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Final Report

Atoll Soil Health Project

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1 Acknowledgement

First, we would like to acknowledge the ongoing support from ACIAR on the research and development needs in the Pacific.

The successful implementation of the project was through various partners. The Pacific Community (SPC) as the lead implementing agency would like to thank the project partners for their contributions. We would like to thank the Ministry of Environment, Lands & Agriculture Development, Tarawa, Kiribati; the Department of Agriculture, Funafuti, Tuvalu; the University of Tasmania and the University of Adelaide. Your technical insight, hard work, and commitment were the key drivers of the project success.

We also thank the in country implementing partners including the IFAD project in Kiribati titled 'Outer Islands Food and Water Project'; the island councils of the five islands in Kiribati (Abaiang, Beru, Abemema, Tab North and Nonouti) and the Funafuti Island Council. Without your blessings and support to the project would not have been implemented successfully.

Last but not the least, we thank all the communities who participated in the project activities. It is our hope that the project will have a profound long-term impact on you.

2 Acronyms

AAs	Agricultural Assistance
AAIS	Abaiang Agriculture Incorporated Society
ACIAR	Australian Centre for International Agricultural Research
ALD	Agriculture and Livestock department of MELAD – Kiribati
ANOVA	Analysis of Variance
BFG	Babai food gardens
CACs	Community Agricultural Committees
CePaCT	SPC Centre for Pacific Crops and Trees
CF	Community Facilitators
CTA	Centre for Tropical Agriculture
DFAT	Department of Foreign Affairs and Trade – Australia
DOA	Department of Agriculture – Tuvalu
FAO	United Nations Food and Agriculture Organisation
FFS	Farmer Field Schools
FSPK	Foundation for South Pacific People – Kiribati
GFSP	Global Food Security Programme
ICM	Integrated Crop Management
ICPMS	Inductively coupled plasma mass spectrometry
ICPOES	Inductively coupled plasma optical emission spectrometry
IF	Island Facilitators
IFAD	International Fund for Agricultural Development
KOIFAWP	Kiribati Outerisland Food and Water Security Project
LOA	Letter of Agreement
MELAD	Ministry of Environment, Lands and Agriculture Development
MNREE	Ministry of Natural Resources, Energy and Environment – Tuvalu
NCD	Non-Communicable Diseases

NGOs	Non-Government Organisation
PGS	Participatory Guarantee System
PNG	Papua New Guinea
PRA	Participatory Rural Appraisal
PRAP	EU-Funded Pacific Regional Agricultural Project
OI	Outer Islands of Kiribati
OP	Open Pollinated
RMI	Republic of Marshall Islands
SPC	Pacific Community (SPC)
UoA	University of Adelaide
UTAS	University of Tasmania
TTM	Taiwan Technical Mission

3 Executive summary

The SMCN-2014-089 project officially started on 19th September 2015 and was extended to 31st December 2020. It was a 4-year ACIAR funded project to support development of sustainable soil health technologies for atolls in order to improve production of staple root crops and nutritious food crops.

The project addressed three objectives:

1. To increase the sustainability and productivity of starchy staple food production systems,
2. To increase household and community production and consumption of local nutritious foods, and
3. To identify and develop opportunities for inter-island trade in high-value crops and products.

The project partner countries were Kiribati and Tuvalu. This project also provided the research support to Component 2 of an IFAD National Project in Kiribati on 'Outer Islands Food and Water'. Component 2 focussed on food security in four outer islands of Kiribati. This ACIAR and IFAD project together leveraged further support from FAO who provided a Letter of Agreement (LOA) with SPC to replicate the research activities in the Marshall Islands.

In delivering the project outputs, a strong multi-disciplinary team with expertise were sourced from:

- The University of Tasmania
- The University of Adelaide
- Pacific Community (SPC) Land Resources Division (LRD)
- Ministry of Environment, Land and Agricultural Development (MELAD), Kiribati
- Ministry of Natural Resources (Tuvalu)
- Ministry of Resources and Development (Marshall Islands)

Throughout the project, we worked with some key partners from the Catholic Parish of Bikenibeu in Kiribati, the Kaupule (Island Council) of Funafuti in Tuvalu, and the Marshall Islands Organic Farmers' Association (MIOFA) in Marshall Islands.

In Kiribati, there were four island target sites, Tab North, Beru, Nonouti and Abemama. Abaiang was also included under Objective 3. In Tuvalu, the target site was Funafala Island.

The project has achieved the following:

1. Cultivars of root crops best adapted to some of the outer islands were selected from locally available germplasm. Sweet potato varieties with local names PNG and PRAP produced the highest yields. All taro cultivars performed well. Two cassava cultivars collected from Banaba and Butaritari can grow well with application of sufficient compost.
2. Applying compost to a trench or planting holes 30 to 40cm deep then planted with root crops or vegetables produced better yields than applying compost to mounds.
3. Pot and on-farm trials showed that applying 15% compost (1 shovel per planting hole) and 25% compost (2 shovels per planting hole) produced better results in vegetables and root crops compared with current practice.
4. Best bet targeted compost recipes have been developed to address limitations of atoll soils and a factsheet is available.
5. Nutritious crops like te mota (wild *Amaranthus*), chaya (*Cnidoscolus aconitifolius*), drumstick (*Moringa oleifera*), hedge panax (*Polyscias scutellaria*), ofega (*Pseuderanthemum whartonianum; P. carruthersii*), beach cowpea (*Vigna marina*), kangkong (*Ipomoea aquatica, Ipomoea reptans*), Cucurbits (pumpkin and choko), bele (*Abelmoschos manihot*), chilli (*Capsicum spp*), and purslane (*Portulaca oleracea*) have been promoted in the food production systems with some success. Factsheets of these have been developed and are available in prints and pdf copies.
6. Babai pits as reserves for a range of foods have been successfully modified in three of the four outer islands in Kiribati.

7. Value chain analyses of some crops from Abaiang to South Tarawa had been completed.
8. An Abaiang Production Plan and Participatory Guarantee System for Root, Fruit and Vegetable Growers has been developed to guide the value chain component of the project.
9. Marketing of produce grown in Abaiang has started in Tarawa.

Results of the project showing sustainability have been adopted by the DFAT funded Food Futures Initiative, which will be targeting Tuvalu and Kiribati as well as urban communities in Fiji. In addition, the IFAD funded Global Food Security Framework has reached out to the team and the above key results were shared for incorporation into the final GFSP programme design.

4 Background

One of the greatest challenges Pacific atoll countries face is how to produce enough good quality food to feed its people both in the main islands and in the outer islands. Malnutrition is a significant concern and non-communicable diseases (diabetes, heart disease and micronutrient deficiencies) are increasingly evident as awareness on the effects of poor diet is low. The food production challenge on atolls is influenced by many factors, including narrow genetic base, poor control of pests and diseases, poor soil conditions, limited water availability, climate change impacts, and fading traditional knowledge.

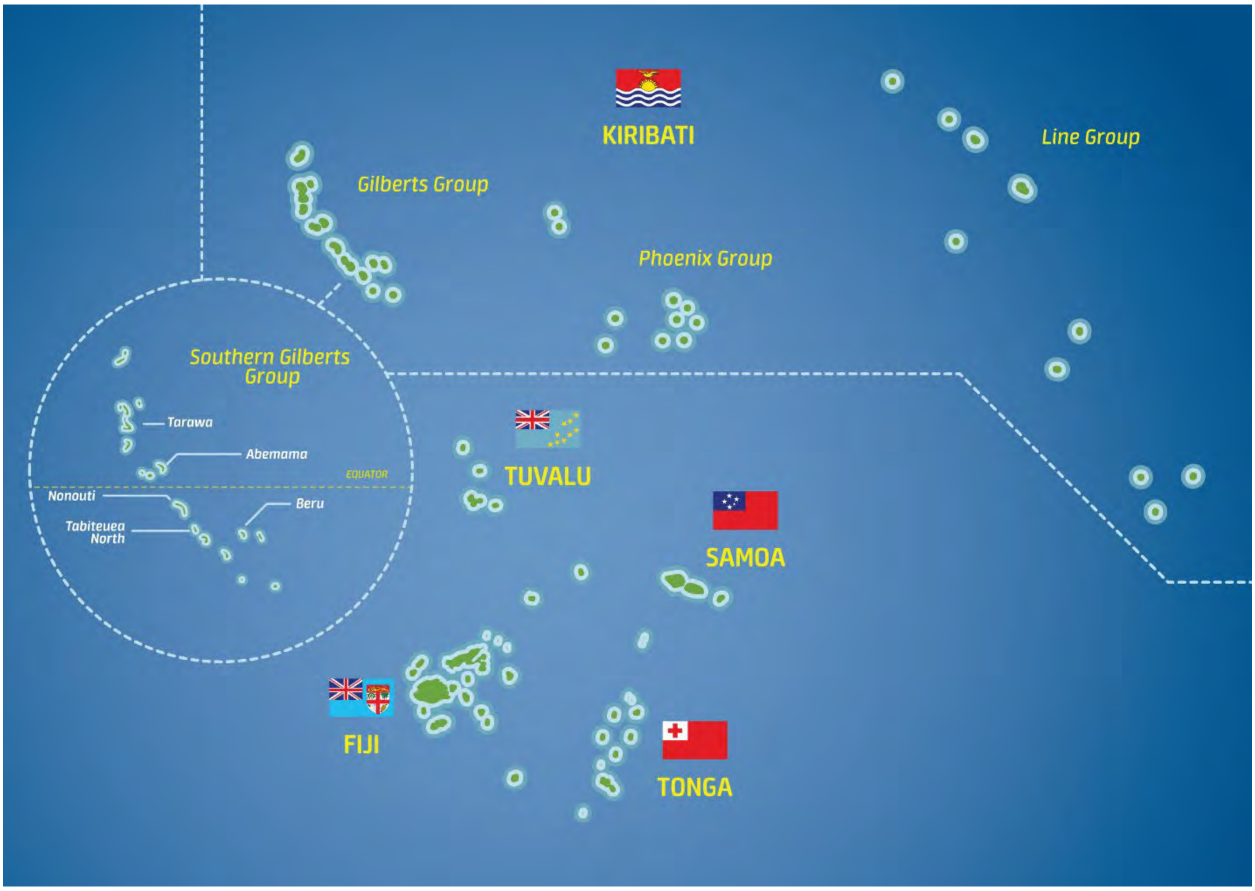


Figure 1. Map showing target sites in Kiribati and Tuvalu

In addition, sea level rise and drought are causing crop damage, contamination of ground water sources, genetic erosion, and loss of arable lands. A range of other socio-economic factors come into play reducing the population's capacity for resilience including, population pressures on natural resources, fragility of environment, limited income opportunities; youth unemployment; poor institutional and human capacities; poor linkages amongst programmes; and outdated policies and regulatory frameworks. These factors, in turn, contribute to the increased heavy reliance on imported food, which are often in low diversity and thus have an impact on food security and the Non-Communicable Diseases (NCD) pandemic.

These multifaceted and often interdisciplinary challenges are prompting greater focus on systemic approach to improving climate change adaptation and sustainable livelihoods and food and nutrition security needs of atolls. In order to achieve food security on atolls, there is a need to address the above critical issues by building capacity of key stakeholders and ensuring there is good partnership amongst these stakeholders. Research plays a pivotal role to develop targeted innovations and technologies to address these problems at multi-layer. This has prompted the development of the project to address food security of atolls by development of soil management, water management, and pest and disease management technologies for the production of selected staple and nutritious foods. Tuvalu having similar food production problems to Kiribati and also in need of increasing local food production – was also included in the proposal.

'Soil health' is the capacity of the soil to function for a given purpose, in this case to support the growth of crops. The degradation of soil impacts the economic viability and environmental sustainability of agriculture, and therefore agriculture's ability to support food security and livelihoods. Before increased agricultural production can occur in Kiribati and Tuvalu, various soil constraints such as sandy texture, rapid drainage, low water holding capacity and little cation exchange capacity need to be addressed.

Traditional land management systems of atolls have been agroforestry systems or the recycling of large amounts of organic material in pits or heaps. Smallholders who have intensified crop production to supply growing urban and export markets have typically failed to replenish soil nutrients and organic matter adequately. Atoll soils are typically calcareous, shallow, alkaline, and coarse textured, and soil fertility is dependent on the organic matter content. In general, the supplies of calcium (Ca) and magnesium (Mg) are abundant but imbalances with potassium (K) and micronutrients cause significant plant nutrition problems. Nitrogen (N) and phosphorus (P) are also generally limiting.

The project was implemented by the the Pacific Community (SPC) in collaboration with the University of Tasmania and the University of Adelaide. The in-country partners including the Ministry of Environment, Lands & Agriculture Development (MELAD), Tarawa, Kiribati; the Department of Agriculture (DOA), Funafuti, Tuvalu.

This project contributes to the development goal of improving the food and nutritional security of communities living on atoll islands in the Pacific. At the project commencement, the project contributed to ACIAR's three main research priority themes for the Pacific region (ACIAR AOP 2018-27): food and nutritional security; agriculture, fisheries and forestry resource management and development; and agriculture, fisheries, and forestry value chains. In ACIAR's current 10-year strategy 2018-2027, during the implementation of this project, it has contributed to all six strategic objectives:

1. Improving food security and reducing poverty among smallholder farmers and rural communities,

2. Managing natural resources and producing food more sustainably, adapting to climate variability and mitigating climate change,

3. Enhancing human nutrition and reducing risks to human health,

4. Improving gender equity and empowerment of women and girls,

5. Fostering more inclusive agrifood and forestry value chains, engaging the private sector where possible,

6. Building scientific and policy capability within our partner countries.

5 Objectives

The specific aim of the project is to improve the livelihoods of the people of coral atolls, Kiribati, and Tuvalu in particular, through increased and diversified agricultural production. The project objectives are to:

1. Increase the sustainability and productivity of starchy staple food production systems,
2. Increase household and community production and consumption of local nutritious foods, and
3. Identify and develop opportunities for inter-island trade in high-value crops and products.

The primary outputs are expected to be:

- Improved food production systems for starchy staples resilient to harsh atoll conditions using integrated pest and soil management.
- Documented information generated by the project on how to organically grow, manage, prepare and preserve nutritious vegetables/fruits in household and school gardens, and
- Identification and development of a fresh produce value chain for sale of surplus food production. The mass balance of nutrients will be incorporated into the value chain analyses.

One of the development goals for atoll island communities is being able to successfully plan and implement investments that result in better nutrition. Within this goal, the project aims to improve the livelihoods of the people of coral atolls, in Kiribati and Tuvalu in particular, through increased and diversified agricultural production, extension approaches, indicators to monitor progress, and underpinned by an understanding of biological processes. This will be achieved by answering the research questions:

1) What soil constraints and pests are limiting food production?
2) Which varieties of starchy staples and nutritious crops (introduced and indigenous) are adaptable to atoll harsh conditions?
3) How can soil health be improved with the resources available in the atolls and will improved soils increase the productivity of starchy staple and nutritious crops?
4) What local nutritious foods are available to be grown in small gardens, and what are the barriers to adoption?
5) How can surplus starchy staple crops and vegetables produced in the outer islands be efficiently and effectively exported to the urban centres in the main islands?

The project's specific objectives and activities are:

Objective 1: Increase the sustainability and productivity of starchy staple food production systems.

Research questions:

1. *What soil constraints and pests are limiting food production?*
2. *Which varieties of starchy staples and nutritious crops (introduced and indigenous) are adaptable to atoll harsh conditions?*

The research activities under this objective were led by SPC and Tasmanian Institute of Agriculture and supported by the School of Agriculture, Food and Wine, University of Adelaide; Kiribati MELAD; and Tuvalu MNREE. The key activities involved:

1.1. Collection and evaluation of genetic materials

The activity involved evaluation of crop varieties for adaptation to harsh atoll conditions as well as the development of resilient food production systems to lessen the impact of climate change. The project started with the collection of available materials in the participating islands: Sweet potato varieties from Abemama (5), Tab North (3); two taro varieties were collected in Abemama; one cassava variety from Banaba Island and one cassava variety were evaluated under the two-soil management regime in Tab North. In Tuvalu, sweet potato and taro accessions were imported from SPC CePaCT, and after hardening off in the Department of Agriculture's nursery, these were evaluated at the Funafala project site.

The nutritious leafy local vegetables like bele (*Abelmoschus manihot*), mota (*Amaranthus dubius*), etc. were collected, analysed and promoted in the outer islands. In addition, to the indigenous (local) vegetables, other vegetables like cabbage, tomato, eggplant, beans, lettuce, pumpkin and carrot were also promoted as nutritious foods.

1.2. Evaluation of the available materials in the outer islands

Linked to activity 1.1, a series of on-farm evaluations were established in the islands to further test the adaptation of the best three or four varieties to local conditions. The evaluation of the crop varieties in all outer islands were conducted under two soil management regimes: (i) increasing soil depth by mounding; and (ii) increasing soil depth by applying the tested compost to the subsoil. Replicated evaluation trials were conducted in Funafala, Tuvalu. In conjunction with the on-farm evaluations, farmer field schools (FFS) were promoted to interested growers of each crop in Kiribati. The FFS activities were facilitated in each main community with approval of the Community Agricultural Committees (CACs) and run by AAs, with assistance from CFs employed by the IFAD project.

1.3. Multiplication of planting materials

To support the efforts to increase the planting of root crops and nutritious foods, community nurseries were supported in partnership with ALD in Kiribati and DOA in Tuvalu with the objective of providing enough planting materials and seedlings (including coconut seedlings) to the participating farmers and home gardeners in all communities. Coupled with these nurseries, compost making facilities were also supported to provide sufficient compost to support sustainable production of vegetables and fruit. In addition, several multiplication plots for the selected varieties of sweet potato, taro and cassava were established in Tanaea Station and the four outer islands and in Funafala in Tuvalu.

1.4. Identification of strategic food reserves and development of babai food gardens

The cultivation of the giant swamp taro (*Cyrtosperma merkusii*), called babai in Kiribati and pulaka in Tuvalu) is traditional on atolls. Pits are dug by hand down to the water table, which in many Kiribati atolls is only 1–2 m below the surface. Many of these pits are now neglected but they provide a strong connection to both culture and fresh ground water. Agriculture Assistants on the outer islands worked with motivated farmers to either dig and plant new babai food gardens or rejuvenate or extend existing babai pits, to include additional food crops, including taro, sweet potato and leafy vegetables.

1.5. Compost making

An important aspect of the soil management technologies involved developing compost technologies that will provide organic matter as well as suitable amounts of plant nutrients for plant growth. Current compost making commonly uses varying proportions of brown and green leaves with addition of animal manure to provide most of the necessary nutrients. However, on many atolls there are limited numbers of pigs and chickens, and manure is not readily available. In addition, unless housed in a pen with a floor, the manure is mixed and diluted with soil. For many atolls alternative compost ingredients are required instead of animal manure.

Results from soil tests highlighted likely nutrient deficiencies and to address these issues, suitable leaves and other inputs are added to improve the composition of the compost. Thus, rather than just making compost with whatever biomass is available, a more targeted approach is being taken. For example, low iron in soil typically shows as yellowing between the veins of leaves (interveinal chlorosis) in deficient plants. Mineral analyses of yellow beach pea (*Vigna marina*: te kitoko/saketa sega) and chaya (*Cnidoscolus aconitifolius*; te tiaia) consistently showed high levels of iron in their leaves, so both plants are good accumulators of this nutrient. When soil iron levels are low, leaves of these plant species can be used when making compost. Therefore, this practice is called "targeted composting".

