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Final report

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1 Acknowledgments

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2 Executive summary

This project aimed to promote adoption of protected cropping systems that are appropriate for use in Pacific Island Countries, and to support growers producing vegetable crops using protected cropping systems in Fiji, Samoa and Tonga to access high value markets for their produce.

Horticultural crop production in Fiji, Samoa and Tonga is largely conducted by smallholders who are in general unable to supply the large tourist industry market as field production of crops is constrained by high precipitation damage in the wet season and lack of water in the dry season. Vegetable production therefore does not match local demand and the shortfall is supplied by imports. If the demand of vegetables was met by local producers, income from high value vegetable production would improve the livelihoods of producers and their communities.

In the Pacific Island Countries, protected cropping for small- and medium-scale farmers is new, and a potentially transformational and enabling technology for vegetable production systems. Although there has been limited use of protective cropping in Fiji and Samoa, increasing recognition by the governments in both countries of the potential impact of protected cropping for domestic food security and for economic development in rural communities has seen the production system emerge as a priority for domestic agriculture and donor aid development programs.

This project assessed a range of protected cropping technologies suitable for smallholders in farmers using a variety of market access strategies. Structure designs and materials as well as agronomy practices for specific crops, environmental constraints, farming systems scenarios and target markets were developed. Simple low-cost protective structures that are passively ventilated (ventilation is not assisted by fans) and tall (>3 m), with open sides all-around, and roof vents with specific roof designs that improve air exchange rates to remove heat, and reduce extreme high temperatures, were recommended for growers. Design features such as fasteners used to hold the plastic cover in place that allow the structure to be disassembled in a short time were also recommended to reduce the risk of structure damage from severe tropical storms.

A survey of existing structures found that around 50% were not in use. The structure itself is only one part of the protected cropping system, and often the other components including crop agronomy and marketing strategies are not considered in enough detail by farmers entering protected cropping. This was particularly evident where international donor aid programs had donated structures to farmers. The training program developed and delivered to farmers in the project was a holistic approach covering the protected cropping structures, crop management including agronomy and crop protection, and commercial aspects of marketing.

The project used the analogy of the culturally significant kava bowl with four legs to promote the protected cropping system. The bowl represents the potential return that can be gained from the system, with larger bowls able to hold greater amounts. The four legs holding up the bowl represent the physical infrastructure (the greenhouse design, materials and associated equipment used in production), the crop agronomy (management of the crop, including varietal selection, pruning, training, irrigation and fertilizer use), management of pests and diseases, and the value chains linking production to market. To prevent the bowl from tipping over, all legs need to be present and of an adequate size. As bowl size increases, the size of each leg (the resources, knowledge and skills needed in each area) also grows. This analogy helps the growers understand that they need to address each of the 4 key areas, and that as they grow the scale of their protected cropping they need to be adding new elements in each of those 4 areas.

In the latter part of the project, progress was impacted by the covid19 pandemic. The ongoing impact of the pandemic on tourism diminished the size of the high value markets for vegetables in the Pacific Island countries, but farmers using protected cropping were

able to pivot to supply local fresh produce markets. In Fiji and Samoa, increased government attention was given to building capacity for self-sufficient supply for domestic markets and protected cropping systems were supported by Pacific Island Country governments as a means to shore up year-round production capacity. Resources from the project therefore were readily adopted in these new agriculture programs. The project developed a comprehensive training manual and engaged in Fiji with Ministry of Agriculture staff to roll out training using the manual. The establishment of new businesses in Fiji supplying irrigation equipment as well as other components of protected cropping systems is further evidence that the influence of the project had spread beyond direct team contacts in that country.

Greenhouse structures erected by farmers in Fiji during the project have delivered excellent financial returns through sales of vegetables. Disruption in import supplies has placed greater emphasis on local production, and the capacity of growers to supply out of season produce has delivered economic benefits for those growers as well as contributing to food security for the population. Data collected by the project indicates that the low-cost structures erected by participating farmers can be fully paid off in 1-2 years, and that galvanised steel structures that farmers have been able to access through government support programs can be fully paid off in 3-5 years.

A new project activity, initiated following a project variation approved in 2020 in response to the impact of the covid epidemic, focussed on strengthening collaboration between the health, nutrition and agricultural sectors, and building a shared understanding of nutrition sensitive agriculture in Fiji. A scoping study was conducted for the Fiji context generally, but with some focus upon the Sigatoka Valley where initial trialling of approaches and materials commenced. This work will ensure agricultural interventions supporting development of protected cropping systems can include awareness of potential health and nutrition impacts, and is intended to reduce the risk of unintended negative heath consequences emerging from the development of protected cropping systems in the Pacific Island Countries.

3 Background

Vegetable production systems in island countries of the South Pacific are dominated by smallholder farmers who produce a broad range of crops including ginger, tropical fruits, root and tuber vegetable and other local vegetables (Iqbal, 1989). In Fiji and Samoa, a large share of the demand for high-value vegetables such as tomato, capsicum and cucumber is being met by imports (Loze and Low, 2008). Production systems such as protected cropping that are able to produce high value vegetables are required to open new import replacement market opportunities for Fijian and Samoan vegetable growers.

The smallholder farmers who conduct the high-value horticulture production in Fiji, Samoa and Tonga are in general unable to supply the large tourist industry market due to technical constraints relating to high precipitation damage in the wet season and lack of water in the dry season. The shortfall is supplied by imports. The issues involved are identified as lack of technical systems (protected cropping structures) and knowledge of appropriate agronomic practices for these systems, and lack of application of appropriate systems of marketing and production. These areas are addressed in the current project.

High-value vegetables such as tomato, cucumber and capsicum are considered to be non-traditionally grown food crops. While more recent figures are difficult to source, a 2015 Government press release (Fijian Government, 2015) provides an example of the scale of imports, noting Fiji annually imports 300 tonnes of tomatoes with a value of $2.5 million and with the price of the local tomatoes in the market ranging from $1.71/kg in the main season to $4.50 during offseason due to the low local production during off season. The tourism industry was estimated to have imported FDJ35 million (AUD $18.8 million) of vegetables (Loze and Low, 2008) and that 80% of the vegetables and fruits consumed by tourists were imported (Young and Vining, 2007). Increased domestic production would reduce this dependence on imports and provide benefits to local producers. Production systems able to supply high value vegetables would also open new export market opportunities for Fijian, Samoan and Tongan vegetable growers.

Prior to the covid pandemic, approximately 600,000 tourists and a further 200,000 transits visited Fiji annually, providing a readily available market for locally-grown produce. In addition, the large urban population provided major demand for fresh produce. The tourism sector has had to rely on the importation of fresh vegetables (Young and Vining, 2007), which has increased over the past decades to meet increases in tourism visits. An estimated two thirds of the overall food import expenditures destined to the tourism sector in Fiji was for products that could have been grown locally (Salvioni, 2007). A subsequent analysis indicated that the import market for vegetables in Fiji had grown, but accurate figures are not readily available to quantify the scale of the current import replacement market opportunity (Fink et al, 2013). A similar situation with local production and imports exist in Samoa, with seasonal production of vegetables preventing local supply to high value markets (Tamasese, 2009).

In Samoa, the hospitality industry attracted 130,995 visitors in 2014. Only limited quantities of vegetables are grown in Samoa. Hotels and restaurants purchase a mix of imported and locally-grown vegetables such as cabbages, tomatoes and lettuce (Tamasese, 2009). According to the Samoa Bureau of Statistics, the monthly imports of vegetables in 2014 was SAT$585,000. Vegetable imports in Samoa exceeded 60% of the estimates for domestic production (1,000 tonnes) in 2007.

Agriculture represented around 18% of Tonga's GDP in 2013/14, and the majority of Tonga's households (86%) are involved in agricultural production. Over 95% of the agriculture active households engaged in subsistence and semi-subsistence agriculture activities with only 5% engaged in commercial agriculture activities (Tonga MAFFF, 2015).Production of non-root crop vegetables represented only a small proportion of agricultural production, with 250 ha of the 9700 ha used for annual cropping. Unlike Fiji and Samoa, tourist visitation numbers are low with Tonga, ranked ninth out of the fifteen

South Pacific countries in terms of visitor arrivals (Trip Consultants, 2013).). A vegetable export trade to NZ, other Pacific Islands and Asia exists in Tonga, and strong interest has been expressed in developing protected cropping systems to improve consistency and quality in vegetable production to increase exports. The DFAT PHAMA program has identified opportunities for Tongan exports of squash, watermelons, zucchinis, eggplant, chilies and beans to NZ as market opportunities.

The dominant vegetable supply chains in Fiji and Samoa are short chains with growers supplying low-value domestic markets such as roadside and municipal markets. Similar chains also dominate in Tonga, but with a small number of larger scale export chains also present. These chains are formed by smallholder farmers who utilise rain-fed field production systems that lead to inconsistent yields and economic returns. A small number of supply chains exists where larger scale growers supply high-value markets (hotels, supermarkets, and chain food stores) using field production and, in just a few cases, protected cropping and hydroponic systems. These chains often involve additional participants including market traders and transport agents. The major supplies to the tourist industry outlets involve chains where “middlemen” procure products from roadside and municipal markets, with these players securing larger margins in the chains, and farmers in some cases do not benefit from their products reaching higher value markets. Few chains actively involving cooperative groups of smallholder farmers exist. One cooperative group, the Participatory Guarantee Scheme (PGS) component under the ACIAR PARDI project showed promise in linking smallholders to high value markets (Underhill et al, 2015). Other groups, such as Natures Way Cooperative, have organised farmers to grow vegetables, conduct pre-export pest disinfection, and export eggplants, papaya and ginger. Resorts, hotels and restaurants usually purchase locally-grown vegetables from agents and municipal markets to supplement imports, but with no direct market link back to the growers, the market agents gain most benefit from these supply chains.

While a high proportion of commercial vegetable sales in Samoa occur through open markets and street stalls, the country is reported to have well-organized retail and foodservice channels (World Bank, 2011). In most countries at comparable levels of development with Samoa, the majority of fresh produce transactions take place within the informal sector, with market control in the hands of brokers, traders, wholesalers, hawkers and street vendors. Often the value captured by these intermediaries is significantly greater than what accrues either to the farmers or to the retailers who sit at either end of the value chain. A small community of organized retailers, hotel operators and restaurants control a very significant proportion (estimated by industry actors at over 60%) of total fruit and vegetable sales to final consumers in Samoa, resulting in less influence from market intermediaries.

The supply chain configurations that exist in Fiji, Samoa and Tonga reflect the low percentage of locally-grown and particularly smallholder grown, vegetables reaching high value markets. The reasons for the low share of domestic supply of high-value vegetables in the supply chain have been described in several studies (Martyn, 2011; Tamasese, 2009; Dwyer,1989; Salvioni, 2007; Young and Vinning, 2007) and more recently in vegetable-related ACIAR PARDI projects. According to these studies, the main reasons are: a) crops and cultivars that do not meet the needs of buyers; b) variability in produce quantity (often does not meet demanded quantities) and inconsistencies in quality throughout the year; and c) inadequate supply during warm, humid months. Growing conditions contribute to all three of these areas. Year-round field production is restricted by frequent and intense rainfall or some long dry periods but with no irrigation system in place, extreme high air temperature and humidity, and high radiation. These extreme environmental conditions are also common and difficult to predict throughout the year and cause crop problems such as a reduced number of plants established; pests and diseases on leaves, stems and fruits; water-logging of roots and soil borne diseases; insufficient pollination; and physiological disorders pre and post harvest. These production issues are most common during the high rainfall summer months, when fresh produce attracts the

highest prices. With field-grown crops, farmers have few effective practices that can be used to alleviate crops from the extreme environmental conditions. Often, these factors lead to either complete crop failure or low marketable yields with accompanying poor quality.

A horticultural market study by Young and Vinning (2007) looked at fresh market tomato in Fiji and recommended “enlarging the current length of its domestic supply, for example, by using greenhouse technology; supporting the use of improved varieties; implementing post-harvest technology through pre-cooling facilities, cold stores, and more rational packages; and having better grading systems for domestic supplies” as critical production and post-harvest practices that are most needed to expand the level of competition of domestic versus imported supplies. The studies by Young and Vinning (2007) and PARDI supply chain reviews in Fiji by Johns (Underhill et al, 2015) and by Tamasese (2009) in Samoa, indicated that many hotels, institutions, supermarkets and restaurants would prefer to buy locally-grown produce and, for specific fresh products, quality would be greater than what is provided by imports.

Previous donor aid programs have organised growers to establish contracts with hotels so that farmers can obtain fair sale values. However, consistency of supply to hotels, especially during the hot wet seasons, has been constrained by the lack of appropriate knowledge on cost-effective protective cropping systems and availability of specific inputs. Field production by these farmer groups is affected by the variability of weather events even during the normally “dry season”. Extreme droughts, such as in 2014 and 2015 led to very low yields in the many small farms that do not have facilities for irrigation. In 2012, heavy rainfall during the normally “dry season” negatively affected crop production.

In each of the Pacific Island Countries, domestic supply increases from May to September-October when outdoor environmental conditions are drier and temperatures moderate. The domestic supply is very small during the wet season period November-April when warm, humid conditions increase disease pressure and rainfall damages exposed crops making outdoor production of vegetables in lowland areas almost impossible. Most farmers are opportunistic producers due to the short production window and therefore do not have a market-oriented production focus. While the production season usually corresponds to the major period of tourist visitation, the short production season limits the capacity of local growers to supply high value markets such as tourist resorts, hotels and restaurants that demand consistent, year-round supplies of a range of basic vegetables (Martyn, 2011).

The reasons for the low share of domestic supply of high-value vegetables in the supply chain have been described in several studies. The main reasons are: a) crops and cultivars that do not meet the needs of buyers; b) variability in produce quantity (often does not meet demanded quantities) and inconsistencies in quality throughout the year; and c) inadequate supply during warm, humid months. Growing conditions contribute to all three of these areas. Year-round field production can be impacted by frequent and intense wet season rainfall, long dry periods in the dry season, extreme high air temperature and humidity, and high radiation. These extreme environmental conditions are also common and difficult to predict throughout the year and cause crop problems such as a reduced number of plants established, pests and diseases on leaves, stems and fruits, water-logging of roots and soil borne diseases, insufficient pollination, and physiological disorders both pre- and post-harvest. These production issues are most common during the high rainfall summer months, when fresh produce attracts the highest prices. With field-grown crops, farmers have few effective practices that can be used to alleviate crops from the extreme environmental conditions. Often, these factors lead to either complete crop failure or low marketable yields with accompanying poor quality.

Low-cost protective structures (rain shelters such as walk-in tunnels and small greenhouses) can effectively and economically overcome many production challenges. These semipermanent structures have frames made of steel, wood or bamboo; are covered with polyethylene films and/or shade screens to reduce radiation and air

temperatures. Low-cost protective structures are effective for increasing marketable yields and improving produce quality per unit of cropped area. Vertically trellising plant canopies of some vegetable crops (e.g. tomato, capsicum, and cucumber) improves the quality of fruits and extends production time. Sequential plantings for continuous supply to markets are also possible in seasons with frequent and intense rain events. In dry seasons, crops also can be grown without the polyethylene cover. Some structures can be disassembled in a short time, a useful design feature when a cyclone event is predicted to occur. These protected cropping systems can assist growers to respond to market demands by modifying climate parameters such as avoiding rainfall over crop canopies and soil and reducing wind speed impacting crops. Protected cropping can also mitigate extremes in high solar radiation; high and low leaf, soil, and air temperatures; and high and low air humidity levels. Insect exclusion screens covering structures can assist reducing the impact of pests on crops.

In Fiji, only a few farmers have ventured into the use of either simple hoop tunnels (a low cost design but which is generally low and unsuitable in the tropics) or more complex and expensive greenhouses. Simple rain covers, with poly film or netting over single planting beds also have been tested but have not been widely adopted by growers. These low tunnels seem to be effective for growing specific commodities (e.g. lettuce) but less effective for plants that can be trellised for longer production and harvesting season (e.g. tomato). In 2012, Taiwan Technical Mission (TTM) commenced testing small walk-in low-cost wooden structures built as demonstration sites on commercial farms but recommendations for use were not developed. In Samoa, the Sino-Samoa Agriculture Cooperation Project set up demonstrations of simple low walk-in tunnel structures, which are not suitable for growing taller crops. In Tonga, greenhouse structures have been established but not maintained at Government sites, while international aid programs have supported construction of structures at several commercial sites. Aid programs from several donor countries have focused on supplying low cost protected cropping structures to farmers in Pacific Island Countries, but a lack of information on key structure design considerations, suitable construction materials that are available locally, and sources/suppliers of materials constrain effective uptake of the technology.

While protective cropping has had very limited research and adoption in the Pacific Islands, the technology is extensively used for growing high-value vegetables in many countries in Asia, Central America and the Caribbean. ACIAR funded projects in the Philippines and Vietnam have also focussed on development of protected cropping systems for high value vegetable production. Structure designs developed in these projects have been produced and contain key structure design considerations which are of value when identifying suitable construction materials that are available locally and sources/suppliers of materials.

A two-year ACIAR funded project in Fiji and Samoa (PRA 2012/05) preceeded this project and identified that farmers and local project participants had little or no previous experience with protected cropping systems. The project established demonstration and initial research trials of protected cropping systems as proof of concept that increased production and extend seasonality of high-value vegetables was possible in Pacific Island Countries using protected cropping. Five 360m^2 specially designed structures with improved ventilation and irrigation were setup in Fiji (Sigatoka, Tavua, Lautoka, and Koronivia) and Samoa (Nu'u and Tapatapao). The design principles were tailored for warm environmental conditions and were also applicable to lower cost design options made with wood. Yield and quality data collected from trials of tomato, capsicum, and cucumber as well as in other potential high-value commodities (cilantro, amaranths, bitter gourd, Chinese and red cabbages) provided objective evidence of the potential for protected cropping in Fiji and Samoa. The project concluded that training in cropping issues (e.g. pests and diseases) was required with emphasis on developing recommendations for minimal dependence on pesticide use by farmers. In addition, the use of screens to exclude insect pests required further testing and any recommendation for using insect exclusion screens should be accompanied with crop hygene training so

that pests are not introduced to crops thus creating greater problems. Agronomy training (e.g. on fertilisation, irrigation, crop support methods, pest and disease management) as well as the evaluation of adaptations of structure designs that use alternative materials to steel (e.g. wood) were also recommended. Farmers will need further recommendations on crop rotation and practices that promote soil health to minimise impacts of soil borne diseases and plant parasitic nematodes under protected cropping.

While protected cropping systems are a means to increase yield, improve quality, and maintain supply during season and off-season, other constraints also need to be addressed to ensure the success of a business that includes protected cropping systems. These include aspects of business operations and supply chains to markets, input availability and social impacts associated with introduction of the protected cropping. To ensure adoption and use of new technology by farmers, these issues need to be taken into consideration. Transition to a market orientation and full scale agribusiness also requires assistance with investments; availability of inputs (e.g. seed, protective structures, irrigation systems, fertilisers, and pesticides) at affordable prices; capacity building of extension officers and farmers; continued support with RD&E on sustainable management practices (e.g. for pests and diseases); continuously updated and easily accessible information for farmers regarding predicted demand of produce and product specifications so that they can plan their activities; and financial arrangements between farmers and buyers for prompt payment after produce delivery.

4 Objectives

Within the broad development goal of improving the livelihoods and resilient socio-economic development of smallholder farmers and their communities in the Pacific islands, the specific aim was to strengthen value chains for high-value vegetables through innovations in technology and business organization. Specific objectives were:

Objective 1: To evaluate key technologies and production practices to enable protected cropping of vegetables by smallholders.

