Australian Government
Australian Centre for International Agricultural Research

Project proposal

project	**Improving soil health in support of sustainable development in the Pacific**
project number	PC/2009/003
proposal phase	Full
prepared by	Mr. Tony Gunua SPC Dr. Mike Smith DEEDI Mr. Tony Pattison DEEDI Mr. John Bagshaw DEEDI
research program manager	Dr Richard Markham, Pacific Crops

Privacy statement

ACIAR, as a Commonwealth government agency, is required to comply with the eleven Information Privacy Principles as set out in Section 14 of the *Privacy Act 1988* (www.privacy.gov.au/publications/ipps.html). These are based on the 1980 OECD guidelines governing the protection of privacy and trans-border flows of personal data.

The personal information provided in this project proposal, including CVs, is stored in hard copy and electronic format in ACIAR. The information is reproduced internally for the purpose of meetings to consider project proposals. It is reproduced for restricted external purposes as part of the contractual documentation exchanged with the commissioned organisation, collaborating institution(s) and partner-country government(s).

Personal information (individuals' contact details) is also stored in ACIAR's project information system. ACIAR endeavours to keep this information as up to date as possible, with the assistance of the individuals whose details are recorded.

The names and contact details of Project Leaders may be listed with project details on the ACIAR web site, provided to other databases and media in the context of briefings and publicity on the ACIAR project portfolio, and used for mail outs of ACIAR corporate publications.

ACIAR does not divulge any other personal information to third parties for any other purpose.

Contents

1 Project outline

Project number	PC/2009/003
Project title	Improving soil health in support of sustainable development in the Pacific (short title: Soil Health - Fiji, Samoa, Kiribati)
ACIAR program area	Pacific Crops
Proposal stage	Full
Commissioned organisation	Secretariat of the Pacific Community (SPC)
Project type	Large
Geographic region(s)	Pacific
Country(s)	Fiji, Samoa and Kiribati
Project duration	4 years
Proposed start date	1 January 2011 (1 March 2011)
Proposed finish date	31 December 2014
Time to impact	Category 2

1.1 Funding request

		Amounts	**Totals**
Year 1 (F/Y) 2010/11 (1 Mar 11)	Pay 1	$441,551	$441,551
Year 2 (F/Y) 2011/12	Pay 2	$146,812	$298.954
	Pay 3	$152,142	
Year 3 (F/Y) 2012/13	Pay 4	$ 154,682	$304,878
	Pay 5	$150,196	
Year 4 (F/Y) 2013/14	Pay 6	$152,271	$299,379
	Pay 7	$147.108	
Year 5 (F/Y) 2014/15	Pay 8	$148,220	$148,220
Total			$1,492,981

1.2 Key contacts

Project leader: commissioned organisation (SPC)

Title and name	Dr. Tony Gunua
Position	Coordinator of the Plant Health Thematic Group
Organisation	Secretariat of the Pacific Community
Phone	(679) 337 0733 ext. 35294
Fax	(679) 337 0021
Email	TonyG@spc.int
Postal address	Secretariat of the Pacific Community, Private Mail Bag, Suva, Fiji
Street address (if different to postal)	3 Luke Street, Nabua, Suva, Fiji

Administrative Contact: commissioned organisation (SPC)

Title and name	Ms Sushil Narayan
Position	Divisional Administrative Officer, Land Resources Division
Organisation	Secretariat of the Pacific Community
Phone	(679) 3370733 Ext: 35226/ 3379226 (dl)
Fax	(679) 3370021/ 3386326+
Email	SushilN@spc.int
Postal address	Secretariat of the Pacific Community, Private Mail Bag, Suva, Fiji Islands
Street address (if different to postal)	Luke Street, Nabua, Suva, Fiji Islands

Collaborating scientist: Australian collaborating organisation

Title and name	Dr. Mike Smith
Position	Senior Principal Scientist
Organisation	DEEDI
Phone	(07) 5453 5941
Fax	(07) 5453 5901
Email	mike.smith@deedi.qld.gov.au
Postal address	PO Box 5083, SCMC, Nambour, Queensland 4560
Street address (if different to postal)	Maroochy Research Station 47 Mayers Road, Nambour

Project coordinator: partner country - Fiji

Title and name	Mrs Miliakere Nawaikula
Position	Analytical chemist; A/Director of Research – Koronivia Research Station
Organisation	Ministry of Primary Industries
Phone	(679) 3477044
Fax	(679) 3400262
Email	miliakere.nawaikula@govnet.gov.fj
Postal address	PO Box 77, Nausori, Fiji
Street address (if different to postal)	Koronivia Research Station, Kings Road, Nausori

Collaborating researcher: partner organization - Fiji

Title and name	Mr Peter Kjaer
Position	Farmer-training coordinator
Organisation	Tei Tei Taveuni (Farmers' Association)
Phone	(679) 888 0261
Fax	
Email	pkppl@connect.com.fj
Postal address	Po Box 99, Waiyevo, Taveuni, Fiji Islands
Street address (if different to postal)	