For this work, over 200 samples of potential compost ingredients (leaves, algae, ash and mud) were collected in the atoll islands and analysed for their nutrient content in Australia. Results from the analyses guided the formulation of targeted compost recipes. A summary of the results was compiled into a factsheet: *Nutritious leafy plants: also valuable for soil health.*

1.6. Identification and evaluation of soil, water and pest management supports

1.6.1. Soil management

Baseline soil analyses were initially conducted with Hanna Quick Soil Test Kit, Palin Test Kit and Solvita respiration test kits. Nutrient analysis for soil and compost samples (about 100) was also conducted by laboratories in Australia. Recommendations for targeted composting were made based on data from these tests.

In general, the key nutrient deficient in soil samples tested from Kiribati and Tuvalu was potassium, with low levels recorded in most of the samples. This is a function of low levels in the coral parent material. In many situations iron and/or manganese are also likely to be limiting and to a lesser degree copper. Nitrogen will likely be limiting in soils where supply of organic matter as fallen leaves, vegetation and addition of compost has been restricted. Soil tests conducted to date have shown phosphorus and zinc are often present in adequate to high levels. Given the expected high 'tie up' of both elements in alkaline soils, this result was surprising and additional tests using different soil P testing methods had been undertaken and showed similar results. Sulphur and boron are not commonly deficient in atoll soils.

Two options for improving soils of atolls were formulated. One was increasing soil depth by mounding on the soil surface or filling tyres, etc. The second was by digging holes down to the subsoil and applying compost to increase soil depth before planting crops. Thirteen on-farm trials had been conducted under the project.

1.6.2. Water management

As an environmental risk management strategy, lysimeter studies may be conducted to study whether these nutrient sources are leaching nutrients past the root zones and are potential contaminants to the groundwater. Bucket irrigation trials were set up in South Tarawa, ALD station in Tanaea, and in the outer islands. Linked to the ACIAR Soil management project, 'fullstops' were installed at experimental sites planted with taro to measure leaching and to determine if there was increasing salinity in the water table in both Kiribati and Tuvalu. In addition, wicking based systems were devised and promoted as an alternative system in low-lying areas where high tides rise to the soil surface in both Kiribati and Tuvalu. Twelve demonstrations were conducted in Kiribati. The wicking systems and food cubes are especially relevant for the site on Funafala, Tuvalu. Food cubes have also been established on Tuvalu outer islands and at the hospital on Funafuti, in order to provide nutritious vegetables for patients and staff.

1.6.3. Pest management

In collaboration with SPC Plant Health team, the current initial assessment identified key economic pests and diseases of concern to both Kiribati and Tuvalu. Based on the assessment, SPC mobilised an integrated pests and disease management jointly with UTAS which resulted in the establishment of a Kiribati Plant Health WhatsApp group to support pests and disease diagnosis and advice. The WhatsApp group remains active and consists of Kiribati Extension Officers, SPC Technical Teams and the ACIAR funded ICM2 project. The group continues to provide technical support and advice on diagnosis of key pests and diseases confronting Atolls.

1.7. Production training provided to extension and services and the farming communities

Several trainings were conducted in both Kiribati and Tuvalu targeted at both extension and the participating communities. In 2018, an integrated training was organised by SPC which included, soil health, soil management, trial design, pests and disease management, and food security benefiting all extension officers in both Kiribati (27) and Tuvalu (22). In addition, a series of trainings on compost production, nursery management, farming techniques and awareness on healthy foods were conducted in all the project sites and various schools.

Objective 2: Increase household and community production and consumption of local nutritious foods

Research questions:

1. *How can soil health be improved with the resources available in the atolls and will improved soil health increase starchy crop productivity?*
2. *What local nutritious foods are available to be grown in small gardens, and what are the barriers to adoption?*

The research activities were conducted by the School of Agriculture, Food and Wine, University of Adelaide with SPC supported by the Tasmanian Institute of Agriculture, Kiribati MELAD, FSPK and Tuvalu MNREE. The team also worked closely with IFAD in the outer islands in the on-farm testing of nutritious crops and in trialling of appropriate cropping systems. The key activities include:

2.1. Evaluation of indigenous and introduced vegetables

Linked to activity 1.1, a survey was conducted to identify the most nutritious leafy food plants, in terms of minerals and protein, that grow in Kiribati and Tuvalu. Particular attention was paid to species that thrive in the atoll environment. Leaf tissue samples were collected in Kiribati and Tuvalu from 2014 to 2018 (n=140), and with the inclusion of leaf mineral data from the previous Pacific-Northern Australia nutritious leafy vegetable project (ACIAR PC/2010/063) [1] (n=274), a total of 414 samples informed the factsheets produced during the current project. Assessment of the nutritional content and taste of plant species was conducted, along with their tolerance to drought, soil salinity, and soil alkalinity, which characterize atolls, especially those of the Southern Gilbert Islands. In Kiribati, samples were collected on the islands of South Tarawa, Abemama, Tabiteuea North, Nonouti and Beru. In Tuvalu, samples were collected on Vaiaku, Funafala and Papaelise. Based on the analysis, 12 factsheets were produced on the most suitable leafy food plants for atolls.

2.2. Training and media campaigns

In order to achieve impact, the project in partnership with the IFAD Outer Islands Food and Water Project collaborated with multiple government ministries (Agriculture, Health, Education, Works), churches, NGOs, Island Councils, and communities on a series of awareness campaigns focusing on schools and communities in the target islands. In Kiribati, about 1500 farmers attended information and training sessions on growing, handling, cooking, and preserving locally grown foods. In addition, community nurseries were supported in the four target islands in Kiribati and in Funafala which facilitated the engagement of communities through the supply of planting material and community/farmer trainings. In Tuvalu, the project has a productive collaboration with the Taiwan Technical Mission (TTM), and Live and Learn are now involved.

2.3. Setting up village market centres

In the campaign to improve consumption of nutritious foods, it was initially envisaged that market centres will be established in villages to sell the nutritious foods to those that do not have access to land. This will also improve awareness of the importance of nutritious foods to the health of the people. In consultation with ALD, it was agreed that the market centre be focused on Abaiang and awareness programs conducted in the other pilot areas/communities. Series of awareness programmes were conducted in partnership with ALD/DOA during various national events such World Food Days, ALD Farmers Days and with schools and within the project communities in promoting marketing and consumption of local foods.

Objective 3: Identify and develop opportunities for inter-island trade in high-value crops and products.

Research Question:

1. *How can surplus starchy staple crops and vegetables produced in the outer islands be exported to the urban centres in the main islands.*

SPC led the activities under this objective supported by the Tasmanian Institute of Agriculture, MELAD ALD, and Tuvalu MNREE. The key activities include:

1. Value chain analysis

The activity focused mainly on Abaiang. A value chain research was conducted with key stakeholders and farmers in Abaiang focusing on horticulture to identify gaps and establish strategies for fresh produce supply to Tarawa to benefit both consumers and producers in the long term. The three crops would be selected from pumpkin, sweet potato, pawpaw, and one of the indigenous crops like wild amaranthus (Mota).

2. Value chain support mechanisms

In partnership with IFAD/CTA project on value chains, funds were provided in the establishment of Abaiang Agriculture Incorporated Society (AAIS). In addition, the support included nursery and planting material support, and export processing facility.

3. Export collection centres and Quality standard systems

The biggest problem in the commercialisation of crops like pumpkin is domestic transport – currently losses during local transport are high – up to 30% in some cases. Getting the produce to where the boats will pick them up without being damaged is a key outcome. As an example, there are 14 villages in Abaiang spread throughout the 37 km length of the island providing challenging logistics to collection of fruits for shipment. The project helped to strategically establish collection centres for storage of produce before shipment. A multi-purpose export collection centre was completed in 2020, consisting of chilling storage equipped with Solar System, seedling distribution centre and training centre for the Abaiang farmers.

4. Livelihood support and Training

Sustaining agriculture production will require capacity building of growers to sustain production and as well as marketing. A series of trainings were conducted with the Abaiang farmers association focusing on seed production, field agronomic practices and agri-business.

6 Methodology

This project was a mixed methodology involving both qualitative and quantitative approaches. Initial qualitative baseline data was collected using Participatory Rural Appraisal (PRA) tools to identify needs of households and constraints to production. Evaluation of available germplasm materials were objectively measured in replicated trial designs with results shared in local farmer field schools and then bulked in several multiplication plots across the targeted islands. Quantitative measures of soil and compost materials were also undertaken and compiled into factsheets for farmer training. A key factor for sustainability of results was establishment of the Kiribati Plant Health WhatsApp group to support pests and disease diagnosis and provide advice to growers from local extension officers, and technical teams such as the ACIAR funded ICM2 Project (HORT/2016/185: *Responding to emerging pest and disease threats to horticulture in Pacific Islands*). The WhatsApp integrated into the wider extension approach that included farmer field schools, grower clusters for production and marketing in a Participatory Guaranteed Scheme (PGS), and trainings that covered soil health, soil management, trial designs, pests and disease management, and food security, compost production, nursery management, farming techniques, value chains, and healthy foods. The method to ensure maximum impact was to conduct these trainings and awareness campaigns with extension officers, communities, project sites, market centres, and various schools. Collaboration with training sessions conducted under the IFAD 'Outer Islands Food and water Project' also increased the impact.

7 Achievements against project activities and outputs/milestones

Summary of achievements and milestones are summarised below (Table 1):

Objective 1: Increase the sustainability and productivity of starchy staple food production systems.

Table 1. Summary of Outputs/Milestones

No.	Activity	Outputs/ Milestones	Completion date	Comments/Achievements
1.1	Collection and evaluation of genetic materials	List of varieties of major staples and nutritious foods for outer islands evaluation and soil health research	September 2015	• 8 Sweet potato varieties, two each taro and cassava varieties were collected and evaluated in Kiribati and Tuvalu • The top performing varieties were selected, characterised, and bulked up and promoted in the five islands in Kiribati and in Funafala in Tuvalu.
1.2	Evaluation of the available materials in the outer islands	Report on adaptability of varieties to the outer island conditions and farming systems	November 2017	• Based on the trials, increasing soil depth showed better results. • The top performing varieties were characterised and promoted throughout the five islands in Kiribati and Tuvalu. • Selected mineral nutrients and the leafy vegetable species found (using opportunistic gene-environment GxE analysis) were studied and found as effective accumulators of minerals with health benefits and for soil health. • Factsheets were produced and an article published
1.3	Multiplication of planting materials	Availability of planting materials to island communities	Ongoing	• Multiplication plots of sweet potato, taro and cassava established in 6 islands (Tanaea, Abaiang, Nanouti, Beru, Abemema & Tab North). The multicrop Nurseries were also established in the 4 outer islands
1.4	Identification of strategic food reserves	Food reserve available and also sites for soil health and water contamination research	November 2016	• Babai pits were studied to assess how different components interact with each other and examine how improvement and modification based on agroforestry system can contribute to sustainability. • The new modified babai pit system was promoted in the 4 outer islands. • Nonouti was the most active island for BFG development, with 12 well maintained in July 2019.
1.5	Compost making	Data base of nutrient contents of compost inputs and compost procedures	September 2019	• Over 200 samples of potential compost ingredients (leaves, algae, ash, and mud) were tested in Australia and results guided targeted compost recipes. A summary of results has been compiled into a factsheet. • Targeted composting as a concept has application in other farming systems.

				• A step-by-step brochure on compost making was developed • Alternative compost recipes without animal manure have been evaluated at Tanaea in pot and field trials. These formulations were also evaluated in the outer islands.
1.6	Identification and evaluation of soil, water and pest management supports	Current soil properties documented at beginning (and end) of project	September 2019	• Baseline soil analyses were initially conducted with Hanna, Palin and Solvita respiration test kits. Soil and compost samples (about100) were also tested for nutrient content in laboratories in Australia. Data from these tests was used as the base for recommendations for targeted composting.
	Water research		September 2017	• Bucket irrigation is recommended for atolls • Wicking based systems promoted as an alternative system in low-lying areas where high tides rise to the soil surface.
	Pests and disease		August 2018	• Key economic pests and diseases diagnosed for both Kiribati and Tuvalu • Plant Health WhatsApp created facilitating diagnosis and recommended IPM practices
1.7	Production training provided to extension services and the farming communities		Ongoing	Several trainings had been conducted in Kiribati, Tuvalu since the project inception in October 2014. • Use of PRA to collect baseline data, on farm trials and pests and diseases identification and control. • Compost making in the outer islands • Basic agronomy of root crops • Training in experimental design, data collection and analyses for both Tuvalu and Kiribati • Training in sustainable soil management for atoll soils

Objective 2: Increase household and community production of local nutritious foods.

No.	Activity	Outputs/ Milestones	Completion date	Comments
2.1	Evaluation of indigenous and introduced vegetables	Initially: list of most promising species from Tarawa trials to be trialled on OI. Then list of the best performing acceptable nutritious vegetables in OI trials.		• Seed production of wild amaranthus was set up in Tanaea in 2015 and seeds were sent to outer islands. • Open pollinated corn and tomato seeds were saved from a plot in Tanaea and distributed to farmers on outer islands. Other OP seeds of egg plants and Chinese cabbages were saved as well. • Seeds of other vegetables such as tomato, eggplant, Chinese cabbage, and cucumber were also distributed.

				• An OP seed saving system was developed but seeds were all distributed and we need to start again after the review. This component will work closely with SPC LRD Pacific Seeds for Life (PS4L) project. • Provision of suitable planting material and development of babai food gardens (BFG) continues. See above, under Objective 1. The BFG program has been particularly active on Nonouti. • In Tuvalu: provision of planting material of the same nutritious vegetables as identified for Kiribati, especially to schools on Outer Islands.
	Soil management research	Current soil properties documented at beginning (and end) of project Report on the impacts of soil management tactics on crop yield and quality and soil physical, chemical and biological attributes available		• See above for 1.5 and 1.6
	Water research	Report on how to manage water for crop production		• The bucket irrigation system promoted in atoll countries. Irrigation sets were promoted with the value chain component of this project in Abaiang, and for Tuvalu • Wicking based system is promising for atolls • DFAT Food Futures started scaling up the wicking based system in Tuvalu, Kiribati, and Fiji.
	Pests and diseases research	Pests and diseases package of practices		• Caterpillar on tomato - treated with neem leaf extract. • Cucumber mosaic virus in pumpkin in Tab North – farmers were advised not to plant from cuttings. • Ants on tomato and beans – treated with neem leaf extract.
2.2	Training	Women, youths and schools improved their knowledge and skills in production, handling, cooking and preserving locally grown foods. Produce school gardens package.		Training and awareness campaigns delivered: • Production of vegetables including te mota. • Seed saving from vegetables like te mota and sweet corn. • Making neem derived pesticide and its use. • Awareness campaign on nutritious foods – done in conjunction with IFAD Project component 2. A recipe book was published. • Collaboration with schools, churches, communities, island councils

				• Research design and pests and disease management.
2.3	Media campaign on awareness raising for nutritious foods	Awareness from political level to grassroots on importance of nutritious foods		• Engagement of the Ministry of Health, IFAD Outer Islands Food security project and project staff visiting schools. • 13 Factsheets have been developed and been used for this as well. An additional brochure on producing nutritious food with compost developed. In Kiribati 3,700 factsheets were distributed to communities, churches, extensionists, etc. • There has been a number of radio interviews of project staff. • Tuvalu: similar awareness activities to those conducted in Kiribati needed. The awareness programs in both countries gained impetus from the publication/provision of the new atoll fact sheets. The Funafuti hospital is growing nutritious vegetables in food cubes using the targeted composts developed in the project and has an exercise program for patients and staff.
2.4	Setting up village market centres	Outer island market centres in place		• Series of awareness and farmers day events organised in promoting marketing and consumption of local foods. • Market centre established in Abaiang.

Objective 3: Identify and develop opportunities for inter-island trade in high-value crops and products

No.	Activity	Outputs/ Milestones	Completion date	Comments
	Value chain analysis	Value chain analysis of 3 crops completed	January 2018	• The value chain analysis and crops promoted include cabbage, capsicum, cucumber, pumpkin and watermelon.
	Value chain support fund	Marketing structure set up	Ongoing	• Abaiang Farmers Association in place • The PGS guidelines list the market structure.
	Export collection centres	Most households in the project sites participate in the program	October 2020	• Provided support in guiding the establishment of a solar-powered cooling facility that has been agreed with the Island Council and established in Abaiang. • In Tuvalu, the component has been taken up by the DFAT Food Futures.
	Quality standards	Set of standards for each value chain commodity	September 2017	• A PGS system developed in harmony with Pacific organic standards. • A Food Safety and Good • Manual on growing root crops in atolls
	Training	Improved knowledge and skills of stakeholders	October 2020	• Supply chain and crop production planning and training conducted on Abaiang with selected high performing farmers to take the lead on the production of vegetables fruits and root crops. • Training in crop production/agronomy of crops • Training in basic book keeping/accounting

				• Training in market negotiation • Recently the project has collaborated/scaled up with a commercial farm near Tanaea and on Maiana, another atoll near Tarawa.
	Livelihood analysis	Report on the livelihood status at the beginning and end of the project	September 2017	A livelihood analysis procedure was developed and used to assess impacts of the value chains on the different aspects of the life of the households in the communities: • Food production is low in these islands. • Farming community, AAs, IFs, and CFs have very little capacity to carry out project activities. • Heavy reliance on imported starches. • Low vegetable and fruit consumption • Farm resilience low • Farm income low

8 Key Results and Discussions

Objective 1: Increase the sustainability and productivity of starchy staple food production systems.

Research questions:

1. *What soil constraints and pests are limiting food production?*
2. *Which varieties of starchy staples and nutritious crops (introduced and indigenous) are adaptable to atoll harsh conditions?*

Activities, Results and Discussions

1.1. Training on the Use of Participatory Rural Appraisal Tools

The project started by consulting with communities to determine the real needs of the households through participatory rural appraisal (PRA) approach. Over 30 people in the collaborating countries were trained in the use of PRA tools to collect baseline data. The training was basically PRA exercises with the PRA tools that were to be used for baseline data collection.

