makers. Failing to acknowledge that the needs and priorities of women may be different to men. There is also an assumption that knowledge transmitted to men in research and development projects will automatically trickle down to women (ADB, 2013). This is a common problem in Melanesia as many research and development projects present gender issues regulated to chapters or sections in projects with little integration and fail to consider basic questions regarding resource use access for men and women, roles and constraints and how proposed interventions can address inequalities. Stephens (2004) highlights that many feminist strategists are in favour of mainstreaming women in all development projects over creating specific projects for empowering women. Cultural forces also impact on how information is received in the community or household as custom protocol in countries such as Vanuatu often see's key information exchange occur at the Nakamal with men only present (Addinsall et al., 2017).

Thirdly, time poverty experienced by many rural women in Melanesia, due to the many conflicting demands on their time, restricts attendance to training. Particularly if the training is for an extended amount of time, held during hours where women must attend to inflexible duties or there is considerable distance to be travelled to attend. Cahn (2008) found that training held in PNG by the United States Agency for International Development had a small representation of women attendees as it required travel and 3 days away from their households.

A fourth factor is the differences in institutional participation between men and women. For example, Addinsall et al., (2015a) found women in Vanuatu tend to be members of civic and religious groups responsible for maintaining social networks, while men are more likely to be members of production groups responsible for income generation, such as cooperatives or producer organisations. These women's groups were the most effective institutions for providing for the community (either through community enhancement activities or by providing social safety nets in time of hardship) and improving wellbeing (Addinsall et al., 2015a). This highlights the importance of selecting the right avenues for channelling extension services. For example, ACIAR LPS/2014/037: *Increasing the productivity and market options of smallholder beef cattle farmers in Vanuatu* found that women's church group meetings were an effective channel for filtering information from the project to female heads of households involved in the project.

Finally, research, development and extension services need to consider gendered roles in agroforestry value chains and acknowledge the constraints experienced by women and their priorities and perspectives. For example, due to land tenure systems in Melanesia women often only have access to informal agroforestry systems (wild or home garden) to generate their personal income. In most cases it was noted that once systems are formalised, they are owned and controlled by men (Addinsall et al., 2018). Also, lower input agroforestry crops such as trees that have specific fruiting periods and have value beyond the community are useful (such as nuts, coffee, cocoa) as this fits with available time resources of women (Addinsall et al., 2018).

Development projects can incorporate women's empowerment into project design. In Fiji, the Nakau Programme has established a long-term forest protection financing program producing carbon and honey. Lalabalavu et al., (2015) identified the barriers to women's participation in the project as;

Many women reside in urban areas during the week to support their children attending high school (especially those from villages without a school within its vicinity) or are busy with household chores and cannot participate in training sessions

Traditionally men are decision makers with clan and village matters, hence engagement with men was required to increase support for women's participation

Women who marry into the villages are not entitled to land ownership, which also impedes their ability to put forward their views and opinions with project activities that relate to land

To address these barriers, the Nakau Programme sought agreement from the communities involved to announce that all members of villages were invited to attend whether or not they were landowners. Project activities were facilitated in a manner that encouraged the active participation of marginalised

groups, by dividing into sub-groups for certain discussions and undertaking training and meetings at times that suited marginalised groups. The project also went so far as to hold meetings in urban centres where women were based to ensure they remained engaged in the project. The final Cooperative Board established as part of the project had our women representatives, including some representing landowner interests. The continued efforts of the project to find ways to engage women was presumed to influence their eventual representation in decision making.

ADB (2013) suggests that due to the difficulties faced by women in accessing credit, agroecological methods focusing on low external input techniques maybe preferred by women. Hence it is vital that research and development projects consider these cultural and custom nuances when designing extension services so that they don't discriminate or further disadvantage women. Achieving this can be addressed with gender sensitive research methodologies that requires a greater representation of female scientists, extension officers and female farmers, producers and consumers involved in the design, implementation and evaluation of agroforestry research and development programs (Meinzen-Dick et al., 2010).

Strengths-based and interactive training has been a useful tool to further engage women by enabling women to recognise their existing skills and leadership roles they already have in the community and identify other possible leadership pathways such as the development of women's leadership teams. These women's leadership teams could build the agricultural and business acumen to improve agricultural productivity through: agricultural/livestock extension; improved banking, saving and skills in financial management for agricultural/livestock; small business activities; increased capability to access micro-finance; and building gender inclusive decision-making capacity within the family and community through the family teams training approach (Rosset et al., 2011).

Conclusion

This literature review considers gender issues in value adding and agroforestry crop production in the South Pacific, with a focus on the four independent countries of Melanesia (Fiji, Vanuatu, PNG and Solomon Islands). Agroforestry is far from a new concept in Melanesia. Mixed plantings have long been a part of traditional farming systems in the Pacific and farmers, especially women, still rely on produce for subsistence and sales from multiple food crops as their main income source and contribution to livelihood's and wellbeing.

This review was influenced by a variety of critical theories such as post-colonialism, feminism and globalisation. This approach enabled an improved understanding of rural people's livelihoods by addressing factors such as inequality, gender, governance, farming systems, land tenure, culture, vulnerability, and resilience. Findings from this literature review show distinct gender differences in the role of men and women in agroforestry value chains, with men often positioned more favourably than women. Social-cultural factors such as: access to resources and land, access to extensions and financial services and markets; the physical nature of value chain activities and cultural norm and customary and formal regulatory arrangements; and the little benefit seen from agricultural research and development efforts, influence women's disadvantage in agroforestry value chains. Serious time constraints for participation such as children, household and other duties including religious or cultural significantly reduces participation as does access to education to actively understand and participate without feeling inferior.

Where female farmers have continued their focus on the family 'gardens', male farming has moved further towards monocropping. In most cases the decision to either plant an agroforestry or monocropping system will fall to senior males in the family, however supporting women to manage, maintain and understand the benefits of agroforestry is crucial.

Women are increasingly engaging in micro enterprise and employment in rural and urban areas. Creating employment opportunities for women in value adding and agroforestry is an avenue to encourage agroforestry uptake that can avoid some of the major constraints existing.

Engaging existing women's groups in revenue raising activities is one way to incentivise agroforestry for women where the activity is seen as contributing to the community and forms part of an expectation for women in a community to commit to charitable work. Therefore, engaging women through collective charitable activities or micro enterprise activities in value adding and agroforestry rather than working with individual women to plant trees may be more feasible in circumstances

where the local governance systems create a barrier to this. Micro-finance schemes have often engaged women's groups and helped individual women to establish micro-enterprise through this medium.

One major barrier to upscaling tree crop production in Melanesia is the supply of high-quality seedlings/ grafted trees with known desirable traits. Nursery establishment in Melanesia is greatly needed and can provide a worthwhile livelihood opportunity for women within the agroforestry value chain as it does not necessarily require formal land tenure access to develop a nursery. However, a significant training input in nursery practice and business management is needed over an extended timeframe to facilitate quality products as well as market pull for products.

Most women farmers in Melanesia sell their produce to local fruit and vegetable markets in village markets, on roadsides and nearby urban centres. There is a need to provide women with the resources and expertise to upscale production from tree crops and have greater and more equitable participation in the agroforestry value chain.

A lack of monitoring and evaluation of gender strategies alongside the influence of gender biased perceptions have resulted in limited awareness and appreciation of the role of women in food security and rural development. Therefore, it is vital that research and development projects operating in Melanesia raise awareness of gender biases and support gender inclusive value chain development. Otherwise projects operating in this space risk continuing to disempower women and undermine food and nutritional security.

The strategies put forward by the Declaration of the International Forum for Agroecology, Nyeleni, Mali, 2015, recognises the central role of women in rural development and aligns closely with the traditional economy and the political, economic and social foundations of Melanesia. Therefore, it is recommended that research and development projects operating in this space consider the integration of agroecology and sustainable livelihoods into their project designs (Addinsall et al., 2017). It is crucial that scientists operating in a rural Melanesian context approach development through a critical lens that challenges and transforms structures of power in society and see's minority groups (such as women and youth) and their knowledge, values, vision and leadership as critical for moving forward. Agroecology provides the framework to enable this to take place.

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11.9 Applying an intersectional lens to addressing gender disparities and disadvantage in rural Melanesia

Activity 3.3

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Abstract

Agricultural research and development projects have gained little traction overcoming structural barriers to the equitable participation of women. This paper considered the gendered elements of development, capitalism and colonialism and how the intersections between them create unique experiences for rural indigenous Melanesian women. Findings showed that meeting gender quotas solely by involving women in programs ultimately designed for men within a patriarchal structure is ineffective and can actually reinforce disempowerment of women. Applying an intersectional approach can facilitate women to freely pursue their economic, social, and cultural development within the existing patriarchal and colonial structure, ultimately challenging and subverting it.

Introduction

Through exploring and applying feminist and post colonialism theory, this study offers a new way of understanding gender disparities and disadvantage in rural areas of Melanesia (a subregion of Oceania extending from the western end of the Pacific Ocean to the Arafura Sea, and eastward to Fiji), and examines the multiple ontologies and world views that exist in this space. An intersectional understanding of discrimination, as proposed by Crenshaw (1989) recognises the way that power structures interact to form various configurations of oppression and produce multilayered identities of privilege and subjugation (McKinnon in Silverstein, 2017, p. 16). This way of understanding development and gender studies highlights that women in Melanesia experience the discriminatory prejudice of colonial structures through institutions and organisations alongside their male counterparts but are also subjected to a gendered experience of this structural oppression (Crenshaw 1989). These theories, when applied to rural farming women, highlight that they are not only subjected to the prejudices of colonial and capitalist administrators and structures due to their ethnicity, but also by the patriarchal nature of these structures – even within their own communities (Borserup, 1965). Morrisson and Jutting (2005, p. 1066) emphasise the connection between the strength of colonialist patriarchal institutions and the status of rural women in developing nations. Despite the introduction of modern capitalist economies and economic growth within Melanesia and the implementation of policies that promote women's access to education and training; gender inequality has remained a barrier to women's development. The discriminatory nature of colonialist institutions, and the portrayal of women in developing nations as a voiceless and a homogenous group has inhibited their status within familial, societal and economic institutions (Morrisson & Jutting, 2005, p. 1066). An intersectional approach to development and agriculture can facilitate these women to freely pursue their economic, social, and cultural development within the existing patriarchal and colonial structure, ultimately challenging and subverting it.

In the past 30 years there have been many conceptual shifts in the feminist development literature, incorporating feminist approaches such as Gender and Development (GAD) (Oakley, 1972; Rubin, 1975), which seeks to understand how society assigns roles, responsibilities, and expectations to gender. Alternative feminist approaches have also been recognised in the gender and development literature such as the capabilities approach (Nussbaum, 2011) and ecofeminism (Adams & Gruen, 2014). The capabilities approach is resolutely 'pluralist about value'; it contradicts capitalism and the free market as it recognises that people may require different quantities of resources and support depending on their position in society. It is deeply concerned with entrenched social injustice and inequality, particularly those that result from discrimination and marginalisation (Nussbaum, 2011). Ecofeminism directly links colonialism and capitalism to the increasing human impact on the environment from the perspective of gender and sustainable development. Ecofeminist theory applies an intersectional model to post-colonialism and environmentalism – and stresses the need

to move away from the masculinist and colonial logic of domination of both the natural world and of women, particularly women of colour (Adams & Gruen, 2014).

In this space, understanding world views and ontologies are crucial as rural development is ultimately a colonial era concept that was used to justify imperial intervention and marginalise colonial subjects or force them to adapt. Feminist and Postcolonial theory critique positivist sociology and acknowledge that the study of people, gender, and culture can make no claim to objectivity (Krieken et al., 2000). In this context, 'post neoliberalism' has gained traction in many developing countries as we see more rural smallholders and governments begin to question globalisation processes which have created some of the greatest levels of inequality (Sader, 2009).

The International Assessment of Agricultural Knowledge, Science and Technology for Development (IAASTD) report (McIntyre et al., 2009, p. 44), describes "the many iterative processes caused from globalisation that have significantly impacted on rural populations such as: rising input costs, low levels of investment, and lack of credit leading to deterioration in economic and social conditions for rural areas". Boserup (1965) suggested that the modernisation of farming that came as a consequence of colonialism and globalisation severely disadvantages women as men were given the training, cash crops and equipment. Sen and Grown (1987) have moved Boserup's theories further beyond the goal of gender equality (by articulating the words of scholars and activists from developing countries) to question the influence of capitalism and the dominance from the West over developing countries. This led to the Development Alternatives for Women for a New Era (DAWN) to emphasise the need for policy to support the most disadvantaged groups, with a particular focus on rural farming women (Sen & Grown, 1987).

Bose (2012, p. 70) argues that an 'intersectional approach is vital to understanding how multiple macro-level structures, like economic neoliberalism, politics, and patriarchy, operate at a regional and national level and are linked to the micro-level of local economic, social, sexual, or cultural forms of violence against women and women's poverty.' This is where an intersectional approach becomes imperative, because too often the needs of Melanesian women are seen as being met by services and projects which are ultimately designed for the male population (Crenshaw, 1989). Mistaken assumptions are made in decolonisation and development discourse and practice about the 'shared' experiences of all Melanesian people, ultimately resulting in projects and services which negatively affect women. The challenge for development and agricultural engagement projects moving forward is to consider the intersections influencing the experience of rural Melanesian women and genuinely facilitate their economic, social, and cultural growth and livelihoods.

FAO (2010, p. 19) documented in their report on gender gaps in agriculture that "access to land in conditions that ensure security of tenure is the single most important condition for economic empowerment". This is based on the realisation that constraints to productive resources such as credit, inputs and access to extension services is conditional on land ownership. FAO (2010) concluded "if women had the same access to productive resources as men, they could increase yields on their farms by 20-30 percent. This could raise total agricultural output in developing countries by 2.5-4 percent, which could in turn reduce the number of hungry people in the world by 12-17 percent (FAO, 2010, p. 40).