Establishing the technical recommendations for protected cropping systems applicable to Pacific Island Countries was critical. Activities:

- Review proposed and new opportunities for collaboration, and engage with partner organisations in the region to review project objectives and activities and review project progress.
- Develop recommendations for protected cropping structures. Integration of local knowledge on available materials and production practices with specialist protected cropping knowledge. This includes identification of design innovations, locally and regionally available materials and suppliers to improve the cost-effectiveness of structures, inputs and technology that are acceptable to farmers for entry into protected cropping, and what protected cropping structure designs perform best under prevalent environmental conditions and preferred crops.
- Develop and deliver recommendations for crop management in protected cropping systems. Evaluate selected high value crops and crop management practices, assessing quality, yield potential, pest incidence and disease tolerance/resistance. This will address the key questions of what are production constraints of early and potential technology adopters, what are the 'best-bet' options for cost-effective management of cropping systems and what pests and diseases are locally prevalent and limiting production in protected cropping?

Objective 2: To increase adoption of protected cropping in market oriented value chains for out-of-season vegetable production

- Identify current and potential adopters of protected cropping systems in Fiji, Samoa and Tonga
- Support growers to successfully utilise protected cropping systems.
- Develop protected cropping industry capacity for continued growth beyond life of the project. This required involvement of input suppliers and other 'chain enablers' in industry development activity within the project to initiate sustained support for protected cropping after the project was completed.

Objective 3. To identify strengths and weaknesses of different market oriented vegetable value chain configurations and build capacity of players in these value chains

- Determine, evaluate and engage with in-country collaborators including NGOs in each region to develop and deliver training to support existing and new value chain members
- Analysis of value chain configurations involving protected cropping systems in Fiji, Samoa and Tonga to identify strengths and weaknesses
- Measure, monitor and evaluate the value chains participating in the project to assess changes in farmers social and economic status occurring due to adoption of protected cropping.

The production component of the project was focussed on evaluating technologies that are suitable for humid tropical conditions and adoptable in the local social and economic context – and then building capacity within project participants to adopt these innovations, empowering them to influence others to ensure the transformational potential of the

protected cropping system endures beyond the project lifespan. Key research questions focused on the cost-effectiveness of innovations in structures and production practices.

5 Methodology

Objective 1: To evaluate key technologies and production practices to enable protected cropping of vegetables by smallholders

An understanding of appropriate structures and production practices are needed for development of protected cropping systems suitable for smallholder farmers in tropical environments. The project sought to address this need by assessing features of different structures used for research and demonstration purposes as well as commercially operated structures to identify desirable structure attributes and collecting data on crop agronomic practices through trials and commercial crop records to develop recommendations for production practices. A Training Manual was produced to document recommendations generated through the project.

Activity 1.2: Develop recommendations for protected cropping structures. Integration of local knowledge on available materials and production practices with specialist protected cropping knowledge.

Survey of protected cropping structures

The project evaluated protected cropping structure designs and crop agronomic practices to identify key areas required for successful production and develop recommendations for growers seeking to adopt protected cropping systems. Structures present in Fiji, Samoa and Tonga at the start of the project were surveyed to identify design features of successfully operating structures. Growers were interviewed and relevant information documented. Information on protected cropping structures used in tropical environments in other regions was collated along with survey findings from the Pacific Island Countries to develop recommendations for structure designs constructed from low cost, locally available materials.

Comparison of environmental conditions between structures

Evaluation of environmental conditions and crop performance will be made in available structures to generate a data set linking structure design attributes to within-structure conditions and crop performance. Hobo dataloggers in mini Stevenson screens were used over a 2 year period to monitor temperature and humidity in the various protected cropping structures supported by the project in Fiji and Samoa. Dataloggers were placed at a height of 1m in the centre of structures for consistency, apart from several short trials where conditions were monitored at different heights and positions within structures.

Activity 1.3: Develop and deliver recommendations for crop management in protected cropping systems. Evaluate selected high value crops and crop management practices, assessing quality, yield potential, pest incidence and disease tolerance/resistance.

Crop performance trials

Agronomic trials were conducted in the protected cropping structures at the three demonstration sites (2 in Fiji, 1 in Samoa) and on 5 commercial farms. These trials focussed on crop trellising strategies and varietal evaluations. Data on crop yields, product quality and production season duration were collected to assist growers in crop scheduling to meet requirements in market-oriented value chains.

Pest and disease analysis

An analysis of pest and disease challenges faced by growers engaged in the project was conducted across locations where protected cropping was introduced. Observations were recorded during field visits to the farmers and through personal communication with farmers. Information included what farmers are currently doing to address pests and diseases, what pest and disease problems already exist, what management strategies are working well and what could be improved to facilitate the successful adoption of protected

cropping. Comparison of pest and disease prevalence in on field and protected cropping systems was also undertaken. The analysis contributed towards the Plant Health System Framework developed in the Pacific Island Countries. The predominant crops grown under protected cropping are tomatoes, capsicum, cucumber and long beans; and these are the crops of focus in the analysis. In addition, trials on pest management options, in collaboration with HORT/2010/090 for integrated pest management approaches, were conducted as required to generate locally applicable practices for growers to implement in their protected cropping systems. Observational data were also collected from commercial crops grown by farmers collaborating in the project.

Training Manual

Information from all activities undertaken to address objective 1 was used to collate a Training Manual. The Manual was designed to assist trainers (predominantly Ministry of Agriculture extension and research staff) to better understand protected cropping systems and to communicate that understanding to farmers.

Objective 2: To increase adoption of protected cropping in market oriented value chains for out-of-season vegetable production

A 3-pronged strategy was adopted to promote adoption of protected cropping: 1) Building awareness of protected cropping amongst farmers and their families, 2) Supporting growers who adopted protected cropping to develop the skills and knowledge required for successful crop production, and 3) Engaging leading growers, input suppliers and other 'chain enablers' to become facilitators and promoters of protected cropping, building capacity in the three countries for development of protected cropping systems beyond the life of the project.

Activity 2.1: Identify current and potential adopters of protected cropping systems in Fiji, Samoa and Tonga

Survey of Protected Cropping Systems in Fiji, Samoa and Tonga

Surveys of existing protected cropping structures in 8 provinces on Viti Levu in Fiji, and on the islands of Tongatapu in Tonga and Upolo in Samoa, were conducted in 2016, 2018 and 2020. Where possible, visits to production sites were conducted but data were also sourced from growers, Ministry of Agriculture staff and input suppliers to identify as many protected cropping structures as possible.

A survey of farmers not using protected cropping was also conducted during the 2018 survey in 8 provinces on Viti Levu in Fiji to assess awareness of protected cropping.

Activity 2.2: Support growers to successfully utilise protected cropping systems

Awareness and Training Program

Support for farmers interested in adopting protected cropping was delivered through workshops, training sessions, visits to commercial production sites, and access to project staff and Lead farmers with expertise in protected cropping. Over 40 training activities were conducted with more than 500 farmers attending across all training sessions. Project activities and information was communicated to growers and the wider community through collaborative networks established with Agriculture Ministries in the partner countries as well as NGO agencies and private enterprises.

Activity 2.3: Develop protected cropping industry capacity for continued growth beyond life of the project

The Training Manual described under Activity 1.3 served as the key resource generated in the project as a legacy to support continued growth of the protected cropping industry. The Training Manual has been adopted by the Ministry of Agriculture in Fiji as the training support strategy to back up investment in new protected cropping structures supplied by the Ministry to farmers. In addition to this resource, the project team conducted a research activity to generate greater understanding of diet and health impacts that may occur as protected cropping becomes more widely adopted.

Dietary diversity study

An adverse impact identified in other studies where farmers increase income through commercial activities has been the tendency for dietary diversity to decrease. Families may use the income from commercial sales to purchase more processed foods, and reduce intake of fresh fruits and vegetables that may be more commonly available in the rural areas. The high prevalence of non-communicable diseases related to poor diet in the Pacific Island Countries make this adverse impact a particularly important one to address.

A study examining dietary diversity (DD) in indigenous food-producing households in rural Fiji was undertaken. Eight rural villages were selected from five different Tikinas (subunits of a province) from the Nadroga-Navosa, Namosi and Ba Provinces in Western Fiji. The research team met in person with the chief/elders of each village and where applicable the leader of local farming groups, to obtain approval to conduct the study. Participation was voluntary. To be eligible for
inclusion, the participant reporting for each household had to be aged 18 years or older and have knowledge of what foods members of the household ate at home in the previous 24-h. Prior to
consenting to participate in the study, households were provided with verbal and written information
in English and translation into local dialect was conducted as necessary. Percent of households sampled varied between 10–90% of village total dependent on village size and data collection time constraints. Ethical approval was obtained from the Fiji National Research Ethics Review Committee (2018.99.WES) and CQUniversity's Human Research Ethics Committee (HREC 2018-006; approval number 21082).

Data was collected during the height of the Fijian harvest season from 31 July to 28 August 2018.
The survey consisted of three sections: (i) personal and household characteristics, (ii) farm diversity, and (iii) household dietary diversity. Household dietary diversity was defined using the United Nation Food and Agriculture Organization's (FAO) Household Dietary Diversity Score (HDDS) Data was collected using the CommCare mobile application (Dimagi Inc., Cambridge, MA, USA, 2018).

Analyses were performed using IBM SPSS (v25.0, IBM Corporation, Armonk, NY, USA). Descriptive statistics were used to present socioeconomic characteristics of the sample, reporting mean and standard deviation for continuous data and percentages for categorical variables. Multinomial logistic regression models were used to examine the relationship between personal and household characteristics, farm diversity and MAD scores (reference category 'high'). Univariate analysis was conducted with all independent variables and all variables with significant associations (employment, household occupants, food purchase and farm diversity) were retained in the final adjusted model. Confidence intervals of 95% and a p-value of <0.05 were assumed for statistical significance.

Scoping study: Strengthening collaboration between the health, nutrition and agricultural sectors in Fiji

Based on the outcomes of the dietary diversity study, a targeted scoping study was undertaken to develop recommendations for strategies to strengthen collaboration between the health, nutrition and agricultural sectors. The study aimed to develop recommendations that would be a step toward enabling agriculture, health and nutrition

partners to work together at a community level to discuss and share ideas related to nutrition sensitive agriculture.

The research team assessed published reports, guidance materials, policies and analyses as well as local knowledge to examine the current situation, and to recommend what could be improved to facilitate collaboration between the health, nutrition and agriculture sectors in Fiji. Specific research questions addressed in the study were:

- What currently exists, what is working well, and what could be improved to facilitate collaboration between the health, nutrition and agriculture sectors in Fiji?
- What existing resources and approaches have the potential to break down sector-siloes, create a shared understanding of nutrition-sensitive agriculture, and enhance intersectoral collaboration in Fiji?

A complete copy of the scoping study report is appended as Appendix 1.

Objective 3. To identify strengths and weaknesses of different market-oriented vegetable value chain configurations and build capacity of players in value chains

The projects third objective draws together the protected cropping production system development and adoption activities in objectives 1 and 2 with the value chain developments needed to connect production to market and the support activities required to ensure positive economic and social outcomes for farming families and communities and other chain participants. In-country collaborators will be engaged to contribute to the value chain, gender research and womens empowerment components of the project.

Activity 3.1: Engagement with in-country collaborators including NGOs in each region to develop and deliver training to support existing and new value chain members

The UN Women program has also committed to supporting a further 10 growers in access protected cropping in Fiji. A comprehensive training manual is being developed through collaboration with the government agriculture departments in the Pacific Island countries. Engagement with agriculture ministries, NGO’s and private sector partners has been an important element of the project, building the support network that will allow the knowledge of protected cropping practices applicable to farming systems in the Pacific to be promulgated after the project is completed.

Activity 3.2: Analysis of value chain configurations involving protected cropping systems in Fiji, Samoa and Tonga to identify strengths and weaknesses

Market analysis

An analysis of vegetable availability, volumes and prices was undertaken in the Sigatoka fresh produce market over 3 one week periods in August 2018, December 2018 and April 2019 (representing peak season, early wet season and late wet season). As the Sigatoka Valley is a major vegetable production region in Fiji, availability in the local market reflects production. Project team members visited the markets on market days and recorded the vegetable that were present. Available product was weighed (vegetables are sold in bunches or piles rather than on a per unit weight basis) and price recorded, with price per kg then calculated to allow comparison between seasons. Where possible, 5 to 10 bunches/piles of each product being sold by different vendors were assessed to determine average price in the market.

Data extracted from Dietary Diversity study (Activity 2.2 above), was used to analyse the purchasing patterns of women farmers from the study region. Data collection was conducted in the Fiji Sigatoka Valley over five weeks in August and September 2018. Ethical approval was gained from Central Queensland University HREC clearance number; -2018-006, and the Fiji National Health Research and Ethics Review Committee HREC clearance number 2018.99.wes.

Land Tenure Report

Research was conducted to analyse the relationship of land and tenure amongst the different culturally based groups and their implications for market access and productivity. The goal of the research was to identify socio-economic and cultural factors, from a property rights perspective, that might hinder farmers' performance in achieving optimum economic benefit. The social and cultural analysis included a focus on the role of women in value chains.

The research gathered data from farmers in the Sigatoka (Nadroga-Navosa Province) area in Fiji. This area is the largest supplier of fruits, vegetables, and spices in the local and export market, and is close to major utilities, infrastructure and markets. The research was conducted with a selection of representative farms, with three conditions set to select the most suitable farms: 1) farms within different Tikina for a geographically distributed representation of views; 2) farms showing a combination of the different tenure types and cultural diversity; and 3) smallholder horticulture farmers only.

The research surveyed 22 different areas, covering 6 districts. Most horticultural farms in Sigatoka are located in the lower and mid valley, mostly found in the Nasigatoka and Ruwailevu area with the greatest production of horticulture crops to market. Nasigatoka tikina covers the areas of Bilalevu, Nadiri, Kulukulu, Naceva and Waicoba. Ruwailevu tikina covers the famous Kawanasgau, Naibito, and Mavua farms. No farms at Malomalo or Vatulele tikina were surveyed. Baravi district covered seventeen (17) farms, Cuvu fourteen (14) farms, Malolo three (3) farms, Nasigatoka thirty-eight (38) farms, six (6) farms from Navosa and twenty-four (24) from Ruwailevu.

A structured survey was conducted with 455 farmers, using focus group and face-to-face methods. First, a focus group discussion was held at the Ministry of Agriculture Sigatoka Research Station and structured questions were distributed to 30 male farmers present during the survey. Each question was explained to the participants in both English and Fijian. Then 70 farms were visited with answers and observations recorded. All research concluded within 4-5 weeks. 59% of those surveyed were male and 41% female. Indian farmers made up 68% of those surveyed, followed by 30% iTaukei and 1% who identified as Tongan.

Data retrieved through the focus group questions and farm visits were documented on an Excel sheet which was cleaned. The numerical and statistical counts for answers to questions were later transferred to the Statistical Package for Social Science (SPSS) Software. Qualitative data were coded and categorized into common themes that corresponded to the research aim, with numbers in different themes recorded. A cross tabulation was made to compare and map relationships between different factors.

6 Achievements against activities and outputs/milestones

Objective 1: To evaluate key technologies and production practices to enable protected cropping of vegetables by smallholders

No.	Activity	Outputs/ milestones	Completion date	Comments
1.1	Review proposed and new opportunities for collaboration. Have an inception meeting to discuss project objectives and activities and conduct annual reviews of project progress. (PC and A)	Inception meeting held	6/2017	Inception meeting was held at Sigatoka Research Station in 2017.
		Agreement on collaborative opportunities and timelines of activities	6/2017	Project participants workshopped and agreed on project activities at a 'soft inception' meeting in early 2017, prior to the formal inception meeting.
		Annual review of collaborations and activities (*integration with Pacific ICM project annual meetings*)	2/2018 to 2/2020	Meetings held in Samoa, Fiji and Tonga with country leaders. The Fiji country leader and SPC team members represented the project at the ICM project meetings.
1.2	Develop recommendations for protected cropping structures. Integration of local knowledge on available materials and production practices with specialist protected cropping knowledge. (PC and A)	Completed surveys in Fiji, Tonga and Samoa that describe structures currently used (including, design, costs, origin and supplier) and identify their key advantages and pitfalls. Survey will include comparison of these structure design features with information on protected cropping structures used in tropical environments in other regions.	6/2017	Surveys of structures present in Fiji, Tonga and Samoa were completed in 2017. Information collected in the survey was incorporated in a paper accepted for publication at the International Horticulture Congress in Istanbul in 2018 and published in 2019, and incorporated in the Training Manual produced to disseminate findings at the end of the project.
		Collation of a list of identified local private business (chain enablers) willing to engage in capacity building. This includes current protected cropping operators, community groups, NGOs and suppliers of cost-effective components.	6/2017 (with further updates)	Meetings were held with businesses and government representatives in Samoa, Tonga and Fiji to introduce the project and collect information on resources available to support the development of protected cropping systems.
		Pamphlet produced with recommended structure designs/design features and containing information on protective cropping inputs (e.g. structures, drip irrigation, etc.) plus supplier contacts	12/2017 (with further updates)	This activity was incorporated as a module in the protected cropping training manual.

		Where structures consistent with the recommended designs do not exist, prototypes are built by the private sector, or farmer/s, with suggestions provided by project team members	6/2018	Prototype low cost structures were erected in the Sigatoka Valley in Fiji. These structures were used successfully by farmers and case study reports of outcomes for farmers were included in a video produced by SPC (https://www.spc.int/updates/blog/2021/08/protected-cropping-system-boosts-fiji-farmers-productivity)
		Monitoring of performance of different structures through data logging (environmental parameters) and annual interviews with growers	10/2017 10/2018 10/2019 10/2020	Hobo dataloggers were used to capture temperature and humidity data from the range of structures present in the project.
		Factsheet outlining key management practices that may save low-cost structures from extreme weather events	6/2018 (with further updates)	Information on key management practices has been incorporated in the 'kava bowl' concept developed for promotion of protected cropping systems. The crop management recommendations has been incorporated as a module in the protected cropping training manual.
1.3	Develop and deliver recommendations for crop management in protected cropping systems. Evaluate selected high value crops and crop management practices, assessing quality, yield potential, pest incidence and disease tolerance/resistance. (PC and A)	Review of crop management practices (available cultivars, fert and irrigation options, pest/disease management, trellising/training, etc) for selected vegetable crops through participatory approach with farmers and farmer groups.	6/2017	Crop management practices used across a broad range of crops grown in the various structures used in the project were documented along with crop yields and returns. This data were used to develop recommendations for crop management in protected cropping systems.
		List of crop management practices to be assessed in replicated trials (in Australia) and demonstration trials (in Fiji/Samoa/ Tonga) developed, and reviewed/updated annually	6/2017 3/2018 3/2019 3/2020	Trials commenced in Fiji. Cyclone damage to structures in Tonga has delayed trial activity, while repairs to structures damaged by cyclone in Samoa were needed in 2018.
		Report documenting recommendations for crop management practices, using results from production trials at demonstration sites assessing pest/disease issues plus marketable and unmarketable yields using standards specified by buyers in the tourism industry and larger markets. Reports to include production inputs to calculate costs and returns	9/2017 9/2018 9/2019	Information was incorporated in a paper presented at the International Horticulture Congress in Istanbul and published in 2019, and included in the Training Manual produced to disseminate findings at the end of the project.

		Pest and disease database Pestnet updated with specific pests of protected cropping systems	12/2017, 12/2019	This activity completed in collaboration with ICM project. A section in the Training Manual contains specific pest and disease management information.
		List chemical options available to farmers with key recommendations for use in protected cropping. Assist MOA and PC with effectiviness tests on products with trial permits to aid with registration and engage commercial supplier (in collaboration with Pacific ICM project)	12/2017, 12/2019	This activity completed in collaboration with ICM project.
		Reporting include publications on applied research and farmers' experience in testing new practices	6/2020	Information was captured in the Training Manual produced to disseminate findings at the end of the project.