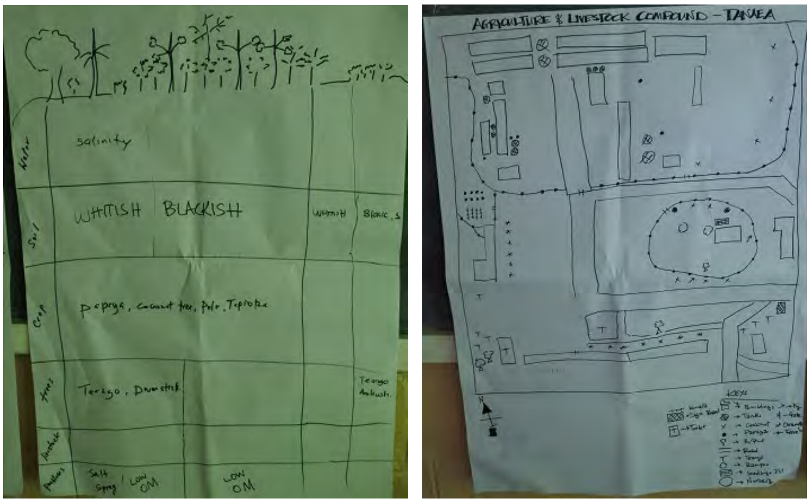


Fig 2. Results of transect walk and resource mapping exercises

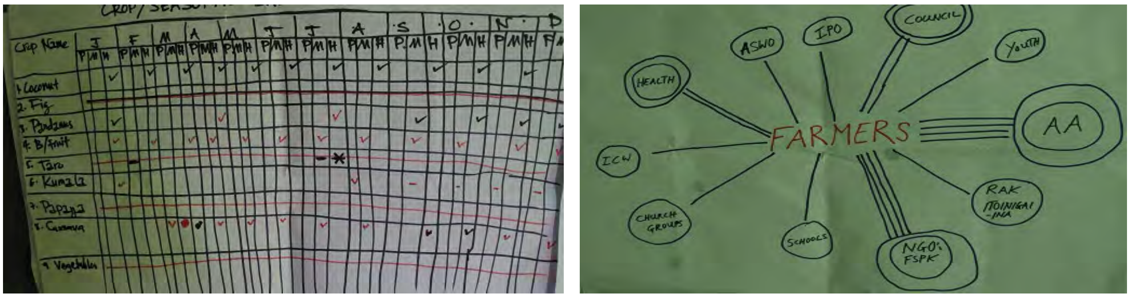


Fig 3. Results of seasonal calendar and Venn diagram exercises

The national project staff then with help of the regional project team conducted some of the baseline data collection using the PRA tools. The data collected was used to develop productivity indexes for the communities.

1.2. Collection and evaluation of genetic materials

1.3. Evaluation of the available materials in the outer islands

Sweet Potato evaluations

In Kiribati 6 sweet potato varieties were collected – PNG, Hawaii, Banaba, PRAP, Unknown 1 (deeply lobed leaves), and Unknown 2 (similar to PNG except the leaves have a single small lobe). The evaluation trials in Kiribati started in 2015. Some of the trials were abandoned because of the effects of the long drought and farmers and AAs not able to manage them well. Because of the drought the soil health team evaluated two soil management methods; (i) building soil depth by mounding on top of the soil surface (ridge), and (ii) increasing soil depth down to the subsoil by applying compost (here-on called flat) down to 30 - 40cm and mixed well in the trench or planting holes. Results were reported together with soil management.

The evaluations were replicated across the islands. Yield data was collected and analysis of variance (ANOVA) done. Tests of significance were done with LSD and Duncan's multi-range test (DMRT).

Abemama

Table 2. Performance of sweet potato varieties collected locally in Abemama.

Variety	Yield (ton/ha)	DMRT
PRAP	9.0 d	b
Unknown	7.0 cd	a
PNG	5.5 bc	a
Hawaii	3.5 ab	a
Banaba	2.0 a	a
$LSD_{0.05}$	2.9	

It was interesting to compare the findings of these two tests (Table 2). Using LSD method, the difference between any two means must be 2.9 ton/ha to be significant. When using Multiple Range test, stricter criteria had to be met. The highest and lowest mean had to differ by 6.7 ton/ha, the second highest and the lowest means had to differ by 6.2ton/ha, the third highest and the lowest by 5.4ton/ha, and the fourth highest and the lowest by 4.2 ton/ha. Using LSD, the yield of PRAP, was not significantly different from Unknow but it was significantly different from PNG, Hawaii and Banaba. Furthermore, the yields of unknown and PNG were significantly higher than Banaba.   Using DMRT, the yield of PRAP is significantly different from all the varieties.

Tabiteuea North

In 2017 four CePaCT sweet potato accessions were introduced (IB/PH/03; IB/PR/10; IB/PNG/29; and IB/US/18) to Tabiteuea North and were tested against the local cultivars of PNG and the unknown. IB/PNG/29, IB/US/18 and IB/PH/03 produced comparable yields to the local varieties. IB/PR/10 did not tuberose.

Table 3. Performance of sweet potato varieties in Tabiteuea North

Variety	Yield (ton/ha)	DMRT
PNG	5.75 b	b
Unknown	3.55 b	ab
Banaba	1.00 a	a
$LSD_{0.05}$	2.51	

Using LSD test, the yield of Banaba is significantly lower than PNG and Unknown, whereas with DMRT only the yield of PNG is significantly different from Banaba (Table 3).

Cassava

One cassava variety from Banaba Island and one from Butaritari were collected and promoted in Tabiteuea North. They were also evaluated at the Tanaea nursery. Both grew and yielded well. Unfortunately yield data were not collected. The new cassava accessions introduced from CePaCT in 2017 - all died.

RMI

This evaluation was conducted under the project and supported by an LOA between SPC and FAO and an IFAD Outer Island Food and Water Security project to replicate trials in RMI. Four CePaCT accessions were imported by RMI and evaluated. IB/US/12 and IB/PNG/29 were the best and needed to be evaluated against the local materials (Table 4).

Table 4. Performance of sweet potato varieties in RMI

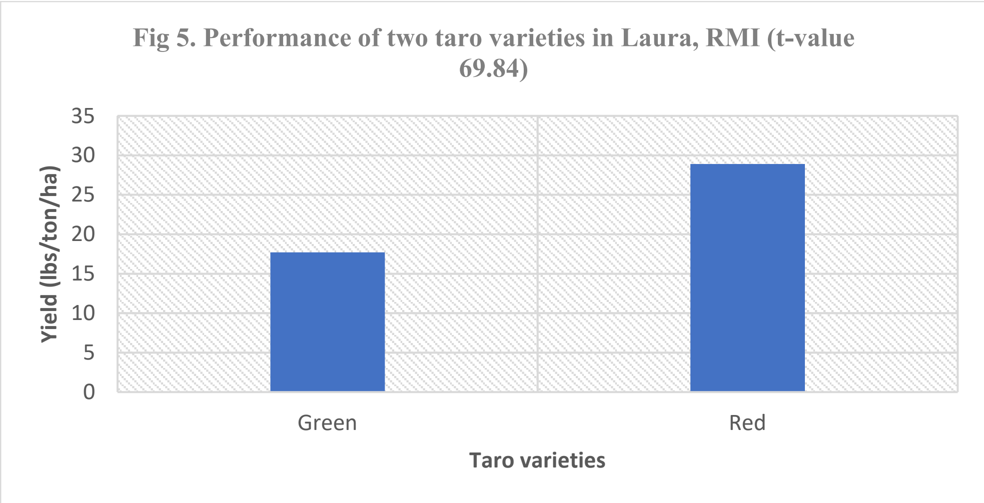
Variety	Yield (ton/ha)	DMRT
IB/US/12	24.6 d	b
IB/PNG/29	17.5 c	b
IB/PR/15	10.3 b	ab
IB/US/23	7.3 a	a
$LSD_{0.05}$	2.6	

The varieties available locally and grown by the communities are IB/PR/15, IB/US/12, IB/US/23, and IB/PNG/29 (locally called PNG). The yield of IBS/US/12 was the highest (24.6 t/ha) and lowest was IB/US/23 with 7.3 t/ha). Using LSD test, yield of all varieties were significantly different. For DMRT test, IB/IS/12 and IB/PNG/29 were significantly different to IB/US/23 but not IB/PR/15.

Taro

The taro accessions from CePaCT (BL/PNG/13, BL/SM/80, BL/SM/152) were evaluated against 3 local varieties (red, green and white). They were comparable in yield, but a taste panel assessed BL/SM/80 best. (Fig 4).

Figure 4. Photo on the left showed the local varieties and the CePaCT introduced accessions on the right. Two comparative trials for sweet potato and taro were planted again in Tab North.



In Kiribati a preliminary observation for taro in Tabiteuea North comparing 3 CePaCT introduced accessions (BL/PNG/13, BL/SM/80 and BL/SM/152) to 3 local varieties was conducted in 2017. Variety Red produced higher yield than Green (Figure 5).

Evaluation of Indigenous leafy plants

For the nutritious leafy vegetables, it was apparent that most were well adapted to the Southern Gilbert Islands and did not require formal field trials. Each of the ALD nurseries grew several of the species identified (by mineral analyses) as the most nutritious. Some of these namely chaya, ofenga and drumstick, were already growing in the nurseries at the start of this project. Pumpkin has been a popular vegetable in both countries for many years. The nurseries, as well as progressive farmers on each atoll, represented valuable sources of planting material for farmers who wished to plant the recommended varieties. The ALD Tanaea HQ on South Tarawa, an unfertile site with soil nutrient deficiencies, was transformed by composting and an improved irrigation system into a model nutritious food garden and important source of planting material. A chaya hedge was particularly impressive, and even a kangkong pond was built. In Tuvalu, secondary bush was cleared, a water supply and irrigation system installed on the island of Funafala, Funafuti atoll, and nutritious crops were grown. Agriculture staff in both countries had been active in getting planting material to farmers.

Once climate/soil-suitability was established for the leafy vegetables, along with acceptable taste, the project focussed on a genotype – environment interaction study in order to identify the best "natural biofortifiers" of minerals important for human and livestock nutrition, and also usually for nutrition of the plants themselves. In more detail:

A survey was conducted to identify the most nutritious leafy food plants, in terms of minerals and protein, that grow in Kiribati and Tuvalu. Particular attention was paid to species that thrive in the atoll environment. Leaf tissue samples were collected in Kiribati and Tuvalu from 2014-2018 (n=140), and with the inclusion of leaf mineral data from the previous Pacific-Northern Australia nutritious leafy vegetable project (ACIAR PC/2010/063) [1] (n=274), a total of 414 samples informed the factsheets produced during the current project. In Kiribati, samples were collected on the islands of South Tarawa, Abemama, Tabiteuea North, Nonouti and Beru. In Tuvalu, samples were collected on Vaiaku, Funafala and Papaelise.

As with the earlier project, an opportunistic genotype-environment (GxE) strategy was employed. This included sampling of single leafy vegetable species growing at different sites as well as sampling multiple species growing at the same site. This enabled the effects of environment (mostly soil type) and genetics (plant species/variety) to be separated, thus allowing an assessment of the ability of each species/variety to take up and accumulate essential minerals in their leaves. The minerals studied were the macronutrients nitrogen, phosphorus, potassium, calcium, magnesium and sulphur, as well as micronutrient sodium, often present in "macro concentrations" but required in micro amounts, along with other micronutrients iron, manganese, boron, copper and zinc. All of these macro- and micronutrients, with the possible exception of boron, are required by humans and animals as well as by plants. A sub-sample was analysed for selenium, an essential micronutrient for humans and animals, but which is not required by higher plants. The analyses also enabled detection of any mineral deficiencies in the plants sampled.

Each leaf tissue sample comprised two handfuls of relatively young leaves: not the youngest or older leaves (e.g., in sweetpotato, the 5^{th} to 9^{th} youngest leaves), sampled from several representative plants, avoiding plants with disease (e.g., virus, scab) symptoms. The exception was pumpkin where just the tips (up to 25cm) were sampled. If the plants were dusty (e.g., if the plants were growing near a road), they were washed in clean water. Samples were dried in a microwave oven or perspex covered trays soon after collection and placed in labelled plastic ziplock bags.

The samples were sent to Australia under a Federal Department of Agriculture permit and irradiated. They were then acid digested, and N analysed by the combustion method, and protein % estimated by multiplying nitrogen % by 4.4. The other minerals listed above were analysed by inductively coupled plasma optical emission spectrometry (ICPOES), while Se was analysed using ICP mass spectrometry (ICPMS). Appropriate quality control measures were applied, including regular duplicate samples and analyses of aluminium and titanium to detect dust/soil contamination, which inflates Fe concentration.

1.4. Multiplication of planting materials

To support the efforts to increase the planting of root crops and nutritious foods, community nurseries were supported in partnership with ALD in Kiribati and DOA in Tuvalu with the objective of providing planting materials and seedlings (including coconut seedlings) to the participating farmers and home gardeners in all communities. Coupled with these nurseries, compost making facilities were also supported to provide sufficient compost to support sustainable production of vegetables and fruit. In addition, several multiplication plots for the selected varieties of sweet potato, taro and cassava were established in Tanaea Station and the four outer islands in Kiribati and in Funafala in Tuvalu.

Figure 6. Characterisation of roots and tubers evaluated under the project

1.5. Identification of strategic food reserves and development of Babai Food Gardens

Babai Food Production systems, which have a traditional role as a food reserve, were modified and upgraded or developed as food systems as part of this project. Activities started in Tab North and Abemama upgrading several babai pits. The conditions of the islands greatly influenced the upgrading to be done. In the northern islands, rainfall is higher and the depth to the water lens is shallower than in the southern islands. This is why cultivating babai in the northern islands is much easier than the southern islands in terms of the amount of effort required to produce better yield from the babai pit. In addition, the women in the northern islands usually do not need to apply large amounts of organic compost when cultivating babai since the soil is richer in organic matter and has good fertility and water holding capacity. In the southern islands however, a lot of organic matter is needed when cultivating babai and a lot more energy will be needed to dig to the water lens. It also takes months to decompose this organic matter before planting in the southern islands compared to the northern islands. Apart from this, people in the northern islands can easily harvest food from babai daily compared to the southern islands where it is very hard for them to consume food from babai daily and hence they use it for special occasions like weddings.

Figure 7. Photos showing how babai pits have been modified by terracing and fruit trees, root crops, and vegetables added to each terrace. Top left and middle are pits in Tab North, top right is in Abemama, and all three at the bottom row are in Nonouti.

Nevertheless, as highlighted above, and shown in the photographs above, babai food gardens were established in all of the 4 Kiribati outer islands in the project. Food plants grown, in addition to babai itself, included taro, sweet potato, kangkong, pumpkin, chilli and ofenga.

1.6. Identification and evaluation of soil, water and pest management supports

1.6.1. Soil management Compost making

The initial activity was to find out the levels of different nutrients in the different soils to guide the compost recipe development. Soil samples from the different sites were taken and analysed with a Hanna Quick Soil test kit that measures nutrients by intensity of colour developed.

Table 5 below show results of the analyses with the Hanna Soil Test kit and the Solvita CO_2 Respiration Test for the sites in Tab North.

Table 5. Soil analyses for Tab North sites.

Soil tests	**Farms/Villages**			
	Terooa	**Teekewa**	**Teukini**	**Tebontebike**
pH Indicator	9	9	9	9
pH 1:2 (soil:water)	7.8	7.8	7.7	8.0
N	Low	Trace	Trace	Trace
P	High	High	High	High
K	Medium	Medium	Medium	Medium
EC	120	90	80	80
Respiration (kg C $ha^{-1}d^{-1}$)	3.5	3.5	3.5	4

The project then bought a Palintest SKW 500 Quick Soil Test Kit to test soils from some sites in Kiribati and Marshall Islands (RMI) to establish levels of these nutrients. Table 6 below shows the results and implications on soil management. On these islands most soils had low levels of K, and all were limiting in Fe, Cu, and Mn. These low nutrient levels prompted the idea that we needed to target compost to apply these limiting nutrients to the soil.

Table 6. Soil analyses of some of the sites in Kiribati and RMI.

Sites	pH Units	EC µSiemen	Nutrients (mg/l)					
			N	P	K	Fe	Cu	Mn
Kiribati								
Tanaea (tomato)	7.8	870	54	60	150	1.4	1.0	0.2
Tanaea (eggplant)	8.2	810	36	47	120			
Kabuna Trial, Tab N	7.6	575	31.4	3	150	0.9	0.2	0.2
Kabuna (new), Tab N	7.8	425	38	24	75	1.0	2.0	0.2
Takaman, Tab N	7.9	676	54	40	55	0.2	1.0	0.2
St. Francis Beru	8.1	445	36	30	95	2.4	2.0	0.3
RMI								
Laura Station	8.0	176	26.4	38	35	2.2	1.6	0.2
Wacner's farm	8.1	162	22.8	21	40	1.0	2.1	0.3

Soil Chemistry Analysis

Key to improving soil health is to validate the limiting nutrients in the major atoll soil. Soil samples were sent for analyses in Australia and sets of Palintest SKW 500 were purchased and given to the countries to use.

Concurrently nearly 100 soil and compost samples from across Kiribati and Tuvalu have been analysed in laboratories in Australia. A summary of soil analyses is given in Table 7.

Table 7. Nutrient analyses (available) of soils from Kiribati and Tuvalu

	pH w	**pH Ca**	**OC**	**min N**	**P**	**K**	**S**	**Cu**	**Zn**	**Mn**	**Fe**	**B**	**TP**
Unimproved soils			%	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Tarawa	8.3	7.7	2.6	38	236	35	21	2.4	14	7	11	1.3	5304
Tab N, Beru	8.5	7.7	1.8	8	69	34	16	0.4	9	2	8	0.4	
Abaiang	8.8	7.8	2.3	20	44	30	14	0.4	3	3	37	0.7	1749
Tuvalu	8.4	7.8	1.7	16	81	27	17	2.6	32	4	12	0.8	1574
Mean values	**8.5**	**7.8**	**2.1**	**20**	**108**	**31**	**17**	**1.5**	**14**	**4**	**17**	**0.8**	**2876**
Improved soils													
Mean values	**8.2**	**7.7**	**3.4**	**86**	**338**	**110**	**40**	**8.0**	**43**	**6**	**51**	**2.0**	**4061**

Table 8. Nutrient analyses of soil from Funafuti, Tuvalu (Most nutrients decrease with increasing depth while pH increases)

	Depth	pHw	OC	*min N*	P	S	K	Cu	Zn	Mn	Fe	B
	(cm)		%	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Unimproved soil	0-15	8.5	2.1	7	21	30	38	0.1	0.8	6	3	0.8
	15-30	8.6	1.0	4	10	65	25	0.1	0.2	2	1	0.5
	30-45	8.9	0.8	8	10	52	25	0.1	0.2	1	1	0.4

The summary of soil analyses from across Tabiteuea North, Beru, Tarawa and Tuvalu (Tables 7 and 8) and the Palin test SKW 500 analyses for soils of Kiribati and Marshall Islands showed consistent trends of high pH and very low levels of K, Mn, Fe and Cu. Linked to the ACIAR Soil Management Project in the Pacific, critical levels for Palin tests will be validated and guidelines developed. Even in improved soils with addition of compost, levels of K were only marginal to adequate. Mineral N levels may also be low in unimproved soils while organic matter inputs in improved soils resulted in higher levels. There were some variabilities e.g., a series of soils on Abaiang recorded relatively high Fe levels. However, the trends in nutrient content are generally consistent. Available and total P and available Zn had generally shown adequate to good levels. Nutrient omission trials had been discussed to determine whether soil tests were accurately predicting P levels for high pH sandy soils. Results of the analyses from Australian labs and the Palintest SKW 500 were mostly correlated, and the soil health team purchased additional kits for each of the participating countries.

Analyses of different composts have shown significant differences in nutrient levels. While compost produced at Tanaea with adequate pig and/or poultry manure supplements had shown high levels of most nutrients, access to these manures is commonly not possible on Outer Islands and some trace elements may still be limiting. In composts produced with supplements of sea cucumber and pig manure extensively mixed with the soil (pig soil), there were lower levels of N, P, K, Mn, Cu and to a lesser degree, Fe.

Based on this, the team decided to conduct compost research into different recipes targeting the nutrient limitations in the different soils. The team started with compost available or commonly made in the islands and found that even though compost was used – it did not consistently provide an effective nutrient supply with plants sometimes still showing deficiency symptoms, particularly of K, Fe and Cu.