A large majority of Melanesian people have to this day access to land that has remained under customary title, which is controlled by clans and families (Anderson & Lee, 2010). Melanesia has amongst the last remaining countries in the world where the traditional economy outweighs the cash economy in terms of providing for livelihoods (Regenvanu, 2010). Unlike many countries that have shared a colonial history, the scale of dispossession of traditional landowners from lands in Melanesia was radically less than that in countries such as Australia and Canada, which experienced nearly complete dispossession from their lands and culture (Fingleton, 2005). Yet colonialism has influenced customary and formal systems of land tenure in Melanesia with concepts and definitions from English Law.

Traditional Melanesian societies appear to have consisted of scattered groups practicing shifting cultivation and led by various people responsible for different activities (such as warfare, sorcery, rituals, food production, hunting) that weren't necessarily gendered. The chief's role was more focused on social organisation than land management. Yet the colonial administration organised groups of people into villages and appointed a chief largely responsible for assigning ownership of land. While the concept of chief is a traditional one, through colonisation, the roles of the chief were

influenced by a patriarchal society which sought to move land from a communally owned asset to one administered by patriarchs (Haccius, 2011).

This 'ideology of chieftainship' conceals the way in which the position of chief has been transformed, and even strengthened, through missionary and colonial influences. Furthermore, like any ideology, powerful actors can manipulate discourses of kastom and claims to 'chiefly title' for personal gain. So kastom is not a straightforward articulation of autochthony or indigeneity against alien loa [Western Law]. Rather, each concept is able to take on aspects of the other according to the contexts and purposes of its deployment (Smith, 2017, 11).

While there are some cases of matrilineal systems of land inheritance, society in Melanesia is generally patriarchal with gender biases existing in every sphere. This process has further disadvantaged Melanesian women by supporting inequitable and exclusionary provisions limiting their access to key resources such as land and credit. Discrimination against women in countries such as Vanuatu and Fiji, is illegal, yet actual enforcement of this when it intersects with custom is unclear (Bowan et al., 2009). Reforms of the legal frameworks in place could work to ensure gender equality are required with distinction made between formal and customary law (Bowan et al., 2009). Under the land tenure reform in Vanuatu, there is now a requirement of gaining consent of the whole community for registration as discussed in (Smith (2017), yet studies show that customary practices and cultural norms continue to inhibit women's ability to exert authority of land use (Napua, 2017). Smith (2017, 11) challenges these cultural norms and highlights that custom signifies "inclusive, consensual, peaceful and relational ethics against exclusionary or individualising processes in shifting political contexts", and therefore suggests the potential for custom to adapt to incorporate social inclusion, increasing community participation and therefore make space for gender equitable decision making (Napua, 2017). Napua (2017, 10) found that the "framing of social inclusion, rather than just a women's issue tied advocacy efforts closer to culturally respected and valued principles relating to communal livelihoods, which helped to gain credibility for advocacy efforts and also earned women a seat at the negotiating table for land reform".

Gendered patterns of control over income are largely influenced by land tenure systems and the type of crops and characteristics of households. Within some households in Melanesia, cash income 'belongs' to whoever produces the goods for sale, particularly in Fijian households, while in other households men control all household income. There is also evidence that increasing women's access to land and assets has been found to significantly reduce the level of domestic violence (Agarwal & Panda, 2007). This is attributed to the fact that women who have property feel that they can leave marital violence (Friedemann-Sánchez 2006; International Centre for Research on Women [ICRW] 2006, p. 12). Tenure security for women not only enhances their role in household decision making, but it enhances their self-confidence and self-esteem and participation in rural institutions (Lastarria-Cornhiel, 2007).

It is important in a Melanesian context to not reduce the value of land as an economic asset to be sold, mortgaged or as investment in the formal economy. Anderson (2011, p. 86) identifies traditional Melanesian land systems as "vehicles for food security, housing, widespread employment, social security, biodiversity protection and ecological stability; they are also a store of natural medicines, as well as a source of social cohesion, inclusion and cultural reproduction". Land rights for women "are not primarily marketable assets but rather a secure foundation for sheltering and nurturing their families and making a living" (Meinzen-Dick et al., 1997). This notion is empowering and subversive in itself as it challenges the dominant patriarchal and capitalist principles which drive conceptualisations of the value of land. In equalising access to land and increasing land rights for women there is a less emphasis places on the land's economic value and more on its cultural, ecological and nurturing role.

In response to this, addressing land rights for women should not be confused with the push for reform of customary ownership of land (with the replacement of freehold or individual title) from neo-classical economists who see customary ownership as a critical barrier to economic growth (Hughes, 2003). Development literature in Melanesia is emphasising neoliberal discourses of 'growth', 'efficiency', 'reform', and 'governance', while only a handful of publications from NGO's and researchers are challenging current economic and trade policy (Addinsall et al., 2015a; Addinsall et al., 2015b; Addinsall et al., 2017; Anderson and Lee 2010; Lightfoot, 2005; Simo, 2010; Regenvanu, 2009). Crucially, these viewpoints fail to recognise the reality in Melanesia, where the vast majority of people reside in rural areas and have vibrant smallholder subsistence and cash-cropping

economies (Allen, 2008).

Anderson (2011) suggests many Western 'growth' strategies favour formal economies and private businesses, in particular export industries, while devaluing and often displacing more traditional 'hybrid' livelihoods which combine formal, informal and subsistence economies. It is these 'hybrid' traditional economies where rural women in Melanesia play a significant role (Addinsall et al., 2015a). Indeed, strategies solely relying on capital and growth can significantly redirect and alter smallholder livelihood futures and ultimately place an additional burden on women through reinforcing patriarchal lines (Ife, 2013). Strategies focused on growth notoriously exclude environmental benefits and costs in their analyses whereas traditional economic activities are often centred on sustaining the resource base and therefore are more often based on sustainability (Anderson, 2011). Allen (2008) suggests "the introduction of a system of freehold or individual title could also lead to sharp socio-economic differentiation and, in the long term, the emergence of a landless peasantry.

There are other preferable methods of increasing agricultural productivity, which are more likely to yield sustainable increases in community living standards without entailing serious social disruption". Therefore, work is needed to explore these 'preferable methods' that can enhance access for women without displacing or eroding customary tenure and the traditional economy which constitutes the political, economic and social foundation of contemporary Vanuatu society (Regenvanu, 2009). This would require new ways of integrating the cash economy and political institutions to work within communal structures and enhance resource ownership and access for women (Westoby, 2010). This needs to be one in which men and women gradually develop innovative cash economy activities that supplement traditional activities, while maintaining customary land ownership and a sustainable use of the resource base (Addinsall et al., 2015b).

The reports of the IAASTD put forward the idea of the 'feminisation of agriculture' that has shown women now constitute over 43% of the global agricultural labour force in developing countries, yet women only have accesses to 13% of agricultural land. These figures mask considerable variation and due to the overall labour burden of rural women (which often exceeds that of men) and in reality, the percentage of unpaid agricultural related duties undertaken by women makes it impossible to verify empirically (FAO, 2011). Mikhailovich et al., (2016) also found that the distribution of labour between women and men was not equal with women having a much greater share of responsibilities and greater working hours. Wilk (1997) argues that these family and caregiver responsibilities, that are largely held by women, do not significantly change with the interaction and participation in capitalist economies, nor do they change with solely subsistent livelihoods. He continues by stating that gender identities and roles do not necessarily rely on the macroeconomy, but with emic, localised structures of kindship, class and household economies.

Gender differs to one's sex as it is not biologically determined, it is rather a result of socialisation into a male or female role. Gender differences in developing countries become clearer when you look at women's overall workloads, particularly in rural areas (Lanjouw & Lanjouw, 2001). In particular, rural women often pursue multiple livelihood strategies which are quite complex. While these activities, such as: producing agricultural crop for subsistence and markets; processing and preparing food; collecting fuel and water; caring for family members; maintaining houses etc., are not defined as economically active employment activities, they are regarded as essential to the well-being of the household.

For governments in Melanesia to keep to their commitments of meeting the UN Sustainable Development Goals there will need to be more emphasis on developing policy and programs to end all forms of discrimination against women. This requires enabling equal rights to economic resources, addressing nutritional needs, offering qualification opportunities, extension services and agricultural training to women, to own land, to have access to water, livestock, and machinery, to self-organise and take part in community decision making. Yet given the gender variability in agricultural roles, policy and extension services should be based on studies that are specific to a geographical and cultural context.

Many see policy as a powerful instrument to create long term impact on gender biases. Agricultural policies have inherently excluded women because the social role of the farmer is seen as male resulting in rural women being significantly behind in most social and economic criteria, which further confirms Boserup's (1965) conclusions from decades ago. What is particularly concerning is that

little improvement in the economic or social status of rural women in Melanesia has occurred since these conclusions were drawn. The literature is particularly scarce on identifying the structural barriers to the equitable participation of women in agricultural value chains and meaningful strategies to overcome these barriers.

There is a growing movement occurring in some agricultural research and development agencies, NGO's and governments to mainstream gender issues in their programs and activities (ACIAR, World Bank, FAO). The two case studies presented in this paper detail gender research and meaningful engagement methods for rural women in Melanesia from three Australian Centre for International Agriculture Research (ACIAR) projects from 2015-2019. The case studies provide empirical evidence on women's and men's roles and responsibilities in agricultural value chains and limiting factors attributing to the exclusion of women where sex-disaggregated data in participation and benefit distribution is scarce. The purpose of these case studies is to 1) demonstrate the importance of considering the intersections between culture and gender and 2) show how engaging women meaningfully can positively influence development and research projects.

Case study: Nadroumai Women's Club Native Tree Nursery, Vitu Levu, Fiji

This case study uses an intersectional approach to explore women's engagement through the Nadroumai Women's Club (NWC), located in the Nadroumai village on the island of Vitu Levu. This case study illustrates the economic, social and environmental necessity of meaningfully engaging and recognizing women throughout the agricultural sector in rural Fiji. Women engaging and facilitating rural agricultural developments is critical to achieving the SDGs on a national and global level. The focus of this engagement was to research possible avenues to refinance the rehabilitation of the Nadroumai upper and middle catchment areas. This project worked closely with the Nadroumai Community for three years (2016-2019) through the ACIAR FST/2014/067 programme with the initial aim of developing an agroforestry site. The project sought to be a demonstration to the Nadroumai community about the increasing concerns of sedimentation and poor water quality from different businesses and industries in the lower catchment, such as the Fijian Shangri-La resort. Subsequent to the first planting, however, the planted demonstration site was destroyed by a severe flood; sadly, illustrating the need for this type of multi-purpose catchment protection, as floods are made worse from climate change and upstream clearing of forest resulting in limited tree cover and fire sensitive grasses. Another significant setback was the lack of immediate monetary gains, as there were little economic drivers as incentives to take the project seriously by the community, and disputed responsibility and ownership by the clans.

A central output of this project was to find meaningful ways to engage women to further agroforestry plantings in the Nadroumai catchment. Significantly, ongoing engagement with the community, especially the community women, opened other avenues to support community-based activity. In particular, women in the Nadroumai community were harvesting wild coffee for 'Bula Coffee', a social enterprise that paid women directly for their work. This was of considerable benefit to the women as this informal employment provided lucrative returns for their labour; however, the wild coffee was of poor quality and the harvesting was unproductive due to the lack of pruning and maintenance from the women. The project team responded by putting forward the suggestion to plant formalised coffee agroforestry systems utilising improved coffee genetics that could raise income for women while having environmental benefits for the catchment. However, Talanoa sessions with key women in the community showed that improving the coffee in situ would require a lease as the coffee would no longer be a wild resource, therefore it would exclude the women from having access. The women explained that various barriers existed for this to occur. Firstly, one female participant explained *"we would need formal approval from the community to plant coffee and an appropriate site for this would not be easy to find*". Facilitating women's engagement must be a central aspect of project design for research and development projects, while also remaining flexible and adaptable to respond to impediments to women's engagement, such as land tenure and time constraints.

Lalabalavu et al., (2015) identified that women who marry into the villages are not entitled to land ownership, which also impedes their ability to put forward their views and opinions with project activities that relate to land. Another female participant explained that establishing a formalised coffee plantation would require significant upfront investment of money and time which she suggested *"I like to just pick coffee for 3 months of the year and not worry about it for the rest of the*

year". Indeed, many of the women expressed their aspirations for diverse, more 'part-time' lucrative livelihood activities to ensure a stable monetary income, rather than relying solely on one activity to generate household income, which may be vulnerable to unforeseen circumstances that impacts that particular value chain, such as cyclones. As such, formal production systems may not fit the livelihood context within communities especially for women as there are no restrictions to access of products collected from wild systems.

Pearson, McNamara and Nunn (2019) argue that Fijian women have an abundance of knowledge and skills associated with agricultural practices (in their case, mangroves) and women were more likely to collect and engage with resources than men; yet, women are not involved in any environmental and ecological decision-making process due to "their subordinate role in society" (p. 2). Therefore, engaging and collaborating with women in agricultural production is a critical avenue for increasing productivity, confidence, knowledge-building, and gender equality in the household, the community and region at large. Similarly, Nabalarua (2005) found that through community groups, especially women's groups, community good governance was increased significantly. Nabalarua (2005) emphasises how important emic, localised good governance is for Fiji, and for broader Pacific, in terms of stability and sustainability.

In Nadroumai, the NWC is a community-run group in which almost all women in Nadroumai are members of and engage regularly with. The group meet on average every fortnight to discuss issues or ideas across the community, such as infrastructure initiatives. Formally, the NWC is organised by an elected executive team (president, secretary and treasurer) who ensure the group's financial and social agendas are transparent and are adhered to. To ensure the group's financial permanency, the members donate $1 or a percentage of their income from picking wild coffee to the group each meeting. This revenue raised by the NWC has been responsible for key infrastructure upgrades in the community, such as retiling the community hall and getting water access to the village. The project team worked with the NWC to develop ideas for greater engagement for catchment reforestation, yet, also considering the constraints of time, availability and land tenure. In this context, the project team found a significant shortage of good quality seedlings to plant out agroforestry systems. As such, the project team proposed the establishment of a native tree seedling nursery situated within the Nadroumai village, on community title that could be managed by the NWC. Buchy and Rai (2008) discuss the role of forestry activities, especially involving women, in Nepal. They state that the commoditisation and marketisation of products within a women's group can pool together funds, which then can be used to develop community development projects or build essential infrastructures. This can enable women to be at the forefront of community decisions and have greater power over resources and control of monetary expenditure.