Objective 2: To increase adoption of protected cropping in market oriented value chains for out-of-season vegetable production

No.	Activity	Outputs/ milestones	Completion date	Comments
2.1	Identify current and potential adopters of protected cropping systems in Fiji, Samoa and Tonga (PC)	Initial list compiled of current users of protected cropping (information extracted from activity 1.2 above) plus groups (Government, NGO's, grower groups) interested in promoting information from the project to potential adopters of protected cropping.	6/2017	Survey of current users in Fiji, Samoa and Tonga completed. Analysis of current greenhouse use status was used to inform the direction of training activities to address issues in protected cropping that were identified by survey participants.
		Project update reports circulated via list above, with invitation to any farmer interested in protected cropping to join the list and receive information on the training program (Activity 2.2)	Twice yearly	Project updates were communicated via in-country leads.
		End of project survey of users of protected cropping, and report on level of adoption of protected cropping in the 3 target countries over the duration of the project	11/2020	This activity was impacted by covid19, with an abbreviated data capture activity completed.

2.2	Support growers to successfully utilise protected cropping systems (PC and A)	Establish five demonstration sites (3 in Fiji, 2 in Samoa, 1 in Tonga).	6/2017	Sites were established in Fiji and Samoa, and Lead Farmer sites were used successfully in delivery of training.
		Participatory workshops with farming families and smallholder farmer groups (including PGS groups) involved in protected cropping to establish training needs and business aspirations.	6/2017	Workshops were held with farmer groups in Fiji, and close alignment achieved with MOA staff to facilitate training activities.
		Report on field days/training workshops held at demonstration sites, designed to allow growers from different regions to discuss their production practices, identify problems and propose solutions, share ideas and develop information sharing networks.	10/2017, 10/2018, 10/2019	Reports documenting participants and training topics were prepared for all group training events held in the project. Over 40 training activities and participation by more than 500 people were recorded.
		Targeted training for specific smallholder farmer groups with identified training needs (eg. PGS groups through training in postharvest management and business management).	3/2017 (ongoing)	Training for PGS farmers was delivered on basic financial literacy and business planning, postharvest management, and crop agronomy..
		Review and updating of training program	6/2018 6/2019	'Kava bowl' analogy developed as a framework for promoting protected cropping. All aspects of protected cropping have been incorporated in the training manual.
2.3	Develop protected cropping industry capacity for continued growth beyond life of the project	Conduct a tropical protected cropping Masterclass in Australia, to be attended by a selected stakesholder groups from Fiji, Samoa and Tonga. These farmers will act as 'champions' of protected cropping in partner countries.	9/2017	This activity was deleted from the project in the 2020 project variation. Covid travel restrictions prevented it from being delivered..
		Engage local private business (chain enablers) identified in Activity 1.2 (output 2) in training activities (Activity 2.2), and collate ideas from them to allow support of 'champions'	10/2017, 10/2018, 10/2019	Input providers and other businesses that support protected cropping were engaged throughout the project, with some input providers attending trainings as well as delivering training for farmers..

		Extension materials produced (e.g. production manual, videos, production practice guides, high value vegetable value chain management guides) based on outcomes from farmers experiences and field production trials.	9/2017, 9/2018, 9/2019 9/2020	The protected cropping training manual was produced in the project to capture all extension materials generated throughout the project.
		Assess options for financing of protected cropping structures and develop recommendations for smallholders	6/2019	Funding options have been incorporated in the 'marketing' section of the training manual.

Objective 3: To identify strengths and weaknesses of different market oriented vegetable value chain configurations and build capacity of players in value chains

No.	Activity	Outputs/ milestones	Due date of output/ milestone	Comments
3.1	Engagement with in-country collaborators including NGOs in each region to develop and deliver training to support existing and new value chain members (PC)	Collaborative arrangements established with in-country institutions (eg USP) and groups (eg PIFON, Samoa Farmers Association), international organizations (e.g. UN Women) and NGOs (e.g. CARE).	6/2017	Constructive linkages were developed during the project with USP, PIFON, and UN Women. A new protected cropping program funded by UN Women was initiated towards the end of the project and utilised the training manual from the project.
		Provide pilot of tailored/region specific information and training to support growers and their families in Fiji in value chain management, market systems and business acumen (including information from Activity 2.3)	9/2017 9/2018, 9/2019 9/2020	Engagement of ministry extension and research staff in the development of the training program ensured that ongoing region specific support could be delivered through use of the training manual
		Review of training program in Fiji (incorporating outputs from Activity 3.2) and updated program delivered in Samoa and Tonga	9/2017 9/2018, 9/2019 9/2020	Engagement of ministries of agriculture in the development and roll out of the training manual has resulted in incorporation of it as a core element of support for protected cropping by the ministry in Fiji.
		Yearly review of training program and delivery of tailored information and training to chain groupings in Fiji, Tonga and Samoa, combined with Activity 2.3 training)	9/2017 9/2018, 9/2019 9/2020	Yearly reviews were completed

3.2	Analysis of value chain configurations involving protected cropping systems in Fiji, Samoa and Tonga to identify strengths and weaknesses (PC)	Develop a 'current state of the region paper' documenting operating and potential high value vegetable chains for each country	12/2018	Paper published in Acta Horticulturae.
		Rapid Value Chain Analysis of representative chains in each country completed	6/2018	Data on supply chains used by smallholder farmers using protected cropping were captured in Fiji and Samoa. Use of middlemen predominated, and farmers had little engagement with markets other than local fresh produce markets. The impact of covid precluded further analysis and development of emerging chains supplying tourism markets.
		Report documenting analysis of the relationships with land and tenure by different culturally-based groups and implications for market access	End of project	A detailed report was prepared.
		Draft value chain analysis recommendations workshopped with chain participants and chain enablers to evaluate validity of outputs and conclusions.	3/2019	Grower groups were supported to pivot chains towards urban markets when covid impacts on resorts/tourist markets occurred. Business training, using the training manual, has assisted the growers in this shift.
		Value chain analysis completed and research published.	End of project	Market data were documented. Loss of high value markets due to covid impacts precluded analysis of the high value supply chains.
3.3	Measure, monitor and evaluate the value chains participating in the project to assess changes in farmers social and economic status occurring due to adoption of protected cropping. (PC)	Identification, prior to inception meeting, of appropriate and relevant social and economic indicators for monitoring in project countries.	12/2017	Draft list compiled at Inception meeting.
		Baseline data collection and reporting	12/2017	Data collected, including detailed health/nutrition data in Fiji.
		End of project assessment and reporting	End of project	Impact stores were documented by SPC in a video. Covid disruptions made detailed assessment of changes difficult to conduct given the changes induced by the pandemic.

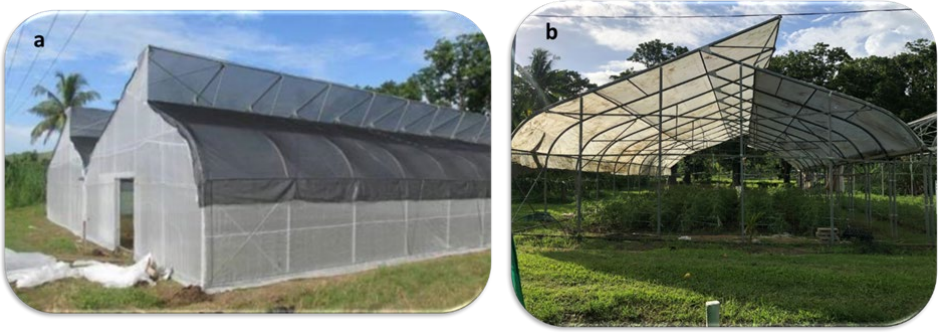
7 Key results and discussion

Objective 1: To evaluate key technologies and production practices to enable protected cropping of vegetables by smallholders

Survey of protected cropping structures

Protected cropping structures were assessed at 15 farm sites in 2016; 12 sites in Fiji, two in Samoa and one in Tonga. A range of structure designs were identified, ranging in construction materials, height, shape, opening systems and cladding material. Based on our field visits, the types of protective structures that were commonly used by the farmers could be classified into 4 broad types.

1. High roof, vented steel structures



These are imported structures and have been provided to farmers through Government support programs or previous donor aid projects. High quality plastic covering was usually used and in some cases the houses incorporated insect mesh screening on side and end walls. Designs also included clip systems for polyethylene plastic covering attachment that facilitated removal of the cover if required to reduce the risk of damage under adverse weather conditions. These permanent structures have a roof vent for passively ventilation.

One of the high roof, vented steel structures assessed was no longer operational as the structure had been bent and polyethylene covering lost in a cyclone. Orientation of this structure was not as recommended, with the roof vent facing towards rather than away from the prevailing wind direction. Evidence of rust on the steel structure also suggested poor galvanizing of the steel frame.

2. Steel frame hoop or tunnel houses

These structures also use imported steel piping They are made from a sheet of clear polythene stretched over a frame. Height of structures vary but they are generally lower that the high roof vented structures. Of the hoop structures surveyed that were no longer in use, loss of the plastic covering was the most common reason for the structure being abandoned, along with lack of irrigation infrastructure. Rusting of frames was commonly observed and this would limit the lifespan of the structures.

3. Wooden/bamboo structure with a plastic roof

These are low-cost structures constructed with locally available timber, bamboo on in some cases plastic pipes. They tend to be smaller than the first 2 structure types. The low height of these structures restricts use for crops such as tomato and capsicum that require trellising. Rotting of framework poles was noted to occur within 2-4 years, restricting the lifespan of the structures. The small size and low height of these structures does allow easier removal of the plastic covering (if the attachment system allows removal) when strong winds are predicted.

4. Shade/Screen House

Use of shade cloth on a frame constructed from locally available materials is common for seedling nursery production on farms. A smaller number of farms have larger structures which are able to accommodate production of some crops rather than purely being used to raise seedlings. Shade cloth offers no protection from rainfall, and crop damage due to rain was noted as a major limiting factor for use of these structures.

The low cost wooden structures and low hoop metal structures were less affected by cyclones but were only used for crops such as herbs and leafy vegetables. When covered with polyethylene film, temperatures in the low structures can be excessive for production of taller crops such as tomato, capsicum and cucumber that are generally trellised in protected cropping systems. Shade cloth covers facilitate crop production but allow only seasonal production as high wet season rainfall often precludes crop growth. Growers using these structures generally supplied local markets, with the production limitations making it difficult to achieve the consistent volume and quality to supply higher value

markets. One low hoop structure owner and one high vented structure owner were supplying high value resort markets, with the highest value crops only being grown in the high vented structure. This system survived the cyclones with the grower removing the polyethylene cover to reduce structure damage.

Design features for high value crop production were identified from the survey and from literature as follows:

- Tall structure (>3 m)
    - To keep the warmer air far from the plant canopies;
    - To allow for high vertical trellising of plant canopies;
    - To increase the surface of lateral openings and thus increase air exchange rate;
- High (>2.5 m) on all sides of the structure for improved ventilation;
- Roof covered with a clear polyethylene film to exclude rain or a whitish polywave fabric to exclude rain and reduce high solar radiation;
- Removable shading screen over the roof and clear polyethylene film material to reduce solar radiation;
- Roof vent, a vertical opening of 0.6-1 m on the roof to allow the escape of warm air through passive ventilation and to increase air exchange rate;
- Structure designed to withstand at least 80-100 km h^{-1} winds and with relatively simple methods for detaching and attaching covering materials and frame;
- Insect exclusion netting that can act as physical barriers to minimise the entry of insect pests. Easy removal of netting in case it is necessary to increase ventilation or facilitate pollination by insects;
- Irrigation system able to supply adequate water to the crops being produced.

It was recognised that different designs were applicable to different situations, and that while the above design features would best facilitate high value protected cropping it would be appropriate for farmers to select other structures dependant on crop selection to be grown, capability to manage crops within a protected cropping structure and financial capacity to invest in a structure.

Comparison of environmental conditions between structures

Large variations in environmental conditions were recorded both within and between structures. High roof, vented steel structures were on average 1-2 degrees cooler at crop level than lower hoop and wooden/bamboo structures. This difference was reduced when side ventilation was present on the three structure types. A typical set of comparison data between 3 structure types at one location over a single day is shown below.

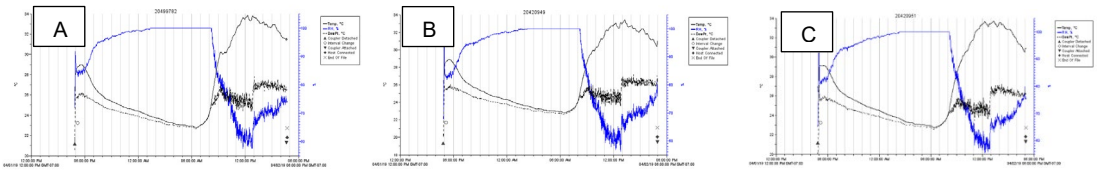


Figure 1. Temperature, relative humidity and dew point at 1m height in A) high roof, vented steel, B) bamboo, and C) wooden structures.

Higher humidity conditions were recorded in the high roof, vented steel structures when insect mesh was used to cover side and end walls.

Large temperature gradients were recorded within structures, with temperature increasing with height towards the roof of the structures. The highest recorded temperatures at 1m (crop height) were over 40 degrees in a low hoop house with plastic covering to within 1.5m of the ground.

Crop performance trials

Agronomic trials were conducted in the protected cropping structures at the three demonstration sites (2 in Fiji, 1 in Samoa) and on 5 commercial farms. These trials will focus on crop trellising strategies and varietal evaluations. Data on crop yields, product quality and production season duration will be produced to assist growers in crop scheduling to meet requirements in market-oriented value chains.

	Tomato		Capsicum		Cucumber	
	Fiji	Samoa	Fiji	Samoa	Fiji	Samoa
No. of crops	17	2	15	4	6	9
Marketable yield (kg m-2)						
Mean	3.2	6.0	2.5	2.4	7.4	4.3
Maximum	6.2	6.2	5.0	3.7	9.9	8.3
Minimum	0.9	5.8	1.1	1.6	4.2	0.9
Gross return	FJD m-2	WST m-2	FJD m-2	WST m-2	FJD m-2	WST m-2
Mean	24.20	41.86	25.67	25.94	27.42	28.28
Crop duration (days)						
Mean	102.3	207.5	123.5	109.2	57.0	90.6
Daily gross return	FJD m-2	WST m-2	FJD m-2	WST m-2	FJD m-2	WST m-2
Mean	0.21	0.20	0.14	0.27	0.45	0.34

Table 1. Summary of crop agronomic trial data.

Growers who have adopted protected cropping in the project have achieved improved livelihood outcomes for themselves and their families. Smallholder farmers who have constructed greenhouses with locally sourced materials costing F$1-3,000 have been able to pay off the cost of the structures in less than 2 years, while growers accessing more permanent structures using support from the government have recorded crop sale profits that would allow the full F$6-10,000 cost of a structure to be repaid in 3-5 years. The skills and knowledge required to succeed with protected cropping are spreading within communities where early adopters have had success, building a local capacity that may support the industry into the future.

Pest and disease analysis

Growing crops under protected cultivation provides a warmer, drier and protected environment that may lead to improved overall plant health. However, those same changes in the abiotic environment may also enable pest proliferation. Based on data collected by Mani Mua (Plant Health Field Coordinator, SPC), there was generally a higher abundance of most arthropod pests under protected cropping than in the open field grown plants. Broad mite (*Polyphagotarsonemus latus*) and tomato fruit borer (*Helicorverpa armigera*) were found to be most damaging in capsicum and tomatoes in both the open field and under the structures. The data also revealed that there was a high prevalence of aphids in capsicum and cucumber irrespective of the cropping systems used, while there was a medium abundance of whiteflies in capsicum, tomato and cucumber both under the structures and the open fields.

Table 2: Abundance of major arthropod pests attacking crops under protected cropping and in an open field. Average Pest prevalence across assessed crops is rated as High (4), Medium (3), Low (2) or None (1).

Crops	**Rating Pest Abundance**						
	Broadmite	Spider mite	Aphids	Leaf miner	Fruit borer	Whiteflies	Squash Bug
Capsicum							
Under structure	4	1	4	3	4	3	1
Open field	3	1	4	3	4	3	1
Tomatoes							
Under structure	3	2	1	3	4	3	1
Open field	3	1	1	3	4	3	1
Cucumber							
Under structure	1	1	4	2	1	3	3
Open field	1	1	3	2	1	2	4

Table 3: Incidence of major diseases attacking vegetables under protective structure. Average Disease incidence across assessed crops is rated as High (4), Medium (3), Low (2) or None (1).

Crops	**Rating Diseases Incidence**						
	Bacteria Wilt	Anthracnose	Downy mildew	Cercospora leaf spot	Powdery Mildew	Stem rot	Root-knot Nematodes
Capsicum							
Under structure	3	2	2	3	1	2	3
Open field	4	4	4	4	1	4	2
Tomatoes							
Under structure	3	2	2	1	1	2	4
Open field	4	3	2	1	1	4	2
Cucumber							
Under structure	2	2	2	2	3	2	4
Open field	3	3	4	3	4	3	2

There was generally a high incidence of diseases in the open fields as compared to crops grown under protected cropping. Bacterial wilt, anthracnose, downy mildew, stem rot and

cercospora leaf spot were quite predominant in capsicum that were grown in the open field. This may be due to the uncontrolled environment which may be conducive to the occurrence of these diseases in the field. Surprisingly there is occurrence of bacterial wilt (*Ralstonia solanacearum*) in all the crops under observation that were grown under protected cropping. Inside the protective structure, moisture extremes are regulated, and this is considered unfavourable to soil-borne pathogens such as *Ralstonia solanacearum*. However, the incidence of the disease may be due to the pathogen from the previous susceptible crop overwintering in the soil where the structure was erected.

A variety of insecticides were used by farmers where these chemicals were readily available through input supplier outlets in the region in which the protected cropping structure is located. None of the farmers in Fiji were using fungicides on their farms and the reason given was that the protectant fungicides required (Mancozeb and Kocide) were not readily available for them to purchase. Insecticides are frequently applied in an insurance fashion against perceived insect-related yield losses and in many instances may not needed. It was also noted that two of the farmers were using broad-spectrum insecticides to control insect pests under the structure. Training was conducted in the project to promote awareness that insecticides as beneficial production tools should only be used in situations where pest pressure exceeds economic damage levels, and the use of broad-spectrum pesticides can also kill the beneficial insects that may be present during the production period. Control measures such as handpicking and the removal of diseased crops from the field to limit the spread of pests and diseases in structures were more widely used after farmers had received training and reduce chemical usage in their protected cropping systems.

Training Manual

A comprehensive Training Manual was prepared in collaboration with the research and extension staff of the Fiji Ministry of Agriculture, with expert input from members of the project team. The Manual contains basic guidelines for protected cropping production in Pacific Island countries and territories and documents recommended approaches to be used by extension staff in training farmers who wish to learn about protected cropping systems. The Manual is available from SPC and the Fiji Ministry of Agriculture.

To ensure that the Manual was viewed as a ‘living document’ able to be added to as people involved in the protected cropping sector in the Pacific Island Countries gained new knowledge and skills, SPC took responsibility for developing the document in collaboration with the Fiji Ministry of Agriculture. Data captured during trials conducted in the project, along with lessons learnt and insights from farmers, were communicated to the team compiling the Manual. The strategy to encourage ‘ownership’ by PIC organisations appears to have been successful as the Ministry of Agriculture in Fiji has continued to use the Training Manual in new projects designed to promote adoption of protected cropping.