A B C D

Figure 8. Nutrient defficiency on crops: A (Cu – tomato leaf cupping), B (Fe – leaf yellowing in cassava), C (K – leaf margin chorosis in taro), and D (P- purpling of cabbage leaf)

To alleviate these deficiencies the project has also tested potential compost ingredients (Table 9) including various wastes and by-products for nutrient levels to help with targeted composting.

Table 9. Nutrient analyses of compost ingredients from Kiribati

Ingredients		**N**	**P**	**K**	**S**	**Cu**	**Zn**	**Mn**	**Fe**	**B**	**Na**
		%	%	%	%	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	%
Ash	*Guettarda*	0.04	0.6	1.2	0.4	16	49	31	380	188	2.2
Ash	coconut husk	0.1	1.6	6.3	0.2	144	183	123	382	365	7.5
Mud	lagoon	0.5	0.04	0.1	0.4	4	5	3	114	71	1.2
Algae	dead	2.5	0.04	0.5	2.1	2	1	5	359	451	9.1
Seaweed	*Acanthophora*	1.6	0.10	4.7	4.2	2	10	5	129	410	3.0
Seaweed	*Sargassum*	1.2	0.14	1.6	1.6	<2	28	27	95	235	2.5
Sea	cucumber	10.2	0.5	0.4		4	40	44	184		8.8
Fish meal		8.3	1.1	0.7		5	102	25	836		0.3
Manure	poultry	2.5	2.1	1.3		49	241	492	727	13	0.2

Table 9 above shows that the ingredients high in certain nutrients. Table 10 below shows the best bets used to supply each nutrient to compost mixes. Actual plant leaf data are presented in the factsheets.

Table 10. Best bets for each nutrient for compost making.

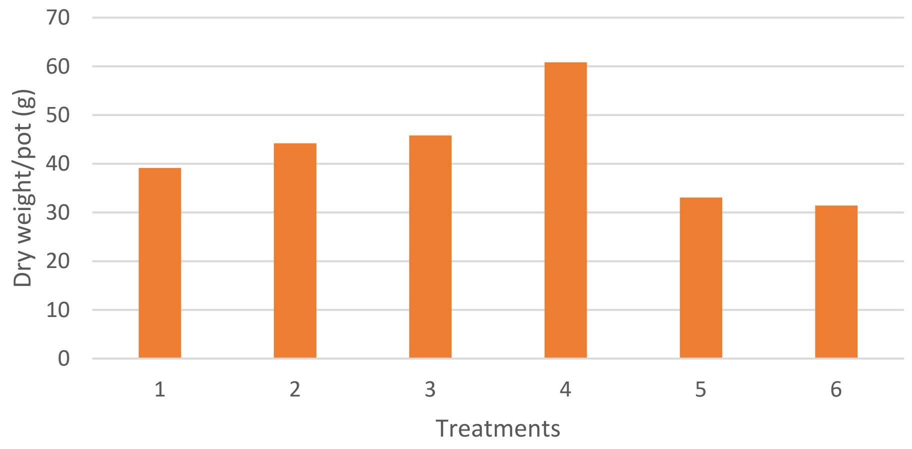
	Compost ingredients (Best bets)
N	sea cucumbers; fish meal; green leaves (chaya, drumstick, purslane, *Vigna*); manure; vegetable scraps
P	manure; ash (coconut husk, shell); green leaves (*Sida*, chaya, drumstick)
K	ash (coconut husk, shell); seaweed (not seagrass); green leaves (purslane, pisonia); manure
Cu	ash (coconut husk, shell); manure; green leaves (pisonia, purslane)
Mn	manure; ash (coconut husk, shell); green leaves (pisonia, *Vigna*, castor weed)
Fe	Manure; fish meal; ash; algae, seaweed; green leaves (purslane, *Vigna*, chaya); *rusty cans?*
Zn	manure, ash (coconut husk, shell); fish meal; green leaves (purslane, hedge panax, *Sida*)

Four different compost recipes were evaluated in a pot trial along with a foliar application and a control treatment. The treatments were:

- Treatment 1: ACIAR alternative based on 3:3 (Brown: Green) but substituting some of the standard ingredients with beach cowpea, drumstick, chaya + ash, rust, te uri soil, old compost.
- Treatment 2: standard 3:3:1 with pig manure
- Treatment 3: standard 3:3:1 with sea cucumber
- Treatment 4: standard 3:3:1 with poultry manure
- Treatment 5: Liquid fertilizer – same as 1. Liquid fertilizer was soil applied to the pots.
- Treatment 6: Control –soil from Betio

The results are shown in Fig 9 below:

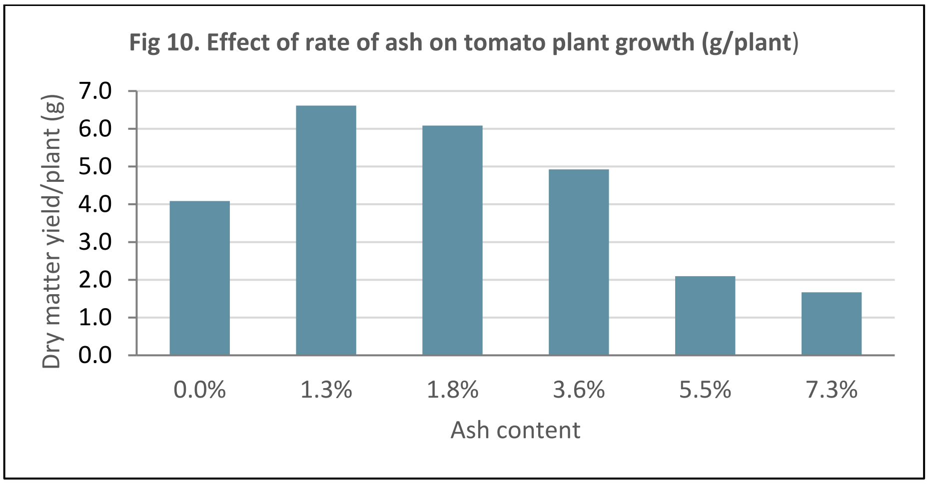
Fig 9. Effects of compost types on dry weight of maize in pots grown on an atoll soils ($p<0.01$)



Four of the five compost recipes tested outperformed the control, and the differences were significant with addition of poultry/pig manure or sea cucumbers to the compost. However, when the control soil was analysed, results showed that it contained high levels of nearly all nutrients, with a Colwell P of 500 mg/kg, which was high. Thus, plant growth in the control soil was assisted by the unusually high nutrient levels.

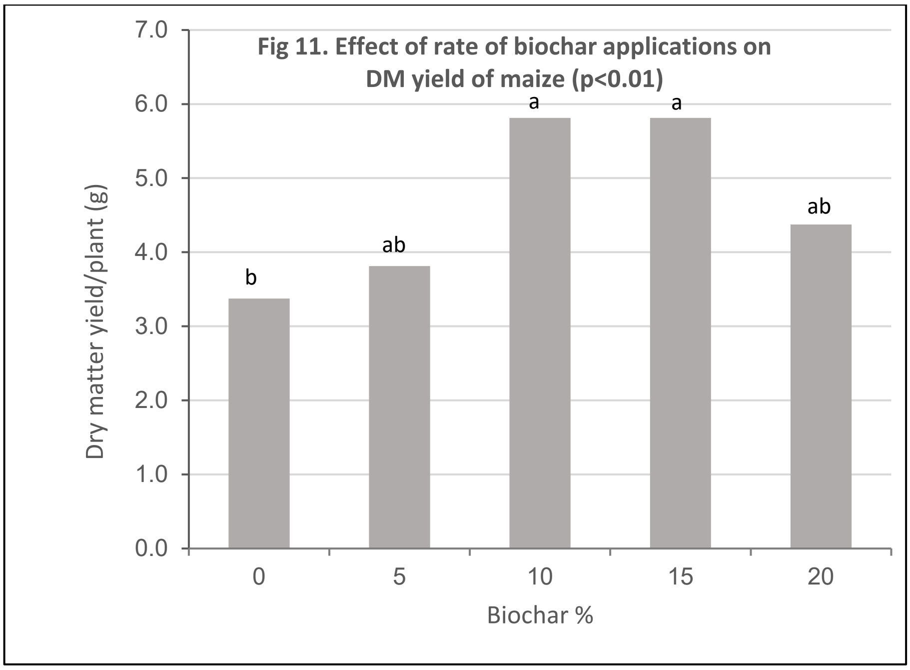
Additional compost ingredient pot trials

Ash: In a preliminary pot trial conducted at Tanaea rates of ash above 5% by weight were found to strongly reduce maize growth. An Honours project at the University of Tasmania using a comparably high pH calcareous soil was conducted with 6 rates of ash ranging from 0 to 7.3%.



Ash rates were optimal around 1-2% by weight and above this was detrimental for growth presumably due to nutrient tie up at the high pH (excess Mg, Ca and Na cations). Addition of ash into compost and potting mixes should therefore be applied with caution. Further in-country trials are required.

Biochar: A biochar trial was conducted with rates of 0, 5, 10, 15 and 20% by weight. To ensure adequate surface area the biochar was partially crushed, and the fines (<2mm) screened and removed. Maize was planted in a pot trial.



Addition of 10-15% ash to the potting mix resulted in a 70% increase in dry matter yield of maize (Figure 11). A second pot trial was planned to measure whether this effect is a result of increased water holding capacity or other factors, but these studies could not be conducted in 2020.

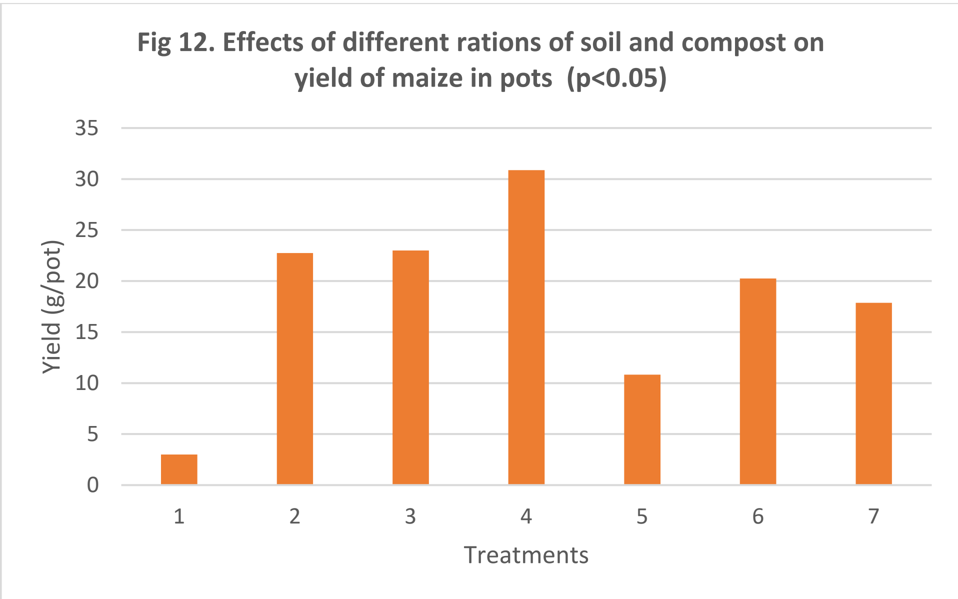
Foodcubes: DFAT organised for 12 Foodcubes to be sent to Uni of Tasmania for two Masters students research studies evaluating appropriate rates of coconut coir in growing media. Results from this work are currently being analysed and theses written up. An Honours student will also conduct a study assessing the impact of biochar on plant growth and growing media properties in Foodcubes.

Compost Pot Rate Trials

The team wanted to start by looking at different ratios of soil and compost and their effects on crop growth. Trials were designed with the following treatments for Kiribati and Tuvalu. Only the Tuvalu trial was completed.

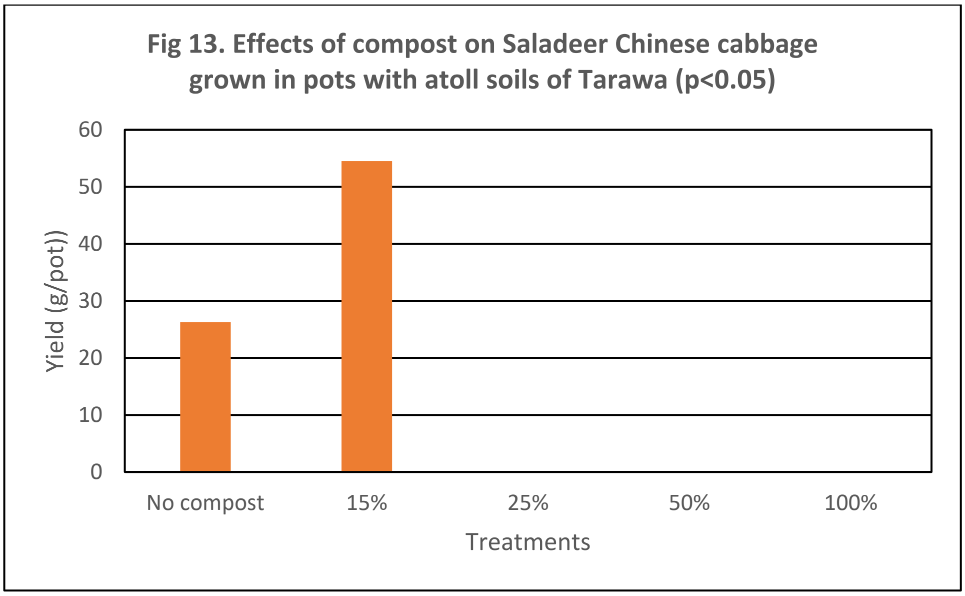
1. 1part soil: zero compost
2. 1part soil: 1part compost
3. 1part soil: 2parts compost
4. 1part soil: 3parts compost
5. 1part soil: 1part compost + 20g ash
6. 1part soil: 1part compost + 10g iron
7. 1part soil: 1part compost + 20g ash + 10g iron

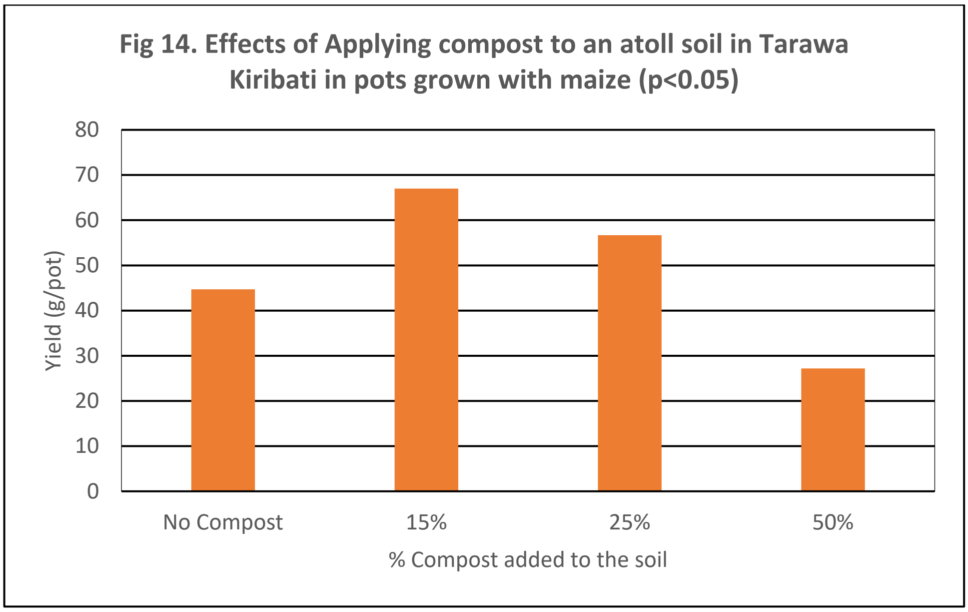
The results (Figure 12) show that increasing the amount of compost in the treatment was the main determining factor.



Based on the above results (Figure 12) the team decided to design compost rate trials with the following treatments: (i) no compost (100% soil); (ii) 15% compost (85% soil); (iii) 25% compost (75% soil); (iv) 50% compost (50% soil); and (v) 100% compost. We started with maize and cabbage using some of the compost recipes developed. The first trial with maize was abandoned because it was not watered over the Christmas period and the plants died.

Due to lack of maize seeds, a repeated trial was planted with cabbage. The result showed that all cabbage plants died from rates of 25% to 100% compost (Figure 13). This could have been because of over watering but the results were interesting. We then repeated the pot trial with no treatment of 100% compost because no farmers are likely do this (Figure 14).





A non-replicated field experiment was also conducted in Marshall Islands applying 0, 1, 2 and 3 shovels of compost to each planting hole. This was again mixed well to about 40cm and planted with taro. After about 2 weeks soil samples were taken when soil and compost had settled and then tested with the Palintest SKW 500 soil test kit. The results are shown in Figure 15. The application of compost did not result in significant improvement of each nutrient but it appeared that the combined effects of the increase of each nutrient resulted in significant increased crop growth and yield. The no compost treatment did not produce any corms, whereas the average tuber weights with addition of 1, 2 and 3 shovels were 0.6, 0.9 and 1.2 kg per tuber respectively.

pH	8.12	8.2	8.2	8.2
EC	65	120	130	140
N	6.7	40	44	44
P	17	33	46	50
K	35	50	52	56
Fe	1.3	3.2	2.4	3.4
Cu	1.4	4.2	3.2	4.0
Mn	0.2	0.2	0.2	0.2
Yield kg/tuber	0.0	0.6	0.9	1.2

Fig 15. Effects of compost rates on yield of taro on an atoll soil in Marshall Islands.

1.6.2. Water management

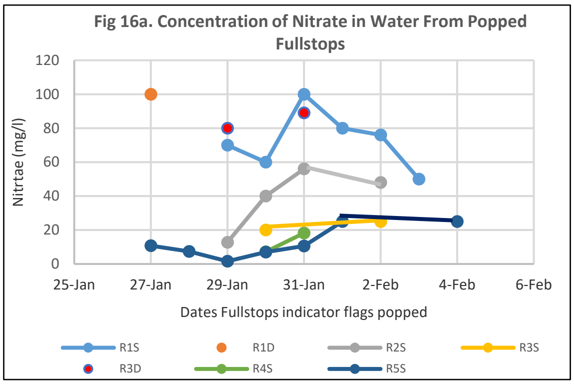
Bucket drip irrigation trials were set up at the Tanaea Station in response to the long drought and were planted with root crops and vegetables and treated with same compost rates used in the soil management trials. However consistent supply from the municipal water was a major problem. Consequently, even with the irrigation set up we were without water for extended periods of time and had to abandon trials. To overcome this problem the team dug a well to supplement the municipal water and modified the Tamana pump to pump water to an overhead tank about 6m above the water level in the well. This modification was quite unique, and we have called this the ACIAR Soil Health Pump. With a regular water supply, the soil health team started new trials. Initially we observed that despite watering, the plants still looked wilted. We then purchased a moisture meter and at about 20cm depth we found that staff were applying insufficient water. We also installed FullStops to monitor water movement and potential for contamination of ground water. The FullStop provides a cost-effective method of assessing whether too much or too little irrigation is being applied, to detect water logging and to monitor nutrient and salt levels in the soil.