Developing a women's run nursery on community title addressed land tenure constraints for women to be engaged in reforestation, as planting trees is seen as a provocative statement of land ownership. Furthermore, this model also aligns with findings from Dr Vincent Lebot who has recommended that Melanesian women could play a key role in setting up nurseries, as they are argued to be more careful with propagation processes and seedling production than men, and therefore stand a better chance of producing healthy, quality seedlings compared to the current male dominated nurseries (Garae, 2018). Similarly, Cahn and Liu (2008) have also suggested that women in PNG are beginning to play an important role in commercial tree-crop agriculture, although men were still the major decision makers and controlling the marketing of these 'formal sector' crops (such as coffee, cocoa and oil palm). Yet, as women increasingly facilitate and engage in successful agricultural initiatives, their social and economic role in the community and broader society increase drastically (FAO, 2018). As such, informal, low-skilled and poorly paid labour markets that are largely represented by women can be mitigated and transformed to ensure representation, equal pay and security, and control over resources (FAO, 2018). Indeed, Akter, et al. (2017) argue that there is a direct link between women's empowerment in agriculture and food security. Moreover, Buchy and Rai (2008) argue that through women only organisations in forest management, such as nurseries, participating members feel a strong sense of pride and a significant increase in confidence, either in themselves or the community.

The NWC native tree nursery is a significant pathway for women's engagement in Fiji that has benefited the members and the whole community, through social and cultural cohesion, environmental understandings and financial gains. Guiding these group decisions is a nursery board of management, separate to the NWC's board. Alongside these positions, the women have access

and designated times to work in the nursery. Previous to the establishment of the NWC, the Nadroumai community had allocated Monday's as a 'community day', many of the women have opted for this to be the primary day of nursery participation and production. These activities enhance the women's knowledge of native trees, processes of seedling collection, storage and potting up, and watering. Indeed, these activities and skill building significantly enhance individual and community confidence and sense of belonging. Indeed, Cahn and Liu (2008) found that women who engage in training have considerable confidence in tree-crop agriculture. Building on this confidence, through appropriately designed training that responds to both community and women's needs, was considered paramount in increasing women's participation in tree crop agriculture.

The NWC native tree nursery is located centrally within the Nadroumai community, between the village and the river (used multiple times a day for washing, bathing and catching fish). Bunchy and Rai (2008) state that management of forestry resources, such as nurseries, should be placed in close proximity to the community as the participating members understand the landscape better and have an invested interest in maintaining the area. This is significant for engagement and trainings, as PHAMA (2018) recommends for nurseries to be strategically located in villages where women can receive specialised training on the practicalities of nurseries and small business management and support to establish nurseries to propagate and sell seedlings to farmers. As such, with support from the Department of Agriculture, Firewheel Rainforest Nursery Australia, ENVITE Australia and Live and Learn, Fiji, the project administrated numerous capacity building activities and training on establishing and maintaining a nursery. These topics covered: creating potting mix from materials found within the village, such as coconut husks, sand and gravel, and soil; seed collection from valuable trees found in the around Nadroumai village, such as Vutu and Breadfruit; raising and taking care of seedlings, for instance, watering and fertilizing; and small business management. These trainings and discussions enhanced the NWC's knowledge and hand's on experience in nursery management to expand and commoditise the cash crops.

With different projects on hand, the NWC, with support, has undertaken numerous plantings along the riverbanks which aimed to mitigate erosion and sedimentation. These plantings enabled the women to communally designate areas to plant along the river. They then clear the site, choose potted plants from the nursery that are mature enough, facilitate plant positioning (ensuring the plants are not too close together), plant and continue to water. These capacity building activities strengthen the women's engagement to mitigating environmental disasters, it also strengthens the women's communication as they voice their concerns and/or discuss the importance of the project with one another. Nabalarua (2005) suggest that women's groups in Fiji have the potential to generate powerful sustainable development initiatives and support the restructuring of gender-based roles.

Due to the success of the nursery and the women's involvement, the nursery has received significant attention from other institutions to undertake other plantings, or provide native plants, in the future. The project is now liaising with industry within the lower Nadroumai catchment and larger donor agencies to gain support for large scale catchment regeneration and to see an increase in local tree crops available for these resorts to purchase. Significantly, the government in Fiji have now expressed interest in expanding this model of women's run nurseries for catchment revegetation to other regions. With the increasing interest in the nursery and services, the NWC is becoming more financially stable. In January 2019, the NWC native tree nursery had approximately $1,000, with an annual turnover of $3000, which will be directed to community infrastructure projects; and the broader NWC had $428 in its bank account in January 2019.

The socialisation and engagement between the women, and the wider community, while working in the nursery displays meaningful engagement. Indeed, the activities that are performed within the nursery (potting up, watering, fertilizing etc.) are all done as a communal group, providing a sense of communal empowerment between the women as they collaborate as a team and share the work. In this context, for women to feel empowered, Mosedale (2005) argues that the project or institution cannot bestow it on them; in actual fact, the sense of empowerment must come from the women, empowering themselves. The NWC nursery provides land and resources for these women to develop themselves, creating a sense of ownership. As such, the current payment system for sales is largely communal; as plants cost $3, $2 of the $3 would be placed in the NWC to be evenly distributed, while the left over $1 would be added to the NWC account to fund infrastructure projects and other NWC needs. Indeed, when the women are engaged in the nursery, they participate in the activities together, unlike in other nurseries. As such, one woman does not pot up one tree, the whole

group are participating in one way or another, through picking seedlings, creating potting mix, potting, fertilizing and watering. This collaborative effort shines a light on the multidimensional impacts of this nursery as it strengthens valuable skills, community participation and economic collaboration.

With these community ties and agroforestry aspirations, Makim and Dart (2002, p. 84) discuss the nursery model creating a "partnership for development cooperation" in Solomon Islands. The NWC are taking advantage of these value chains through partnerships, and at the same time, are regenerating the catchment and riverbank areas to ensure future stability for their village and lower catchment areas. As rural households across Fiji have difficulty controlling capital flow (see Addinsall et al. 2015), the NWC native tree nursery ensures these women have control over their markets and cash economies. Indeed, as the women are at the forefront of production, maintenance and sales, they are in a position of central leadership and familial financial gains. At the same time, the nursery and surrounding area provides subsistence benefits for households to take advantage of. Indeed, the women have been inter-cropping vegetables, such as eggplant, to consume in the nursery area as well as in the planting sites. This increase in food security also provides the group with a greater motivation to maintain the sites, such as controlling the weeds and watering, as the immediate benefits of vegetables is gained. Indeed, the NWC native tree nursery enables multilayered socioeconomic opportunities as it continues to provide market and subsistence-based returns.

Research and development interventions through catchment revegetation and productive agroforestry systems in Melanesia should be approached with caution, as findings from this case study identify women's access to tree crops is restricted if there is any attempt to improve the trees such as pruning and fertilising or if the plantings are formalised in any way (e.g. improved germplasm, the development of plantations) as most produce picked by women in Melanesia is from wild tree crops or within their household gardens (Addinsall et al., 2018). Again, this leads back to the issue of policy, customary land laws and patrilineal and matrilineal systems. Through patrilineal succession property devolves through the male line where with matrilineal systems, property is traced through the mother's line, therefore often giving women greater rights than patrilineal systems (yet even through matrilineal system's land is still generally owned and controlled by men) (Cotula, 2006). Further where community agreement to support women in the agroforestry value chain is agreed to within the community, adequate business training and extension services must continue for women to maintain a position within the value chain.

In 2018, the NWC was granted land tenure to an area of forest located on the perimeter of the village. This site is significant for gender inclusion and equality as they have been able to create a permanent space and seek to revegetate the area through planting trees from the nursery, with the financial assistance from SPC. Alongside this, the NWC no longer has to rely on patrilineal land rights and systems for land tenure, creating a space of security and inclusion while validating their role in the club and community. This echoes significant studies (Anderson 2011; Meinzen-Dick et al., 1997; Lastarria-Cornhiel, 2007), demonstrating the importance of land rights for women in broader Melanesian society. In addition, this land provides legitimacy for the NWC to contribute to community decision making and planning, positioning the women in leadership roles (Carnegie et al., 2012).

As the nursery grows in stock, area and responsibility, the women have found themselves juggling their other household and community daily livelihood activities. To ensure an even cash-flow throughout the year, many women have diverse livelihoods and incomes in which they tend to daily. In addition, they also have gendered-role for subsistence gains or household 'chores'. These monetary incomes fluctuate with season and demand; however, due to the range of activities it ensures the women are constantly busy. These livelihood activities include: sewing and making pillow cases (generally for weddings) which take approximately one month to make, as they are commonly in sets of four, and cost $80 for a set of four, or $20-25 each; catching and selling prawns, fish and eels on the river (usually in the dry season), for 1-3 hours per day. On the same day, the women would then go to the market to sell, making approximately $40; and washing clothes in the river approximately once a day. These activities either provide immediate monetary or material gains and/or are gendered livelihood activities that the women priorities to fulfil their role in the household and community. Carnegie et al. (2012) discuss this further by stating that Melanesian women have limited time to fulfil these responsibilities, often sharing the load to ensure household duties are completed. In this context, it was initially difficult for the NWC to off-load or fast pace these activities in order to participate in the nursery. Furthermore, Akter, et al. (2017, p. 271) discuss the "unmanageable workload" women in rural developing areas face. As such, as the nursery did not

provide immediate monetary gains (as the plants need to grow to be sold or planted) the members initially sought to prioritise traditional small daily incomes to sustain their livelihoods. Yet, as the nursery expanded and their cash economies increased with greater interest from external stakeholders, the NWC members have a greater motivation and incentive to integrate nursery work into their livelihood routines. As Monday's have become a 'nursery designated' workday, the women are increasingly becoming more engaged with planting and maintenance. As such, the women are beginning to integrate nursery maintenance into their daily routines, instead of weekly. In doing so, the nursery has received an expansion in 2019 to house the booming stock.

The NWC nursery illustrates the potential for women to rehabilitate and mitigate sedimentation and erosion along the riverbanks, alongside gaining a lucrative income for familial and community growth. Indeed, the NWC's nursery has shown to enhance community understanding of women's social and economic importance in environmental governance and ecological trajectories. Although there were initial challenges of community productivity, motivation and income, the group have continued to engage and benefit from the initiative. They have completed more plantings along the river, as well as potted up hundreds of seedlings to be sold.

Case Study: Peer Female Farmer to Farmer Training, East Coast Santo, Vanuatu

This next case study presents a strategy for engaging rural women in agricultural capacity building and extension through a gender-sensitive training programme. The gender-sensitive training programme was developed from the findings of a gender livelihoods analysis conducted with 45 participating households in East Coast Santo, Vanuatu (Addinsall, Rihai & Nasse, 2019). Vanuatu has a total land area of 12,190 square km which is divided into six provinces (see table 1) and two urban centres. Luganville is the second largest urban centre and is located on Espiritu Santo in the SANMA province. Espiritu Santo (or Santo) is the nation's largest island with an area of 4248km2 and a population of approximately 47,899 in the northern part of the Vanuatu archipelago (VNSO, 2016). Importantly, rural agriculture is a critical livelihood activity for subsistence and market gains, as 73.4% of households across the SANMA province are engaged in formal or informal agriculture.

Haverhals et al., (2014, p. 4) found in their literature review on gender and agriculture that there is an "absence of gender disaggregated data on male and female activities" and a lack of monitoring of gender focused chain interventions with minimal baseline studies. Haverhals et al., (2014) put forward recommendations for future studies on gender and agricultural value chains to not just focus on women's involvement but to consider the impacts of interventions on both women and men and how they interact. The gender livelihoods analysis responds to the absence of gender disaggregated data by providing an understanding of the risks and vulnerability context that impacts on rural households, influencing structures and processes (such as societal norms, gender roles and relations, organisations and traditional policies), access to and control of resources, choice and success of livelihood activities, priorities for livelihood outcomes and the incentives that people respond to (Addinsall et al., 2019). This case study presents a gender strategy which is informed from the findings of the gender livelihoods analysis.

Findings from the gender livelihoods analysis, demonstrated women's daily activities almost double those of men. Female participants showed a high level of labour commitments in the informal economy such as: subsistence farming; household duties, such as washing or cleaning; community obligations and helping other women in the community with childcare. Findings also revealed that gender patterns of control over income were seen to be largely influenced by land tenure systems, the type of crops and characteristics of the households. Within some households, cash income 'belonged' to whoever produces the goods for sale, while other households, men controlled all household income. Men were predominantly seen to be the decision makers on the farm and within the household; although, a small number of female participants suggested they were able to make decisions about how income was spent that was directly earnt by them through their market gardens etc.

In Melanesia, women are predominately segregated into low-technology occupations and concentrated into certain phases of the supply chain, such as selling of produce at local markets, packaging, post processing which can limit the opportunities to gain new skills and capabilities (FAO, 2011). Women are also overrepresented in lower wage jobs and experience generally poorer labour standards. The combination of limited decision making within the household and lower access to

resources and household income can lead women to accept lower wages and conditions. While these pay segregations are common in Melanesia, there are new forms of organisation in agricultural supply chains for export-orientated crops and agro-processing which have wages that are typically higher and better working conditions than traditional agricultural employment (FAO, 2011). FAO (2011) associate the underperformance of the agricultural sector in many developing countries to the severe constraints women face in access to productive resources which in turn reduces their productivity. This is fuelled by the recognition of women's involvement in agriculture which sees women as: being the majority of all farmers in developing countries; having a longer work day then men, with many reaching their limits; harbouring specialised knowledge representing a highly skilled pool of labour in agriculture; contributing the most income to their household expenses and communities; productivity is severely constrained by the fragmentation of their time from competing responsibilities; becoming more responsible for households in rural areas as men leave for remunerated work. Similarly, for the health issues for both men and women.