Two key concepts that were identified through the project and incorporated in the Training Manual were 1) that growers should look at working through a series of steps, beginning with very basic protected cropping systems, to reduce financial risks and increase the likelihood of long term success, and 2) that growers need to build competence in 4 core aspects of protected cropping (appropriate structure with the right technology inside the structure; a suitable programme to manage the growth of the crop; a suitable programme to control the weeds, pests and diseases that can affect the crop; a market for the product grown in the system that is profitable for that system). The analogy of a kava bowl with 4 legs needed to give the bowl stability was used to communicate the second concept in a way that was easy to understand.

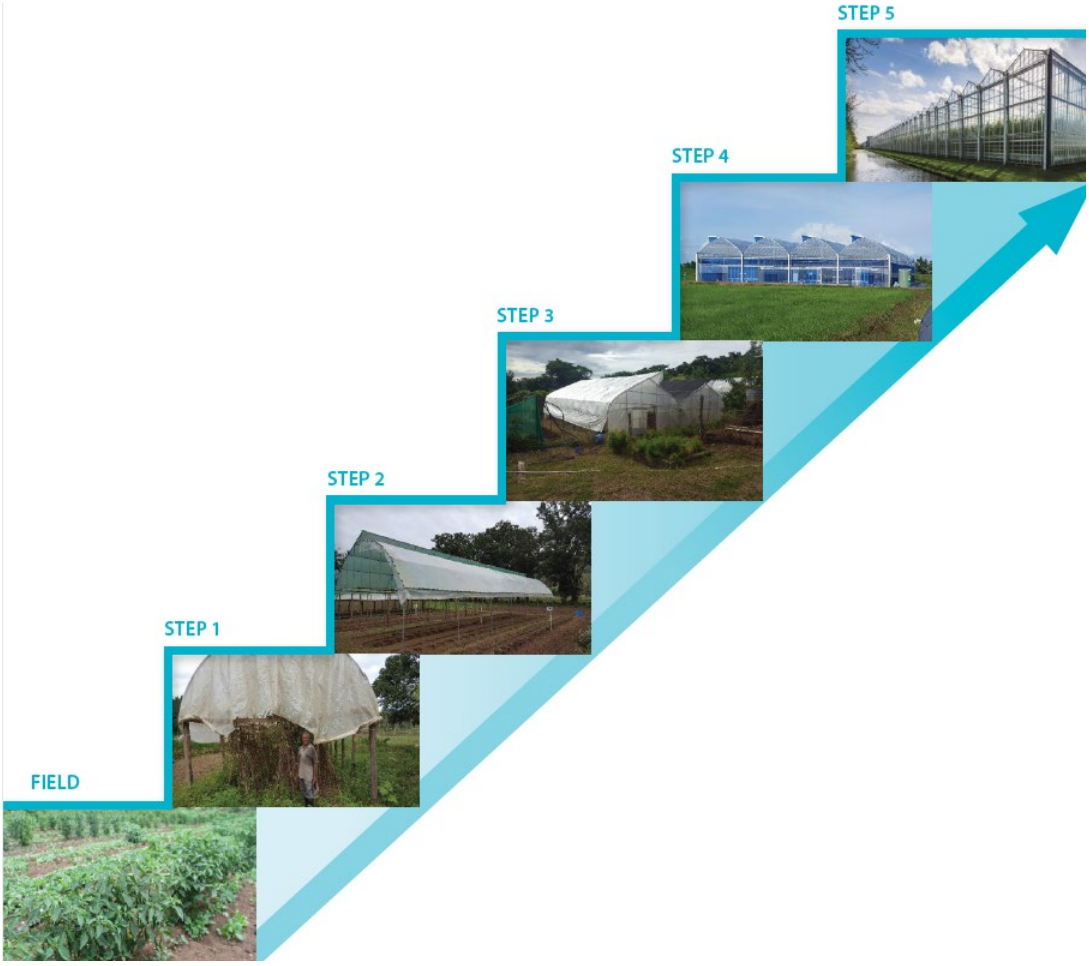


Figure 2. Visual presentation of the concept of a stepped approach to adoption of protected cropping, where farmers can initially engage with low costs structures to learn protected cropping systems with low financial risk before using more advanced systems as their skill, confidence and capacity to manage financial risks increase.

The two core concepts were very important learnings from the project as farmers characteristically were focussed predominantly on features of structures and desired the most advanced structures that they could access. When presented with the concept of the 4 cores aspects of protected cropping systems that need to be mastered, they displayed a greater appreciation of the complexity of the systems. The kava bowl analogy helped reinforce that as the systems become more complex on each higher step, there was a need for more advanced skills in managing the 4 core areas (in kava bowl analogy, as the bowl becomes larger, signifying the greater yield and production potential on each step up, the legs need to become stronger to ensure the bowl is stable). Use of a culturally relatable analogy helps the farmers remember and understand the 4 key aspects of protected cropping systems.

Objective 2: To increase adoption of protected cropping in market oriented value chains for out-of-season vegetable production

Survey of Protected Cropping Systems in Fiji, Samoa and Tonga

Increased numbers of protected cropping structures in each of the three targeted countries were recorded over the duration of the project. The most significant increase occurred in Samoa and was due to a new China Aid program conducted with the Samoan Ministry of Agriculture. High hoop structures, water tanks and irrigation systems were given to farmers to promote use of protected cropping through the program.

In Fiji, three large commercial protected cropping businesses each with multiple houses in commercial production, were not included in the survey figures. These operations represent more sophisticated production systems than those being promoted to smallholder farmers in the project. Visits by farmers to the Grace Road facility were included in the training provided to smallholder farmers and provided insight into the changes in management expertise and investment required to progress to more advanced steps in protected cropping.

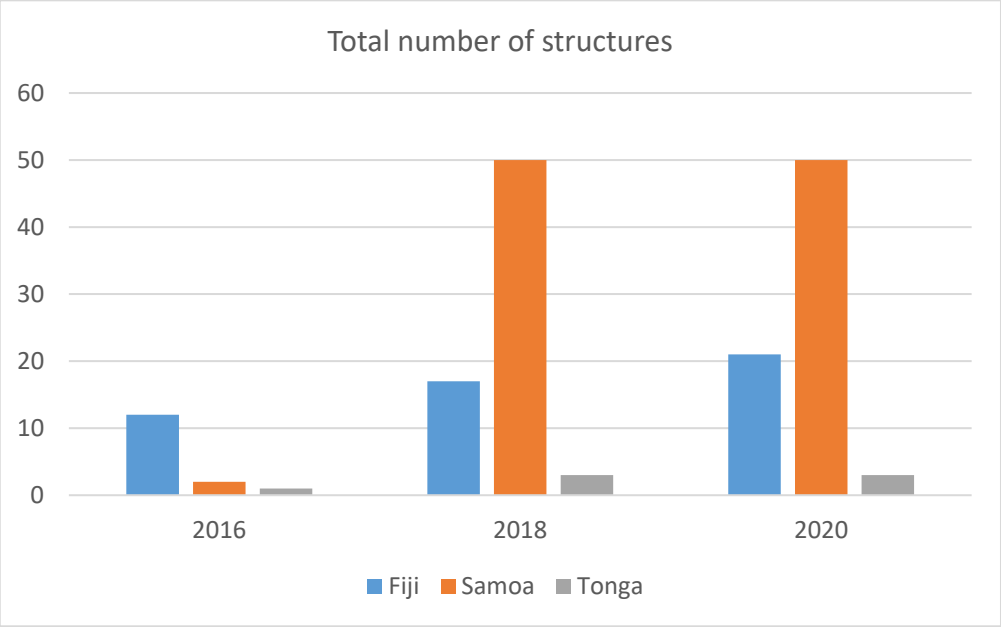


Figure 3. Estimated number of protected cropping structures present in Fiji, Samoa and Tonga.

The 2018 survey of existing structures that were visited by the project team in 8 provinces on Viti Levu in Fiji, and the islands of Tongatapu in Tonga and Upolo in Samoa, found that 19 out of 50 were not in use. Data on status of structures was collected in all three surveys in Fiji and revealed an increase in the percentage of structures that were in active use over the course of the project. Feedback from farmers highlighted that without appropriate support and training the provision of structures is unlikely to lead to successful adoption of protected cropping. The structure itself is only one part of the protected cropping system, and often the other components (e.g. agronomy and marketing strategies) are not considered in enough detail by farmers entering protected cropping. This was particularly evident where previous aid programs had donated structures to farmers.

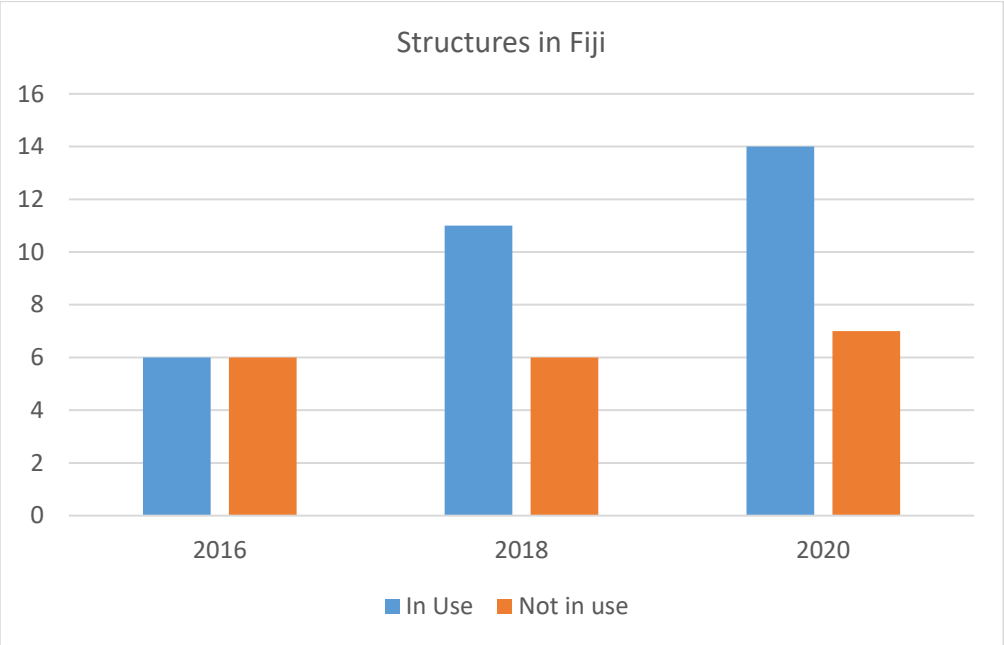


Figure 4. Number of used and disused protected cropping structures present in Fiji.

Awareness on protected cropping amongst farmers not currently using the production system was assessed through a survey of 44 farmers in Rewa, Tailevu and Nadroga provinces. Of those farmers, 6 had previously tried protected cropping. 93% of the farmers were aware of protected cropping, with 50% of the farmers only becoming aware in the last 5 years. The major barrier to use of protected cropping was identified by the farmers as cost. All but 2 of the farmers rated potential of protected cropping as good, very good or best.

Awareness and training program

An extensive program of awareness building and capacity training was delivered throughout the project. The training was delivered on all aspects of protected cropping systems to farmers in Fiji and Samoa and supported ongoing demonstration site infrastructure at 2 sites in Fiji, one in Samoa. A site in Tonga has been funded but construction of the demonstration protected cropping facility was delayed due to cyclones, covid and volcanic activity. Two of the demonstration sites (Tavua in Fiji and Tapatapao in Samoa) were on farmers properties and those farmers acted as Lead farmers in providing training and information to other farmers interested in protected cropping. A Fiji Government owned site (Sigatoka Research Station) also acted as a demonstration site and Ministry staff participated in training activities to support farmers.

If Fiji, farmers participated in training on crop agronomy, irrigation, postharvest management and pest and disease management. Visits to operating structures at Tavua, Sigatoka and the Grace Road facility in Fiji. In addition to training for growers, the project delivered training sessions for MoA staff in Fiji and Samoa. Two-day workshops on irrigation management and data collection/analysis were held, with the aim to equip MoA research and extension staff with the knowledge and skills to then deliver training to growers.

The Protected Cropping training manual, developed in partnership with Ministry staff in Fiji, Samoa and Tonga, will continue to guide future training. The manual provides background information on protected cropping for trainers, and a guide to delivering training for growers in all facets of production and business management at different stages of protected cropping development. Several training sessions with growers have been conducted using the manual, and Ministry staff have been supported to allow them to roll out the training.

The project focussed on building capacity in country for training delivery, and in addition to Ministry staff who are able to deliver formal training programs the support given to two Lead Farmers with experience in low cost protected cropping systems has ensured a strong knowledge based exists in both Fiji and Samoa. Feedback from farmers attending training has highlighted the value they place on being able to discuss protected cropping with another farmer who has experience in commercial operations as a critical supplement to knowledge gained from formal training activities.

Lead Farmer: Munsami Naicker (Tavua, Fiji)

Munsami Naicker has been sharing the gained knowledge and providing capacity building to regional farmers. During the project, Munsami carried out a number of vegetable crop evaluations (e.g. tomatoes, cucumbers, capsicums, bitter gourd, watermelon, and leafy vegetables, as well as herbs). The project provided him with guidance to design structures and to grow crops under the protective structures, including adopting drip irrigation. The returns from growing and selling vegetable crops and seedlings from a first structure with an area of 360 m^2 has allowed him to build two more structures of approximately 1,000 m^2 each. Munsami has constructed structures using wood and steel and has tested a few designs that allow him to remove the covering materials quickly in the event a cyclone is forecasted to impact the region. Since 2014, he had to remove and reattach the covers of structures in five occasions therefore being able to save the structure frame and covering materials.

To grow vegetables under protective structures in Tavua, Munsami cover the roof of the structure frames with shading materials during the dry season (to reduce extremes in solar radiation and leaf temperature). During the rainy season, he covers some structures with polyethylene film to avoid rain over the crops and therefore reduce foliar diseases and overwatering crops. Capsicum crops have been successful crops during the dry season. Crops such as watermelons, grown with drip irrigation, were excellent cash crops for the summer and they could still be grown with good yields when planted on elevated planting beds and under the shade houses. Munsami has sold his produce directly to hotels, supermarkets and farmer markets. He has also taught how to grow capsicums under protected cropping to another grower in Lautoka who had a greenhouse. Together they collaborated to supply to a resort.

Figure 5. Munsami and Anjini Naiker

Before this project, Munsami kept much of the agronomy and marketing information in his head. Now with his daughters and sons becoming more involved in the family business, they have all agreed that record keeping is critical. Record keeping allows them to share information and knowledge within the family and other farmers and to monitor and evaluate the performance of their business and implement appropriate changes.

Lead Farmer: Edwin Tamasese (Tapatapao, Samoa)

Growing vegetables outdoors is challenging in Samoa as annual precipitation can exceed 2,500 mm with rainfall events spread throughout the year. A demonstration site with a protected cropping structure was established in Tapatapao, Samoa through support from the ACIAR-funded PARDI – AGB/2008/044 project to demonstrate potential of the system. Farmer Edwin Tamasese has been using this structure to grow a variety of high value crops such as capsicum fruits of different colours, tomatoes and seedless cucumbers. Among these crops, cucumber is a crop which is more likely to give high yields and which does not require high growing skills under the structures. Cucumbers are high yielding even during the wet summer months.

The current project is supporting farmers and research and extension officers by generating information on crop agronomy and identifying production constraints and solutions for farmers aiming to adopt protected cropping technologies. Edwin recognises that farmers will need to gain new knowledge and skills to adopt protected cropping and has hosted visits by other farmers, agriculture students from USP, and Agriculture Ministry staff to pass on the knowledge he has gained through experience growing crops in protected cropping. Crops such as tomatoes, capsicums and cucumbers are grown over long periods and will be harvested multiple times, and Edwin has learnt production strategies such as plant pruning and trellising, irrigation, fertilisation, and pest monitoring and management to support lengthy cropping seasons. The new skills require time to be mastered and Edwin has demonstrated that short season crops such as cabbage, broccoli and leafy vegetables, which require less skills and labour, can provide a faster return to investment. These short crops still benefit from the use of protective structures and drip irrigation, and through trialling Edwin has demonstrated that it is possible to assure supply of cabbage and broccoli when it is challenging to grow crops outdoors and demand and prices are high. Tanya Lesa, a Master of Agriculture student at University of the South Pacific, completed her research higher degree on irrigated lettuce production with support from Edwin.

Edwin focuses on growing crops with minimum use of pesticides and takes soil health in consideration because crops are grown in the same soil plot under the protective structure. The knowledge he has acquired allows him to act as a resource for other farmers adopting protected cropping, that this has been particularly important in Samoa as international donors have been supplying low cost protective structures to farmers. The presence of experienced farmers able to support others to gain knowledge and skills in crop production strategies will underpin growth in protected cropping in Samoa.

Dietary diversity study

The results of the dietary diversity study have been published: O'Meara et al (2019) Predictors of Dietary Diversity of Indigenous Food-Producing Households in Rural Fiji, *Nutrients* 11, 1629 http://dx.doi.org/10.3390/nu11071629.

Briefly, of the 161 households from 8 villages surveyed, only 15% had high household dietary diversity scores when assessed using the UN FAO methodology. The high prevalence of diet- linked noncommunicable diseases in the Pacific Island countries underscores the importance of increasing dietary diversity, particularly through vegetable consumption. Most households exhibited medium dietary diversity (DD) (66%; M = 7.8 ± 1.5). Commonly consumed foods included sweets (98%), refined grains (97%) and roots/tubers (94%). The least consumed foods were orange-fleshed fruits (23%) and vegetables (35%), eggs (25%), legumes (32%) and dairy (32%). Households with medium DD were more likely to be unemployed (OR 3.2, p = 0.017) but less likely to have ≥6 occupants (OR = 0.4, p = 0.024) or purchase food ≥2 times/week (OR = 0.2, p = 0.023). Households with low DD were more likely to have low farm diversity (OR = 5.1, p = 0.017) or be unemployed (OR = 3.7, p = 0.047) but less likely to have ≥6 occupants (OR = 0.1, p = 0.001). The study supported the conclusion that during nutrition transitions there is a

need for public health initiatives to promote traditional diets high in vegetables, fruits and lean protein and agricultural initiatives to promote farm diversity.

Objective 3. To identify strengths and weaknesses of different market oriented vegetable value chain configurations and build capacity of players in value chains

Market analysis

As expected, produce availability was highest in peak season and average price was lowest. For tomato, price varied from FJD1.54 in peak season to 6.06 and 16.67 in early and late wet season. Similar variation was noted for capsicum, while cucumber and eggplant maintained a relatively stable price.

	Average Price per KG $FJD			Average sale price $FJD	Sale price Variation of lowest & highest item $FJD (%)
	August 2018	December 2018	April 2019		
Chinese cabbage (bok choy)	1.49	2.55	6	3.35	4.51 (303)
Lettuce	4.17	-	-	4.17	-
Corn	0.5	2.92		1.71	2.42 (483)
Pumpkin	1.32	2.53	1	1.62	1.53 (153)
Carrots	2.63	6.31	3.67	4.20	3.68 (239)
Tomato	**1.54**	**6.06**	**16.67**	**8.09**	**15.13 (982)**
Eggplant	**2.2**	**4.42**	**1.67**	**2.76**	**2.75 (165)**
Okra	2.9	10.07	2	4.99	9.96 (403)
Cucumber	**3.54**	**1.53**	**2.82**	**2.63**	2.01 (131)
Cauliflower	4.46	-	14.44	9.45	9.98 (224)
French beans	4.48	-	-	4.48	-
Snake beans	6.73	13.72	5.88	8.78	7.85 (117)
Capsicum	**7.27**	**19.6**	**-**	**13.44**	**12.33 (170)**
Cassava	0.92	1.02	1.02	0.99	0.10 (11)
Taro (with stems)	2.8	1.45	2.28	2.18	0.83 (193)
Purple sweet potato	3.16	-	-	3.16	-
Watermelon	1.94	-	3.75	2.85	1.81 (93)

Table 4. Market prices of selected vegetable in Sigatoka fresh produce market

Shopping behaviour of women from farming communities was assessed in the Sigatoka Valley region. Women's shopping behaviours characteristic show women more likely to shop once a week (60.7%) than 2 or more times a week (17.1%), and to shop in both the supermarket and fresh produce markets (73.1%). Furthermore, the most frequented place of purchase all products was the supermarket (51.3%) although closely followed with purchasing from both the supermarket and the fresh produce market (44.4%). The highest rates in of discretionary food intake was in consuming discretionary food while in town for shopping (66.7%). Households also reported an extremely high rate of adding sugar to beverages (99.1%).