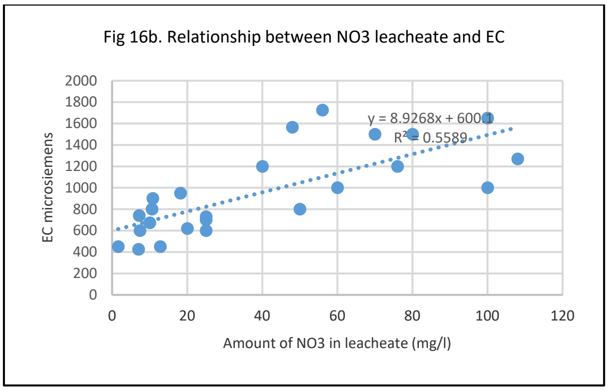
The heart of the FullStop is a funnel shaped collector which is buried in the soil. As moisture moves through the soil profile (a wetting front), it converges in the funnel and collects in a reservoir in the base of the unit. An indicator flag is fitted to an extension tube which protrudes above ground. When water collects in the base of the funnel, floats within the extension tube cause the indicator flag to pop up to show that the wetting front has arrived. The indicator flag is held up with a magnetic latch and must be pushed down to reset it. If the soil is still very wet, the flag will pop up again. An outlet tube at the base of the FullStop allows water collected in the funnel to be extracted using a syringe and tested for EC and nitrate levels. Fullstops were installed as explained below.

- The detector must always be placed directly under a dripper. Suggested depth for the shallow detector is 30cm and for the deep detector, 60cm
- Deeper placement is required for widely spaced drippers or long irrigation intervals. Shallower placement suits closely spaced drippers, frequent irrigation, or shallow rooted crops
- It is common for detectors to respond quickly under drip because all the water is being concentrated around the dripper, with dry soil between drippers. In such cases less water should be applied more often.

Figure 16. FullStops are installed at two different depths. Plate 1a in the middle shows a moisture meter used to indicate whether water applied is enough. Plate 1b on the right is a taro irrigation trial with FullStops installed.

Water samples from popped shallow and deeper placed FullStops were taken and analysed for NO3 and EC. Results are given in Figure 16a and b below.





Results (Fig 17a) showed that concentration of NO3 in the water samples from the popped shallow placed FullStops increased with increasing rates of compost applied (R5 – no compost, R4 – 2 shovels of compost, R3 – 4 shovels, R2– 8 shovels per 4m rows). Only 3 deeper placed FullStops popped during the observation period from 26th January to 5th February indicating that we had not over irrigated. The graph on the right (Fig 17b) above shows the relationship between amount of NO3 in the water samples and the EC of the samples

Low lying areas where high tides rise to the soil surface and Wicking based System

In this zone any planting will be killed by the high tide. The option for this zone was to use the wicking based system. The soil was dug out to about 15 to 20cm depth and then lined with a plastic sheet. Water was then filled to the surface and structure like concrete blocks and rocks were put into the water filled plastic sheet and then a screen was laid on top touching the water surface. Soil was mixed with compost and put-on top of this and planted with crops. When the tide rose, it would not contaminate the system (Figure 18).

Fig 18. Wicking system and the growth of the cabbage before harvest.

2. *<u>Areas where high tides are below 30 to 50cm depth</u>*

In this zone when there were high tides – at least a 30 to 50cm rooting depth was left for the crops. In this zone apart from the wicking system, we could also use bucket irrigation system (Figure 19).

Fig 19 Bucket irrigation system and cabbage ready for harvest

2.1.1. Pest management

In collaboration with SPC Plant Health team the current initial assessment identified key economic pests and diseases of concern to both Kiribati and Tuvalu. Based on the assessment, SPC mobilised an integrated pests and disease management program jointly with UTAS which resulted in the establishment of a Kiribati Plant Health WhatsApp group to support pests and disease diagnosis and advice. The WhatsApp group remains active consisting of Kiribati Extension Officers, SPC Technical Teams and the ACIAR funded ICM2 project. The group continues to provide technical support on diagnosis and advise on key pests and diseases confronting Atolls. Table 11 provides the key pests and diseases diagnosed through the WhatsApp Group.

Table 11. List and pictures of diseases diagnosed in Tuvalu and Kiribati

	
Coconut scale infestation diagnosed in TV	Mealy bug on breadfruit
	
Taro beetle	Coconut stick insects damage on coconut
	
Ladybird beetle	

2.2. Production training provided to extension and services and the farming communities

Several trainings were conducted in both Kiribati and Tuvalu targeted for extension and the participating communities. In 2018, an integrated training was organised by SPC which included, soil health, soil management, trial design, pests and disease management, and food security, building the capacity of all extension officers in both Kiribati (27) and Tuvalu (22). In addition, a series of trainings on compost production, nursery management, farming techniques and awareness on healthy foods were conducted in all the project sites and various schools.

Objective 2: Increase household and community production and consumption of local nutritious foods

Research questions:

1. *How can soil health be improved with the resources available in the atolls and will improved soil health increase starchy crop productivity?*
2. *What local nutritious foods are available to be grown in small gardens, and what are the barriers to adoption?*

Activities and Results

2.1. Evaluation of indigenous and introduced vegetables

In Kiribati, the team had been working with farming systems development both in Babai pits and rain fed systems. The systems include fruit trees (breadfruit, pawpaw, banana, etc), root crops and nutritious crops including indigenous plants like te mota, te buka (*Pisonia*), and ofenga.

Local indigenous green leaves like te mota, ofenga, te buka and the introduced chaya and drumstick are easier to produce than cabbages and other temperate green leaves. They are now being grown in home gardens. Planting materials can be obtained from the ALD stations in Tanaea or nurseries in the project outer islands. They are also easily available in Tuvalu and some in RMI.

Figure 20. (left and middle) showing indigenous nutritious vegetables (ofenga and te buka) and exotic vegetables (Photo on the right) produced in Kiribati.

Nutritious leafy food plants adapted to alkaline, salty, coral soils could form part of a food system strategy to reduce NCD rates. The project also identified and analysed locally available leafy plants that have shown in other studies to have anti-NCD effects. The analysis was conducted by University of Adelaide who has all the data. Factsheets were developed and promoted the leafy plants summarised below:

1) **Amaranth**: Grows best in well composted soil. High in Zn, Ca, Mg, K, protein, carotenoids (thus good for eyes and immunity). Anti-diabetes effect.
2) **Chaya**: Grows strongly on atolls, even on poor soil. High in protein, Fe, Ca and carotenoids. Stimulates lactation, protects liver and kidneys from toxins, and useful against diabetes, heart disease and inflammation. Contains small amounts of glycosides but is safe to eat when cooked for at least three minutes. A valuable, atoll-adapted plant.
3) **Drumstick tree**: Grows fast, even on poor soil. Possibly the world's healthiest plant for humans, with activity against viruses, bacteria, cancer, heart disease and diabetes. Exceptional at accumulating selenium and sulphur. Selenium is important in controlling RNA viruses, including coronavirus. Drumstick leaves are strong-flavoured when raw but are easy to eat when cooked. Also high in Fe, Ca, protein and carotenoids.
4) **Hedge panax**: Well adapted to alkaline coral soils on atolls. Its young leaves cooked with coconut cream taste very good. It increases lactation and decreases diabetes and inflammation. Its ground up bark can be used to treat ciguatera poisoning. High in Zn and Ca.
5) **Ofenga**: Useful not only for embalming, but for the living also: nutritious and medicinal, useful for treating wounds and with effects against diabetes and heart disease. High in Mg and Ca. There are several types, with different coloured leaves.

6) **Yellow beach pea**: Included mainly for its soil-strengthening (N increasing) activity. Pods best eaten when green. Young leaves can also be eaten but are chewy. High in protein, Fe, Mn, Cu and Zn, thus ideal as a compost component. Helps heal wounds and is drought- and salt-tolerant.
7) **Kangkong**: Aquatic sweet potato, which needs to grow in water, e.g., a babai/pulaka pit. Protects the liver from toxins and has anti-diabetes effects. High in protein, Fe, B and carotenoids.
8) **Pumpkin & choko**: Pumpkin in particular is familiar on atolls and productive on composted soil. Valuable not only for its fruits: the tendrils/young leaves contained the highest all-round nutrients of all plants surveyed. High in Fe, Ca, Zn, K, P and protein. Anti-heart disease, diabetes, anaemia. Covers the ground and controls weeds.
9) **Bele**: Its flavour and nutrient value make it the most popular leafy vegetable in PNG and Solomon Islands. There are many varieties, with variable leaf shapes. Not as hardy as Chaya, bele likes well composted soil and insect control. High in Zn, Ca and Mg. Good for treating diabetes and diarrhoea, and stimulates lactation and bone repair.
10) **Chilli**: very nutritious, a good all-rounder, high in Ca, B, Mn, Cu and S. Useful for treating skin problems like psoriasis. Anti-bacterial and anti-diabetes.
11) **Purslane**: Ubiquitous (grows everywhere) and usually regarded as a weed but is one of the world's most nutritious plants. High in the beneficial omega-3 fatty acid EPA, and in Fe, Zn, Mg and K. Stimulates lactation, and has effects against diabetes, heart disease, cancer and fever. It may exist close to the ground, but purslane is outstanding for nutrition and medicinal value.

An alley cropping demonstration plot was established in Tanaea Station using drumstick and chaya combination versus drumstick and ofenga alley crops and intercropped with sequence of root crops. In late 2019 the agroforestry systems were bulldozed by ALD for other development purposes.

Fig 21. Drumstick, ofenga and chaya alley trees intercropped with watermelon and sweet potato.

Some of the root crop varieties and open pollinated vegetables evaluated found their way to babai pits promoted by the project in the outer islands.

Figure 22. Photos showing how babai pits have been modified by terracing and fruit trees, root crops, and vegetables added to each terrace. Top left and middle are pits in Tab North, top right is in Abemama, and all three at the bottom row are in Nonouti.

2.2. Training and media campaigns

In order to achieve impact, the project in collaboration with the IFAD Outer Islands Food and Water Project collaborated with multiple government ministries (Agriculture, Health, Education, Works), churches, NGOs, Island Councils, and communities on a series of awareness campaigns were conducted with schools and communities in the target islands. In Kiribati, about 1500 farmers attended information and training sessions on growing, handling, cooking, and preserving locally grown foods. In addition, community nurseries were supported in the four target islands in Kiribati and in Funafala which facilitated the engagement of communities through the supply of planting material and community/farmer trainings.

2.3. Setting up village market centres

In the campaign to improve consumption of nutritious foods it was initially envisaged that market centres will be established in villages to sell the nutritious foods to those that do not have access to land. This will also improve awareness of the importance of nutritious foods to the health of the people. In consultation with ALD, it was agreed that the market centre be focused on Abaiang and awareness conducted in the other pilot areas/communities. A series of awareness programmes were conducted in partnership with ALD/DOA during various national events such World Food Days, ALD Farmers Days and with schools and within the project communities in promoting marketing and consumption of local foods.

Objective 3: Identify and develop opportunities for inter-island trade in high-value crops and products.

Research Question:

3. *How can surplus starchy staple crops and vegetables produced in the outer islands be exported to the urban centres in the main islands.*

SPC led the activities under this objective supported by the Tasmanian Institute of Agriculture, MELAD ALD, and Tuvalu MNREE. The key activities involved:

5. *Value chain analysis*

The project successfully conducted a value chain analysis for 3 key crops involving various stakeholders (Figure 23, 24).

Figure 23. Value chain stakeholders/partners

The value chain approach involved a stepwise approach involving identify, engage, empower, enable and support stakeholders to evolve into livelihoods/agribusiness entrepreneurs (Figure 24).

Research	Capacity Building	Targeted crop production	Active Supply Chain	Improved nutrition
Composts: targeted, rates, best bets	Farmer field schools	Market Driven Demand	Seed funding	Sustainable supplies
Shade regulation	On farm trials	Wholesalers	Island council	Locally produced crops
Irrigation	Compost production	Retailers	Banks	Ministry of Health
Soil analysis	Microbe harvesting	Hoteliers	Dept commerce	Cooking programs
Leaf analysis	Agronomy	Shipping agents	Grower clusters	Mass media
Tissue culture	Value Chain	Road side markets	Board of directors	NGO's
ALD	Climate Smart agriculture	Hospitals/correction centres	PGS	Affordable produce, changing diets

Figure 24. Value chains approach

The focus of the value chain was to identify key gaps and issues across the value chains for the agricultural produce and marketing from Abaiang to South Tarawa markets. The key gaps identified include post-harvest handling, storage, and reliably consistent means of shipping from Abaiang to South Tarawa and pricing as the key problems (Figure 25). The value chain study on Abaiang was completed in 2016 and identified post-harvest handling, storage, and reliably consistent means of shipping from Abaiang to South Tarawa as the key problems.

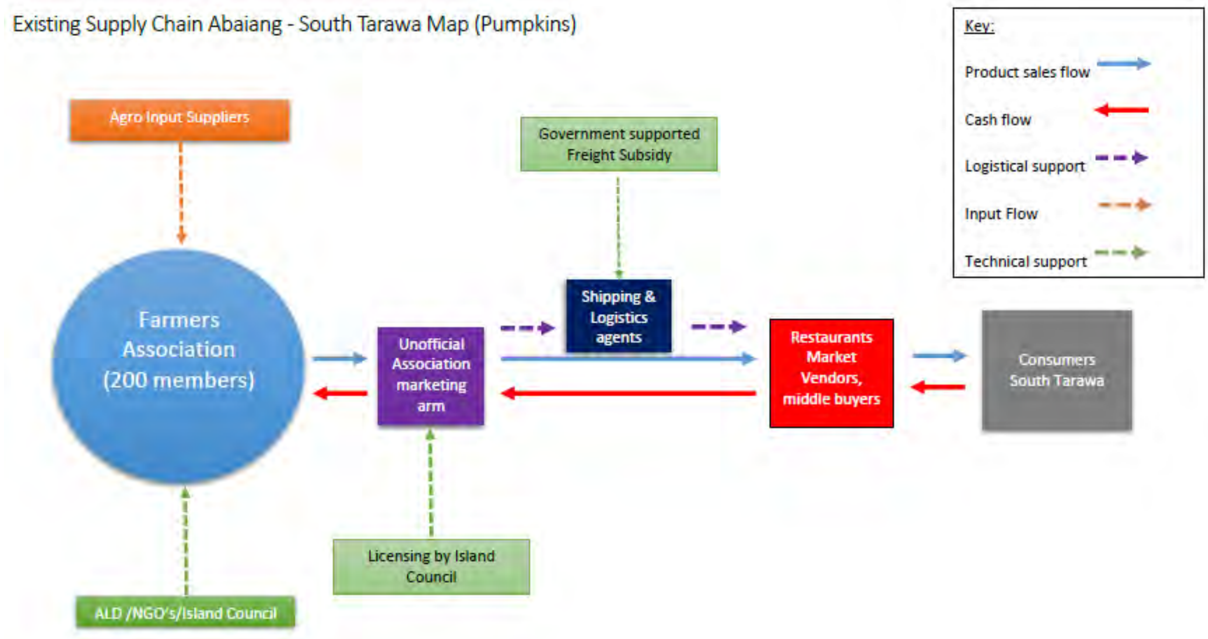


Figure 25. Gaps/Issues on Value Chains

The project needed to address these two issues whilst addressing other production aspects of the project to ensure that there is a consistent quantity and quality of produce being directed to the South Tarawa markets. As a result, the team established an improved and sustainable value chain model for Kiribati (Figure 26 and Table 12).

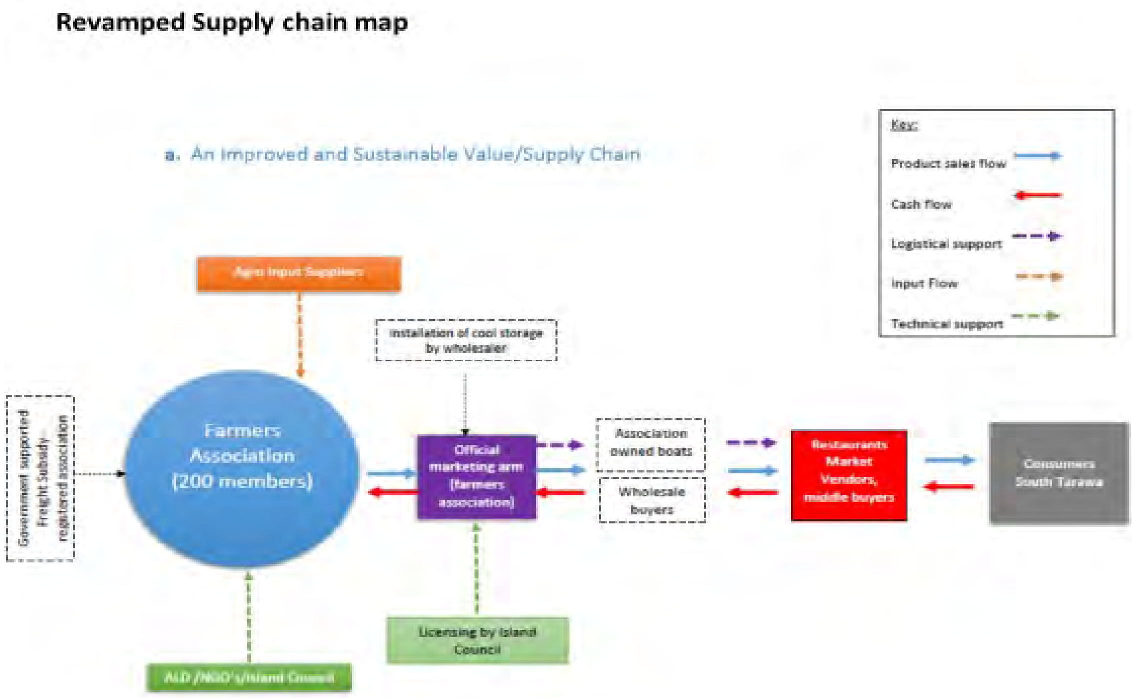


Figure 26. Improved and sustainable value chains model for Abaiang

Table 12. Summarised costs and benefits for pumpkin along the supply chain

Actor	Cost Description	Details	Cost ($)	Benefit	% Gain
Farmer	Production (5m x 5m)	10days x 15 minutes x 1.20hr	3		
	Harvest	estimate yield at 22kg's x 5 minutes x 1.20hr	0.005		
	Transport to ship	fuel 1.35 litre x 1 MC trip	1.35		
	Freight	20c kg	2.2		
	Total Cost		6.55		
	production cost per kg + freight		0.30	1	336 %
Shipping agent	Operational and overheads	?	?	20c kg	?
Wholesaler	Cost of purchase		1		
	other costs (transport/value adding/deterioration/ labour per kg)		0.1		
	Total wholesaler costs		1.1	2.5	227 %
Restaurant /Market vendors	Cost of purchase		2.5		
	Other costs (transport/value adding/deterioration/ labour per kg)		0.1		
	Total retailer costs		2.6	2.94	113 %

In addition, the team also supported an operational guideline on management, GAP and food safety was developed and training conducted for the value chain farmers. In late 2017 some farmers started growing vegetables and sold these for income. Production plans were developed and Internal Control Systems and other necessary documentation for compliance to village by laws and National law of Abaiang organic status were also developed. The PGS system will need to be supported strongly, especially production, post-harvest, and marketing. The island council, the market outlets, producers, and technical bodies will have to work collaboratively to make the supply chain work and become sustainable.