Across Melanesia women are critical in achieving food security through their various roles throughout the agricultural value chain, "from production on the family plot, to food preparation, to distribution within the household" in addition to supply of produce to local markets (ADB, 2013, p. 8). Yet while women make up the bulk of labour in agricultural value chains, their roles are generally undervalued and constrained by a number of factors largely influenced by social norms and practices that determine the gendered division of labour. The underreporting of women's activities in agriculture is causing disagreements among scholars as to the extent of the feminization of agriculture (de Brauw et al., 2008; de Brauw et al., 2012; Chang, MacPhail, & Do, 2011; Mu, & van de Walle, 2011). This is due to the fact that women's activities are largely within the informal economy (traditional economy). To address this there needs to be recognition of women's contribution to the 'traditional economy'. Addinsall et al., (2015a) found that rural women in Vanuatu play a key role in maintaining traditional economic systems that were vital in reducing vulnerability, providing resilience (to disasters such as cyclones, droughts etc.) and supporting livelihoods, which is in line with research undertaken in Vanuatu and Solomon Islands by Feeny et al., (2013).

Gender differences in Vanuatu are evident when evaluating women's overall workloads, particularly in rural areas. Rural Ni Vanuatu women often pursue multiple livelihood strategies which are quite complex. The workload of Ni Vanuatu women is increasing with the need to find additional income, while women continue to maintain their traditional gendered responsibilities. While these traditional gendered responsibilities such as: producing agricultural crops for subsistence and markets; processing and preparing food; collecting fuel and water; caring for family members; maintaining houses etc. are not defined as economically active employment activities, they are regarded as essential to the well-being of households (Addinsall et al., 2015). Familial well-being is often fulfilled by the women of the household and as such are required to perform the majority of unpaid household duties, often restricting them in other livelihood activities.

Gender inequality with female smallholders in Melanesia results in a number of constraints to generating income from participating in the agricultural value chain. Women in Melanesia experience limited access to productive resources and the business knowledge and acumen to improve access (Chambers et al., 2012). Yet, Chambers et al., (2012) found empowering female smallholders as being one of the most effective ways to improve household livelihoods as women are more likely to invest additional resources (such as income and food) back into their families and communities. Findings from the gender livelihoods analysis showed that both male and female participants were unanimous in their preference for farmer to farmer information exchange over participating in workshops or training days at institutions. However, majority of the female participants suggested that due to cultural and custom considerations they would be more comfortable participating in training with women only. In fact, Buchy. And Rai (2008, p. 140) argues that these 'women-only' spaces "allow women to ascertain their power to act, mobilizing the power from within", especially in agricultural and forestry-management settings. Indeed, the sense of acceptance and comfortability that is created in these women's trainings is productive, empowering and collaborative (Buchy & Rai, 2008; Chambers et al., 2012). Indeed, these spaces allow for the rejection of patriarchal colonist domination that often influences community relations and systems, as the women are in charge of the trajectory.

Based on these findings the authors developed a gender-sensitive training programme grounded in the female farmer to farmer strengths-based and interactive training approach as a strategy to better

engage women in agriculture and build their capacity based on their priorities. The gender-sensitive training programme was based on the concept of women only 'storian sessions'. The central feature of 'storian' is relationship building between the members of the group which enables a collaborative environment to address the research problem (Warrick, 2009), and which is key to empowering communities (Beeton, 2006). This style of research is also known as 'Talanoa groups' in Fiji (Nabobo-Baba, 2008, p. 320). Storian sessions and Talanoa groups are seen as culturally appropriate Oceanic research methods. Nabobo (2008, p. 320) describe such methods as a movement towards decolonisation from "Western ideology of subjective empathy to an inter-subjective empathy". These storian sessions enabled female participants to express thoughts in a non-threatening way.

The gender-sensitive training programme was conducted with 6 female Ni Vanuatu farmers over 12 months, meeting once a month for half day meetings and lunch. The training used peer-to-peer, activity-based learning methods with no role for teachers, experts, or external consultants specialised in this skill area. Instead, participants worked together through a series of activities and discussions guided only by simple step-by-step instructions in the training manual. New knowledge, skills and competencies were developed through the interactions between participants and sharing of existing local knowledge and experience. In this way the programme is a low cost, sustainable option for any organization or community. Participants were trained in a participatory manner in topics that they had requested such as: agricultural/livestock extension; compost training; improved banking, saving and skills in financial management for agricultural/livestock; small business activities; increased capability to access micro-finance; and building gender inclusive decision-making capacity within the family and community.

While improved knowledge on these topics was important, the priority for the training was to increase female participants self-esteem to participate in household and community discussion making around the management of farm activities and finances. Part of this self-esteem building was based on the farmer to farmer information exchange with recipients of the gender-sensitive training programme facilitating the gender-sensitive training programme in neighbouring communities. This took place in October 2018 between 6 members of a women's group in East coast Santo and 14 female Ni Vanuatu farmers from Malo.

A mixed gender farmer to farmer training also took place in February 2019 with four Ni Vanuatu female farmers from the East Coast Santo group, three Ni Vanuatu female farmers from the Malo group and seven male farmers from East Coast Santo. The authors conducted an evaluation of the gender-sensitive training program conducted with women only present and mixed gender to provide a comparison. The evaluation of the female only training consisted of a structured quantitative survey, open structured questions and four storian sessions with 19 female Ni Vanuatu participants. The storian sessions were conducted in English and Bislama with the support from two Ni Vanuatu research assistants. An evaluation of the mixed gender training was conducted with both male and female participants. The evaluation consisted of a structured quantitative survey, open structured questions and four storian sessions with Ni Vanuatu female farmers. All questions presented in the quantitative survey were in Bislama.

Storian sessions with the female Ni Vanuatu participants uncovered a number of issues when comparing mixed gender to the female only training. Data from storian sessions found overwhelming sentiments that both the female participants and trainers preferred the female only training over mixed gender. There were comments made in regard to the overall reluctance to participate in discussions with men present such as:

"When it was just women in the training I enjoyed participating in discussions, asking questions and I wasn't very nervous when presenting, but with men present I didn't feel as confident".

This demonstrates the participation pull, as women feel more welcome, comfortable and less intimidated surrounded by other women in similar circumstances. Indeed, women feel more inclined to join these trainings if it is only women, unlike a mixed gender training which the men may *"take over"* or *"complain"* as one woman expressed:

"*During household level training or mixed gender training the men take over, they complain, they take charge and don't let the women contribute properly, it's better to have training with women only and allow us to gain the skills to feel confident in a group, then we have more confidence to speak at home in the household*".

Some female Ni Vanuatu participants suggested that due to custom obligations and an overall shyness to talk in public places having all women training enabled greater participation from the women. There were also comments made in regard to heightened intimidation to present and contribute in discussions due to well-established and respected male farmers being present in the training. When asked to explain the reasoning behind this, one female Ni Vanuatu participant commented that:

"the mixed gender training had some very well-respected male farmers, I felt like they didn't think they could learn anything from me when I presented and this made me feel intimidated".

Ni Vanuatu female participants in this project were particularly responsive to this model of horizontal sharing, suggesting it was less intimidating than top down conventional methods they had experienced in the past. One woman reported that:

"Teaching other women how to manage their household budgeting is the most important thing you can teach if you want them to improve their livelihoods, you can increase productivity but if are not managing the income properly it's just a waste. I've made lots of new connections with other women from this project, this makes me happy", alluding to the increase in financial control and household well-being through these trainings.

Participants also suggested how the gender sensitive training program had enabled them to have the confidence to approach their husbands about their spending and how they could manage their finances better.

"By keeping a record of my income and spending it helps as a supporting document to take to the bank to prove that I can manage money. By keeping a record, I can also take this to my husband and show him look you have overspent on kava, alcohol and cigarettes this month you need to cut down next month or we won't be able to pay school fees, he was so shocked, he said that he could have brought a boat for us with the amount he has spent on alcohol, kava and cigarettes."

This sense of empowerment and control in the household is essential for the representation and equality of women in the community and region. These women training sessions provide a space where women can openly communicate and discuss new ideas and avenues, for either the household or community, while getting the support and encouragement from other women.

As part of the ACIAR Project LPS/2014/037: *"Increasing the productivity and market options of smallholder beef cattle farmers in Vanuatu"* male project team members piloted a household farm productivity training package with a Ni Vanuatu female farmer (that had participated in the gender-sensitive training programme prior) and her husband. The authors conducted a storian session with the Ni Vanuatu female farmer after she has participated in the household level training. The female Ni Vanuatu farmer suggested:

"I would have felt scared to participate in the household training if I hadn't had all the training with the women first and taught the Malo women. My husband has actually been really happy about how much I've learnt".

She then went on to suggest:

"I know I'm a good strong farmer and I have lots of knowledge to share. If the project had of just worked with my husband to improve the fence, and pasture this would not have made big changes to our household, both my husband and I agree that the women's training group and storian sessions have made the biggest changes to our household".

A key finding from the evaluations conducted on the household level training found that mixed gender household level training will not engage Ni Vanuatu women in a meaningful way if they haven't first been empowered to feel confident and back up what they say, it is essential that this is done in a non-threatening environment.

Therefore, the key principles to the gender-sensitive training programme put forward in this case study are:

- Training in mixed gender groups or at the household level will not engage women if you haven't first empowered them to feel confident and back up what they say, this need to be done in a non-threatening environment.
- Don't make training too difficult! Build up the skills slowly, don't underestimate the power of

students teaching students, its builds self-esteem and enhances understanding of the subject.
- Care about women's needs not just project objectives, listen to them in the design of the training materials.
- Ensure training is family friendly and enables women to still meet their other livelihood priorities.

Discussion

This study sought to consider gender issues in agriculture in Melanesia, presenting case studies from Fiji and Vanuatu. Women in particular play a key role in traditional farming systems in Melanesia as they rely on produce for subsistence and sales from multiple food crops as their main income source and contribution to the household's wellbeing.

There are a number of factors attributing to the lack of engagement of women in rural research and development projects and the predominate failure of extension services to empower rural women. The current development agenda performed by many organisations may consider colonial, capitalist or gender-based prejudices, however do not adequately consider the intersections between these subjugations and the ways in which they impact rural indigenous women differently.

Firstly, globally there is a striking underrepresentation of female extension service agents and agricultural and forestry scientists (De Shutter, 2010). The evidence from the two case studies performed in the Melanesian context clearly highlights the significance of using female led research projects, workshops and information sessions on participation and subsequent results. When the workshops and organisations are led by women, there is an increased sense of confidence and self-esteem, as well as increased understanding and empathy. If Melanesian women do not see equal representation in the nation's leading these development project and research, how can they have faith in the messages and systems that are being encouraged and upheld? There is also an issue in recognising and allowing for the unique livelihoods and lifestyle of Melanesian women, resulting in some women being excluded from attending extension services run by men due to religious, social or cultural rules or they can just feel intimidated or uncomfortable to a group of male trainers and participants.

Secondly many research and development projects automatically assume that men are the only producers in the household and the sole decision makers. Failing to acknowledge that the needs and priorities of women may be different to men. While both groups are subject to colonial and capitalist pressures, the patriarchal element and gender-based experiences of these pressures and institutions vary between men and women. There is also an assumption that knowledge transmitted to men in research and development projects will automatically trickle down to women (ADB, 2013). Projects which are designed for and led by men will only serve to benefit men, something that this research has made evident. While when projects and trainings are designed for and led by women it has the capacity to benefit not only men as well as the women, but the community as a whole. This is a common problem in Melanesia as many research and development projects present gender issues regulated to chapters or sections in projects with little integration and fail to consider basic questions regarding resource use access for men and women, roles and constraints and how proposed interventions can address inequalities. Stephens (2004) highlights that many feminist strategists are in favour of mainstreaming women in all development projects over creating specific projects for empowering women. Cultural forces also impact on how information is received in the community or household as custom protocol in countries such as Vanuatu often see's key information exchange occur at the Nakamal with men only present (Addinsall et al., 2017).

Thirdly, time poverty experienced by many rural women in Melanesia, due to the many conflicting demands on their time, restricts attendance to training. Particularly if the training is for an extended amount of time, held during hours where women must attend to inflexible duties or there is considerable distance to be travelled to attend. Cahn (2008) found that training held in PNG by the United States Agency for International Development had a small representation of women attendees as it required travel and 3 days away from their households.

A fourth factor is the differences in institutional participation between men and women. For example, Addinsall et al., (2015a) found women in Vanuatu tend to be members of civic and religious groups

responsible for maintaining social networks, while men are more likely to be members of production groups responsible for income generation, such as cooperatives or producer organisations. These women's groups were the most effective institutions for providing for the community (either through community enhancement activities or by providing social safety nets in time of hardship) and improving wellbeing (Addinsall et al., 2015a). This highlights the importance of selecting the right avenues for channelling extension services such as the gender sensitive training program.

Finally, research, development and extension services need to consider gendered roles in agricultural value chains and acknowledge the constraints experienced by women and their priorities and perspectives. For example, due to land tenure systems in Melanesia women often only have access to informal agricultural systems (wild or home garden) to generate their personal income. Findings from the case studies presented found that once systems are formalised they are owned and controlled by men. Also, lower input agricultural crops that have specific fruiting periods and have value beyond the community are useful (such as nuts, coffee, cocoa) as this fits with available time resources of women. As many policy makers and agricultural development projects do not recognise the importance of the subsistence and informal sectors, much of the capacity building and training is targeted to the formal commercial sector where men dominate. Household prioritises also inhibit women from attending agricultural extension and training. These constraints for women to participate in capacity building limits their potential as economic agents (Koczberski, 2007; Manchón & Macleod, 2010; Live and Learn, 2010).

These case studies of female smallholders in Vanuatu and Fiji sought to respond to the differences in the literature concerning gendered nature of work in agricultural production (Cahn & Liu, 2008; Bourke & Harwood, 2009). Like, Mikhailovich et al., (2016) this study sought to understand the agricultural context that women in Melanesia operate in by gaining information on financial and business knowledge, practices and issues; and how culture, gender, family and regional factors impact on their economic development. The case studies considered gender relationships carefully taking a gender-inclusive approach to seeking to promote gender-equitable relationships and the importance of asset sharing. The findings showed that that while women smallholders are key to food production the clearly defined gender roles has led to a long tradition of agricultural extension/training benefiting men, while creating an 'invisible barrier' to women.