The women who consumed discretionary food whilst in town were mostly in the highest age group 30-54 years (71%), with other factors linked to discretionary food intake being annual household income of FJ$5001- $15,000 (70.6%), education (completed secondary or higher and did not complete secondary) (66.7% for both categories), women participating in paid work (79.4%) and women who shop weekly (70.4%).

Land Tenure Report

Land tenure is a legal term that means to hold or possess land; it includes the rights and obligations held by the holder. A property on the other hand is said to have a bundle of rights that can belong to individual or several different groups. There are three tenure types of freehold, crown and native lands (with around two-thirds of native lands held under lease and a third as reserve/communal lands) in Fiji. Leases are managed through the iTaukei Land Trust Board or, if registered, through the Land Use Unit of the Ministry of Lands and Mineral Resources. There are other tenures including native sub-lease,

vakavanua and sharecropping arrangements and informal settlement. These reflect subleases which increase access to land for those without formal recognition. Farms surveys in this study covered 8 land tenure types (figure x).

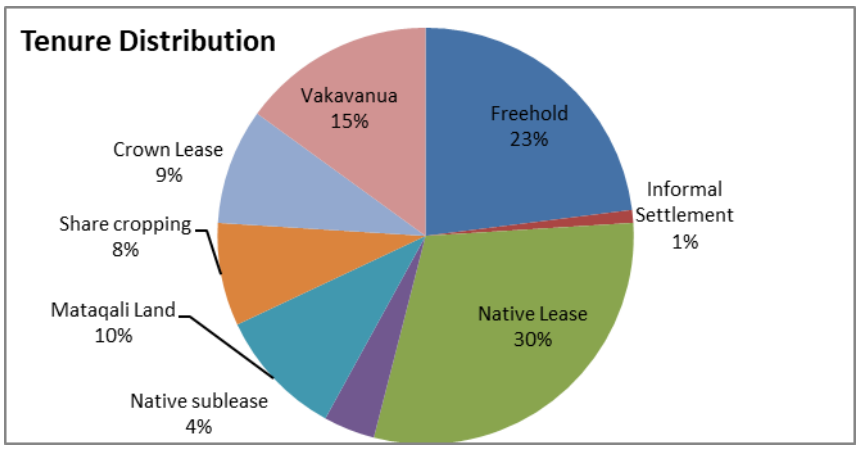


Figure 6. Percentage of farms surveyed in each land tenure class.

This research worked with farmers in the Sigatoka Valley, using a focus group with 30 members and face-to-face surveys during 70 farm visits, and found that tenure has a complex and nuanced relationship with agriculture and in general, there are more pressing constraints on agricultural development than tenure. The different forms of tenure do not reflect farm size, or types of produce and markets, however, there were variations in productivity related to farmers' capacity to farm, technology, information and willingness to be part of a cooperative or group. This reflects that an adaptation, rather than replacement, approach to land tenure holding is the best solution where innovation builds on existing, including customary, forms of holding land. Tenure security is perhaps the most pressing tenure concern. Security for investment and clearly defined property rights are needed. Key debates around property rights mostly reflect an owner/tenant divide, with rents received and lease duration the critical points respectively.

Farmer decisions on choice of produce were mostly based on market demand, liquidity of crop, improved market access or opportunities, and good harvest periods. If farmers were diversifying or choosing alternatives crops it was based on primarily two factors 1) climate and soil; and 2) market price and opportunities. Farmers' perceptions of the market are related to time and money, as they prefer immediate cash on hand from sale with higher liquidity of crops, which means they may fail to receive higher value for their produce from corporate markets. Some other farmers try to avoid risks and prefer not to conduct research other markets. There are many reasons for these choices. Firstly, it was observed that the quantity produced by a single farmer is frequently not sufficient for the corporate market. Second, some farmers prefer to work individually rather than in a group, because of past experiences around poor management of groups, which means they may fail to benefit from government field officer training in large groups (to save their time and money) around matters such as quality standards. And third, farmers in this study were uncertain whether they will be holding the piece of land for a long period of time and therefore avoid making larger investments. During the research it was highlighted that farmers' lacked confidence that their native lease, sharecropping and vakavanua land leases would be renewed, the prime reason for lack of risk-taking ability or more investment choice. One of the farmers' on native lease stated "I cannot build a concrete home on this land, because I do not know when this will be taken away from me.", and a vakavanua farmer "I cannot approach the bank for loans, we have to rely on salary slips. As long as I have some cash coming in, I am fine."

Although some farmers were hesitant to disclose income and profit levels, it was noted that on average, with location and season as variables, horticulture farmers are able to earn approximately FJD$200 - $500 per week. The variations to the income related to farmers' capacity to farm, size of farm or type of produce, technology, information and

willingness to be part of a cooperative or group, choice of supply market, farmers' competitiveness and investment choices.

Most freehold landholders are in the $15,000 to $30,000 bracket, and the highest in the $45,000 to $60,000 bracket. Informal landholding examples of the informal settlement, vakavanua and the sharecropping landholders earned similar percentages as the freeholders. However with sharecropping farmers, a much higher number were able to earn $30,000 - $50,000 per annum compared with the freehold tenure (Figure 7). It is a reflection of farmers' ability to earn income regardless of the type of tenure. The crown lease landholders did not share data on income, and the approximate costs per farm was also not disclosed by the farmers. However, farmers mentioned that vakavanua landholders costs of rental and administration were greatly reduced compared with freehold or lease holders. It can also be witnessed that mataqali landholders produce similar profits to native lease holders. While productivity is not affected by the form of tenure only, it can be deduced that leasing drives farmers to be more competitive to derive returns before the end of the lease period.

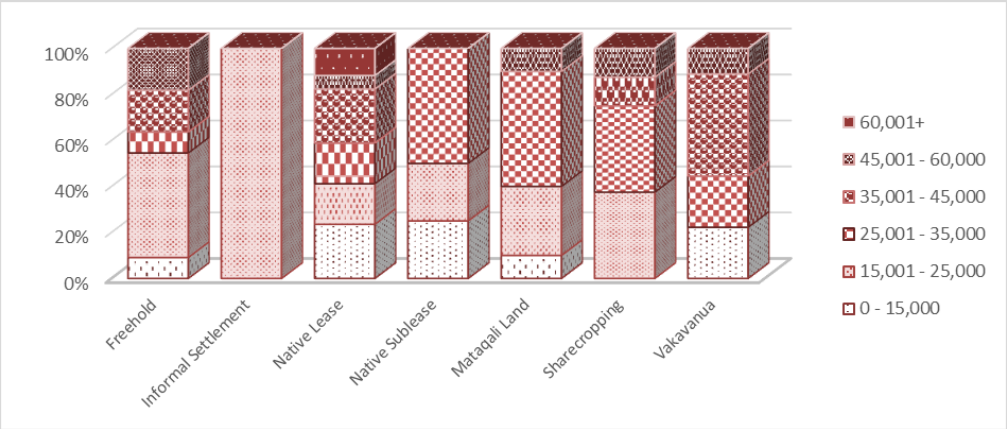


Figure 7: Mean annual farm income level by tenure

Moreover, it was observed that farmers' productivity level was not determined by economic measures alone, but also by the social advantages that it presents. Farmers with different forms of tenures were requested to list one major advantage for the type of tenure they held. It was interesting to note that only 92 respondents gave at least one advantage while the other 8 respondents, who occupied mataqali and native lease lands, chose not to state any advantage. The informal arrangements which were informal settlements, vakavanua land and sharecropping households stated that the major advantage for the form of tenure they held was there was no cost to renew the lease, or pay rentals. The leased land under native and crown arrangements listed their advantage as security and control over land where their property rights were defined and fixed for a certain duration. For mataqali land, the major advantage was social security, sense of belonging and livelihood. These farmers held that belonging to a society is a statue of respect, recognition and identity more paramount than the need to have individual property rights.

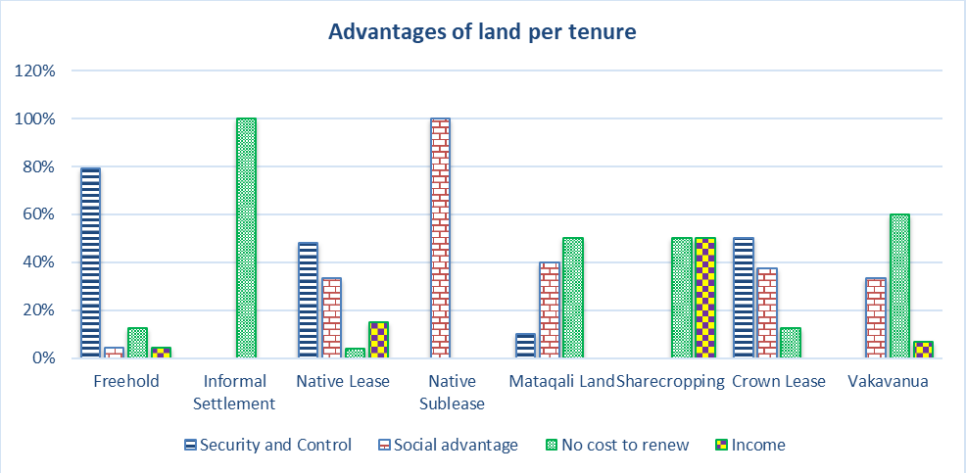


Figure 8. Farmer perceptions of advantages of land tenure types.

In comparison, participants were requested to state one major disadvantage for the type of tenure held. These were later classified into common themes and groups. Freehold tenure had no major disadvantage commonly related to land tenure. Informal arrangements noted the major theme of limited or no security over their land. Native lessees mentioned the cost of renewal as expensive and often the fear of non-renewal of leases. The same was not true for crown leases, because the challenges faced by these farmers had more to do with inability to divide land or use for purposes other than agriculture. While both leases have conditions under the Torrens system, native leases are more constraining to some farmers because of the influence of customary norms, rules and beliefs. The ethnic difference had a role to play with the disadvantages mentioned.

All farmers perceived their right of direct use as strong, however, the perceptions about right to indirect gain were mixed. The right of land control is influenced by the relationship that tenants have with the landowner, and the duration of the lease. Strengthening the social ties that exist between informal as well as formal tenants with the landlords is an important factor that influences the ability for tenants to have some control. Defined usage periods with exclusive use or clearly defined mixed rights in that period are needed.

Land tenure was rated low in terms of its socio-economic impacts, with natural disasters the highest socio-economic concern. Women's rights to land could also be better protected, including the right to use with fixed or intermittent durations. Ethnicity tends to reflect either landowner or tenancy, as does the form of public/international aid that tends to be received. The ability to have land holdings and profits seen as collateral for investment would also help.

Landowners, villagers, lessors, lessee and relevant institutions are all linked and need to operate holistically to tackle the interconnected issues affecting agricultural growth between lessors and lessee, including a more holistic measure of productivity that includes customary values and cultures. Hence, it is not the tenure per se, but a lack of appropriate recognisable, enforceable and protected rights, alongside various socio-economic and cultural factors, that hinders productivity across the various tenure forms.

8 Impacts

8.1 Scientific impacts – now and in 5 years

There is potential impact associated with recommendations of appropriate structures and production practices for protected cropping in the Pacific Island Countries. Research on dietary diversity impacts associated with a shift to protected cropping systems may inform extension programs in future protected cropping project to reduce the risk of unintended adverse diet-related health outcomes emerging from the increased income generating capacity of protected cropping.

Research from the project has been published as follows:

Brown, Groves, Jovicich (2019) Development of protected cropping systems for out-of-season vegetable production in the Pacific Islands. Acta Horticulturae DOI 10.17660/ActaHortic.2019.1257.28

O'Meara, L.; Williams, S.L.; Hickes, D.; Brown, P.(2019) Predictors of Dietary Diversity of Indigenous Food-Producing Households in Rural Fiji. Nutrients, 11, 1629.

O'Meara, L. (2019) Factors influencing food security and dietary diversity of indigenous food-producing households in rural Fiji. BSc(Honours) Thesis, CQUniversity.

Lesa, T.S. (2018) The effect of irrigation interval on growth, yield and water use of lettuce (*Lactuca sativa*) in protected cropping. Master of Agriculture Thesis, USP.

8.2 Capacity impacts – now and in 5 years

The project strategy revolved around demonstration sites with staff at those sites proving a source of expertise for other growers engaging in protected cropping. At the Ministry of Agriculture (MoA) Sigatoka Research Station, ministry staff have erected several structures that complement the larger structure funded by ACIAR. This investment by MoA demonstrates the impact of the project and the capacity that is being built in Fiji to sustain the protected cropping momentum instigated by ACIAR projects. Private sector investment has also occurred with new businesses established to sell irrigation equipment and other components of protected cropping systems.

An honours graduate (Lydia O'Meara) and Master of Agriculture graduate (Tanya Lesa) undertook their research studies in the project and gained insights that will be valuable for their future careers.

8.3 Community impacts – now and in 5 years

There has been strong support for the project, particularly from communities in Fiji where protected cropping is at a more advanced stage of adoption. The level of interest from farmers, along with engagement of the Government of Fiji through the Ministry of Agriculture in supporting protected cropping, is likely to see new structures erected and more farmers succeeding in protected cropping.

8.3.1 Economic impacts

Crops grown via protected cropping out-yielded field-grown crops by 2-3 times and generated a higher proportion of quality produce acceptable to high-value markets. Working together, farmer collectives were able to deal directly with resorts to supply them with vegetables at prices higher than they would receive in the urban markets during peak production season. When COVID-19 shut down the resort market, the growers successfully pivoted to supplying urban markets in the off season and achieved sales that encouraged further investment into their protected cropping activities. Gross returns of

FJD 24.2, 25.7 and 27.4 per m^2 of greenhouse space were obtained, and a payback period of 2-4 years calculated for a basic greenhouse structure.

8.3.2 Social impacts

Households that used protected cropping were able to generate increased income from produce sales and had access to a higher diversity of vegetables, both of which were shown to increase the likelihood of having improved dietary diversity. Of the 161 households from 8 villages surveyed, only 15% had high household dietary diversity scores when assessed using the UN FAO methodology. The high prevalence of diet-linked noncommunicable diseases in the Pacific Island countries underscores the importance of increasing dietary diversity, particularly through vegetable consumption.

8.3.3 Environmental impacts

Inclusion of Integrated Pest Management (IPM) approaches in protected cropping has reduced chemical use by up to 25% compared to field-grown crops while increasing production by 2-3 times. This delivers environmental benefits by reducing land area needed for food production as well as lowering the risk of pesticide contamination.

8.4 Communication and dissemination activities

Over 40 workshops and training sessions were held during the project.

Activities and outcomes were showcased on the SPC website (https://www.spc.int/updates/blog/2021/08/protected-cropping-system-boosts-fiji-farmers-productivity) and by ACIAR (eg https://www.aciar.gov.au/media-search/blogs/protected-cropping-systems-provide-insurance-fijian-farmers, https://www.aciar.gov.au/media-search/blogs/linking-nutrition-and-agriculture-better-health).

The project was presented at the ‘Accelerating Agricultural Productivity Growth For A Sustainable, Resilient World’ conference at the National Press Club, Washington D.C. This conference included a session highlighting actions/initiatives by the members of the Sustainable Productivity Growth for Food Security and Resource Conservation Coalition (SPG) and as a member country Australia chose to present on “Protected cropping systems in the Pacific”. A recording of the presentation session is available at https://www.youtube.com/watch?v=kb8lIXr8kEU (Australian presentation starts at 2:16:21).

9 Conclusions and recommendations

9.1 Conclusions

Protected cropping production systems were demonstrated to have the potential to allow farmers in Pacific Island Countries to access high value markets for vegetable products that are otherwise very difficult to access with conventional production systems. High marketable yields and gross margins for tomato, capsicum and cucumber crops grown in high, passively-vented structures were demonstrated. However, the skills and knowledge required to manage the structures and the production systems differ from field production, and farmers investing in these systems must acquire the skills and knowledge to balance the investment risks in establishing the systems.

There are a range of potential protective structures for warm and tropical climates, and the level of risk varies between the structures and production systems. Which structure design is best suited for a grower will depend on several factors, most notably crop species to be grown, plant growing system, specific environmental and biological constraints of the location, desired level of environmental control, expected strength and durability of the structure, investment budget available and access to appropriate markets for produce.

Protected cropping resulted in higher yields of vegetables in both wet and dry season. Adoption of this technology across the Pacific Island Countries would contribute to improved food security at national levels, as well as being a source of income for smallholder farmers and having the potential to contribute to improved human nutrition and health through greater availability of affordable vegetables.

Investment in protected cropping structures for vegetables is economically feasible in Pacific Island Countries, especially for skilled growers who apply appropriate inputs. For imported steel structures, a return on investment in 2 to 4 years is achievable while basic structures using locally available materials and cheap plastic covers may be profitable for farmers in less than 2 years. Non-steel structures do however degrade rapidly under tropical environmental conditions so farmers engaging with protected cropping for the first time with such structures need to plan for future investments to replace or upgrade the structure if they are to continue using protected cropping. The concept of a stepped progression with increasing levels of sophistication in protected cropping systems is valuable in promoting protected cropping as it helps farmers see the need to upgrade both structures and technical skills if they are to progress to more advanced systems.

The kava bowl analogy used in the project is also valuable in highlighting to farmers the need to develop new skills and knowledge in crop production practices, pest and disease management, and financial management including market engagement as part of their protected cropping system. Since there is little history of protective cropping in the Pacific Island Countries, farmers are unfamiliar with the management techniques and financial strategies required for economic stability. Appropriate support to farmers to develop this knowledge and skills is required, and will continue to be needed as grower progress from basic systems to more advanced structures and production systems. The value of farmer to farmer learning cannot be understated as a key element of this capacity building, and support for more lead farmers willing to share their knowledge and skills will increase the rate of adoption of protected cropping.

Institutional support from the government and private sectors will buttress the spread of protected cropping systems. Support for farmers to gain new knowledge and skills may be provided by government staff and private sector input suppliers, and be disseminated further through connections between growers. This support will be particularly important while protected cropping goes through an initial establishment phase in a region or country, and will remain important to address the inevitable challenges that will emerge through the consolidation and maturation phases of the industry. Protected cropping if Fiji

is at the point of critical mass whereby current growers are likely to persist with the system, and support from the government and private sector may assist with more widespread adoption. The status of protected cropping in Samoa and Tonga is more nascent, with a more proactive engagement from government and/or donors likely to be needed to progress the industry. In all countries, the potential for protected cropping to contribute to improved food security in a time when climate change threatens reliability of current production systems should make it an attractive proposition for government support.