Project coordinator: partner country - Samoa

Title and name	Mr David Hunter
Position	Senior Lecturer in Soil Science, School of Agriculture – Alafua Campus
Organisation	University of the South Pacific
Phone	(685) 21671
Fax	(685) 22347
Email	hunter_d@samoa.usp.ac.fj
Postal address	University of the South Pacific, Private Mail Bag, Apia, Samoa
Street address (if different to postal)	USP Alafua Campus, Apia, Samoa

Collaborating researcher: partner organization - Samoa

Title and name	Mr Parate Matalavea
Position	Director of Research
Organisation	Ministry of Agriculture and Fisheries
Phone	(685) 23416
Fax	(685) 20607
Email	parate.matalavea@crops.gov.ws
Postal address	Nu'u Research Station, Crops Division P.O. Box 1874 Apia
Street address (if different to postal)	

Project coordinator: partner country - Kiribati

Title and name	Mr. Tokintekai Bakineti
Position	Principal Agricultural Officer
Organisation	Ministry of Environment, Lands & Agriculture Development
Phone	(686) 29418 / 29419 / 28108
Fax	
Email	tokintekai@gmail.com
Postal address	Ministry of Environment, Lands & Agriculture Development, Tarawa, Kiribati
Street address (if different to postal)	Bikenibeu, Tarawa, Kiribati

1.3 Project summary

Declining soil fertility and biological soil health represent a major threat to sustainable agricultural development in the Pacific. Traditional land management systems on the Pacific islands were based on a long bush-fallow system, or in the case of atolls, recycling of large amounts of organic material in pits or heaps. However, smallholders who have intensified crop production to supply growing urban and export markets, have typically failed to replenish soil nutrients and organic matter adequately. They have consequently experienced falling yields and increasing problems with soil-borne diseases and nematodes that are symptomatic of declining soil health. In Queensland, soil health issues in intensive horticultural crops have arisen mainly through an over-reliance on inorganic fertiliser and pesticides.

A major project on the Development of Sustainable Agriculture in the Pacific (DSAP) involved sixteen Pacific Island countries and has had considerable success in introducing participatory research and extension approaches to diagnose crop production problems and develop solutions that could be adopted at community level, including technologies for mitigation of declining soil fertility and erosion. However, in the absence of a coherent strategy for underpinning intensification of Pacific cropping systems and convenient tools for monitoring the biological health and fertility status of soils, progress has been hard to assess and consolidate. In Queensland, researchers have successfully developed concepts and methods in soil health management (especially in banana production systems), but are at an early stage of encouraging adoption by growers.

The present project builds on the success of DSAP in participatory trialling of soil fertility management technologies and of the research-and-development community in Queensland in developing integrated approaches to managing soil health in fragile tropical soils under intensive production in ecologically sensitive areas. A Small Research Activity (SRA – PC/2010/038), funded by ACIAR, has allowed the project team and their partners to assess the current status of soil health research and extension in the target countries (Fiji, Samoa and Kiribati); to identify cropping-systems-in-crisis and appropriate pilot sites to investigate them; as well as field research partners and initial strategies to tackle the respective problems. The proposed project now focuses on developing strategies for restoring soil health and research-based indicators that growers and extension officers can use to assess soil health status (including key chemical, physical and biological variables), as well as extension approaches to communicate soil health concepts and methods to growers.

This project, building on the lessons learned during DSAP and the SRA, contributes to the broader development goal of improving the economic and environmental sustainability of intensive smallholder crop production in the Pacific Region. Its specific aim is to develop strategies for improving soil health in selected Pacific cropping systems. It has three objectives:

- To elucidate crop production and related soil health problems at specific pilot sites and develop physical, chemical and biological indicators underpinning an integrated approach to improving soil management.
- To evaluate ‘best-bet’ soil improvement practices for sustaining intensive Pacific crop production.
- To increase the understanding of soil health concepts (including physical, chemical and biological processes) among smallholder horticulture producers and their service providers and enhance their capacity to apply these concepts for sustained productivity.

Research will focus on pilot sites in Fiji and Samoa (taro), Kiribati (vegetables) and Australia (banana). Detailed discussions with farmers and rapid surveys will be conducted at each pilot site to assess current knowledge, skills and aspirations of land holders and to benchmark current soil properties and management practices. Soil physical, chemical and biological indicators will be developed (at different levels of sophistication for different stakeholders) that can be used in developing soil health management strategies. 'Best-bet' soil improvement and management tactics will be trialled at four locations (three in the Pacific and one in Australia) to determine the best options for soil health management on weathered basalts (Fiji and Samoa), coral atolls (Kiribati) and an alluvial plain (North Queensland). Information packages and extension techniques will be developed to assist growers and their intermediaries to develop sustainable soil health management practices for tropical crops in the Pacific region.

Expected outputs of the project are an enhanced understanding of the role soil biology plays in sustaining productivity, along with strategies and best practices for improving soil health in key cropping systems, and soundly-based indicators appropriate for monitoring the health status of soils by researchers, extension officers and smallholders. The capacity of farmer intermediaries to understand soil health concepts and to use participatory methods in support of helping farmers to improve soil health will be enhanced. An outcome of this capacity building will be that growers themselves are able to use soil health concepts and practices to sustainably improve the productivity of crops.