Access to credit and microfinance can protect households and empower women to establish small businesses, and cope with economic stress and shocks (Feeny et al., 2013). The access to financial resources can also help to get the best economic return from agricultural production by avoiding selling at low-price points such as when payment of school fees are due (Addinsall et al., 2015a). The gender sensitive training program put forward in the case studies showed a direct improvement in household budgeting and record keeping, providing the ability to plan savings for school fees, sell commodities at high times and have evidence of saving capability for financial institutions. Female strengths-based and interactive training has been a useful tool to further engage women by enabling women to recognise their existing skills and leadership roles they already have in the community and develop women's leadership teams. Building the self-esteem of rural women using methods such as the gender sensitive training program and female farmer to farmer storian sessions can then enable more complex and directed household level training to be more gender inclusive as women are more inclined to participate in that setting (Rosset et al., 2011).

Developing women's run nurseries incorporating high-value native tree species with subsistence gardens and cash cropping also presents an alternative that is compatible with traditional knowledge, can be inclusive of both male and female smallholders and, can enhance sustainable livelihoods and wellbeing over the long term (Addinsall et al., 2015b). One major barrier to upscaling tree crop production in Melanesia is the supply of high-quality seedlings/ grafted trees with known desirable traits. Nursery establishment in Melanesia is greatly needed and can provide a worthwhile livelihood opportunity for women within the agricultural value chain, as it does not necessarily require formal land tenure access to develop a nursery.

Conclusion

This paper outlines a practical and comprehensive strategy for the meaningful engagement of rural women in Melanesia. Meeting the Sustainable Development Goals must be approached from an intersectional perspective as the failure of achieving one impacts the ability and credibility to achieve the others, just as success within one goal relies on success in the others. 'Achieving gender equality and empowering women', can only be realised from gaining an increased understanding of gender relations and dynamics to uncover the complexity in which rural women operate, and by understanding and adapting the purpose and objective of projects to meet the needs of rural women.

It is necessary for these projects to consider the gendered elements of development, capitalism, colonialism and how the intersections between them create unique experiences for rural indigenous women. As demonstrated by the case studies in Fiji and Vanuatu, inclusion of women through solely meeting gender quotas and involving them in programs ultimately designed for men within a patriarchal structure is ineffective. Building the self-esteem of rural women using methods such as the gender sensitive training program and female farmer to farmer storian sessions can then enable more complex and directed household level training to be more gender inclusive as women are more inclined to participate, engage and respond in that setting. In order to achieve truly meaningful engagement that empowers these women and in turn the broader local community, there needs to be flexibility, understanding, adaptability and respect. As can be seen in both case studies, when projects and research evolve and accommodate the needs and experiences of indigenous women, they are more successful and have a greater influence on the confidence and self-esteem of participants. This pride and confidence facilitate an activation of indigenous women's knowledge and has the power to rejuvenate culture and custom. By considering these experiences in projects and research, a more inclusive, productive and culturally rich outcome will be achieved.

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11.10 Soil nutrient dynamics under agroforestry systems in Vanuatu

Activity 4.4

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September 2020

Soil Nutrient Dynamics Under Agroforestry Systems in Vanuatu

Acronyms and Abbreviations

Acronym / Abbreviation	Full Term
ACIAR	Australian Centre of International Agricultural Research
Al	Aluminium
B	Boron
BD	Bulk density
C; C%	Carbon; percent carbon
C/N ratio	Carbon to nitrogen ratio
Ca; Ca^{ex}	Calcium; exchangeable calcium
cm; cm^3	Centimetre; cubic centimetre
cmol+/kg	Centimoles of positive charge per kilogram
dS/cm	Decisiemens per metre
EAL	Environmental Analysis Laboratory (Lismore, Australia)
EC	Electrical conductivity
ECEC	Effective cation exchange capacity
Fe	Iron
g	Gram
H^+	Hydrogen ion
K; K^{ex}	Potassium; exchangeable potassium
K*sat*	Saturated permeability
m	Metres
Mg; Mg^{ex}	Magnesium; exchangeable magnesium
mg/kg	Milligrams per kilogram
N; N%	Nitrogen; percent nitrogen
Na; Na^{ex}	Sodium; exchangeable sodium
P; P^{Bray1}; $P^{Colwell}$;P^{Morgan}	Phosphorous; Phosphorous$^{Bray1\ /\ Colwell\ /\ Morgan}$
pH; pH_w	Potential of hydrogen; pH measured using a water suspension
S	Sulfur
Santo	The island of Espiritu Santo, Vanuatu
Si	Silicon

Executive Summary

Background

Traditional agroforestry systems continue to play a vital role in smallholder livelihoods in Vanuatu, and are key sources of nutrition, fuel, timber and other non-timber products to associated communities. These traditional systems rely on a fallow period at the end of a cultivation cycle to replenish soil fertility, whilst controlling crop pests and disease. Fallowing land is the primary means by which soil fertility is managed within these traditional systems and is essential to maintaining successive crop yields.

Vanuatu's forests have endured impacts from post-colonial logging and shifting agriculture, resulting in degraded forest landscapes and heavily depleted wild stands of timber.

Innovative agroforestry strategies that incorporate fast-growing and valuable native timber and food species have been proposed as culturally appropriate options to encourage both commercial and smallholder plantation timber enterprises. By incorporating these strategies into existing agroforestry systems, as either a managed fallow or by intercropping trees with food gardens, nutrient cycling may be enhanced, serving as a dual benefit to the development of forestry activities.

There is a need to understand the influence of these agroforestry systems on soil nutrient dynamics and whether these systems can contribute to improving soil fertility and catchment quality more broadly. The research herein provides an analysis of baseline soil data sampled from various agroforestry and traditional fallow regimes.

Methodology

Field measurements and soil sampling were conducted at five sites on Espiritu Santo (Santo), Vanuatu and adjoining areas of natural fallow, traditional gardens or pasture. The sites were either trials or agroforestry plantations established by ACIAR projects from 2007 onwards. Within these sites, various treatments were assigned based on site, location, age, and agroforestry/ agricultural regime.

Chemical, physical (bulk density and permeability) soil parameters were analysed at each site and treatment. Soil was described at each site. Notable characteristics for each site and individual plot/treatment were described during site visits, such as plant composition and arrangement, site history and spatial / topographical features. Chemical and physical data soil underwent statistical analysis to detect differences in parameters between sites and treatments.

Key Findings

Soils measured across all sites were relatively fertile within most key chemical variables, indicating that inherent soil fertility or replenishment is broadly adequate in these agroforestry and fallow treatments. However, all treatments / sites were inherently low in readily and slowly-available forms of phosphorous, whilst high in more recalcitrant forms of phosphorous. Further, bulk density was suboptimal in most soils, particularly those in pasture treatments, indicating the potential for inhibition of plant root growth, at least in surface soils.

At the site level, only marginal differences in soil fertility were observed between agroforestry treatments containing different stocking rates and species composition. Any significant differences between treatments observed are attributed primarily to the inherent variation in soils and or differences in historical land uses at the site level prior to the establishment of trees. The influence of agroforestry systems on soil fertility may be more discernible in the later stages of tree growth when litter accumulation and turnover is more advanced.

At this stage of establishment, soil fertility under agroforestry trials are comparable to more traditional fallows of similar age. It is expected that the uptake of different agroforestry and managed fallow prescriptions by smallholders and land managers will be driven primarily by livelihood opportunities over soil amelioration.

This study supports the feasibility of agroforestry strategies that combine short-term cropping and forestry activities, whilst encouraging the maturation of trees and concomitant replenishment of soils at a level comparable to traditional fallow systems.

Background

Traditional agroforestry systems continue to play a vital role in smallholder livelihoods in Vanuatu, and are key sources of nutrition, fuel, timber and other non-timber products to associated communities (Sardos et al., 2016). These traditional systems rely on a fallow period at the end of a cultivation cycle to replenish soil fertility, whilst controlling crop pests and disease (Harrison & Karim, 2016). Fallowing land is the primary means by which soil fertility is managed within these traditional systems and is essential to maintaining successive crop yields.

Increasing land scarcity and shifts from subsistence to cash crops in Vanuatu have shortened fallow cycles and subsequently diminished their function (Clarke & Thaman, 1997; O'Sullivan, 2010; Viranamangga & Vila, 2003). Declines in soil fertility, crop productivity and catchment quality (mainly due to increased erosion) have been observed as a result. This adds pressure to rural livelihoods that are reliant on subsistence and cash cropping activities, increases regional food insecurity and reduces the resilience of ecosystem services to support these communities.

Of further concern is the longevity of Vanuatu's forests and forestry industries, which have endured impacts from post-colonial logging and shifting agriculture, resulting in degraded forest landscapes and heavily depleted wild stands of timber (Page et al., 2012; Viranamangga & Vila, 2003).

Innovative agroforestry strategies that incorporate fast-growing and valuable native timber and food species have been proposed as culturally appropriate options to encourage both commercial and smallholder plantation timber enterprises (Addinsall et al., 2016). By incorporating these strategies into existing agroforestry systems, as either a managed fallow or by intercropping trees with food gardens, nutrient cycling may be enhanced, serving as a dual benefit to the development of forestry activities. The combining of agricultural and forestry activities into the same farming system would reduce the competition between these two land uses, both in terms of land area and the energy required to maintain these plots. The supply of fast and medium-term yielding subsistence and cash products in the initial and mid-stages of growth in these timber stands may encourage the prolongment of these managed fallow periods as timber trees are left in place to reach maturity and maximum value (Harrison & Karim, 2016). This may allow for more optimal soil replenishment to occur on smallholder land and increase the sustainability of successive crop cycles.

Currently, only limited research exists pertaining to nutrient dynamics within traditional and modified agroforestry systems in Vanuatu, and their potential to ameliorate soils. Currently there is a need to understand the influence of these agroforestry systems on soil nutrient dynamics and whether these systems can contribute to improving soil fertility and catchment quality more broadly.

As part of the ACIAR Project *FST/2014/067: Enhancing value added products and environmental benefits from agroforestry systems in the Pacific*, a number of agroforestry pilot sites have been established in Vanuatu (among other Pacific Island Nations) to develop and demonstrate these innovative agroforestry strategies. The research herein provides current baseline soil data for these pilot sites and compares soil nutrient dynamics between various agroforestry and other cropping/pasture systems.

Overview of traditional agroforestry in Vanuatu

Although various traditional cropping systems exist within Vanuatu, they can be broadly characterised as swidden agriculture. As a broad definition, an area of forest/bush is hand-cleared, and perennials, annuals and trees are intercropped together within temporally and spatially heterogeneous multi-storey gardens (Siméoni & Lebot, 2012). These gardens aim to maximise the provisioning of food, fuel, timber, medicine and culturally important products by promoting a range of growing conditions and mutualism between crops (Clarke & Thaman, 1997). These gardens are intensively cultivated for 1-3 years, with the most nutritious and culturally important foods—predominantly roots and tubers—being the pivotal crop. Following intensive cropping of annuals,

less pivotal residual crops including annuals, perennials and food trees (either planted or remaining after clearing) become the focus of production within these gardens (Weightman, 1989). During this time, the garden transitions slowly into a fallow period as pioneer forest species return, whilst a plot is cleared for successive food gardening cycles. (Clarke & Thaman, 1997). A typical garden life cycle—from clearing, to gardening, and to fallow—occurs over an 8-12-year period depending on the length of fallow depending on land availability and the requirements for food or cash (Siméoni & Lebot, 2012; Weightman, 1989). Within these systems, recently introduced and traditional crops have also been incorporated, primarily for cash, including, coconut, cattle, kava and cocoa (Lamanda et al., 2006; Weightman, 1989).

The influence of fallows on soil fertility

Soil fertility can be defined as the capacity for soils to support plant growth via the storage and transfer of nutrients and water, and by providing structural support to vegetation and resisting erosion (Stockdale et al., 2006). This can be further extended to consider soil at an ecosystem scale, in which soil not only supports human activities (notably agriculture and forestry), but also biodiversity, carbon and water cycles, and buffering against environmental change (Karlen et al., 1997).

Due to high rainfall, an abundance of sunlight and relatively young soils of volcanic origin, soils in Vanuatu are typically physically fertile and sustain highly productive agricultural systems. Traditional fallows still remain as the primary means by which soil fertility and crop disease and pests are controlled within these traditional systems (Siméoni & Lebot, 2012; Weightman, 1989). This occurs via the following mechanisms:

- Plant roots, invertebrates and soil microbes that populate fallowed land transport and cycle nutrients throughout the soil.
- Organic matter in the form of leaf and woody material are deposited above ground from vegetation.
- Rainfall dissolves and inputs water into soils containing soluble nutrients washed from the surface of plants and litter.
- The deposition and turnover of organic matter in soils help buffer pH, increases soil surface area, cation exchange capacity and further supports beneficial soil microbial populations.
- Where nitrogen (N) fixing plants are incorporated into fallows, their rhizobia capture atmospheric N in soils.
- Plant roots, fungal networks and organic matter that accumulate in fallowed soil improve the aggregation, mixing and porosity of soils. This reduces erosion and increases the uptake and retaining of soil water, gases and nutrients; and
- Land under fallow supports lower populations of crop pests and diseases and encourages a period of hiatus within pest and disease lifecycles.

Methodology

Field measurements and soil sampling were conducted at five sites on Santo that contained agroforestry plantations and adjoining areas of natural fallow or pasture.

Within these sites, various treatments were assigned based on site, location, age, and agroforestry/ agricultural regime. Table 11-1 provides further detail regarding each site used in the study.

Table 11-1. Summary of sites included in the study.

Site	Location	Established	Design*	Prior use	Site preparation
1 – Kelsai[ll]	Lorum	2014	RCB	Fallow	Hand cleared; burning of residue in gardens
2 - Jubilee gardens	Luganville	2008	None	Fallow	Hand clearing
3 - Jubilee mixed coconut	Luganville	2008	None	Coconut; cattle grazing	Hand clearing
4 - Trees and pasture	Luganville	2004	None	Pasture	Hand clearing in woodlot
5 – Lapita fallow	Luganville	n/a	None	Fallow (ongoing)	n/a

*RCB = Randomised complete block. Sites that are bolded represent ACIAR pilot / demonstration sites; Site 4 is a non-ACIAR trial site; Site 5 was soon to be established as an ACIAR pilot site at the time of writing.