As with all technology implementation projects, the risk of unintended consequences due to introduction of protected cropping need to be carefully considered. In this project, the potential for increased supply of vegetables to improve diets, and therefore health outcomes, for farmers and members of rural communities may not be met if increased income from the production system drives changes in food purchasing and consumption patterns towards more processed foods. The need to implement a coordinated strategy involving agriculture, nutrition and health expertise to ensure the benefits of improved availability of affordable vegetables from protected cropping result in improved diets and health outcomes for rural communities was highlighted in the project.

9.2 Recommendations

1. The use protected cropping is recommended to ensure year-round supply of vegetables. Ideally, structures that are high and have passive ventilation along with capacity for rapid release of the plastic covering before severe tropic storms arrive are recommended.

2. Farmers should be encouraged and supported to build knowledge and skills in crop production, crop protection and connection to markets as well as acquiring structures when they first adopt protected cropping.

3. Adoption of protected cropping should be scaffolded through a series of steps of increasing technical sophistication, with growers encouraged and supported to build sufficient skills and knowledge in all aspects of the protected cropping system at each step before investing in more advanced structures.

4. The Training Manual produced by the project should continue to be developed and refined by extension and research staff based in Pacific Island Countries, building a resource containing locally relevant training strategies, information and contacts. Any future aid projects could base engagement with agriculture ministries in Pacific Island Countries around support in developing and using the training resource.

5. Further research focussed on integration of protected cropping systems and open field production systems is warranted, with smallholder farmers likely to be using both systems in their farming operations. Optimisation of protected cropping and open field production within a single farming operation, including aspects such as timing of crop production in both systems, use of inputs such as irrigation across the systems, financial optimisation with cash flows, risk management and supply chains to markets, would deliver a more holistic support program to farmers.

6. Support for agriculture, nutrition and health professionals to work together in delivery of agriculture development programs should be encouraged to ensure positive diet and health outcomes are achieved along with the economic benefits that often flow from improved production systems.

In response to feedback from the project review panel, the following additional recommendations are made:

7. Research addressing longer term soil health management in protected cropping systems be incorporated in any future research projects. This item would be able to be integrated into recommendation 5, with soil health in both protected cropping and open field production examined.

8. Consider continuation, and extension, of the protected cropping program in the Pacific with differentiated activity programs in different countries depending on the status of protected cropping adoption in the country. Fiji should act as a Pacific hub in a ‘hub and spoke’ model for protected cropping in the Pacific given the more advanced progression of protected cropping adoption in that country.

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11 Appendixes

11.1 Appendix 1:

Strengthening collaboration between the health, nutrition and agricultural sectors in Fiji.

A scoping review prepared by Rebecca Robinson and Aloesi Dakuidreketi-Hickes.

Australian Government

Australian Centre for International Agricultural Research

"Strengthening collaboration between the health, nutrition and agricultural sectors in Fiji"

A SCOPING REVIEW

Prepared by Rebecca Robinson and Aloesi Dakuidreketi-Hickes

Scoping review completed as part of ACIAR project (HORT/2014/80) "Integrating protected cropping systems into high value vegetable value chains in the Pacific and Australia".

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Date: August 2021

Contents

Acronyms

ACIAR	Australian Centre for International Agricultural Research
DFAT	Department of Foreign Affairs and Trade
EU	European Union
FAO	Food and Agriculture Organisation
FIRST	Food and Nutrition Security Impact, Resilience, Sustainability and Transformation program
MoA	Ministry of Agriculture
MoHMS	Ministry of Health and Medical Services
NFNC	National Food and Nutrition Centre
NGO	Non-Government Organisation
NSA	Nutrition Sensitive Agriculture
RTC	Rural Transformation Centre
SDG	Sustainable Development Goal
SPC	South Pacific Community

Introduction

Increasing access to a diverse range of food is a precondition for good nutrition; however, global food systems are not producing adequate amounts of nutritious food. A key tenet of nutrition sensitive agriculture (NSA) lies in the agricultural sectors' potential to directly address inadequate access to nutrient rich food (Sharma et al., 2021). While many international agricultural development projects are underway in Fiji, most programs do not consider nutritional outcomes. Indeed, one of the unintended consequences of such programs has been developing a 'crops for profit' mentality, which has reduced the availability and accessibility of fresh produce within villages (O'Meara et al., 2019). Strengthening the links between agriculture, nutrition and health is a priority for Fiji, yet the sectors remain distinct, non-overlapping research disciplines. Projects that aim to increase the production of fruit and vegetables can improve nutritional outcomes, however, the lack of connection between the agriculture, nutrition and health sector often results in that benefit not being realised (Jaenicke & Vurchow, 2013). This scoping report, funded as part of an ACIAR project based in the Sigatoka Valley, Fiji (HORT/2014/80), forms the first stage of an ACIAR initiative to co-construct an activity to strengthen collaboration between the health, nutrition and agricultural sectors, and build a shared understanding of nutrition sensitive agriculture in Fiji. The project is a step toward enabling agriculture, health and nutrition partners to work together *at a community level to* discuss and share ideas related to nutrition sensitive agriculture.

This report examines the current situation, and what could be improved to facilitate collaboration between the health, nutrition and agriculture sectors in Fiji. Specific research questions to be addressed in this scoping report:

- What currently exists, what is working well, and what could be improved to facilitate collaboration between the health, nutrition and agriculture sectors in Fiji?
- What existing resources and approaches have the potential to break down sector-siloes, create a shared understanding of nutrition-sensitive agriculture, and enhance intersectoral collaboration in Fiji?

The report draws upon published reports, guidance materials, policies and analyses (see annex) as well as local knowledge.

This report, and later interviews to be undertaken with agriculture, health and nutrition partners in the Sigatoka Valley will inform potential approaches and preliminary development of materials to improve nutritional outcomes within agricultural programs. Outcomes from this project (undertaken as part of HORT/2014/80), will establish the basis for further development and refinement of materials that support collaborative implementation of nutrition sensitive agriculture (NSA) concepts and approaches by health and agriculture extension workers sectors *in family, community and settlement contexts.*

Context

Fiji is comprised of an archipelago of 332 islands. It is divided into four administrative divisions (Northern, Eastern, Central, Western), and further divided into 15 provinces and 86 Tikinas (sub-districts). Rainfall is variable and, on the larger islands, is heavier on the southeast portions of the islands than on the northwest portions. Fiji is subject to frequent cyclones. Topography, soil and rainfall varies across Fiji affecting agricultural patterns and potential.

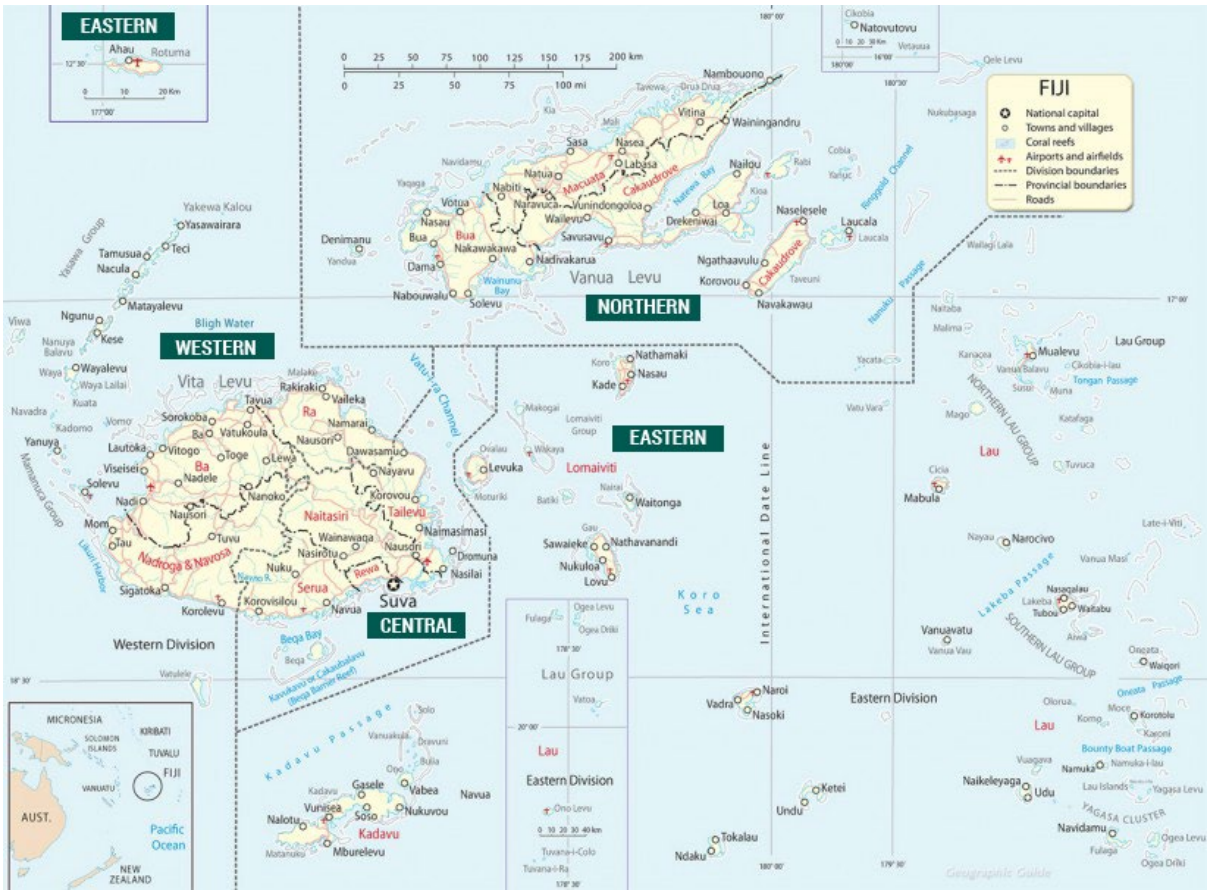

Figure 1 Map of Fiji and Divisions (from http://www.health.gov.fj/about-us/). Sigatoka Valley is located in Nadroga and Navosa province on the island of Viti Levu.

Fiji's population is comprised of **two major ethnic groups**: indigenous Fijians or *i-Taukei* (57% of the population) and Fijians of Indian descent (38% of the population). The population of Fiji recorded in the 2017 census was 884 887 with 44.1 percent of the population living in rural areas. The rural population has decreased continuously at least since 1960 when more than 70% of the population resided in rural areas.

The Fiji Agricultural Census 2020 found that about 34% (300,861) of the population live in **agricultural households** (earning incomes from crops, livestock, fisheries of forest**)**[1]. Of these agricultural households a

[1] **Agricultural Household/Farming Household** – A household is a small group of persons who share the same living accommodation, contribute their income and wealth to acquire certain goods and services and share the same eating arrangement. The same defines an agricultural household where the main economic activity identified is farming or practice of any agricultural activity (crop, livestock, fisheries and forest).

little over a third (83,395) have farming as their primary or secondary occupation. The census defines a farmer as a member of an agricultural household who identifies farming (crop and/or livestock) as his/her primary or secondary occupation. Men make up the majority (85.6%) of those who identify farming as their primary or secondary occupation. The gender analysis (volume 3) of the Fiji Agriculture Census indicates a number of reasons why men outnumber women in farming as a primary or secondary occupation:

- Women are less able to access extension, provincial and district meetings, and are less likely to be selected to attend (most farmer or agriculture representatives are men)
- Of the owners or leasers of freehold, state lease, and native lease land, women have access to only 6.7% of the land. The larger the size of land, the smaller the proportion of female owners.
- Women are more involved in decision making about subsistence farming than income generating or commercial and larger scale farming.
- Women tend to participate in agricultural activity that is compatible with other household and family responsibilities (and expectations).

The agricultural census found that most agricultural households have only small areas of agricultural land, 65% with less than 1 hectare[2]. Only 1% of households have 50 hectares or more of agricultural land. Small scale, subsistence and backyard gardens have traditionally sustained local food supply and the diets and livelihoods of the majority of rural families in Fiji. Interestingly, although roughly only 44% of the population now reside in rural areas, more than 70% of the population is engaged in subsistence or semi-subsistence agriculture *to some degree*, indicating the importance and potential of subsistence or backyard agriculture for improved nutrition.

85 percent of the **land** base is held by *i-Taukei* patrilineal land-owning groups called *mataqali.* Other tenure arrangements include freehold leases and leases of crown land. *I-Taukei* villages are areas where rural Fijians live and are governed under traditional *mataqali* systems. A village may be comprised of one or more *mataqali*. Freehold land can be bought and sold, whereas *i-Taukei* Land and State or Crown Land cannot be bought and sold but is available on a leasehold basis. Settlements on leased land are generally occupied by Fijians of Indian or other descent and are often linked to smallholder farming and market gardening activities. Both indigenous Fijian and Indo-Fijian inheritance practices favour men, and decision-making norms commonly exclude women from participating in decisions over land. Women, then, have fewer opportunities to participate in decision-making to support their own or their family's food security. Women and men generally have different roles and responsibilities in agricultural work. Larger scale plantation crops are commonly organised and managed by men. Women generally have the main responsibility for household food production. Female Fijians of Indian descent generally undertake less agricultural labour than *i-Taukei* women.

[2] 65.0% households, have agricultural land that is less than 1 ha, followed by 21.0% with land area from more than 1 to 3 ha, 6.2% from more than 3 to 5 ha, 4.4% from more than 5 to 10 ha, 2.0% between more than 10 to 20 ha, and 0.9% between more than 20 to 50 ha (p12)

A Closer View: Sigatoka Valley

Located in the south-western corner of the island of Viti Levu, the Sigatoka Valley, which is where this research project is based, covers approximately 1700km2 of rugged mountains and valleys. The upper valley is dominated by its steepness and extreme elevations. As a whole, the Sigatoka valley is typified by sedimentary deposits that are moderately to highly fertile, with the best soils distributed in the middle and upper portions of the valley. The climate is tropical in Sigatoka. Sigatoka has significant rainfall most months, with a short dry season. Most villages are located along the Sigatoka River, with alluvial soil types that are prone to both excessive dry periods, or droughts, and flood. Some rural populations in the Sigatoka Valley lack access to reliable roads and must walk to reach main roads and public transport.

As elsewhere in Fiji, male and female gender roles are strongly embedded in culture and tradition. The roles of women vary with ethnicity and vary in degree at the household level, but male-dominated hierarchies tend to be common regardless.

Farm sizes range from half an acre (0.2 hectares) to 27 acres (almost 11 hectares). That is, the farming community in the Sigatoka Valley is predominantly small holder farmers. Access to land from which to generate a viable livelihood is a major issue in Fijian agriculture. The most common form of land tenure for the Sigatoka people is Mataqali land, while a few communities farm on freehold lands and I-Taukei Land Trust Board leases. Farmers with freehold land have a slightly higher average sized farm than farmers under other systems. Root crops and vegetables are a significant component of this farming system, and this is an important driver in improving food security.

Non-communicable diseases are the leading cause of death in Fiji (77%). About 70% of the population is either overweight or obese and the prevalence of diabetes and hypertension is rising. Anaemia is a public health issue, particularly among Fijian women of Indian descent, and dietary diversity is poor. Prevalence of obesity is around 20 percent among men and 41 percent among women. Increasingly there is low consumption of fresh produce, and high consumption of energy dense, nutrient poor processed imported foods. Local fresh produce, which is healthier, can be expensive, with seasonal shortages, while imported food is cheaper, more consistently available and higher in sugar, fat and salt. Prices and availability of locally grown produce have also been distorted by crop cultivation for export. An over-reliance on food imports has made Fiji it vulnerable to external shocks, including the current Covid 19 pandemic.

Research indicates that Fijians' **food choices** are mainly determined by value for money, followed by ease of preparation and by personal preference, and women are generally responsible for food purchasing and meeting the family's nutritional needs. In response to travel restrictions and food costs caused by the **Covid 19** pandemic people may or may not be increasing agricultural production for household food consumption. Research in 2020 on Covid 19 impacts on Fiji farmers, market vendors and consumers found a small decrease in consumption of fruit and vegetables, as well as greater decrease in consumption of fresh fruit and vegetables by women than men. Conversely other research in 2020 found that, in communities studied, impacts of Covid 19 included: an increase in food being sourced from backyard gardens and farms; an increase in the consumption of aquatic resources; households turning to farming and fishing to increase access to food and income; and the re-emergence or intensification of cultural practices such as *Na*

solesolevaki (working together), sharing food and bartering. Whatever the effects of the Covid 19 pandemic upon agriculture and nutrition, those effects are likely to have greater impacts as the pandemic continues.

Fiji has some **policy** foundation for nutrition sensitive agriculture through its National Development Plan (2017-36), the now out of date Fiji Food and Nutrition Policy (2008), and Fiji Plan of Action for Nutrition (2010-2014), and the current Ministry of Agriculture Strategic Develop Plan (2019-23). The most recent nutrition policy (Fiji Policy on Food and Nutrition 2019-23) has not yet been endorsed. Once endorsed it will prioritise multi-sector leadership, and ownership and coordination of national food security and nutrition action, and will aim to enhance and promote sustainable, diversified and resilient food system. Key activities and outcomes in the Ministry of Agriculture's Strategic Development Plan for intersectoral collaboration rely upon the endorsement of the latest nutrition policy and the development of an implementation plan. Agriculture, rural development and the environment are among the priority areas of the Fiji National Gender Policy.

Nutrition Sensitive Agriculture (NSA) in Fiji

The **definition of nutrition-sensitive-agriculture** used here is that used by DFAT which is drawn from the World Bank and DFID definition of nutrition-sensitive agriculture:

> *Nutrition sensitive agriculture aims to maximise the impact of nutrition outcomes for the poor, while minimising the unintended negative nutrition consequences of agricultural interventions and policies on the poor, especially women and young children.*

"Nutrition sensitive" activities may tackle underlying causes of poor nutrition, while "nutrition specific" activities tackle immediate causes. People's agricultural practices and choices interact with food security, caring resources and practices, and health services and water sanitation and hygiene (WASH) and these can be critical for nutrition sensitive agriculture. Food production, agricultural income, and women's empowerment are key agriculture-to-nutrition pathways. Each agriculture to nutrition pathway is affected by factors such as the food market environment, natural resource environment, water, sanitation and hygiene, and nutrition and health knowledge and norms. How to facilitate and promote nutrition sensitive agriculture with farming families, communities, settlements and villages in Fiji will depend in part upon the ways in which an agricultural intervention (such as a project supported by ACIAR) is designed, where it is implemented, and its potential affects in agriculture-to-nutrition pathways and the enabling environment.

Australian Government support for a nutrition sensitive agriculture (NSA) in agriculture and food security development initiatives has been in place at least since 2015 when DFAT published its nutrition sensitive agriculture operational guidance note. A 2020 review of Australia NGO Cooperation Program (ANCP) funded agricultural development and food security projects recommended that projects should be more nutrition sensitive "…not only encouraging people to grow more and different food, but also adding behaviour change interventions to ensure this translates into increased dietary frequency and diversity. ACIAR has a Nutrition-Sensitive Agriculture Advisor whose role is to provide nutrition and food security advice, develop key products on nutrition-sensitive agriculture in the Indo-Pacific region, and work towards achieving more sustainable food systems for healthier and more nutritious diets. The use of DFAT's NSA operational guidance and the input of the ACIAR/DFAT NSA advisor should mean that Australian government funded agriculture project designs, including those in Fiji, will be nutrition sensitive (at a minimum applying a "do no harm" approach).

ACIAR's Annual Operational Plan 2020-21 notes that a model called "Livelihood Improvement through Facilitated Extension (LIFE)", developed in the Philippines, is soon to be trialled by ACIAR through a project called "Landcare—an agricultural extension and community development model at district and national scale in Fiji". The model recognises the benefits of an approach where the extension worker is a facilitator for local decision making and action. Depending upon the appropriateness of the model to the Fiji context, the project may provide opportunities for a shift in agricultural extension to deliberately enable contextual and locally led approaches to NSA.