6. Value chain support mechanisms

Initially the team was working towards creating a sustainable supply chain by September 2017. This was however, delayed because of the drought and getting irrigation facilities to Abaiang. In the beginning of 2018 irrigation facilities were supplied and 10 plots were set up and planted with a variety of vegetables (Fig 27).

Fig 27. Some of the irrigation plots established in Abaiang.

The irrigated plots were mostly growing well. Some had too much shade that needed to be removed. Some showed deficiencies, which indicated that there was a need for making more compost to ensure enough, was given to the crops. There is a need to look at effects of shade on productivity as well. In partnership with and IFAD/CTA project on value chains, funds were provided for the establishment of Abaiang Agriculture Incorporated Society (AAIS). In addition, the support involved nursery and planting material support, and export processing facility.

7. Export collection centres and Quality standard systems

The biggest problem in the commercialisation of crops like pumpkin is domestic transport – currently losses during local transport are high – up to 30% in some cases. Getting the produce to where the boats will pick them up without being damaged is a key outcome. As an example, there are 14 villages in Abaiang spread throughout the 37 km length of the island providing challenging logistics to collection of fruits for shipment. The project will help strategically establish collection centres for storage of produce before shipment. A multi-purpose export collection centre was completed in 2020 consist of chilling storage equipped with Solar System, seedling distribution centre and training centre for the Abaiang farmers.

8. Livelihood support and Training

The final analysis to any project is, how did we impact the community. The project developed an index called productivity index which was used to establish as baseline at the start of the project and assess change by revisiting farmers with the questions at the end of the project. There were seven factors identified that affect the productivity of the selected farms which were ranked from 1 to 5 according to the Table 13 below:

Table 13. Selected factors for developing the productivity index.

Factors / Ratings	Income		Decision making on land use	Farming skills (farmers, AAs, IFs, CFs)	Farm productivity (current production)	Farm resilience		Quality of land (from PRA and soil test)	GHG emission reduction (biodiversity & soil C)
	Total ($/week)*	% use to buy food				Above ground	Below ground		
1	<7 (70)	>100	Very problematic	Very poor	Very low	1 food plant	0-1	Trace	Very low
2	<14 (140)	90-100	Some problems	poor	Low	2 food plant	1-2.5	Low	Low
3	<28 (280)	50-90	Little problems	Medium/fair	Medium	4 food plant	2.5-3.5	Medium	Medium

4	<42 (420)	20-50	No problem	Good	High	8 food plant	3.5-4	High	High
5	>42 (420)	<20	Very good	Very good	Very High	>8	4-5	Very high	Very high

***Figures in brackets are for Laura and Kavatoetoe**

Results were used to develop spider webs (Fig 27a).

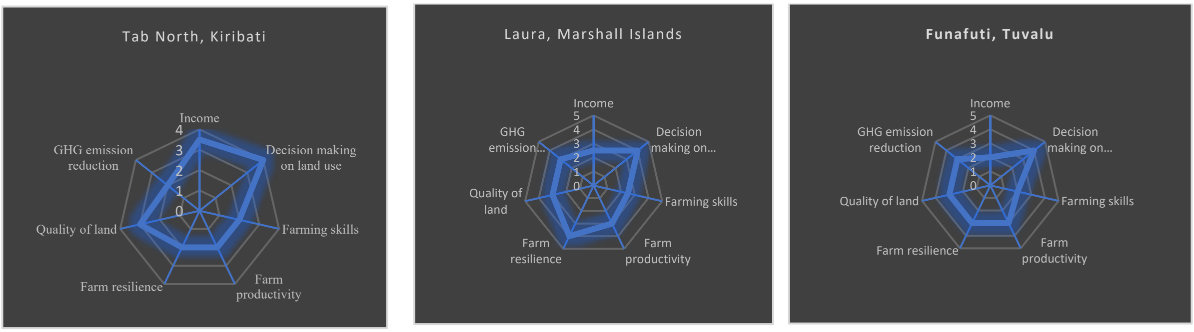


Figure 27a. Productivity indexes from the 3 countries.

The spider diagram show that farming skill and household incomes were consistently the most limiting factors followed by farm resilience and productivity. These spider webs are good baselines for each farm (community), and we can individually address each factor to improve productivity. An ideal sustainable situation will be all factors having indexes of 4. The team revisited these communities, assessed the productivity parameters, and found that through soil management the land quality improved, the skills of farmers improved from capacity building and resilience improved because of introduction of trees (Figure 27b). To complete this evaluation, we should look at effects of these improvements on household incomes.

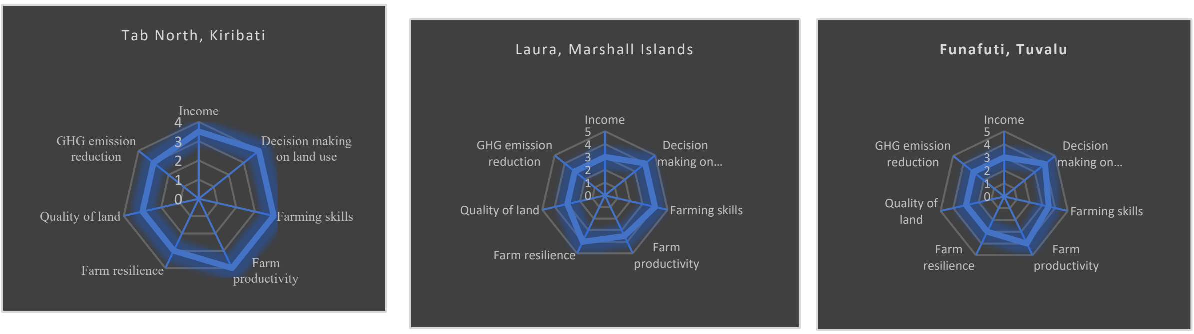


Fig 27b. Productivity indexes improvement.

9 Project Impacts

9.1 Scientific impacts

The project has produced a scientific paper, factsheets and some of the project results have been presented in international and regional meetings.

Lyons, G., Dean, G., Tongaiaba, R., Halavatau, S., Nakabuta, K., Lonalona, M. and Susumu, G., 2020. Macro- and Micronutrients from Traditional Food Plants Could Improve Nutrition and Reduce Non-Communicable Diseases of Islanders on Atolls in the South Pacific. *Plants*, 9(8), p.942.

Growing root crops on atolls, 2018. compiled by Dr Siosiua Halavatau, SPC, Suva Fiji

Edis, R., Dean, G. and Lyons, G., 2017. How Food Gardens Based on Traditional Practice Can Improve Health in The Pacific. [online] The Conversation. Available at: https://theconversation.com/how-food-gardens-based-on-traditional-practice-can-improve-health-in-the-pacific-75858

Leafy green crops to improve diets on Pacific Islands. *Bulletin of the World Health Organization* 2018; 96: 595-596.

Presentations at Conferences:

- Status of Soil Organic Carbon in SIDS. Paper presented at the Global Symposium on Soil Organic Carbon, Rome, Italy, March 2017
- Dean, G., **Halavatau, S.,** Tongaiaba, R. and Lonalona, M. 2018. Being nutrient and carbon smart: *To Support Climate Smart Agriculture in the Pacific Islands* First Symposium of the International Society for Tropical Root Crops – Pacific Branch (ISTRC-PB), 24-27 April 2018, Nadi, Fiji.
- Same paper was presented at the Pre COP 23 meeting in Suva 23rd July 2017 to Pacific Leaders.
- Global Alliance for Climate Smart Agriculture – Towards Innovative Solutions. Presentation at the 2nd International Conference on Agriculture, ICFA 2018. Jharkhand, India.

The scientific impacts of the nutritious leafy vegetables component of the program are embodied in the factsheets and *Plants* article.

Key impacts:

- A novel opportunistic genotype x environment survey method was employed to survey mineral nutrients accumulated in the leaves of leafy food plants, and found significant genotypic variation (Tables 1 & 2)
- Numerous well adapted, tasty, nutritious leafy food plants were identified which could make a valuable contribution to diets of people living on Pacific atolls, especially in view of the reported anti-diabetes activity of these species
- It was evident that abandoned giant swamp taro pits could be rejuvenated and repurposed to form diversified nutritious food gardens (Figure 1). And see Nonouti trip report, attached

A brief note on possible/potential **health impacts** resulting from nutrition projects (i.e., Are people who include leafy greens in their daily diets healthier than those who do not?) are usually difficult to demonstrate in the short term, although this should be self-evident, based on long experience, for the medium to long term. Awareness/knowledge impacts are easier to assess.

Table **14.** Effect of species on concentration of several micronutrients and macronutrients in leaves (dry weight basis) of food plants growing together at Vaiaku, Funafuti, Tuvalu in August 2014

Species	***Nutrient***							
	Fe	**Mn**	**B**	**Cu**	**Zn**	**Mg**	**K**	**N**
	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	%	%	%
Brazil spinach	30	9	33	11	97	1.48	3.6	3.5
Chaya	76	19	19	9	42	0.55	1.64	5.1
Drumstick tree	52	12	21	7	39	0.61	1.09	5.2
Hedge panax	47	29	26	7	71	0.58	3.2	2.9
Lettuce tree	50	29	43	21	20	0.61	2.1	4.2
Ofenga	45	21	25	28	62	1.72	3.4	3.0
Purslane	68	5	50	14	103	2.2	3.1	3.3
Variation (-fold)	2.5	5.8	2.8	5.6	5.2	4.0	3.3	1.8

Notes: Concentrations are on a dry weight (DW) basis throughout the manuscript
N % x 4.4 provides an estimate of crude protein %
Ca was uniformly high (range 1.61 – 2.20 %)
S was moderate in six species (0.21 – 0.38 %) but high in drumstick tree (1.13 %)

Table **15.** Selected mineral nutrients and the leafy vegetable species found (using opportunistic GxE analysis) in this study to be the most effective accumulators of these minerals in leaves. Samples were collected from various locations in Kiribati and Tuvalu. The values in brackets are representative concentrations of the relevant mineral for each species in this region

Nutrient (units)	***Best accumulators (concentration in leaf)***
Iron (mg/kg)	Purslane (79), yellow beach pea (72), pumpkin (69), kangkong (68), chaya (65)
Manganese (mg/kg)	Giant swamp taro (94), cassava (34), taro (34), chilli (27)
Boron (mg/kg)	Chilli (60), drumstick (48), birdsnest fern (41), sweetpotato (41)
Copper (mg/kg)	Tree lettuce (21), pumpkin (13), chilli (12), ofenga (11)
Zinc (mg/kg)	Purslane (119), cassava (107), pumpkin (97), hedge panax (81)
Calcium (%)	Chilli (3.8), bele (3.4), ofenga (2.7), hedge panax (2.5)
Magnesium	Purslane (2.5), ofenga (2.0)
Potassium (%)	Pumpkin (4.3), birdsnest fern (4.1), taro (3.0), kangkong (2.9)
Phosphorus (%)	Pumpkin (0.74), cassava (0.54), sweetpoptato (0.52)
Sulphur (%)	Drumstick (1.1), chilli (0.6), sweetpotato (0.55)
Nitrogen (%)	Pumpkin (5.1), cassava (5.0), chaya (5.0), drumstick (4.7)
Selenium (µg/kg)	Drumstick (400)
Multiple nutrients	Pumpkin, purslane, chilli

Notes: Se is a micronutrient for humans and animals but not for higher plants; µg = micrograms; N % x 4.4 provides an estimate of crude protein % in leaves

Factsheets on Nutritious Leafy Vegetables for Atolls

1. Tackling NCDs from the ground up: Nutritious leafy vegetables to improve nutrition security on Pacific atolls.
2. Amaranth
3. Chaya
4. Drumstick Tree
5. Hedge Panax
6. Ofenga
7. Yellow Beach Pea
8. Kangkong
9. Pumpkin and Choko
10. Bele
11. Chilli
12. Purslane
13. Nutritious leafy plants: Also valuable for soil health

Brochure: Making compost for healthy atoll soils

9.2 Capacity impacts

Agriculture officers, based at HQ and in the field, in Kiribati and Tuvalu have increased their knowledge of mineral flux from soil to plant, and the range in ability of different food plant species to take up and accumulate in leaves certain minerals, which are essential to plants, livestock and humans. Furthermore, they and the health officers involved in the project have increased their knowledge of the value of nutrient/micronutrient-rich local foods, especially their role in reducing NCD rates in Pacific island countries.

Given that research and extension capacity in atoll countries is poor and the importance of staff in supporting farmers, the project has undertaken a series of capacity building activities to upskill both research and extension staff as well as the farming communities. The most significant of these was the Atoll Soil Health Conference conducted in Kiribati Mar 31–Apr 5, 2017 with attendees from Kiribati, Tuvalu, RMI, Tonga and Fiji. In conjunction with other partners, two Soil Health Clinics of one week duration were also conducted in Tarawa and Funafuti in September 2019 for extension staff of respective countries.

Table 16. Capacity building activities.

No.	Training Subject Area	Venue & Date	Type	Trainees
1	Use of PRA tools to collect baseline data, on-farm trials, pests and disease controls and identification of mineral nutrition disorders	Kiribati 29th February to 4th March 2016	Workshop/training Combination of PowerPoint presentations and practical exercises.	• 24 Agriculture staff involved in the project (13 women) • 6 IFAD staff
2	Compost making	Tab North, Kiribati 30th April 2016	Workshop and practical	• 30 Community of Eita in Tab North
3	PRA training and compost making	Marshall Islands 18th – 19th May 2016	Workshop and exercise/practical	• 8 project staff (2 females) • Agriculture staff and youths
4	Soil management	Tuvalu 6th June	PowerPoint presentation	• 10 participants (2 women)
5	Integrated Business Model	Kiribati 17th June 2016	Partnership and integration. Discussing how regional, international and national stakeholders should engage in food security activities	• 30 participants (12 females) • Staff of MELAD, other government ministries and NGOs.
6	Nursery management and seedling production	Kiribati 27th June 2016	Practical training	• 5 project casuals in Tanaea
7	Basic agronomy of root crops	Marshall Islands 4th – 6th July	Workshop and practical	• 10 staff (2 women)
8	Basic root crop agronomy	Tuvalu 27th September, 2016	Workshop and practical training	• 12 participants (1 woman) • Nurseryman • Extension and research staff
9	Crop production and compost making	Nonouti, Kiribati …. October, 2016	Practical training	• 30 community members

10	Making neem-based insecticide	Kiribati 4th October 2016	Practical	• Project staff
11	Basic agronomy of root crops and basic soil nutrient requirements of crops	Kiribati 5th October 2016	Workshop and practical training	• 30 participants (8 women) • Extension and research staff, NGOs, farmers
12	Seed saving	Kiribati 13th October	Practical	• Project staff
13	Compost training	Fanning 14th November	Practical demonstration	• Community
14	Compost training	Washington 17th November	Practical demonstration	• Community
15	Compost training	Kiritimati 22nd November	Practical demonstration	• Community and Agriculture staff
16	Basic agronomy of root crops	Kiritimati 22nd November	Workshop and practical	• Agriculture staff
17	Basic agronomy and nutrition	Tonga 18th January 2017	Workshop and practical	• Agricultural staff, teachers and farmers
18	Inaugural Atoll Soil Health Workshop	April 1 to 5th 2017	Workshop, training and practicals-list these?	• Project stakeholders from Kiribati, RMI, Tuvalu and invited guests from Tonga, FSM and RMI
19	Climate Smart Agriculture workshop	16 to 17 May 2017 Tonga	Workshop, training and practicals	• Staff and community
20	Climate Smart Agriculture workshop	Kiribati 7th and 8th June	Workshop, training and practicals	• Staff and community
21	Climate Smart Agriculture workshop	RMI 27th and 28th July	Workshop, training and practicals	• Staff and Marshall Islands Organic Farmers Association
22	Climate Smart Agriculture workshop	Tuvalu, 17th -18th August 2017	Workshop, training and practicals	• Staff and women groups
23	World Soil Day	Kiribati 5th December 2017	Workshop and celebration	• Staff and farmers
24	Compost making training	Nonouti, December 2017	Training	• Growers, agriculture and community extension staff, teachers
25	Integrated Soil/Plant Health Training	Kiribati September 2019	Training	• Extension Officers
26	Integrated Soil/Plant Health Training	Tuvalu	Training	• All Extension Officers

9.3 Community impacts

Project staff have given a number of presentations at schools (in trip/visit reports). In Tuvalu, a ca 50% increase in home gardens in villages was observed within the communities the project engaged with in Tuvalu during the life of the project, and Kabuati reports increasing engagement of communities in farming activities on the four study atolls. Various interviews on local radio in Tarawa about making compost, eating nutritious vegetables e.g., 20th June 2018 (after the Atoll Soil Health MTR).

SCIENCE on ABC Radio Australia - Pacific Mornings; 15/6/18: http://www.abc.net.au/radio-australia/programs/pacificmornings/pacific-mornings/9852288 *about atoll soil health and compost making*

9.3.1 Economic impacts

Value chain analyses of some crops from Abaiang to South Tarawa had been completed. An Abaiang Production Plan and Participatory Guarantee System for Root, Fruit and Vegetable Growers has been developed to guide the value chain component of the project. A success story from Abaiang value chain is given below.

One of the value chain members benefiting after joining the PGS

Name: Birito Temoana

Started: 6/12/2017

Sold $1052 worth of cabbage

Diversified to copra meal

Purchased $1320 worth of copra meal

Sold for $2860

Purchase motorbike $2890 for hire

He also has catering services

His Plan

1st plan - Selling cabbages

Figure 28. Birito is a farmer that has benefitted from this initiative.

9.3.2 Social impacts

Nutritious crops like te mota (wild *Amaranthus*), chaya (*Cnidoscolus aconitifolius*), drumstick (*Moringa oleifera*), hedge panax (*Polyscias scutellaria*), ofega (*Pseuderanthemum whartonianum; P. carruthersii*), beach cowpea (*Vigna marina*), kangkong (*Ipomoea aquatica, Ipomoea reptans*), Cucurbits (pumpkin and choko), bele (*Abelmoschos manihot*), chilli (*Capsicum spp*), and purslane (*Portulaca oleracea*) have been promoted in the food production systems with some success. Factsheets of these have been developed and are available in prints and pdf copies.

-Water pump - modified the Tamana pump to pump water to an overhead tank about 6m above the water level in the well. This modification is quite unique.

9.3.3 Environmental impacts

Babai pits are food reserve for atoll communities that was modified into a food production system by incorporating into it the soil management technologies, varieties of root crops, and nutritious food crops. The project successfully modified Babai pits in three of the four outer islands in Kiribati. This will improve resilience of the production system, produce more food, and can also improve family income. Participating households usually have a babai food garden as well as food plants growing nearby on the land surface and around the house. These include sweet potato, ofenga, Chaya, lemon grass, chilli, Brazilian spinach, pumpkin, banana, pawpaw, coconut, and breadfruit. In addition, improving organic matter content through compost could reduce contamination to groundwater for vulnerable atoll islands. On Nonouti, the most active island for this activity, had 12 babai food gardens well developed and maintained in July 2019.