The following soil and site parameters were assessed at each site, including:

Chemical parameters

- Topsoil was sampled to a depth of 10 cm in the rows and interrows of each treatment by taking auger cores from within a 1 metre quadrat. Where no rows were present (e.g., fallow and garden treatments) multiple samples were taken at randomly assigned locations within the treatment.
- Individual samples were air dried and subsequently tested at Environmental Analysis Laboratory (EAL), Southern Cross University, Australia for various chemical parameters (further discussed in Section 3 - Results).
- Excess chemical soil samples from each site (but not each treatment/replicate) were tested for allophane to determine any presence of Al and Fe hydroxides and indicate the soils broad capacity to adsorb phosphorus following the methods outlined in Fieldes & Perrot 1966.
- Chemical data was collected over three years (2014, 2015, and 2017) at Site 1 only.

Physical parameters

- Bulk density samples were taken for each treatment and plot/replicate close to chemical sampling points, but in undisturbed soil. Bulk density samples were air dried for three days at ambient temperature, after which subsamples were weighed and packaged for subsequent oven drying and final weighing.
- Saturated permeability tests were conducted within each treatment/replicate in undisturbed soil near to chemical sampling.
- Physical data was collected from all sites during 2017 only.

Notable characteristics for each site and individual plot/treatment were also described during site visits, such as plant composition and arrangement, site history and management, topography, location/elevation and coastal proximity. Soil was described at each site (profile, field texture and Munsell colour). Table 11-2 summarises the data collected per site per study year.

Statistical analysis (analysis of variance) of chemical and physical data was performed to detect differences in parameters between sites, treatments of soil chemical and physical parameters between sites and treatments, between years. Pairwise correlation and multiple regression analyses were used to investigate the relationship between notable chemical and physical parameters.

Table 11-2. Summary of treatments and data collected per site per study year.

Site	Treatment	Species*	Spacing (m)	Management	Measurements taken per study year**				
					2014	2015	2017		
					Che	Che	Che	BD	Perm
1	WW-Standard[a]	WW	6x8	Weeding conducted until canopy closure.	6	6	6	3	3
	WW-Standard[+PP]	WW and PP	3x8	Weeding conducted until canopy closure; pigeon pea was pruned in 2015 and used as mulch within plot.	6	6	6	3	3
	WW-High-density	WW	4x5	Weeding conducted until canopy closure.	6	6	6	3	3
	WW-Mix[a]	WW, NT and NM	6x8	Weeding conducted until canopy closure.	6	6	6	3	3
	Garden	Garden crops	Random	Initial crop cultivation in 2014-2015; plot returned to natural fallow with succession of pioneer plants, e.g. Hibiscus spp. and weedy vines.	6	6	6	3	3
	Fallow	Merremia, Hibiscus, Macaranga spp.	Random	Unmanaged; plots dominated by weeds	3	3	6	3	3
2	WW-Standard[b]	WW	6x8	Weeding conducted until canopy closure			4	2	2
	WW-Mix[b]	WW, NT and NM	6x8	Weeding conducted until canopy closure; sporadic harvest of NM at 5-7 years			4	2	1
	Pasture[a]	Pasture	Random	Sporadic cattle grazing			2	2	1
3	WW-Coco-Mix	WW, NT, NM and coconut	6x8	Weeding conducted until canopy closure; sporadic harvest of NM at 5-7 years			6	3	1
4	NT	NT	5x5	Weeding and gardening conducted until canopy closure; sporadic grazing around trees by cattle			3	3	3
	Pasture[b]	Pasture	Random	Cattle grazed			3	3	3
5	Fallow[b]	Merremia and Hibiscus	Random	Unmanaged; plots dominated by weeds			3	3	3

*WW=whitewood, PP=pigeon pea, NT=natapoa, NM=namamou. **C = chemical tests; BD = bulk density; Perm = permeability tests (conducted in 2014, 2015 or 2017.

Results

Soil Description - All Sites

Soils were described to a depth of 90 cm and broadly classified as Hapludalfs (USDA soil classification) (Soil Survey Staff - USDA, 2014).

Soils from study sites derive from volcanic ash over coral bedrock and well-drained. Topsoils, which had a depth of approx. 20-25 cm were very dark brown (7.5YR2.5/2) to (7.5YR2.5/3) light clay loam to silty clay loam with a strong fine granular structure. These graded into subsoils (depth: approx. 50-55cm) that were very dark brown (7.5YR2.5/3) to (7.5YR3/3) light clay to silty light medium clay with a blocky structure. Field textures found these soils to be clay loam to light medium clays, however, Grant et al. (2012) noted that soils at these sites are likely sub-plastic, and that clay content may be higher than indicated by field texture.

Soil Fertility in 2017 - All Sites

Key results from chemical and physical parameters tested at all sites in 2017 include:

- pH - soil pH ranged from being slightly acidic to neutral (ranging from 6.2-6.8).
- Percent carbon (C%) - all sites recorded extremely high C% (4.2-8.0%).
- Percent nitrogen (N%) and carbon/nitrogen ratio (C/N ratio) - N% ranged from high to very-high at all sites (0.4-0.8%) and C/N ratios were balanced.
- Phosphorous (P) - PBray1, which represents both soluble P (readily plant available) and sorbed P (poorly/slowly plant available) was low across all sites (2-10 mg/kg). PColwell, which represents the total pool of different P fractions (labile to recalcitrant P fractions) ranged from moderate to high across sites (12-50 mg/kg), except for Pasturea (Site 2) and Natapoa (Site 4), which were low.
- Electrical conductivity (EC) - slightly saline to moderate EC levels were recorded in all treatments (0.2-0.6 dS/m) in all Site 1 treatments when using a conversion factor for clay loam soils.
- Effective cation exchange capacity (ECEC) - ECEC was predominantly moderate across treatments (21-28 cmol+/kg). Exchangeable cations: calcium (Caex), magnesium (Mgex) and potassium (Kex) were high to very high.
- Bulk density (BD) - All treatments were rated as having bulk densities with the potential to inhibit root growth.
- Permeability (Ksat) - permeability tests were slow to moderate across most sites indicating slow water infiltration, except at Site 1 which recorded predominantly fast permeability rates in WW and Garden treatments.
- Allophane tests found that all sites had a moderate response to the test indicating the presence of allophane and P-binding capacity that was similar across sites (rating scale: nil, weak, moderate and strong).

The results of key chemical and physical tests are shown in

Table 11-3. The fertility status of each treatment is shown in Table 11-4.

Table 11-3. Summary of results of chemical and physical tests for each site and treatment. Results are the mean of replicates ± (standard deviation). Highest values are bolded and coloured in dark grey.

Year	Site	Treatment	Age	n	pH_{water}	Bulk dens. (g/cm^3)	Ksat (mm/h)	Total C (%)	Total N (%)	C/N (ratio)	P^{Bray1} (mg/kg)	EC (dS/m)	ECEC
2014	1	WW-Stand[a]	3	6	6.7 (0.1)	*Not measured in 2015 and 2015*		6.6 (0.2)	0.69 (0.01)	9.6 (0.2)	7.5 (2.4)	0.23 (0.03)	24.2 (1.6)
		WW-Stand[+PP]	3	6	6.7 (0.4)			6.7 (0.6)	0.70 (0.05)	9.6 (0.3)	7.3 (1.4)	0.22 (0.03)	24.2 (5.5)
		WW-High Dens.	3	6	6.6 (0.1)			6.3 (0.5)	0.66 (0.05)	9.5 (0.2)	6.9 (2.8)	0.21 (0.03)	22.7 (2.8)
		WW-Mix[a]	3	6	6.5 (0.2)			6.7 (0.5)	0.71 (0.04)	9.4 (0.2)	10.1 (6.4)	0.22 (0.02)	23.4 (5.2)
		Garden	3	6	6.8 (0.2)			7.4 (1.0)	0.76 (0.09)	9.8 (0.3)	9.2 (1.9)	0.24 (0.04)	25.3 (2.2)
		Fallow[a]	3	5	6.4 (0.2)			6.3 (0.5)	0.65 (0.04)	9.7 (0.2)	8.6 (4.2)	0.18 (0.02)	22.1 (1.5)
2015	1	WW-Stand[a]	3	6	6.5 (0.2)	*Not measured in 2015 and 2015*		6.8 (0.7)	0.69 (0.06)	9.9 (0.4)	5.1 (0.4)	0.30 (0.06)	22.9 (3)
		WW-Stand[+PP]	3	6	6.6 (0.1)			7.1 (0.5)	0.72 (0.05)	9.9 (0.2)	5.2 (0.9)	0.33 (0.08)	24.4 (1.9)
		WW-High Dens.	3	6	6.6 (0.3)			7.8 (1.3)	0.77 (0.09)	10.1 (0.6)	7.3 (3.3)	0.34 (0.05)	26.8 (5.6)
		WW-Mix[a]	3	6	6.5 (0.2)			7.6 (0.8)	0.75 (0.08)	10.0 (0.2)	6.0 (3.1)	0.31 (0.06)	24.8 (4.0)
		Garden	3	6	6.5 (0.2)			6.8 (0.6)	0.69 (0.03)	9.8 (0.4)	6.5 (3.4)	0.25 (0.02)	23.6 (3.0)
		Fallow[a]	3	5	6.6 (0.1)			8.0 (0.5)	0.78 (0.07)	10.2 (0.4)	7.7 (2.9)	0.44 (0.08)	28.6 (0.9)
2017	1	WW-Stand[a]	3	6	6.5 (0.1)	1.68 (0.02)	20 (26)	6.7 (0.6)	0.67 (0.04)	9.6 (0.3)	2.9 (0.5)	0.25 (0.02)	23.8 (4.4)
		WW-Stand[+PP]	3	6	6.6 (0.4)	1.71 (0.08)	45 (45)	6.5 (0.9)	0.65 (0.07)	9.8 (1.3)	3.5 (1.9)	0.24 (0.04)	25.4 (4.1)
		WW-High Dens.	3	6	6.5 (0.2)	1.67 (0.05)	32 (26)	6.3 (0.4)	0.65 (0.04)	9.6 (0.4)	3.1 (0.3)	0.23 (0.02)	22.4 (3.9)
		WW-Mix[a]	3	6	6.4 (0.1)	1.54 (0.21)	28 (19)	6.2 (0.6)	0.64 (0.06)	9.9 (0.4)	2.9 (0.7)	0.22 (0.04)	24.7 (3.2)
		Garden	3	6	6.5 (0.3)	1.65 (0.10)	22 (20)	6.8 (0.9)	0.70 (0.08)	9.9 (0.4)	3.7 (1.8)	0.25 (0.06)	21.4 (6.1)
		Fallow[a]	3	5	6.5 (0.1)	1.59 (0.10)	1.3 (0.6)	6.6 (0.5)	0.67 (0.04)	9.8 (0.4)	3.1 (1.0)	0.24 (0.02)	25.0 (4.0)
2017	2	WW-Stand[b]	10	4	6.7 (0.2)	1.77 (0.13)	19 (7)	4.2 (0.3)	0.40 (0.05)	9.7 (0.4)	1.8 (0.7)	0.25 (0.02)	22.9 (4.9)
		WW-Mix[b]	10	4	6.6 (0.2)	1.81 (0.01)	12 (1 meas.)	4.2 (0.8)	0.41 (0.1)	9.5 (1.0)	2.1 (0.4)	0.24 (0.03)	22.9 (4.3)
		Pasture[a]	0		6.5 (0.3)	2.04 (0.19)	6 (1 meas.)	5.0 (1.1)	0.53 (0.14)	9.6 (0.5)	1.9 (0.1)	0.24 (0.04)	24.8 (4)
	3	WW-Coco-Mix	10	5	6.2 (0.2)	1.81 (0.05)	3 (1 meas.)	4.6 (0.3)	0.48 (0.08)	10.2 (0.7)	3.0 (2.1)	0.22 (0.03)	22.2 (2.6)
	4	Natapoa	14	3	6.5 (0.2)	1.86 (0.03)	3 (1)	5.9 (0.3)	0.57 (0.04)	9.8 (0.1)	2.2 (0.3)	0.32 (0.02)	24.7 (3.7)
		Pasture[b]	0	3	6.2 (<.1)	2.08 (0.10)	4 (4)	5.4 (0.1)	0.59 (0.06)	9.7 (0.4)	1.6 (0.4)	0.60 (*0.63*)	20.9 (5.4)
	5	Fallow[b]	3	3	6.5 (0.1)	1.73 (0.03)	15 (11)	5.0 (0.9)	0.54 (0.09)	9.7 (0.2)	3.9 (1.4)	0.26 (0.05)	27.0 (8.9)