The UN/FAO's recently funded project *"Gathering evidence and supporting multi-stakeholder engagement on the role of diets and food systems in the prevention of obesity and non-communicable diseases in Pacific Island Countries (Fiji). 2019 – 2020",* aims to provide evidence-based data on nutrition and health outcomes in Fiji and connections to the Fijian food system. The project, led by the University of the Sunshine Coast, examines local food environments, including availability of and accessibility to food, school food environments, and mapping the fresh food system. Of note, the project aims to develop an understanding of how the multisector policy landscape influences dietary behaviours and will identify opportunities for future multi sectoral research, collaboration and actions.

Organisations in Fiji, including relevant government Ministries, are not explicitly active in nutrition sensitive agriculture, though some organisations are active in promoting food security, healthy food and growing kitchen gardens. In 2019, the MoA launched their Backyard Gardening Program and promotion of fruit orchards in village communities to improve food security and nutrition. A home gardening program was also run by the MoHMS, funded by the FAO, where the MoA collaborated with the MoHMS in providing seed growing training to communities around Fiji. As an emergency food security response during the Covid 19 pandemic, the MoA has been further promoting kitchen gardens and providing seed packs to selected families in lockdown. While these nutrition specific programs aim to improve food security and nutrition, they do not address the need or opportunity for general agricultural programs and activities to integrate nutrition sensitive approaches more broadly in agricultural sector (e.g. in commercial agriculture and agricultural export projects), nor the ways in which approaches to improved nutrition can go beyond immediate causes to the underlying (multi-sectoral) causes of poor nutrition.

The Fiji National Food and Nutrition Centre (NFNC), housed in the Fiji Ministry of Health and Medical Services, has collaborated with the MoA in some activities intended to increase awareness about good nutrition and to promote improved nutrition, through these are not institutionalised into MoHMS or MoA process and practice. The MoHMS promotes improved nutrition as part of its public health remit, but the MoA and the MoHMS do not formally collaborate on the nexus between agriculture and nutrition. Nutrition sensitive agriculture considerations are not integrated or mainstreamed across agricultural initiatives. Aligning with the general findings in the 2020 ANCP review (earlier), there is little activity directed at behaviour change approaches with agricultural communities or families.

Under programs such as the Food and Nutrition Security Impact, Resilience, Sustainability and Transformation program (FIRST[3]), research is being conducted to better understand how market access, food availability, food preferences and other factors affect dietary choices. The program has also supported

[3] FIRST is an FAO and EU funded program to strengthen targeted countries' capacities to address food security and nutrition through more effective policies and investments. FIRST focuses primarily on the provision of policy assistance for food security and nutrition (FSN) and capacity development support at the country level. http://www.fao.org/3/i4927e/i4927e.pdf

the multi-sector-inclusive development of the (not yet endorsed) Fiji Policy on Food and Nutrition 2019-23 and supported the development of the MoA's Strategic Development Plan (2019-23). These have the potential to affect how MoA agricultural initiatives connect with improved nutrition, and how different sectors can collaborate towards shared nutrition goals but are contingent upon endorsement of the Policy and the corresponding development of an implementation plan.

There are **Fiji materials or guides** for healthy eating, subsistence or kitchen gardening practice, and Pacific behaviour change based training for health. Materials may be used by extension workers from different sectors or different disciplines. As yet the ideas and information are not linked together for nutrition sensitive agriculture and Fijian contexts.

Reaching agricultural communities and families

Jurisdiction over food production and food supply is seen as the role of the MoA, while diet is seen as the responsibility of the MoHMS. The MoA's mission is "to create an enabling environment that accelerates sustainability, economic opportunities, climatic viability, food and nutrition security for all Fijians." The MoHM's mission is not explicitly concerned with improved nutrition however, MoHMS does have a role in nutrition reflected in its strategic plan, and its medical services are directed towards non-communicable diseases, many of which are the result of poor nutrition.

Currently housed under the MoHMS, Fiji has a National Food and Nutrition Centre (NFNC). Established in the early 1980s, it is still guided by the 2008 Fiji Food and Nutrition Policy, and the related Fiji Plan of Action for Nutrition (2010-2014). The small and low resourced NFNC team will be guided by the Fiji Policy on Food and Nutrition Policy 2019-23 (and a subsequent action plan) once it has been endorsed.

The MoHMS and the MoA are structured through hierarchies that extend to local levels[4]. Agricultural extension officers (Agriculture Technical Officers and Agriculture Assistant Officers), and village or community health workers[5], and the nursing station nurses who oversee them, could potentially collaborate to facilitate and promote local understanding, planning, and action for nutrition sensitive agriculture. Some NGOs and some private sector agricultural organisations also provide limited or targeted extension services in some locations.

Ministry of Agriculture

The MoA consists of five implementing divisions[6]: 1. Human Resources Finance & Information; 2. Economic Planning and Statistics; 3. Crop Extension; 4. Animal Health and Production, and 5. Crop Research.

For the purposes of this scoping report Crop Extension is a key division within the MoA. Its role includes conducting and facilitating farmer training, assisting farmers to transition from subsistence to

[4] The Ministry of Rural and Maritime Development and Disaster Management may also, one day, have networks and resources to provide extension services, but does not yet have capacity. The mission of Fiji's Ministry of Rural and Maritime Development and Disaster Management is "to build the integrated rural development framework for productive, progressive, and resilient communities in Fiji".

[5] Community health workers are community members trained by public health nurses "to assist people on issues such as maintaining good child health, safe motherhood and promote wellness and at the same time work closely with the Zone nurses who attend to patients in the villages during the outreach programmes." http://www.health.gov.fj/community-health-workers-complete-training-in-basic-health-services/

[6] In 2019 the MoA began a restructuring process, so there may be (as yet unpublished) differences to that reflected here.

semicommercial operations and monitoring agriculture projects. The Crop Extension Division uses a "Technology Transfer model" reflecting an emphasis upon agricultural technical skills and knowledge to move farmers from semi-subsistence to commercial growers.

According to the MoA's 2014 Agriculture Policy Agenda 2020, an Indian and Malaysian "Rural Transformation Centre (RTC)"[7] model was to be adopted, and the Annual Corporate Plan of 2015 included RTCs and indicated an intention to embark on "rural transformation" through an integrated approach with other Ministries such as Education, Women and Social Welfare and MoHMS. The MoA Strategic Development Plan (2019-23) does not mention RTCs, and the idea appears to have been dropped.

Nearly 50% of MoA extension staff are women, but there are no programmes targeting women agricultural producers, and extension officers are not trained in gender analysis of agricultural issues, needs and services – critical for nutrition sensitive agriculture . Agricultural extension services have tended to target high income earning crops, mostly sold by men, rather than household or domestic and semi-subsistence food production where women have greater responsibility and are more visible. The importance of "backyard" and subsistence agriculture for food security and economic resilience has become increasingly apparent during the Covid 19 pandemic. Lessons from the Covid 19 pandemic response may lead to a reassessment of the long-term importance and value of backyard or subsistence farming along with commercial growing by agricultural families.

Ministry of Health and Medical Services

The MoHMS delivers health services through a network of 98 nursing stations, 84 health centres and 19 subdivisional hospitals. Each of Fiji's four administrative division has at least 20 functioning nursing stations which are the first point of contact with the health system for many rural Fijians. A nursing station is typically staffed by one registered nurse, and each caters to a population of anywhere between 100 and 5000. At the community level, volunteer village health workers in Fijian villages, and community health workers in other rural areas such as settlements, provide basic first aid and coordinate referrals to nursing stations. The registered nurses at local nursing stations and near-by village health workers and community health workers may be the appropriate people to collaborate with agricultural extension workers to facilitate NSA activities at local levels.

NGOs, farmer groups, private sector

Outside of government, the private sector, NGOs, donors and others have a role in extension services. Farmer organisations and farmer cooperatives sometimes provide their own peer to peer or farmer to farmer extension. Organisations such as the Fiji Crop and Livestock Council (FCLC) is comprised of associations representing commodities, and the farmers in these associations have mobile phone access to

[7] RTCs were meant to be integrated rural development initiative facilities strategically located to facilitate collaboration between development organisations and government agencies (for development services of rural communities). Under the model informal community-based education would occur at village centres through Farmers Field Schools (FFSs), which would serve as the operating units of RTCs (Ministry of Agriculture, 2014 https://pafpnet.spc.int/pafpnet/attachments/article/219/fiji-2020-agriculture-sector-policy-agenda.pdf). The main feedback mechanism would be through extension staff of the Crop Extension Division. Depending on the context, RTCs might have facilities for information on crops, new technologies and off-farm livelihood enterprises, for selling agricultural inputs, for tools and training, for energy self-sufficiency and value adding and for partner bank assistance desks. https://www.aciar.gov.au/sites/default/files/2020-08/ASEM-2018-117%20Final%20Report.pdf

advice and information[8]. Nature's Way Cooperative - NWC (which has partnered with ACIAR on research projects)- provides a small extension service to its farmer and exporter members and works with the Ministry of Agriculture. International donors have introduced participatory approaches, which are key to effective extension, but these approaches are commonly linked to specific projects rather than to sustained institutional changes in extension approach and process. A limited number of local NGOs[9] provide training and extension, though this is largely dependent upon donor and partner funding or resources.

Gaps

The Fiji Policy on Food and Nutrition 2019-23 (previous policy was 2008-2014), has not been endorsed and consequently an implementation framework to enable collaborative work towards shared outcomes has not been established. An action plan could clarify how different sectors (and Ministries) could or should collaborate in nutrition sensitive agriculture.

There is **not an established process and framework for coordination in planning and budgeting towards common outcomes between separate ministries**. Extension workers in different ministries have different work-planning and budgeting procedures, fitting within wider program workplans and towards planned outcomes or performance indicators. Extension workers in different ministries also necessarily have different reporting lines. Longer term, collaborative activity would require some level of shared work-planning, setting of objectives, and agreement over responsibility and resourcing. As noted earlier, the absence of a current endorsed national nutrition policy and implementation plan make it more difficult to achieve collaborative planning and action.

The absence of a national guiding nutrition policy and implementation plan and shared targets or outcome areas is a barrier to collaboration between sectors or ministries– **why work together when it is neither core business nor easier to arrange than business as usual?** There is a need for policy to be in place so that ministries have an incentive to plan collaborative or complementary work and engage with the private sector and NGOs and others and allocate resources accordingly. This is not to say activities that establish workable and effective approaches and materials to facilitate local collaboration in the short term cannot be developed, rather that these activities may not become institutionalised unless there is a policy framework and ministry commitment within which they fit.

[8] The recent Fiji Agriculture Census found that men are much more likely to own a mobile phone than women. Relying on access to information through mobile phones may exacerbate information access and communication disparities between men and women in agricultural households. The FCLC board is all male and of the fifteen council members, representing different commodity associations, only one is a woman.

[9] According to http://www.pcdf.org.fj/whoweare.aspx - Partners in Community Development Fiji (PCDF) was founded in 1978 and is one of Fiji's longest established NGOs doing community development projects. According to http://friendfiji.com/ - Foundation for Rural Integrated Enterprises & Development (FRIEND) uses integrated approaches to tackle social, economic and health challenges in communities around Fiji. FRIEND engages communities in programs focussed on good governance, sustainable livelihoods, disaster preparedness and healthy living, targeting women, youths, marginalised people, and men in each community for sustainable development. According to https://teiteitaveuni.com/ - Teitei Taveuni is a grassroots non-profit organization that promotes sustainable farming practices on the island of Taveuni. Its aim is to resolve the issue of unsustainable farming practices on Taveuni. It is dedicated to: sustainable farming and soil regeneration; food security and sustainable livelihood; conservation and environmental awareness.

In common with other many Pacific island countries agricultural **extension officers are not formally required to use "functional " or "soft skills",** despite these skills being recognised as key to effective and inclusive extension or rural advisory services. Extension officers lack training in the skills needed to take participatory gender responsive and inclusive approaches. Extension workers are trained in the technical aspects of their sectors (information, skills and technology use, etc), and this is reflected in their job descriptions. Transferring information, skills, and knowledge to target people (e.g. "farmers") are seen as the work of agricultural extension workers, and treatment or referral, advice, information sharing and health promotion are the work of community health workers, but community and farming family engagement and behaviour change towards improved nutrition is not necessarily seen as "core business". That is, work is focussed on "what" more than "how" or "why". On the whole existing agriculture and nutrition materials reflect this.

Women's empowerment is a critical pathway for nutrition sensitive agriculture, but extension workers are not trained in approaches that are inclusive and gender responsive (let alone gender transformative). Extension workers are not trained or required to understand or examine gender norms and structures and how these play into their work and the activities or services they provide. There is a lack of institutionalised policy, process and practice for participatory gender responsive and inclusive approaches to extension (agriculture and health), though Fiji does have a National Gender Policy.

Both the **MoA and MoHMS have very limited resources**, and the resources they do have are further stretched in the face of the ongoing Covid 19 pandemic response and its economic impacts. If activities or approaches to working at *family and community level* are to be institutionalised and sustained, or deployed in targeted ministry programs, they will need to be low cost and require only simple coordination. However, approaches that enable locally led development may provide an opportunity for low resource action – costs would be associated with greater extension worker engagement, but not necessarily with "project" resourcing.

Currently there are limited NSA materials for collaborative delivery or facilitation in a participatory community setting. There are Fiji specific and regional nutrition materials and there are food garden materials – backyard or kitchen-garden. There are international NSA materials, which would need substantial changes to be contextually appropriate and enable collaborative facilitation by health or agriculture extension workers or other sectoral extension workers.

Concluding recommendations for an activity enabling cross-sector collaboration for NSA at settlement or village level

Currently there are international and regional frameworks, guides and training related specifically to NSA, and elements of these may be adapted to Fijian contexts. There are Fiji specific materials on healthy eating and growing fresh produce for home consumption and these materials could complement a facilitated approach to NSA *at community or village level* where agricultural projects or programs are being implemented.

A national nutrition policy is awaiting endorsement and has the potential to then enable and mobilise greater multi-sector collaboration, particularly if a framework for policy implementation is also developed and if the MoA Strategic Development Plan's contingent nutrition priorities can then be implemented.

The Ministries of Agriculture and Health are structured to have extension workers reaching village and community levels, but face significant capacity constraints (numbers of personnel, skills, process, resources), and added burdens (Covid19 response, and reduced budgets). Depending upon location, other stakeholders

with an interest in engaging with NSA may be available to collaborate as facilitators with government extension workers, or to provide expertise to local people implementing NSA activities that they have identified as their priorities.

Delivery of facilitated NSA workshops would require approval from relevant ministries for extension workers to be involved, and resourcing support for arranging and running workshops.

Leaders in potential sites (whether settlements or villages) would need to be approached for their endorsement for workshops to go ahead, then local awareness would need to be conducted on the purpose of the workshop, and then invitations sent/given to local farming families.

Resources required would include: workshop site/venues where all participants feel welcome, healthy fresh snacks and lunch, stationery or other materials. Other considerations would include: provision for child care while parents are involved in the workshop and timing of workshop to fit in with family needs.

Initially the process would aim to enable cross-sector experiential reflection and learning, targeting farming families, in villages or settlements, with the potential for additional participation of representatives from local groups (farmer groups, church groups, health committees, etc).

Workshop material would:

- foster or enable collaborative facilitation by people (agriculture and health extension workers) with little training or experience as facilitators
- encourage inclusion (gender, disability, difference)
- be participatory and promote constructive critical thinking to enable the identification of priorities and planning for contextualised and participant led solutions for NSA
- encourage spouses and other family members to participate together to constructively examine and plan for NSA as a farming household

Anticipated results would include:

- Participant learning about NSA
- Problems, resources, opportunities and solutions in relation to NSA identified at family/household level
- Participant identification of NSA action items (things that they can implement themselves)
- Extension worker experience in collaborative facilitation for NSA
- Evaluative feedback from participants and facilitators for improved approach and materials

As outlined above, this project was to have developed and trialled an approach and materials for collaborative facilitation of a participatory NSA workshop in the Sigatoka Valley. Due to a second wave of Covid 19 with widespread lockdowns and other restrictions to control its spread and reduce mortality, the approach within this project will now look at sketching out greater detail for a *potential workshop and its materials.* Data to inform the workshop and materials will be drawn from this scoping report and from interviews undertaken with agriculture, health and nutrition partners in the Sigatoka Valley (Upper Valley, Mid Valley, Lower Valley and East Bank). The selected localities are those who are currently affiliated with the current ACIAR project, so relationships are well established within these villages. Depending upon the availability and interest of key Fiji stakeholders across sectors, an online discussion may then be facilitated *to further refine the approach* and possible materials for future development and piloting.

Longer term sustainability and institutionalisation of collaborative nutrition sensitive agriculture activities suited to farming households and communities or villages would be part of a broader set of activities.

Together these activities would establish top-down support and commitment for facilitated bottom-up, inclusive and locally led solutions:

1. Support efforts to enable endorsement of the Fiji Policy on Food and Nutrition (2019-23)
2. Support efforts to develop a multi-sectoral policy implementation plan
3. Establish agreement between agriculture and health ministries on collaborative approaches, particularly in relation to nutrition sensitive agricultural activity
4. Take a participatory approach to engaging with MoA and MoHM in developing a theory of change, design and monitoring evaluation and learning for NSA
5. Work with the ministries to institutional process and practice for participatory and inclusive extension (standards, training, institutional policy and practice guides)
6. Enable training and assessment against the standards
7. Provide training of extension workers across sectors to be trainers/facilitators
8. Enable collaborative (agriculture and health) work planning, budgeting, reporting, etc
9. Provide health and agriculture extension workers with material to collaboratively facilitate participatory and inclusive workshops with farming families to identify NSA issues and plan family and local solutions.
10. Support roll-out of approach
11. Continue to evaluate training/workshops and approaches
12. Continue to revise process and materials

Annex: Summary of key publications

Document	Type of document	Summary of key points
National Development Plan (NDP) for Fiji, 5 years (2017-21) and 20 years (2017-36), the Ministry of Economy	National development plan (Fiji)	Policy goal: Develop a national food and nutrition security policy or framework. Key strategies include: • Create an enabling environment for the agriculture-nutrition nexus. • Support evidence-based policy and planning. • Promote nutrition-sensitive value chains to improve accessibility of nutritious food products. • Improve multi-sector co-ordination of food and nutrition security policy. • Mainstream nutrition into national sectoral policies and action plans. The national development plan supports integrated or collaborative approaches between sectors/ministries.
Fiji Policy on Food and Nutrition 2019-23 (replacing the former *Fiji Food and Nutrition Policy (2008)* and the *Plan of Action for Nutrition 2010-2014)* *[unable to locate a copy of the revised policy]*	Policy (Fiji)	The revised policy is currently awaiting cabinet endorsement. Development of the policy was led by the National Food and Nutrition Centre (http://www.nutrition.gov.fj) with assistance from the Food and Nutrition Security Impact, Resilience, Sustainability and Transformation (FIRST[10]) program. Fiji's (yet to be endorsed) National Policy on Food and Nutrition aims to bring together the Ministry of Agriculture (MoA), the Ministry of Health and Medical Services (MoHMS), Ministry of Education, Ministry of Women, Children and Poverty Alleviation, Ministry of Industry and Trade/Tourism, and Ministry of Youth and Sports. The priority areas (communicated by the NFNC) of the yet to be endorsed policy are:

[10] FIRST is an FAO and EU funded program to strengthen targeted countries' capacities to address food security and nutrition through more effective policies and investments. FIRST focuses primarily on the provision of policy assistance for food security and nutrition (FSN) and capacity development support at the country level http://www.fao.org/3/i4927e/i4927e.pdf

		1 Improve multi-sector leadership, ownership and co-ordination of national food security and nutrition action 2 Enhance and promote sustainable, diversified and resilient food systems 3 Promote investment in nutrition-sensitive value chains 4 Improve food safety and quality standards and promote safe water 5 Enhance maternal, infant, young child and adolescent nutrition 6 Support healthier school food environments 7 Promote healthy diets and lifestyles to reduce non-communicable diseases (NCDs) 8 Promote adequate and appropriate micronutrient intake for better health outcomes 9 Support the enhancement of social protection programmes through the inclusion of complimentary food security and nutrition interventions 10 Scale up evidence-based action to reduce food and nutrition insecurity
Fiji National Gender Policy (Ministry of Women, Children and Poverty Alleviation, no date, launched 2014).	Policy (Fiji)	The National Gender Policy does not directly refer to food or nutrition. With respect to "agriculture, rural development and the environment", the policy seeks to: • "Promote gender aware and gender sensitive policies, plans and strategies in the Ministry of Rural Development, Ministry of Agriculture, and the *i-Taukei* Land Trust Board, which foster gender equality in the agriculture and rural development sectors, and promote strategies to increase the participation of women in decision- making at all levels… • Facilitate the acquisition of data on the role played by women in the rural and agricultural sector and using such data for gender responsive budgeting and national planning in agriculture... • Promote increased regard for environmental sensitivity, climate change impacts and disaster risks and the role of men and women at all levels …" • Train men and women on gender equity in the division of labour and on the economic empowerment of women in the agricultural sector." The Ministry of Women, Children and Poverty Alleviation is mandated to facilitate the implementation of the National Gender Policy across ministries but has limited staff capacity and budget. The Ministry of Agriculture has had a draft National Sub Policy on Women in Agriculture since 2015 (not sighted).