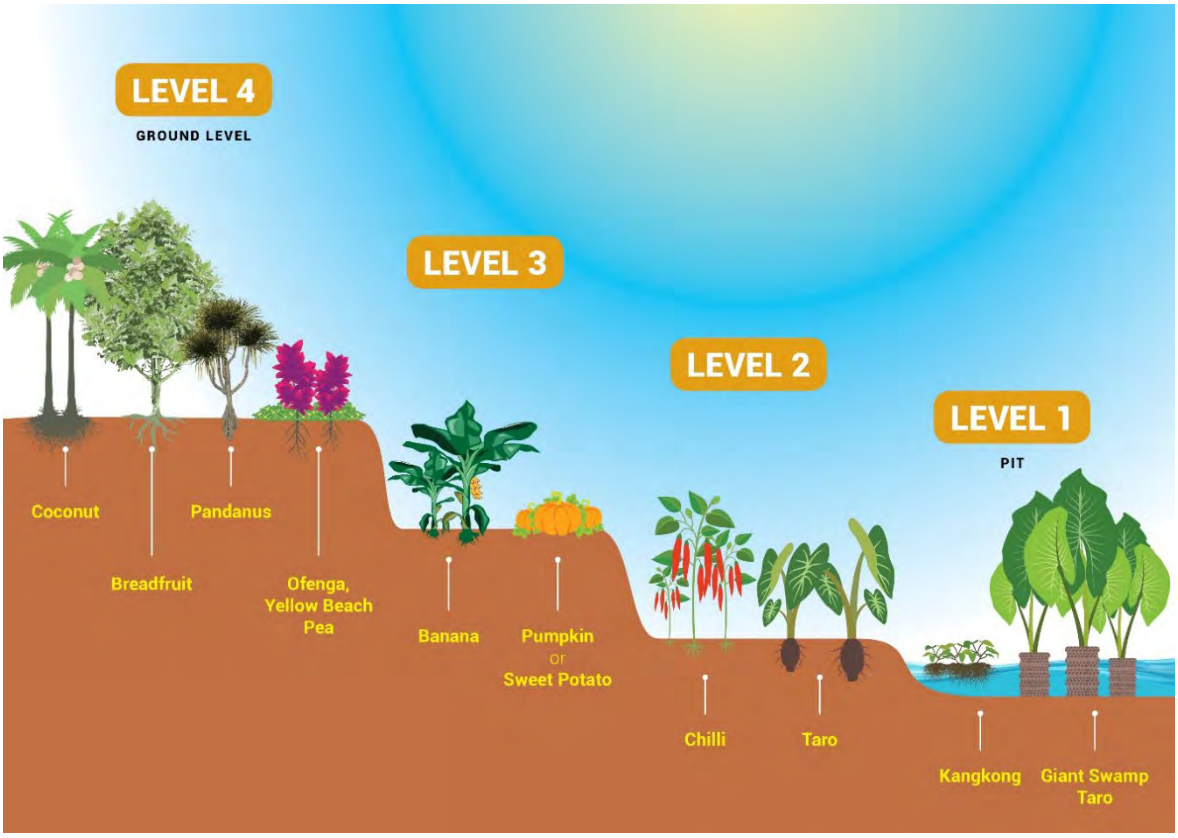


Figure 29. Layout of a babai/pulaka food garden. Other nutritious food crops can be substituted or added if desired

Developing a suitable compost methodology reduces the need for use of inorganic fertilisers. The latter having high concentrations of soluble nutrients means nutrients can be easily leached from the soil is not carefully managedand contaminate the freshwater lens. Utilisation of local waste and by-products may also be environmentally advantageous.

Production in wicking beds and Foodcubes has a number of environmental benefits: Water use efficiency is substantially increased, there is little or no leaching of nutrients into the freshwater lens and they are less impacted by inundation of land during high tides and storm events.

9.4 Communication and dissemination activities

The factsheets formed the basis of the awareness activity. Rosalind Kiata was active in promoting project activities in local media (newspaper and radio) and internationally via social media. Interviews were conducted on NZ radio, and articles published in The Conversation and the WHO Health Bulletin. An article has been recently published in the journal Plants for a special issue on underutilized food plants. All six publications are attached to this report.

Involvement of children is integral; in many countries their importance in influencing lifestyle factors, especially diet, is becoming recognised. For example, schools can include food gardens featuring the most nutritious local plants, provide more nutrition education, and students can transfer knowledge back to their villages. Graham Lyons, usually accompanied by Routan, Geoff or Eera (The Nonouti agriculture officer) gave talks at 10 schools and community meetings, usually with samples of nutritious leafy plants. In addition, the team had presented the project results in various conferences including:

- Status of Soil Organic Carbon in SIDS. Paper presented at the Global Symposium on Soil Organic Carbon, Rome, Italy, March 2017

- Same paper was presented at the First Symposium of the International Society for Tropical Root Crops – Pacific Branch (ISTRC-PB), 24-27 April 2018, Nadi, Fiji
- Being Nutrient and Carbon Smart: *To Support Climate Smart Agriculture in the Pacific Islands.* Presentation at the Pre COP 23 meeting in Suva 23rd July 2017 to Pacific Leaders.
- Global Alliance for Climate Smart Agriculture – Towards Innovative Solutions. Presentation at the 2nd International Conference on Agriculture, ICFA 2018. Jharkhand India
- The Conversation article May 2017 https://theconversation.com/how-food-gardens-based-on-traditional-practice-can-improve-health-in-the-pacific-75858
- Growing root crops on atolls, 2018. compiled by Dr Siosiua Halavatau, SPC, Suva Fiji

10 Conclusions and Recommendations

The project developed a procedure that atoll nations should follow in conducting research in soil health. Firstly, establishing research priority of atolls should focus on participatory approach to understand the factors that will determine the ultimate outcomes and impacts. Our approach revolves around the following:

1. *Key constraints to agricultural production – soil, water and biodiversity*

It is vital that crop varieties adaptable to harsh atoll conditions and inherently poor soils must be selected. The soil health part of the research must first identify limiting nutrients in the soils and then develop a targeted compost research program to develop compost recipes that will adequately supply the limiting nutrients. Compost rates pot trials should then be conducted to estimate the optimum compost rates to produce maximum yield for a particular crop. Once this is established then rate trials in the field should be conducted to confirm the rates to be applied in the fields for adaptable crops. The crops selected under the project should be further evaluated against other varieties from CePaCT to determine recommended adapted varieties for atolls and as well as market preference.

2. Climate change – vulnerabilities (exposure, impacts and adaptation capacities)

To assess impacts of these technologies the productivity index effectively provided a baseline of the food systems in the atolls, and provided insights into changes in practice at the end of the project. Climate smart technologies (e.g., wicking bed systems and food cubes) should be promoted to ensure sustainability of agricultural production in atolls. Most of the nutritious leafy food crops promoted by this project are tolerant of drought and salinity, and hence can be regarded as “climate ready”.

3. *Income and food security – value chains, market opportunities*

The value chain approach adopted for Abaiang could help farmers and stakeholder not only understand the linkages and markets but most importantly appropriate pricing of local commodities to sustain supply and demand for local food. It is very pleasing to see extension of project findings to Tuvalu outer islands and Maiana atoll near Tarawa.

4. *Socioeconomics of countries – social, cultural governance and capacity needs*

Last but not least, the participatory approach should be adopted at all levels of implementation to ensure ownership and sustainability of any intervention. Key to this is to ensure that interventions built in capacity building opportunities and involving government role in the planning and exit process is vital.

11 References

10.1 No references cited

10.2 List of publications produced by project

Lyons, G., Dean, G., Tongaiaba, R., Halavatau, S., Nakabuta, K., Lonalona, M. and Susumu, G., 2020. Macro- and Micronutrients from Traditional Food Plants Could Improve Nutrition and Reduce Non-Communicable Diseases of Islanders on Atolls in the South Pacific. *Plants*, 9(8), p.942.

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Edis, R., Dean, G. and Lyons, G., 2017. How Food Gardens Based on Traditional Practice Can Improve Health in The Pacific. [online] The Conversation. Available at: https://theconversation.com/how-food-gardens-based-on-traditional-practice-can-improve-health-in-the-pacific-75858

Leafy green crops to improve diets on Pacific Islands. *Bulletin of the World Health Organization* 2018; 96: 595-596.

Presentations at Conferences:

- Status of Soil Organic Carbon in SIDS. Paper presented at the Global Symposium on Soil Organic Carbon, Rome, Italy, March 2017
- Dean, G., **Halavatau, S.,** Tongaiaba, R. and Lonalona, M. 2018. Being nutrient and carbon smart: *To Support Climate Smart Agriculture in the Pacific Islands* First Symposium of the International Society for Tropical Root Crops – Pacific Branch (ISTRC-PB), 24-27 April 2018, Nadi, Fiji.
- Same paper was presented at the Pre COP 23 meeting in Suva 23rd July 2017 to Pacific Leaders.
- Global Alliance for Climate Smart Agriculture – Towards Innovative Solutions. Presentation at the 2nd International Conference on Agriculture, ICFA 2018. Jharkhand, India.

12 Appendixes

Appendix 1 Abaiang List of Beneficiaries (a)

Abaiang Vegetable Distribution Record					
Name	**Date**	**Address**	**Seeds/Crops**	**Propagation**	**Qty**
				(Seedling, root cuttings, etc)	
Tekanene	4-Jan-18	Taburao	seedling cabbage	Seed	28
Nei Raerae	8-Jan-18	Taburao	seedling cabbage	Seed	40
Katawea	11-Jan-18	Tebero	sweet pepper	Seed	4
Nei Raerae	11-Jan-18	Taburao	seedling cabbage	Seed	15
Berenato	12-Jan-18	Takarano	seedling cabbage	Seed	45
Kamwakin	12-Jan-18	Tebero	Papaya	Seed	4
Teretia	12-Jan-18	Tuarabu	seedling cabbage	Seed	44
Tenutaake	12-Jan-18	Tebero	Papaya	Seed	4
Sauaba	15-Jan-18	Tebero	seedling cabbage	Seed	20
Berenato	15-Jan-18	Takarano	seedling cabbage	Seed	20
Kiakia	15-Jan-18	Tabontebike	seedling cabbage	Seed	45
Kueman	16-Jan-18	Taburao	seedling cabbage	Seed	22
Teabo	31-Jan-18	Aonibuaka	seedling cabbage	Seed	20
Teborau	1-Feb-18	Taburao	seedling cabbage	Seed	52
Kabwebwe	1-Feb-18	Tabontebike	sweet pepper	Seed	14
Barekiau	21-Feb-18	Tebunginako	sweet pepper	Seed	15
Taio	21-Feb-18	Tebero	Papaya	Seed	3
Tebuti	21-Feb-18	Tebero	Papaya	Seed	3
Taio	25-Feb-18	Tebero	Papaya	Seed	13
Tebwaia	17-Mar-18	Taburao	Seedling cabbage	Seed	15
Biroto	3-Apr-18	Koinawa	cabbage	Seed	50
Itinrerei	4-Apr-18	Tuarabu	cabbage	Seed	25
Biroto	6-Apr-18	Koinawa	cabbage	Seed	25
Biroto	11-Apr-18	Koinawa	cabbage	Seed	30
Nei Uaa	11-Apr-18	Tebero	Pandanus	Cuttings	6
Biroto	3-Apr-18	Koinawa	Cabbage	Seed	20
Etuati	6-Jun-18	Tebunginako	cabbage	seedlings	100
Biroto	6-Jun-18	Wakaam	Cabbage	seedlings	250
Biroto	14-Jun-18	Wakaam	Seedling cabbage	seeds	105
Rubeaua	17-Jun-18	Tanimaiaki	Cabbage	seedlings	100
Teaieta	19-Jun-18	Tuarabu	cabbage	seedlings	100
Biroto	19-Jun-18	Waakaam	cabbage	Seedlings	50
AA Nonouti (Eera)	20-Jun-18	Nonouti	Lime	Cuttings	21
AA Nonouti (Eera)	20-Jun-18	Nonouti Island	Breadfruit (Tembwarekana)	Root cuttings	21
Ioane	27-Jun-18	Tebero	Papaya seedlings	Seed	10
Karakoa	9-Jun-18	Morikao	Papaya seedlings	Seed	8
Karakoa	10-Jun-18	Morikao	Papaya seedlings	Seed	6
Iataake	16-Jun-18	Tebero	Papaya seedlings	Seed	10

Karakoa	9-Jul-18	Morikao	Papaya seedlings	Seed	5
Karakoa	10-Jul-18	Morikao	Papaya seedlings	Seed	10
Iataake	16-Jul-18	Tebero	Papaya seedlings	Seed	5
Taaio	30-Jul-18	Tebero	Papaya seedlings	Seed	7
Tamarawa	30-Jul-18	Tabontebike	Papaya seedlings	Seed	8
Benebene	30-Jul-18	Tabontebike	Papaya seedlings	Seed	8
Beete	30-Jull-18	Tabontebike	Papaya seedlings	Seed	8
Kaue	30-Jul-18	Tabontebike	Papaya seedlings	Seed	8
Raeua	30-Jul-18	Tabontebike	Papaya seedlings	Seed	8
Runeti	30-Jul-18	Tabontebike	Papaya seedlings	Seed	8
Rotaake	30-Jul-18	Tabontebike	Papaya seedlings	Seed	8
Kung	30-Jul-18	Tabontebike	Papaya seedlings	seed	8
Taeteiti	30-Jul-18	Tabontebike	Papaya seedlings	Seed	8
Taio	31-Jul-18	Tebero	Papaya seedlings	Seed	4
Taio	1-Aug-18	Tebero	Iaro	Cutting	3
Taio	1-Aug-18	Tebero	Papaya seedlings	Seed	3
Ewena Meang	31-Aug-18	Ewena	Fig	cuttings	25
Ewena Maiaki	31-Aug-18	Ewena	Papaya seedlings	Seed	34
Kobaia	31-Aug-18	Bikenibeu (Tarawa)	Lime	Cutting	2
Nei Kambwa	11-Sep-18	Tebunginako	Papaya seedlings	Seed	3
	13-Sep-18	Ewena	Kumala	Cutting	10
Arobati	13-Sep-18	Tuarabu	Lime	Cutting	1
Tinaai	14-Sep-18	Tebero	Iaro	Cutting	7
Kakoroa	17-Sep-18	Tuarabu	Cabbage seedlings	Seed	25
Bwebwennata	18-Sep-18	Tuarabu	Lime	Cutting	1
Teatao	22-Sep-18	Tuarabu	Lime	Cutting	1
Terabena	22-Sep-18	Borotiam	Cabbage seedlings	Seed	110
Arobati	22-Sep-18	Tuarabu	Cabbage seedlings	Seed	17
Terabena	24-Sep-18	Borotiam	Cabbage seedlings	Seed	50
Arobati	24-Sep-18	Tuarabu	Egg plants seedlings	Seed	6
Arobati	24-Sep-18	Tuarabu	Tomato seedlings	Seed	7
Raerae	28-Sep-18	Taburao	Cabbage seedlings	Seed	25
Karakoa	28-Sep-18	Morikao	Egg plants seedlings	Seed	10
Burekaua	1-Oct-18	Ewena	Cabbage seedlinngs	Seed	20
Reen	4-Oct-18	Aonibuaka	Cabbage seedlings	Seed	30
Barekiau	10-Oct-18	Tebunginako	Cabbage seedlings	Seed	25
Merean	10-Oct-18	Waakam	Breadfruit	Root cutting	2
Funika	10-Oct-18	Waakam	Lime	Cutting	1
Rubeaua	10-Oct-18	Tanimaiaki	Tomato seedlings	Seeds	37
Rubeaua	10-Oct-18	Tanimaiaki	Fig	Cutting	10
Karakoa	18-Oct-18	Morikao	cabbage	seedlings	40
Nei Tieivia	19-Oct-18	Takarano	Egg plant	seedlings	200
Nei Tieivia	19-Oct-18	Takarano	Tomato	seedlings	2
Moarite	20-Oct-18	Ewena	Cabbage	seedlings	13
Ioane	20-Oct-18	Ewena	Cabbage	seedlings	11
Karakaua	20-Oct-18	Ewena	Cabbage	seedlings	8
Teweia	20-Oct-18	Ewena	Cabbage	seedlings	17

Taburimai	20-Oct-18	Ewena	Cabbage	seedlings	40
Ruatara	20-Oct-18	Ewena	Cabbage	seedlings	10
Kaure	20-Oct-18	Ewena	Cabbage	seedlings	8
Teekea	20-Oct-18	Ewena	Cabbage	seedlings	15
Touri	20-Oct-18	Ewena	Cabbage	seedlings	20
Ititaake	20-Oct-18	Ewena	Cabbage	seedlings	43
Ienimoa	20-Oct-18	Ewena	Cabbage	seedlings	25
Teaianga	20-Oct-18	Ewena	Cabbage	seedlings	38
Kiboboua	25-Oct-18	Ewena	Cabbage	seedlings	27
Kaitaake	26-Oct-18	Ewena	Cabbage	seedlings	20
Amerita	26-Oct-18	Ewena	cabbage	seedlings	20
Manika	26-Oct-18	Ewena	Cabbage	seedlings	20
Taokai	26-Oct-18	Ewena	Cabbage	seedlings	20
Nabuatara	26-Oct-18	Ewena	Cabbage	seedlings	20
Ioane Terang	26-Oct-18	Ewena	Cabbage	seedlings	20
Nititi	26-Oct-18	Ewena	Cabbage	Seedlings	10
Nititi	26-Oct-18	Ewena	Papaya	seedlings	2
Raerae	26-Oct-18	Taburao	Cabbage	seedlings	20
Biroto	26-Oct-18	Waakam	Cabbage	seedlings	45
Biita	27-Oct-18	Taburao	Cabbage	seedlings	20
Biroto	27-Oct-18	Waakam	Cabbage	Seedlings	24
Rataake	28-Oct-18	Tabontebike	Lime	seedlings	1
Rataake	29-Oct-18	Tabontebike	Papaya	seedlings	8
Tiewia	30-Oct-18	Takarano	Egg plant	seedlings	150
Tinaai	31-Oct-18	Tebero	Iamai	Seedlings	56
Tiewia	6-Nov-18	Takarano	Egg plant	Seedlings	150
Ikauea	15-Nov-18	Tanimaiaki	Pumpkin	Seedlings	1
Riben	26-Nov-18	Taburao	Tomato	Seedlings	32
Benatetaake	27-Nov-18	Taburao	Sweet pepper	Seedlings	8
Benatetaake	27-Nov-18	Taburao	Cabbage	Seedlings	100
Benatetaake	27-Nov-18	Taburao	Iaro	Seedlings	2
Tinaai	11-Dec-18	Tebero	Iaro	Seedlings	6
Tinaai	11-Dec-18	Tebero	Iamai	Seedlings	100
Biroto	14-Dec-18	Aonobuaka	Cabbage	Seedlings	34
Biroto	15-Dec-18	Aonobuaka	Cabbage	Seedlings	35
Biroto	17-Dec-18	Aonobuaka	Cabbage	seedlings	12
Biroto	1-Jan-19	Wakaam	Cabbage	seeds	28
Biroto	02 Jan 19	Wakaam	Sweet pepper		1
Teuota	02 Jan 19	Taburao	Cabbage		22
Teuota	04 Jan 19	Taburao	Cabbage		18
Kiboboua	04 Jan 19	Taburao	Cabbage		42
Tinaai	05 Jan 19	Tebero	Iaro		174