Year	Site	Treatment	Ca^{aae} ($cmol^+/kg$)	Mg^{aae} ($cmol^+/kg$)	K^{aae} ($cmol^+/kg$)	Na ($cmol^+/kg$)	Al ($cmol^+/kg$)	H ($cmol^+/kg$)	$Ca/Mg^{\%BS}$ (ratio)	$Mg/K^{\%BS}$ (ratio)	$Ca/K^{\%BS}$ (ratio)
2014	1	WW-Stand[a]	17.8 (1.4)	4.1 (0.3)	2.0 (0.4)	0.21 (0.02)	0.018 (0.01)	0.013 (0.031)	4.4 (0.4)	2.1 (0.4)	9.1 (1.9)
		WW-Stand[+PP]	18.1 (4.7)	4.0 (0.2)	1.9 (0.9)	0.21 (0.04)	0.019 (0.01)	0.031 (0.048)	4.5 (0.9)	2.6 (1.3)	11.2 (5.2)
		WW-High Dens.	17.1 (2.7)	3.7 (0.6)	1.6 (0.5)	0.26 (0.04)	0.020 (0.007)	0.012 (0.03)	4.6 (0.5)	2.6 (1.2)	12.5 (7.0)
		WW-Mix[a]	18.2 (4.7)	3.4 (0.2)	1.4 (0.5)	0.24 (0.03)	0.025 (0.013)	0.040 (0.047)	5.4 (1.4)	2.7 (1.0)	13.3 (2.6)
		Garden	18.6 (2.6)	4.3 (0.5)	2.2 (1.0)	0.22 (0.04)	0.015 (0.01)	0.008 (0.02)	4.4 (0.9)	2.6 (1.5)	12.3 (9.7)
		Fallow[a]	16.5 (1.5)	4.0 (0.5)	1.3 (0.2)	0.28 (0.01)	0.024 (0.013)	0.046 (0.042)	4.2 (0.5)	3.2 (0.7)	13.2 (3.0)
2015	1	WW-Stand[a]	17.6 (2.6)	3.8 (0.4)	1.2 (0.2)	0.25 (0.02)	0.035 (0.008)	0.023 (0.025)	4.7 (0.4)	3.1 (0.5)	14.6 (2.7)
		WW-Stand[+PP]	18.1 (2.3)	4.1 (0.6)	1.8 (0.3)	0.24 (0.02)	0.036 (0.005)	0.01 (0.025)	4.5 (1.2)	2.3 (0.4)	10.3 (2.2)
		WW-High Dens.	20.2 (5.1)	4.2 (0.6)	2.1 (0.3)	0.23 (0.02)	0.030 (0.004)	0.023 (0.035)	4.7 (0.9)	2.0 (0.3)	9.8 (2.6)
		WW-Mix[a]	19.0 (3.6)	4.2 (0.5)	1.2 (0.2)	0.28 (0.03)	0.038 (0.004)	0.028 (0.031)	4.5 (0.5)	3.5 (0.7)	15.8 (4.2)
		Garden	18.2 (2.3)	3.7 (0.6)	1.4 (0.4)	0.24 (0.03)	0.031 (0.006)	0.028 (0.031)	5.0 (0.3)	2.7 (0.7)	13.4 (3.6)
		Fallow[a]	21.5 (0.9)	5.0 (0.9)	1.9 (0.6)	0.27 (0.01)	0.034 (0.007)	0.018 (0.031)	4.4 (0.7)	3.0 (1.7)	12.7 (5.1)
2017	1	WW-Stand[a]	19.0 (2.7)	3.8 (0.4)	1.7 (0.5)	0.20 (0.04)	0.017 (0.002)	0.034 (0.054)	5.0 (0.8)	2.9 (1.4)	14.1 (6.2)
		WW-Stand[+PP]	17.9 (3.9)	4.3 (0.9)	2.2 (0.6)	0.16 (0.03)	0.024 (0.010)	0.034 (0.041)	4.7 (0.7)	2.5 (1.2)	11.6 (4.8)
		WW-High Dens.	18.8 (3.3)	4.1 (0.5)	2.4 (0.5)	0.17 (0.02)	0.019 (0.004)	0.063 (0.049)	4.6 (0.7)	3.1 (1.4)	13.8 (5.4)
		WW-Mix[a]	17.9 (3.4)	3.6 (0.5)	1.3 (0.4)	0.21 (0.04)	0.017 (0.004)	0.044 (0.049)	4.7 (0.6)	2.5 (1.1)	12.2 (7.0)
		Garden	20.2 (4.6)	3.7 (0.9)	1.4 (0.8)	0.21 (0.02)	0.020 (0.004)	0.064 (0.050)	4.3 (1.1)	3.1 (1.8)	12.6 (5.8)
		Fallow[a]	20.3 (3.9)	4.2 (0.3)	1.3 (0.6)	0.28 (0.08)	0.017 (0.002)	0.085 (0.049)	4.6 (0.5)	1.8 (0.9)	8.7 (5.1)
2017	2	WW-Stand[b]	17.2 (2.2)	3.9 (0.4)	2.7 (0.4)	0.23 (0.03)	0.020 (0.006)	0.074 (0.051)	5.3 (1.0)	3.7 (1.0)	19.1 (5.3)
		WW-Mix[b]	18.1 (2.6)	3.4 (0.3)	2.7 (0.5)	0.21 (0.03)	0.023 (0.003)	0.070 (0.082)	4.9 (0.8)	3.0 (3.8)	14.6 (17.7)
		Pasture[a]	19.7 (4.3)	3.2 (0.3)	1.7 (0.6)	0.24 (0.03)	0.023 (0.001)	0.025 (0.035)	6.1 (0.7)	2.1 (0.9)	12.9 (7.0)
	3	WW-Coco-Mix	12.3 (2)	3.5 (0.5)	1.1 (0.9)	0.34 (0.05)	0.021 (0.002)	0.036 (0.035)	4.5 (1.0)	2.9 (3.2)	11.7 (11.4)
	4	Natapoa	16.8 (1.6)	4.0 (0.7)	1.5 (0.7)	0.28 (0.08)	0.020 (0.005)	0.062 (0.054)	5.0 (0.5)	2.7 (1.5)	13.7 (8.8)
		Pasture[b]	13.5 (0.3)	3.1 (0.2)	2.2 (2.9)	0.27 (0.04)	0.019 (0.002)	0.058 (0.052)	4.0 (0.7)	3.6 (1.6)	13.6 (4.3)
	5	Fallow[b]	14.8 (2.7)	3.1 (0.5)	2.4 (0.5)	0.13 (0.01)	0.020 (0.007)	0.065 (0.058)	5.3 (0.4)	1.8 (0.7)	9.7 (4.2)

Table 11-4. Means of measurements within treatments converted to soil fertility ratings based on Webster (2007); rating key is shown below.

Site	Treatment	pH_w	C%	N%	C/N	P-B1	P-Col	EC	ECEC	Ca^{ex}	Mg^{ex}	K^{ex}	Na^{ex}	Ca/Mg^{ex}	BD	Ksat
1	WW-Stand[a]	Sl-acid	Extremely high	V-Hi	Balanced	Low	Hi	Slightly saline	Mod	Hi	High	Hi	Low	Bal.	Potentially critical	Mod
	WW-Stand[a+PP]	Neutral		V-Hi			Mod		High	Hi		V-Hi	Low	Bal.		Fast
	WW-Hi. Dens.	Sl-acid		V-Hi			Hi		Mod	Hi		V-Hi	Low	Bal.		Fast
	WW-Mix[a]	Sl-acid		V-Hi			Mod		Mod	Hi		Hi	Low	Bal.		Fast
	Garden	Sl-acid		V-Hi			Hi		Mod	V- Hi		Hi	Low	Bal.		Fast
	Fallow[a]	Sl-acid		V-Hi			Hi		High	V-Hi		Hi	Low	Bal.		Slow
2	WW-Stand[b]	Neutral		Hi			Mod		Mod	Hi		V-Hi	Low	Bal.		Mod
	WW-Mix[b]	Neutral		Hi			Hi		Mod	Hi		V-Hi	Low	Bal.		Mod
	Pasture[a]	Sl-acid		V-Hi			Low		Mod	Hi		Hi	Low	-Mg		Mod
3	WW-Coco-Mix	Sl-acid		Hi			Hi		Mod	Hi		Hi	Mod	Bal.		Slow
4	Natapoa	Sl-acid		V-Hi			Low		Mod	Hi		Hi	Low	Bal.		Slow
	Pasture[b]	Sl-acid		V-Hi			Mod		Mod	Hi		V-Hi	Low	Bal.		Slow
5	Fallow[b]	Sl-acid		V-Hi			Mod		High	Hi		V-Hi	Low	Bal.		Mod

pH_w: Strongly acid = 5.1-5.5; Moderately acid = 5.6-6.0; Slightly acid = 6.1-6.5; Neutral = 6.6-7.3; Mildly alkaline = 7.4-7.8; Strongly alkaline = 8.5-9.0.

C% Low to moderate = 0.6-1.59; Moderate to high = 1.59 - 1.99; Very high = 2.00 - 2.99; Extremely high = 3.0 - 8.7; Organic soil material = >8.7.

N% Very low = 0.05-0.15; low = 0.15-0.25; medium = 0.15-0.25; high = 0.25-0.50; very high = >0.5.

C/N Decomposition can proceed at max rate = <25; Decomposition will slow unless N is increased/ N unavailable for crops = >25.

P-Bray1 Low = 0-10; Medium = 10-20; High = >20 (mg/kg).

P-Colwell Low = 0-18; Medium = 18-40; High = >40. (P-Olsen: Low = 0-9; Medium =9-24; High = >24)

EC Non-saline = <2; slightly saline = 2-4; moderately saline = 4-8; highly saline = 8-16; extremely saline = >16. Converted using clay loam factor (EC x 8.6) (dS/m)

ECEC Very low = <6; low = 6-12; moderate = 12-25; high = 25-40; very high = >40.

Ca Very low = 0-2; low = 2-5; moderate = 5-10; high = 10-20; very high = >20. ($cmol^+/kg$)

Mg Very low = 0-0.3; low = 0.3-1; moderate = 1-3; high = 3-8; very high = >8. ($cmol^+/kg$)

K Very low = 0-0.2; low = 0.2-0.3; moderate = 0.3-0.7; high = 0.7-2; very high = >2. ($cmol^+/kg$)

Na Very low = 0-0.1; low = 0.1-0.3; moderate = 0.3-0.7; high = 0.7-2; very high = >2. ($cmol^+/kg$)

Ca/Mg Ca deficient = <1; Ca low = 1-4; balanced = 4-6; Mg low = 6-10; Mg deficient = >10. ($cmol^+/kg$)

Ksat Ksat: in mm/h (Slow = 2.5-5; Moderate = 5-20; Rapid = 20-70). (mm/h)

BD Potentially critical (Pot. Crit.)value/root growth is impeded = <1.4; normal agricultural soil = 1.6. (g/cm^3)

(ex) = exchangeable cations from ammonium acetate extraction

Soil fertility over time at Site 1

Time series data for recorded during 2014, 2015 and 2017 were collected at Site 1 corresponding to the first, second and fourth year of the Site's establishment.

All treatments at Site 1 recorded a significant change in at least one chemical parameter during this period, namely C%, N%, EC, P^{Bray1}. The mean of variables: pH, ECEC, Ca, K, and H, recorded negligible change in all treatment from 2014 to 2017. WW-High-density recorded the most significant change with increases from 2014 to 2015 occurring in C% (+24%), N% (+17%), EC (+62%), and Mg^{ex} (-14%). No other treatments recorded significant changes in N%.

WW-Mixed[a] treatments also recorded an increase from 2014 to 2015 in EC (+41%) and Mg^{ex} (+24%), but a decrease in C% from 2015 to 2017 (-18%). Similarly, the Fallow treatment at Site 1 recorded a significant and notable increase in EC (+244%) from 2014 to 2015.

Most notably, phosphorous (P^{Bray1}) significantly decreased between 2014 sequentially through to 2017 within WW-Standard[a] (-61%), WW-Standard^{+PP} (-60%), and Garden treatments (-60%) as shown in Figure 11-6. This decrease was not significant in WW-High-density, WW-Mix, and Fallow treatments. P-Morgan and P-Colwell were not measured in 2014 and 2015, so it is unclear whether decreases in these other P fractions occurred also.

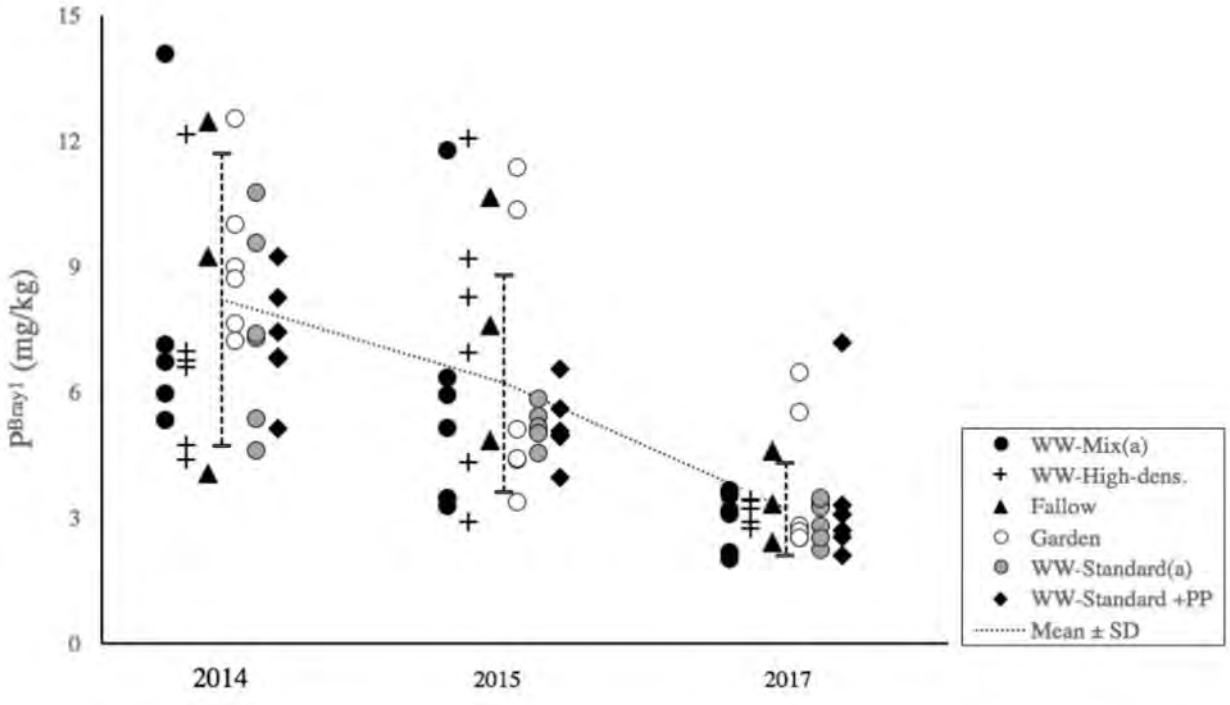

Figure 11-6. P-Bray1 measured at Site 1 in 2014, 2015 and 2017. The mean and standard deviation (error bars) are from the aggregated data to show broad change over time. Each observation is shown. N = 33.

Discussion

Fertility status - Comparing sites and treatments - 2017

Chemical fertility

Soils measured across all sites in 2017, including those under pasture, were relatively fertile within most key chemical variables, indicating that inherent soil fertility or replenishment is currently adequate in these fertility indicators, namely C%, N%, and exchangeable Ca, Mg and K.