National Food and Nutrition Policy for Schools (2009 Ministry of Education, Heritage and Arts)	Policy (Fiji)	The policy's objectives are: • To create an enabling environment in schools for: "healthy food choices: the only choice for all." • To incorporate nutrition in the curriculum for all levels of formal and non-formal education. • To ensure that food security is promoted and practiced at all levels of education. • To improve and maintain all aspects of food quality and safety.
Ministry of Agriculture Strategic Development Plan 2019-2023	Sectoral strategic plan (Fiji - agriculture)	The main instrument for the implementation of Ministry of Agriculture policies. Developed with support of the FIRST program. Aligns with the National Development Plan and the Food and Nutrition Security Policy. Development included involvement of other ministries such as the Ministry of Health and Medical Services, and Ministry of Education. The Sustainable Development Plan is supported by directly connecting to the MoA's annual costed operational plans. Strategic key performance indicators (among others) include: • Improved production and access to local, safe and nutritious food for communities • Increased adoption of local food gardens by school and demand for diverse, nutritious and safe food • Increased production of resilient, safe and nutritious food in rural and urban communities • Strong multi-sector approach supported by Food and Nutrition Security Policy. While it is a MoA Strategic Development Plan (so doesn't directly enable cross sectoral collaboration), its development included other ministries such as MoHMS, and it does have a performance indicator for multi-sector approaches. The multi-sector collaboration indicator is dependent upon the endorsement of the food and nutrition policy, and a resultant "framework for implementation for joint action".
Strategic Plan, Ministry of Health and Medical Services. 2020-2025	Sectoral strategic plan (Fiji - health)	The strategic plan has three strategic priorities, the first of which is of some relevance to our project: Reform public health services to provide a population-based approach for diseases and the climate crisis. One outcome area for this strategic priority is:

		Reduce communicable disease and non-communicable disease prevalence, especially for vulnerable groups. The plan does not explicitly connect nutrition and agriculture. The plan does not directly link with the MoA Strategic Development Plan (see above). In terms of nutrition the focus is on primary care and prevention advice for non-communicable diseases (dietary advice).
Policy effectiveness analysis SDG2[11]: Fiji (not dated. 2021?)	Policy analysis (Fiji)	A country-level policy effectiveness analysis focused on the two main policies that the FIRST program supported in Fiji: • the Fiji Policy on Food and Nutrition Security (2019-23) and its Action Plan [*not yet endorsed*], and • the five-year Strategic Development Plan of the Ministry of Agriculture. Other related policies are also considered, with special attention to the National Development Plan. Appendix 4 provides a comprehensive list of policies and strategies linked to Food and Nutrition Security.
Fiji Agriculture Census 2020	Agriculture Census (Fiji)	Released in 2021 the Agriculture Census is published as four volumes with a summary of key findings: Fiji Agriculture Census 2020: Key Findings Volume 1: General Table and Descriptive Analysis Report Volume 2: detail Analysis and Report of Enumeration Areas Volume 3: Gender Analysis Report Volume 4: Administration Report
Country gender assessment of agriculture and the rural sector in Fiji. 2019. FAO and SPC	Assessment of gender in agriculture (Fiji)	An assessment that makes findings and recommendations on the enabling environment for gender mainstreaming, and gender-responsive community engagement in rural sectors. The report is a useful overview of gendered inequalities in agriculture in Fiji. The report notes that: "The jurisdiction for food security, nutrition and health is currently divided among multiple ministries. The complexities of cross-sector collaboration constrain provision of consistent, quality services to 1) communities and 2) women who are likely to be the household members most closely involved in daily

[11] SDG2 (Sustainable Development Goal 2) is: "End hunger, achieve food security and improved nutrition and promote sustainable agriculture"

		food provision and nutrition…There is a need for a multisectoral approach for the advancement of women agricultural producers in general, and gendered aspects of food security and nutrition in particular." and that "developing appropriate modalities for both capacity building on gender and cross-sector coordination are areas where further work is needed." (p26)
Working across sectors is crucial for food security and nutrition in Fiji, 2020 (FAO brief, FIRST program)	Brief (Fiji)	Summarises the malnutrition situation in Fiji (triple burden: "widespread rates of anaemia affect all age groups, and undernutrition, overweight and micronutrient deficiencies coexist on the same family.") The brief notes the need for: a multisectoral approach to address malnutrition; nutrition sensitive agriculture; and accessibility of and demand for diverse and nutritious food. The brief reinforces the need for a multisectoral approach and NSA.
CTA[12] technical brief 28: the agriculture-nutrition-income nexus in Fiji, 2019	Brief (Fiji)	The brief summarises the intersection of agriculture-nutrition-income in Fiji: • Agriculture in Fiji contributes 9% of gross domestic product and absorbs 40% of the labour force. Over 70% of the population is engaged in subsistence and semi subsistence agriculture. • Insufficient production capacity, inconsistent quality and limited knowledge of the nutrient and health benefits make local fruits, root crops, seafood and vegetables uncompetitive. • Non-communicable diseases are the leading cause of death (77%). About 70% of the population is either overweight or obese; the prevalence of diabetes and hypertension is rising. Anemia is a public health issue. Dietary diversity is poor. • Women play an important role in household nutrition and are custodians of fishery and agricultural knowledge but face many barriers to accessing business, financial and other services. Only about 1% of the 33,000 registered farmers in Fiji are female [figures are slightly different in latest Agriculture survey]. • Numerous policies, programmes and organisations shape the agriculture nutrition-income agenda

[12] The Technical Centre for Agriculture and Rural Cooperation ACP-EU (CTA) was founded in 1983 under the Lomé Convention and then the Cotonou Agreement between the European Economic Community (EEC) and African, Caribbean, and Pacific (ACP) countries. CTA assisted organisations in formulating and implementing policies and programmes to reduce poverty, promote sustainable food systems, sustainable food security, preserve the natural resource base and contribute to building self-reliance in ACP rural and agricultural development. The centre closed in 2020, after the ending of the Cotonou Agreement and the subsequent end of its financing. https://en.wikipedia.org/wiki/Technical_Centre_for_Agricultural_and_Rural_Cooperation_ACP-EU_(CTA)

		but with mixed results and very limited impact. The brief's recommendations are: • Establish a cross-sectoral, multistakeholder, gender-sensitive technical oversight committee to improve coherence in policy and decision-making for improved agriculture and agribusiness performance, economic empowerment and nutrition outcomes. • Develop and implement a monitoring and evaluation framework for tracking achievements against agreed targets across government ministries, working in partnership with producers, academia and the private sector including financial institutions. • Support and strengthen community-based organisations that are piloting innovative and effective solutions that contribute to women's agricultural and economic transformation and particularly benefit rural households. • Conduct more scientific research on the nutrient content and health benefits of traditional Fijian crops and marine resources and support the development of new/improved/novel healthy Fijian food products. • Design and conduct more targeted education, communication and marketing campaigns to promote more diversified diets for good health. Align the agriculture and nutrition curricula from primary to tertiary level to increase awareness of the health and economic benefits of local nutrient dense foods. • Increase access to affordable business, financial and technical services and mentorship support to enhance value chain performance. Train farmers, fisher folk and agribusinesses/small-medium enterprises on food safety, postharvest handling and production/processing techniques.
Food and Health Guidelines for Fiji (2013)	Healthy eating guidelines (Fiji)	Produced by the World Health Organisation, The Fiji Ministry of Health and the National Food and Nutrition Centre.
Grow your own Food: Promoting healthy eating through home food gardening. National Food	Vegetable gardening guide (Fiji)	A guide for gardeners, families and communities to establish home food gardens and grow fresh vegetables, fruits and starchy staples for household consumption. Produced by the National Food and Nutrition Centre with the FAO's Promotion of Fruit and Vegetable

and Nutrition Centre, 2017		Production and Consumption for Health Program, and the FIRST program. The MoA also helped develop
Grow your own food - MyKana App, Fiji Version 2.0	App (Fiji)	A free app that can help users quantify their calorie intake each meal and each day, and provides vegetable gardening tips, with a view to improved diet (5000+ downloads, varying but mostly positive reviews, and the app is being updated/improved in response). *[Note that, according to the recent Agriculture Census, data show that 35.3 percent of male farmers and 45.5 percent of female farmers do not own a mobile phone]*
The crop farmer's guide. MoA (n.d. 2015?)	Crop guide (Fiji)	Intended for farmers, agriculture students, backyard gardeners, and extension officers. It provides advice on crop spacing, fertilising, weed control, disease control, harvest/yield/food value, disaster risk and climate change mitigation.
Fiji Farm Management: Budget Manual, MoA, 2014	Farming manual (Fiji)	The manual (more than 590 pages) is intended to assist farmers (with support from agriculture extension officers) to prepare farm business plans and project proposals. A large number of pages are copies of legislation and regulations. The manual is divided into three parts: Technical Information; Financial Information; References (forms and guidance materials including legislation). It has a great deal of un-curated information. More relevant for business development, but even then, is not user friendly.
Garden to Fork Cookbook, Foundation for Rural Integrated Enterprises and Development (FRIEND)	Recipe book (Fiji)	A recipe book using ingredients that can be home grown and that align with Pacific guidance on healthy nutrition (diverse diets using less sugar, salt, and fat). FRIEND is a Fiji social enterprise (see http://friendfiji.com/)
Pacific Examples of Good Extension Practice, Pacific Islands Extension Strategy Consultancy Report (by the University of the Sunshine	Extension practice assessment (Pacific)	Confirms need for multiple levels and multiple sectors. Analysis is divided into three main areas of practice: 1. policies and institutional support 2. capacity building 3. extension models

Coast's Sustainability Research Centre -under the Pacific Agriculture Policy Project) to the SPC		Analysis concludes that best practice extension requires best practice in the three areas above as well as effective, efficient and efficacy-based monitoring and evaluation processes.
Participatory needs assessment for capacity building in extension (Pacific Islands) ACIAR (not located – referred to in the assessment report above)	Extension needs assessment (Pacific)	Confirms low capacity, high demand for improved understanding of participatory approaches, tools and practice. Among 12 participating countries, the report identifies 50 different areas of capacity building. Highlights that farming communities are now required to operate in a more open and free market structure, placing more diverse requirements on extension personnel. Capacity building needs in areas such as communication skills, networking and participatory approaches were ranked highly by participants. Three main categories emerged in the study including (a) Livelihood, or the context for participatory RD&E (Research, Development and Extension), (b) Management of Participatory RDE, (c) Participatory RD&E Skills.
The Pacific Islands Extension Strategy: strategic priorities in agricultural extension and rural advisory services in the pacific region (2018-2028). Land Resources Division, SPC	Extension strategy (Pacific)	The Pacific Islands Extension Strategy (PIES) "provides a vision and direction for regional collaboration in strengthening agricultural extension and rural advisory services (RAS) across the Pacific." The strategy provides a regional framework for agricultural extension and advisory services comprised of four focus areas: (1) capacity development for RAS human resources; (2) policy development support for RAS; (3) strengthening systemic partnerships in RAS, and; (4) knowledge management in RAS. A focus on the need for functional skills is a strategic priority under the Pacific Islands Extension Strategy 2018-2028.
Operational guidance note: nutrition sensitive agriculture. 2015. DFAT	NSA guidance (general)	Designed to support integration of nutrition considerations in agricultural programming. Uses the concept of nutrition-sensitive agriculture, and provides guidance from analysis, program design, implementation, and monitoring and evaluation.

		The guidance note aligns with *Agriculture and nutrition: a common future, a framework for joint action* (2014), by the European Commission, FAO, CTA and World Bank Group [see lower in table], which identifies common pathways through which agriculture can improve nutrition. The document notes that agriculture programs alone are not able to tackle the nutrition challenges and need to collaborate with other sectors, including health, education, water and sanitation, and social protection, to address the basic, underlying and immediate causes of malnutrition. Annex one of the operational guidance note includes a (2015) list of key resources.
Pacific guidelines for healthy living: a handbook for health professionals and educators. 2018. SPC	Health Guidelines (Pacific)	Background information and guidance on use of the Pacific guidelines for healthy living. Intended for Pacific health professionals and educators, as well as regional agencies responsible for developing and delivering food and nutrition programmes. Promotes healthy living by integrating diet (consumption of locally grown and produced foods), physical activity and other lifestyle factors such as tobacco smoking and use of alcohol. It notes that the guidelines may need to be adapted by different countries including incorporating additional information to reflect the burden of non-communicable diseases. FAO is designing and funding the regional project called - Technical support for national Food-Based Dietary Guidelines (FBDGs) in Fiji, Marshall Islands, Samoa, Solomon Islands, Tonga and Vanuatu. The regional project runs until the end of 2021 (http://www.fao.org/asiapacific/news/detail-events/en/c/1310766/) - The Fiji National Food and Nutrition Centre has held workshops to develop an *i-Taukei* (indigenous Fijian) version of the Food and Health Guidelines for Fiji, with plans for it to be further fine-tuned through Divisional training of trainers followed by cascading training workshops in the Subdivisions. A training package for the "Food and Health Guidelines Fiji" project is also being developed.

Training Manual Pacific Guidelines for Healthy Living. 2020. SPC	Training manual (Pacific)	The manual is intended as a tool for health educators (including community health educators, public health nurses and dieticians/nutritionists, agriculture extension officers, youth club members, school teachers, church group leaders, sports team coaches) to use in facilitating workshops with various potential target groups of 12 to 24 people. The manual is intended to support the implementation of the *Pacific Guidelines for Healthy Living* (above*).* The learning modules seek to take a behaviour change approach rather than simply "education" or "awareness". Doesn't directly make the connection between agricultural practice and ensuring nutrition sensitive outcomes. *[Note that there is evidence that most people's general knowledge of good nutrition is already consistent with health expert guidelines (e.g. p4 https://pace.usp.ac.fj/wp-content/uploads/2018/04/CTA-2020-Fiji-Final.pdf), but this does not mean that people then use that knowledge and eat a heathy diet].*
Regional Framework for Accelerating Action on Food Security and Nutrition in Pacific SIDS 2018 (draft)	Food Security and Nutrition framework (Pacific)	The Pacific Framework is "... the mechanism to coordinate implementation of the Global Action Programme on Food Security and Nutrition in Small Island Developing States (GAP) within the Pacific [Small Island developing States] SIDS region…(2018-2022)." The goal of the Pacific Framework is: to strengthen the coherence and coordination of development partner support for food security and nutrition in Pacific SIDS. There are four priority outcomes: 1. Evidence base strengthened to support multi-sectoral policy action 2. Enhanced multi-sectoral commitment and action 3. Improved sustainability, resilience and nutrition-sensitivity of Pacific SIDS food systems 4. Actions to improve food security and nutrition among key target groups are scaled up

Agriculture and nutrition: a common future, a framework for joint action (European Union, the Food and Agriculture Organization of the United Nations, the Technical Centre for Agricultural and Rural Cooperation and the World Bank Group) 2014	Agriculture and nutrition framework (International)	The "…framework outlines the potential of agriculture to improve nutrition, sets out the guiding principles and provides a joint strategic response for shaping policy dialogue and ensuring alignment in the design of policies and operational programmes in agriculture and nutrition." It identifies pathways through which agriculture can improve nutrition: 1. agriculture as a source of food 2. agriculture as a source of income 3. agriculture as a driver of food prices 4. agriculture to empower women 5. agriculture to contribute to macroeconomic growth 6. agriculture to ensure sustainable food and nutrition security and resilience. It has three strategic priorities: 1. Enhance resource mobilisation and political commitment to strengthen the link between food and agriculture systems and nutrition at international, regional and country levels 2. Scale up proven nutrition-sensitive food and agriculture interventions at country level 3. Increase knowledge and evidence to maximise the impact of food and agriculture systems on nutrition.
New Extensionist Learning Kit (a series of manuals by the Global Forum for Rural Advisory Services - GFRAS)	Extension training manuals (International)	The kit is designed for self-directed, face-to-face or blended learning. Each module contains a pack with a textbook, workbook, lecturer's guide and Power Point presentation that can be downloaded from the GFRAS website. Each pack also contains an interactive eLearning version that can be taken as part of the Massive Open Online Courses (MOOCs). Modules cover core functional skills that cut across different fields and are aimed at strengthening the capacities of individual field extension staff, managers, lecturers, farmers' organisations, non-governmental organisations (NGOs) and training institutions. NELK modules are 1. Introduction to the 'New Extensionist' 2. Extension Approaches and Methods 3. Extension Programme Management

		4. Professional Ethics 5. Adult Education for Behavioural Change 6. Knowledge Management for rural advisory services (RAS) 7. Facilitation for Development 8. Community Mobilisation 9. Farmer Organisational Development 10. Value Chain Extension 11. Agricultural Entrepreneurship 12. Gender in Extension and Advisory Services 13. Risk Management and Adaptation in RAS Not designed for use at community or farming family levels. Something along these lines could possibly be adapted and appropriate if applied in existing agriculture and community health worker training institutions, or rolled out as ongoing professional development (in-service).
Nutrition-Sensitive Agriculture Training Resource Package. SPRING (Strengthening Partnerships, Results, and Innovations in Nutrition Globally) USAID 2018	NSA Training manuals (International)	Designed to provide guidance, recommendations, and ideas for individuals training others on nutrition-sensitive agriculture. Materials tends to focus upon *under*-nutrition. Illustrations are from India and West Africa. Comprised of seven sessions: 1. Strengthening Agriculture-Nutrition Linkages: Why it Matters 2. Essential Nutrition Concepts for Nutrition Sensitive Agriculture Activities 3. Essential Concepts in Agriculture and Food Systems 4. Agriculture to Nutrition Pathways 5. Developing a Seasonal Calendar 6. Social and Behaviour Change for Nutrition-Sensitive Agriculture 7. Designing Effective Nutrition-Sensitive Agriculture Activities Some potential for adaptation for Fijian contexts. Would first require adaptation to Fijian context, then training of extension workers to use and understand, and then them delivering training/workshops.