Tinaai	05 Jan 19	Tebero	Iamai		6
Biroto	08Jan 19	Wakaam	Egg plant		6
Biroto	08 Jan 19	Wakaam	Cabbage		76
Biroto	09 Jan 19	Wakaam	Cabbage		24
Biroto	11-Jan-19	Wakaam	Cabbage		20
Teaieta	14-Jan-19	Tuarabu	Cabbage		16
Teaieta	14-Jan-19	Tuarabu	Egg plant		1
Teaieta	15-Jan-19	Tuarau	Cabbage		30
Teaieta	15-Jan-19	Tuarabu	Egg plant		4
Biroto	25-Jan-19	Wakaam	Kumala		10
Biroto	25-Jan-19	Wakaam	Tomato		2
Biroto	27-Jan-19	Wakaam	Tomato		2
Tinaai	27-Jan-19	Tebero	Cabbage		92
Tinaai	27-Jan-19	Tebero	Egg plant		34
Teuota	4-Feb-19	Taburao	Cabbage		14
Karakoa	5-Feb-19	Morikao	Cabbage		12
Teuota	6-Feb-19	Taburao	Tomato		4
Kiaieta	6-Feb-19	Taburao	Egg plant		28
Tinaai	6-Feb-19	Tebero	Cabbage		57
Kiaieta	6-Feb-19	Taburao	Egg plant		18
Kiaieta	12-Feb-19	Taburao	Egg plant		38
Itaaka	20-Feb-19	Tanimaiaki	Cabbage		11
Kiaieta	22-Feb-19	Taburao	cabbage		13
Kiaieta	22-Feb-19	Taburao	cabbage		15
Teuota	25-Feb-19	Taburao	cabbage		10
Arii	25-Feb-19	Ewena	Cabbage		12
Tebwanteiti	4-Mar-19	Tuarabu	Cabbage		64
Itaaka	4-Mar-19	Tanimaiki	Cabbage		36
Bureti	4-Mar-19	Tuarabu	Fig		1
Itaaka	9-Mar-19	Tanimaiaki	Cabbage		30
Iebwe	15-Mar-19	Tebero	Cabbage		12
Aribete	18-Mar-19	Tebero	Cabbage		20
SJC	28-Mar-19	Tabwiroa	Fig		7
SJC	1-Apr-19	Tabwiroa	Fig		5
SJC	1-Apr-19	Tabwiroa	Pandanus tree		5
SJC	1-Apr-19	Tabwiroa	Lime		2
SJC	5-Apr-19	Tabwiroa	Kumala		81
SJC	5-Apr-19	Tabwiroa	Iamai		10
SJC	5-Apr-19	Tabwiroa	Pandanus tree		5
SJC	5-Apr-19	Tabwiroa	Fig		5
SJC	5-Apr-19	Tabwiroa	Lime		1
Tabita	5-Apr-19	Tuarabu	Cabbage		15
Tabita	5-Apr-19	Tuarabu	Iamai		5
Bwaara	5-Apr-19	Tebunginako	Iamai		6

Bwaara	5-Apr-19	Tebunginako	Iaro		6
Barekiau	13-Apr-19	Tebunginako	cabbage	Seeds	25
Barekiau	13-Apr-19	Tebunginako	Iaro	cuttings	5
Katuraia	13-Apr-19	Tebero	Iamai	Cuttings	2
Reen	15-Apr-19	Aonobuaka	Lime	Cuttings	1
Reen	15-Apr-19	Aonobuaka	Iamai	Cuttings	2
Reen	15-Apr-19	Aonobuaka	Iaro	Cuttings	1
Reen	15-Apr-19	Aonobuaka	Cabbage	Seeds	20
Nemwani	20-Apr-19	Tabwiroa	Cabbage	seeds	26
Tawana	24-Apr-19	Taniau	Fig	Cutting	5
Tawana	24-Apr-19	Taniau	Iaro	Cutting	10
Tawana	24-Apr-19	Taniau	Lime	Cutting	2
Tawana	24-Apr-19	Taniau	Iamai	Cutting	40
Nei Ari	24-Apr-19	Ewena	Lime	Cutting	1
Karakoa	24-Apr-19	Koinawa (Morikao)	Cabbage	Seedling	20
Nei Kanganga	26-Apr-19	Tebero (SJC)	Pandanus seedlings	cuttings	4
Nei Kanganga	26-Apr-19	Tebero (SJC)	Iamai	Cutting	6
Baara	29-Apr-19	Tebunginako	Cabbage	seedling	5
Baara	1-May-19	Tebunginako	Fig	Cutting	1
Buka	2-May-19	Tebero (SJC)	Fig	Cutting	3
Bwaraniko	4-May-19	Tebero (SJC)	Taro	Sucker	20
Maria	5-May-19	Tebero	Cabbage	Seedling	45
Maria	6-May-19	Tebero	Cabbage	seedling	44
Maria	7-May-19	Tebero	Cabbage	Seedling	18
Biroto	16-May-19	Koinawa (Waakam)	Cabbage	seedling	44
Biroto	17-May-19	Koinawa	Cabbage	Seedling	48
Biroto	18-May-19	Koinawa	Cabbage	seedling	48
Tinaai	18-May-19	Tebero	Cabbage	Seedling	50
Reen	20-May-19	Aonobuaka	Cabbage	seedling	50
Tokataake	20-May-19	Ewena	Cabbage	Seedling	50
Tokataake	20-May-19	Ewena	Egg plant	seedling	25
Tiang	24-May-19	Tanimaiaki	Cabbage	Seedling	21
Tiang	24-May-19	Tanimaiaki	Tomato	Seedling	25
Tenata	27-May-19	Tuarabu	Cabbage	Seedling	50
Biroto	27-May-19	Koinawa	Cabbage	seedling	50
Biroto	28-May-19	Koinawa	Cabbage	Seedling	50

Biroto	31-May-19	Koinawa	Cabbage	seedling	50
	4-Jun-19	Taniau	Cabbage	Seedling	50
Tinaai	05 Ju 19	Tebero	Cabbage	seedling	50
Maria	6-Jun-19	Tebero	cabbage	Seedling	7
Iebwe	6-Jun-19	Tebero	Cabbage	Seedling	50
Biroto	6-Jun-19	Koinawa	Cabbage	Seedling	50
Mautaake	12-Jun-19	Koinawa	Cabbage	seedling	50
Moaraoi	12-Jun-19	Koinawa	Cabbage	Seedling	50
Ioata	18-Jun-19	Koinawa	Cabbage	seedling	50
Buranibeia	12-Jun-19	Koinawa	Tomato	Seedling	100
Ioata	18-Jun-19	Koinawa	Tomato	seedling	50
Moaraoi	19-Jun-19	Koinawa	Cabbage	Seedling	50
Korauea	24-Jun-19	Tebero	Pumpkin	Seedling	1
Tinaai	28-Jan-20	Tebero	Egg plant	Seedling	8
Tabita	27-Feb-20	Tuarabu	Iamai	Cutting	10
Tabita	27-Feb-20	Tuarabu	Papaya	Seed	5
Tokotoko	27-Feb-20	Tuarabu	Egg plant	Seed	5
Tinang	27-Feb-20	Tanimaiaki	Iamai	Cutting	12
Batiua	27-Feb-20	Ewena	Iamai	Cutting	10
Batiua	27-Feb-20	Ewena	Egg plant	Seed	6
Batiua	27-Feb-20	Ewena	Lemon grass	Seedling	12
Dr Kautu	26-Feb-20	Tanimaiaki	Dragon fruit	Cutting	3
CM Tebero	26-Feb-20	Tebero	Iamai	Cutting	78
Tokarei	13-Mar-20	Koinawa	Egg plant	Seed	6
Teiti	13-Mar-20	Taniau	Egg plant	Seed	3
Teiti	13-Mar-20	Taniau	Spinach	Cutting	5
Teiti	13-Mar-20	Taniau	Chaya	Cutting	5
Kabwebwe	13-Mar-20	Tuarabu	Egg plant	Seed	10
Kabwebwe	13-Mar-20	Tuarabu	Iamai	Cutting	5
Kabwebwe	13-Mar-20	Tuarabu	Lemon Grass	Seedling	10
Morikao (SWHS)	13-Mar-20	Koinawa	Egg plant	Seed	54
Morikao (SWHS)	13-Mar-20	Koinawa	Papaya	seed	154
Morikao (SWHS)	13-Mar-20	Koinawa	Iamai	Cutting	6
Anne Wootton	13-Mar-20	Tebero (SJC)	Egg plant	Seed	2
Anne Wootton	13-Mar-20	Tebero (SJC)	Papaya	Seed	2
Anne Wootton	13-Mar-20	Tebero (SJC)	Pumpkin	Seed	1
Anne Wootton	13-Mar-20	Tebero (SJC)	Iamai	Cutting	1
Teretia	14-Mar-20	Tuarabu	Egg plant	Seed	2
Bitin	14-Mar-20	Tuarabu	Egg plant	Seed	3
Otita	14-Mar-20	Tuarabu	Egg plant	Seed	3
Mena	14-Mar-20	Tuarabu	Egg plant	Seed	2

Bitin	14-Mar-20	Tuarabu	Iamai	Cutting	1
Kabwebwe	14-Mar-20	Tabontebike	Egg plant	Seed	2
Batiua	16-Mar-20	Ewena	Papaya		15
Teannako	17-Mar-20	Tabontebike	Te mai keang		2
Teannako	17-Mar-20	Tabontebike	Te mai kora		2
Teannako	17-Mar-20	Tabontebike	Fig		3
Teannako	17-Mar-20	Tabontebike	Iamai		28
Teannako	17-Mar-20	Tabontebike	Lemon grass		20
Teannako	17-Mar-20	Tabontebike	Chaya		10
Teannako	17-Mar-20	Tabontebike	Papaya		17
Taboo	18-Mar-20	Tanimaiaki	Egg plant		8
Taboo	18-Mar-20	Tanimaiaki	Mai keang		2
Taboo	18-Mar-20	Tanimaiaki	Lemon grass		5
Kabwebwe	19-Mar-20	Tuarabu	Pandanus		2
Kabwebwe	19-Mar-20	Tuarabu	Papaya		134
Kabwebwe	19-Mar-20	Tuarabu	Te non		4
Emireta	19-Mar-20	Tuarabu	Iamai		10
Emireta	19-Mar-20	Tuarabu	Lemon grass		2
Emireta	19-Mar-20	Tuarabu	Egg plant		2
Tebukatau	19-Mar-20	Tuarabu	Papaya		3
Tebukatau	19-Mar-20	Tuarabu	Iamai		7
Tebukatau	19-Mar-20	Tuarabu	Lemon grass		5
Tenutaake	20-Mar-20	Ewena	Papaya		10
Tenutaake	20-Mar-20	Ewena	Egg plant		2
Tenutaake	20-Mar-20	Ewena	Iamai		4
Tenutaake	20-Mar-20	Ewena	Okira		4
Tenutaake	20-Mar-20	Ewena	Mai keang		4
Koraing	26-Mar-20	Koinawa	Egg plant		8
Akinete	26-Mar-20	Tuarabu	papaya		5
Akinete	26-Mar-20	Tuarabu	Egg plant		6
Akinete	26-Mar-20	Tuarabu	Mai kora		1
Teroba	26-Mar-20	Tuarabu	Egg plant		10
Tenutaake	25-Mar-20	Ewena	Okira		5
Tenutaake	25-Mar-20	Ewena	Papaya		10
Tenutaake	25-Mar-20	Ewena	Iamai		10
Tenutaake	25-Mar-20	Ewena	Egg plant		5
Nataake	26-Mar-20	Tebero	Iamai		2
Kaeiei	26-Mar-20	Tebero	Iamai		1
Naibunaki	27-Mar-20	Tebero	Fig		3
Naibunaki	27-Mar-20	Tebero	Mai keang		4
Naibunaki	27-Mar-20	Tebero	Iamai		10
Naibunaki	27-Mar-20	Tebero	Chaya		2
Naibunaki	27-Mar-20	Tebero	Lemon grass		4
Naibunaki	27-Mar-20	Tebero	Egg plant		4
Nei Tau	27-Mar-20	Tebero	Papaya		3
Nei Tau	27-Mar-20	Tebero	Iamai		2
Been	27-Mar-20	Tebero	Papaya		3

Tooma	27-Mar-20	Aonobuaka	Iamai		2
Tooma	27-Mar-20	Aonobuaka	Iamai		12
Been	27-Mar-20	Tebero	Egg plant		5
Arobati	31-Mar-20	Tuarabu	Lemon grass		12
Nei Taabo	31-Mar-20	Tanimaiaki	iamai		20
Irate	1-Mar-20	Tebero	Iamai		3
Irate	1-Mar-20	Tebero	Papaya		3
Tamoa	1-Mar-20	Tebero	Papaya		3
Tamoa	1-Mar-20	Tebero	Iamai		3
Meera	1-Mar-20	Tebero	papaya		3
Meera	1-Mar-20	Tebero	iamai		3
Katarina	1-Mar-20	Tebero	Papaya		3
Katarina	1-Mar-20	Tebero	Iamai		3
Anne	1-Mar-20	Tebero	Papaya		5
Karakoa	5-Mar-20	Morikao	Egg plant		5
Karakoa	5-Mar-20	Morikao	Okira		2
Mwereue	10-Mar-20	Tebunginako	Iamai		20
Mwereue	10-Mar-20	Tebunginako	Egg plant		1
Mwereue	15-Mar-20	Tebunginako	Egg plant		6
Mwereue	15-Mar-20	Tebunginako	Maikeang		1
mwereue	15-Mar-20	Tebunginako	fig	Cutting	2
Katarake	26-Apr-20	Ribono	Lemon grass	Seedling	19
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Appendix 1b. Abaiang List of Beneficiaries

Abaiang Agroforestry Distribution Records			
Date	**Tree Crops**	**Propagation**	**No. of plants**
	(Type of Plants)	(seed, seedlings, root, cuttings, marcot, etc)	
2018	Coconut seedlings		609
2018	Coconut seednut		2280
2018	Fig seedlings		0
2018	Iamai (Ofega)		12
2018	Iaro (Ofega)		135
2018	Pandanus (Antinakarewe)		19
2018	Egg plant		205
2018	Mustard cabbage		38
2018	Saladeer cabbage		197
2018	Tomato		12
2018	Breadfruit (as mother plant)		1
2018	Papaya (as mother pant)		11
2018	Fig (as mother plant)		1
2018	Coconut tree (as mother plant)		7
2018	Pumpkin (as mother plant)		1
2018	Tomato (as mother plant)		93

2018	Kumala (as mother plant)		93
2018	Iaro (as mother plant)		7
2018	Iamai (as mother plant)		359
2018	Egg plant (as mother plant		25
2018	Watermelon (as mother plant)		7
19-Mar-19	Coconut tree (as mother plant)	Seednut	7
19-Mar-19	Coconut tree (as mother plant)	Seednut	7
19-Mar-19	Coconut tree (for distribution)	Seednut	5014
19-Mar-19	Fig (as mother plant)	cutting	1
19-Mar-19	Fig (for distribution)	cuttings	104
19-Mar-19	Iaro (as mother plant)	cuttings	7
19-Mar-19	Iaro (for distribution)	cuttings	161
19-Mar-19	Iamai (as mother plants)	cuttings	279
19-Mar-19	Iamai (for distribution)	cuttings	100
19-Mar-19	Kumala (as mother plants)	cuttings	270
19-Mar-19	Breadfruit (as mother plant)	marcot	1
19-Mar-19	Pandanus (for distribution)	cuttings	15
19-Mar-19	Eggplant (for distribution)	cuttings	15
19-Mar-19	Eggplant (as mother plant)	seeds	27
19-Mar-19	Lime (as mother plant)	cuttings	4
19-Mar-19	Lime (for distribution)	cuttings	108
19-Mar-19	Lemon grass (as mother plant)	seedlings	19
19-Mar-19	Pumpkin (as mother plant)	cuttings	1
19-Mar-19	Papaya (as mother plants)	seeds	6
19-Mar-19	Tapioca (as mother plant)	cuttings	5
28-Jun-19	Coconut tree seedling	seednut	6822
28-Jun-19	Fig (as mother plant)	Cutting	45
28-Jun-19	Taro (as mother plant)	Cutting	97

28-Jun-19	Cabbage (for distribution)	Seed	200
28-Jun-19	Tomato (for distribution)	Seed	500
28-Jun-19	Papaya (for distribution)	Seed	4
28-Jun-19	Spinach cabbage (as mother plant)	Cutting	90
28-Jun-19	Jair (as mother plant)	Cutting	81
28-Jun-19	Sweet potato (PNG) (as mother plant)	Cutting	184
28-Jun-19	Numbered (as mother plant)	Cutting	50
28-Jun-19	Iro (as mother plant)	Cutting	45
28-Jun-19	Lemon Grass (as mother plant)	Seedling	20
28-Jun-19	Papaya (as mother plant)	Seed	7
28-Jun-19	Fig (as mother plant)	Cutting	1
28-Jun-19	Breadfruit (as mother plant)	Marcot	2
28-Jun-19	Coconut tree (as mother plant)	Seednut	7
28-Jun-19	Iamai (as mother plant)	Cutting	279
28-Jun-19	Taro (as mother plant)	Sucker	40
28-Jun-19	Lime (as mother plant)	Cutting	4
28-Jun-19	Cassava (as mother plant)	Cutting	1
28-Jun-19	Sweet potato (prap) (as mother plant)	Cutting	270
30-Dec-19	Coconut seedling (as mother plant)	Seednut	4435
30-Dec-19	Fig (as mother plant)	Cutting	141
30-Dec-19	Egg plant (as mother plant)	seed	800
30-Dec-19	Okira (as mother plant)	Seed	122
30-Dec-19	Pumpkin (as mother plant)	Seed	76
30-Dec-19	Noni (as mother plant)	Seed & cutting	4
30-Dec-19	Cabbage (as mother plant)	Seed	50
30-Dec-19	Coconut tree (as mother plant)	Seednut	7

30-Dec-19	Fig (as mother plant)	Cutting	1
30-Dec-19	Breadfruit (as mother plant)	Root cutting	2
30-Dec-19	Papaya (as mother plant)	Grafting	7
30-Dec-19	Baby cucumber (as mother plant)	Cutting	4
30-Dec-19	Iamai (as mother plant)	Cutting	279
30-Dec-19	Chaya (as mother plant)	Cutting	17
30-Dec-19	Dragon Fruit (as mother plant)	Cutting	24
30-Dec-19	Lemon grass (as mother plant)	Seedling	10
30-Dec-19	Lime (as mother plant)	Cutting	4
30-Dec-19	Sweet potatoes (as mother plant)	Cutting	50
7-Jan-20	Seeded Breadfruit (curly)	Seed	100
7-Jan-20	Seeded Breadfruit	Seed	100
7-Jan-20	Pandanus tree	Cutting	15
15-Jan-20	Papaya	Seed	550
15-Jan-20	Egg plant	Seed	121
22-Jan-20	Iamai	Cutting	180
22-Jan-20	Iaro	Cutting	240
15-Jan-20	Noni	Seed	828
15-Jan-20	Seeded breadfruit (curly) (as mother plant)	seed	1
15-Jan-20	Seeded breadfruit (Tembwarekana) (as mother plant)	Marcot	1
15-Jan-20	Iamai (as mother plant)	Cutting	279
15-Jan-20	Chaya (as mother plant)	Cutting	
15-Jan-20	Dragon Fruit (as mother plant)	Cutting	24
15-Jan-20	Lemon grass (as mother plant)	Seedling	
15-Jan-20	Lime (as mother plant)	Cutting	4
15-Jan-20	Sweet potatoes (as mother plant)	Cutting	
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