At this stage of establishment, soil fertility under agroforestry trials are comparable to more traditional fallows. Low levels of readily and slowly (plant) available forms of phosphorous were detected within all sites and treatments. Soils that are largely of volcanic origin, such as those in this study, commonly contain allophanic minerals. It is likely these allophanic minerals are immobilising labile phosphorous into unavailable forms. This is supported by the results of allophane tests and the relatively high levels of PColwell, which comprises mainly unavailable P fractions.

Site 1 was indicated to be of higher fertility status compared to other sites. This is likely due to the underlying soil properties and differences in previous management between sites, more so than the current agroforestry/agricultural regimes that are present in each plot. Negligible differences in key fertility indicators: C%, N%, and exchangeable Ca, Mg and K were visible between treatments of the same site.

Fallow and garden treatments were similar in fertility status to nearby agroforestry plots at Site 1, indicating similar nutrient dynamics and requirements across tree, fallow and garden treatments, at least in the early stages of establishment. It is likely that given the recent establishment of Site 1 (3 years) differences in nutrient uptake and turnover, as influenced by the different treatments, is not clearly discernible.

Physical fertility

Bulk density measured in all treatments were suboptimal, indicating the presence of compacted soils and the potential for the inhibition of root growth. However, as only field texture was obtained in the study, actual clay content in these soils may be higher than estimated, which could explain the higher bulk density and potentially mean that these samples should be assigned a higher bulk density threshold rating for optimum plant growth.

Bulk density in pasture treatments was markedly higher than that of adjacent tree treatments, indicating that the presence of trees, and or, the exclusion of cattle can improve the physical structure of soils. However, negligible differences were detected in the nutrient status between pasture and adjacent tree plots at the site level. As such, low stocking of livestock under established trees may be a suitable multi-land use coupled with agroforestry as livestock can help to control weeds and provide additional and diversified livelihood sources for smallholders. The risk of compaction would need to be balanced by the benefits of this coupled land use.

Saturated permeability was moderate to fast in most treatments. Sites 3 and 4 were particularly slow, likely owing to the current or previous grazing of cattle on these plots leading to compacted soils, as typically, similar soils in the region are well-draining. Some saturated permeability rates measured in this study were visibly influenced by the presence of a large rock, buried woody material or a hole in the soil. It is likely that saturated permeability was not a suitably accurate test to characterise the physical fertility of soils in this study given the high rate of erroneous data than can occur.

Changes in soil fertility over time at Site 1

The underlying mechanisms influencing the variation in nutrient levels recorded during each year's measurement at Site 1 are unclear. However, this variation is likely due, in part, to the differences in the density and composition of vegetation, as well as differences in management practices during early establishment, e.g. the WW-Standard^{+PP} treatment included an initial cover crop of pigeon pea, which was subsequently harvested in 2015 and used as mulch in rows.

The clear trend in reducing P^{Bray1} also does not show a clear pattern among treatments and can broadly be seen as an effect at the site level, likely due to seasonality. Samples from 2014 and 2015 were taken in later months further from the rainy season compared to 2017. During the rainy season, turnover rate of residues can decrease whilst leaching of soluble nutrients (notably K, N) typically increases in soils. In any case, nutrient flux in sites with pioneer trees is expected to be dynamic with a closer to steady-state likely only reached in later stages of tree growth when litter deposition/decomposition is more stable and advanced, and when canopy capture is achieved.

Summary of findings and broader implications

The key findings and broader implications of this study are as follows:

- Soils measured across all sites in 2017, were relatively fertile within most key chemical variables.
- Detectable differences between treatments appeared to be largely driven by inherent differences in soils between sites or the uniform management histories shared at the site level prior to the establishment of trees.
- Soils in the study area were indicated to be inherently low in readily and slowly-available forms of phosphorous whilst high in more recalcitrant forms of phosphorous. Broader declines observed over time at Site 1 are likely the result of seasonal influences on phosphorous, with high leaching expected during the rainy season.
- Bulk density was suboptimal in most soils, particularly those in pasture treatments, indicating the potential for inhibition of plant root growth, at least in surface soils.
- Negligible differences were detected in the nutrient status between pasture and adjacent tree plots at the site level. As such, low stocking of livestock under established trees may be suitably incorporated into agroforestry plots provided over-compaction does not occur. This would deliver additional livelihood benefits for smallholders.
- Marginal differences in soil fertility were observed between agroforestry treatments containing different stocking rates and species composition. The influence of agroforestry systems on soil fertility may be more discernible in the later stages of tree growth when litter accumulation and turnover is more advanced.
- At this stage of establishment, soil fertility under agroforestry trials are comparable to more traditional fallows of similar age.
- This study supports the feasibility of agroforestry strategies that combine short-term cropping and forestry activities, whilst encouraging the maturation of trees and concomitant replenishment of soils at a level comparable to traditional fallow systems.
- It is expected that the uptake of different agroforestry and managed fallow prescriptions by smallholders and land managers will be driven primarily by livelihood opportunities over soil amelioration.

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Supplementary Information A: Additional results from laboratory chemical analyses.

Year	Site	Treatment	P^{Morgan} (mg/kg)	$P^{Colwell}$ (mg/kg)	S (mg/kg)	Zn (mg/kg)	Mn mg/kg)	Fe (mg/kg)	Cu (mg/kg)	B (mg/kg)	Si (mg/kg)
2014	1					*Not measured in 2015 and 2015*					
2015	1					*Not measured in 2015 and 2015*					
2017	1	WW-Stand[(a)]	2.8 (0.3)	40 (7)	46 (7)	3.0 (0.7)	181 (29)	30 (4)	11.3 (1.5)	0.35 (0.02)	12 (3)
		WW-Stand[(+PP)]	2.6 (0.4)	32 (9)	49 (14)	4.3 (1.3)	193 (47)	28 (7)	11.0 (2.7)	0.37 (0.14)	19 (10)
		WW-High Dens.	2.6 (0.3)	45 (13)	43 (3)	3.1 (0.8)	179 (15)	28 (8)	10.6 (0.7)	0.33 (0.13)	16 (7)
		WW-Mix[(a)]	2.6 (0.6)	36 (15)	46 (13)	3.0 (0.9)	188 (34)	30 (5)	10.2 (0.7)	0.33 (0.09)	15 (8)
		Garden	2.9 (0.8)	48 (29)	48 (9)	4.0 (1.4)	170 (50)	31 (5)	10.6 (2.7)	0.33 (0.11)	14 (4)
		Fallow[(a)]	2.7 (0.5)	41 (19)	43 (11)	3.8 (1.5)	189 (26)	26 (9)	12.1 (2.2)	0.34 (0.08)	16 (6)
2017	2	WW-Stand[(b)]	1.8 (0.4)	39 (9)	37 (8)	3.6 (1.6)	186 (36)	29 (7)	10.4 (0.4)	0.35 (0.09)	21 (6)
		WW-Mix[(b)]	1.9 (0.3)	46 (7)	37 (11)	5.2 (1.8)	186 (31)	21 (3)	10.7 (1.1)	0.42 (0.18)	29 (3)
		Pasture[(a)]	1.8 (0.2)	12 (2)	82 (59)	5.1 (2.5)	198 (4)	22 (3)	9.8 (0.4)	0.55 (0.18)	32 (3)
	3	WW-Coco-Mix	1.7 (0.1)	50 (7)	54 (14)	4.6 (1.4)	161 (12)	21 (1)	10.7 (1.6)	0.28 (0.06)	25 (3)
	4	Natapoa	2.2 (0.1)	12 (3)	55 (11)	3.2 (1.4)	194 (8)	34 (3)	11.8 (2.3)	0.37 (0.08)	12 (2)
		Pasture[(b)]	2.3 (0.4)	26 (0)	42 (18)	4.4 (1.4)	183 (46)	22 (1)	9.6 (1.7)	0.24 (0.01)	24 (4)
	5	Fallow[(b)]	1.8 (<0.1)	35 (32)	54 (5)	5.1 (2.6)	207 (65)	28 (8)	10.9 (2.0)	0.41 (0.15)	21 (14)

N.B. Results are shown as the mean of replicates sampled per treatment. Standard deviation is shown in brackets.

Supplementary Information B: Graphed results of key chemical parameters

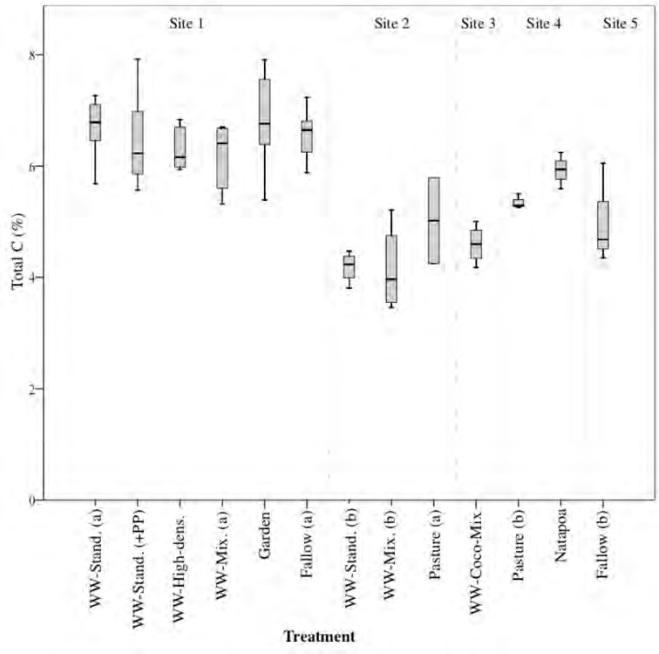

Figure B-1. Total C% measured across all treatments in 2017.

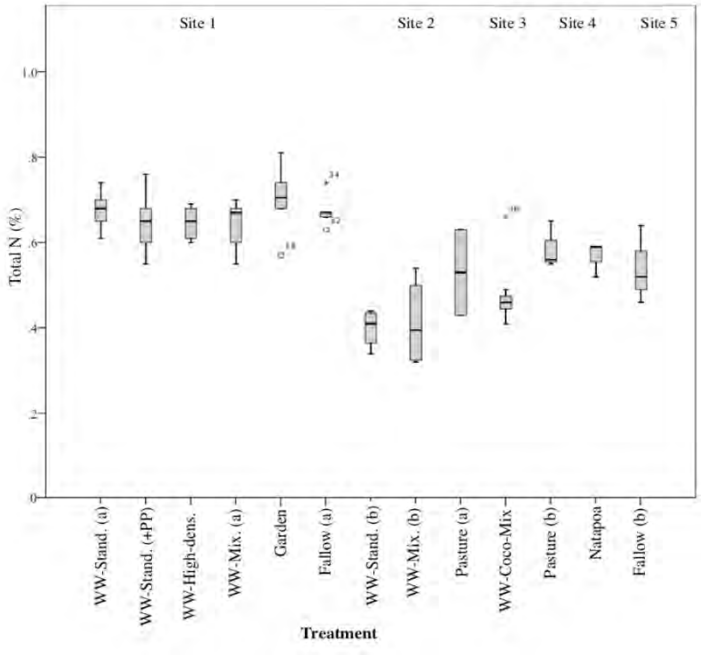

Figure B-2. Total N% measured across all treatments in 2017.

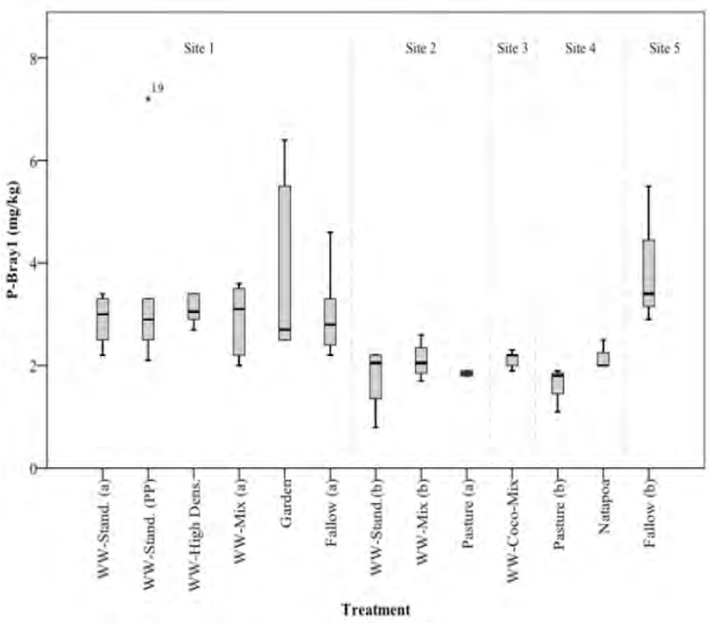

Figure B-3. PBray1 measured across all treatments in 2017.

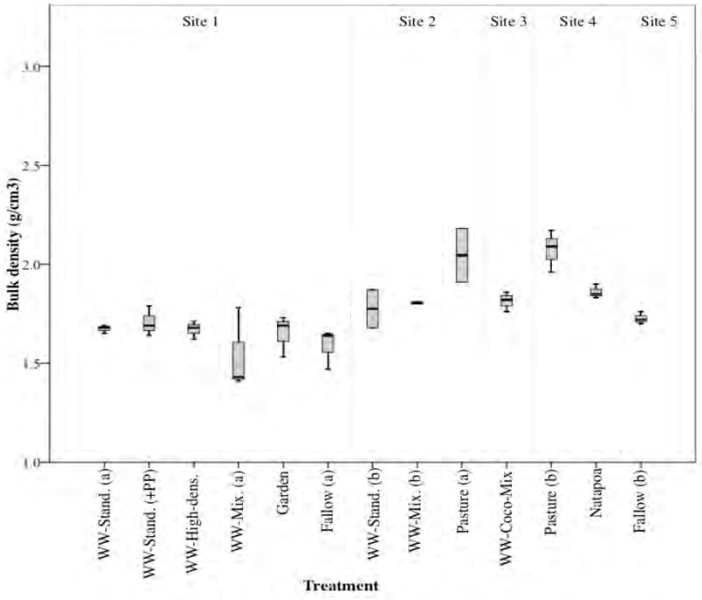

Figure B-4. Bulk density measured across all treatments in 2017.