Community-level impacts of the project will include more sustainable incomes from key commodities (taro, vegetables and bananas) with reduced environmental impacts from agriculture (including reduced clearing of forests due to improved taro yield), more efficient use of agricultural inputs, and reduced soil erosion. In Kiribati, food security and improved nutrition will be fostered by developing more resilient and sustainable vegetable production systems.

2 Justification

2.1 Partner country and Australian research and development issues and priorities

'Soil health' refers to the ability of the soil to function for a given purpose, in this case to support the growth of crops, and includes the chemical, physical and biological processes necessary for this. The degradation of the soil in any of these dimensions impacts on the economic viability and environmental sustainability of agriculture and in turn on agriculture's ability to support food security and livelihoods. In both Pacific island countries and Australia, growers have intensified crop production, especially of high-value horticultural crops, in response to economic signals without sufficient attention to securing this vital part of the natural resource base. Conventionally, where attention has been given to soil issues, priority has been given to chemical nutrients (usually addressed through inorganic fertiliser application) and physical structure, with less attention to biological soil health (which assures 'ecosystem services' including nutrient recycling and biological control of pests and pathogens).

Pacific

Smallholder production of horticultural crops is the main source of staple foods and a major source of rural incomes in the Pacific island countries. However, the productivity and sustainability of many cropping systems is threatened by a decline in the fertility, structure and biological health of soils. In volcanic islands, soil fertility was traditionally maintained through long 'bush fallow' periods; on atolls, leaf-fall tended to sustain shallow but fertile soils in diverse agro-forestry systems or growers assembled large amounts of organic matter in heaps or pits for intensive horticulture. Both systems have tended to break down with increasing population pressure and migration. Problems have in some cases reached crisis point as farmers have evolved from subsistence production of staple foods for local consumption to selling crops off the farm to supply growing urban and export markets for staple crops such as taro and cassava, as well as high-value vegetable crops, without adopting new technologies to sustain this more intensive production. Moreover, traditional knowledge of actively managing and investing in organic residues has been lost. The results have been 'nutrient mining' and a decline in the physical, chemical and biological properties of soils; the loss of biological functions of soil is reflected in increasing problems with nematodes and soil-borne pathogens (e.g. *Pythium* spp. in ginger and *Erwinia* in taro); quality and biosecurity problems in fresh export products (especially taro); and declining productivity from existing land, stimulating farmers to open new land, leading to deforestation and associated negative environmental impacts.

The importance of these problems has been recognised in an ACIAR priority for the Pacific Islands of *Improving Food and Nutritional Security* by the development and adoption of integrated and more sustainable production management packages for food staple, fruit, vegetable and plantation crops. This priority is based on those of the Land Resources Division of the Secretariat of the Pacific Community (SPC) that have been developed in close consultation with the governments and agricultural research and extension services of Pacific Island Countries.

A major project on the Development of Sustainable Agriculture in the Pacific (DSAP), implemented by SPC and national partners in sixteen countries, used participatory rural appraisal (PRA) with farmers and rural communities for the identification and adoption or adaptation of technologies to solve agricultural problems. The priority problems identified in this way were soil infertility and erosion (along with poor availability of planting materials and narrow genetic base of traditional crops, irregular supply of water, pests and diseases of crops, poor management of livestock, poor quality local feeds for animals, and poor solid waste management). Among the technologies trialled on farm for soil improvement, using participatory research and extension methods were: the use of: composts, charcoal and other soil amendments; cover crops like *Mucuna* and *Dolichos lablab* and multipurpose tree species such as *Gliricidia sepium*; vetiver grass as live contour barriers; and the application of specific nutrients (especially iron and zinc). Significant uptake and impacts at community level were reported (for instance for *Mucuna* in Tonga) and considerable awareness and capacity developed among national researchers and extension staff. However, the project stopped short of establishing long-term strategies for continuing and supporting the improvement of soil health and fertility. This would in any case have been difficult given the lack of an adequate scientific knowledge base concerning soil processes in Pacific island soils and appropriate indicators to monitor progress.

Soils in the Pacific vary greatly in their inherent properties (especially between atolls and islands of volcanic origin and depending on their age, climate and cropping systems), which means that soil management strategies need to be tailored to the specific soil environment and needs of farmers. Therefore, to improve the sustainability of agriculture in the Pacific region, a robust set of soil health indicators needs to be developed that enable land managers to recognise problems, develop management systems to overcome soil constraints and monitor progress in implementing them. Current nutrient testing services are able to offer advice relating to soil chemistry (though not necessarily with reliability and at an affordable price), but they do not account for the physical and biological components of soil health nor their interactions in the soil environment. Extension capacity needs to be further strengthened both in the understanding of soil health concepts and in their application through participatory research and training approaches.

Australia

Soil health research fits into the priorities of the Australian banana industry as it is able to address multiple constraints faced by the industry. Soils in the north Queensland banana production areas are typically clay loam soils with good drainage characteristics prior to intensive cultivation. Current practices designed to favour banana production also increase the risk of agricultural impacts on the environment. Nutrient management and applications of nitrogen and phosphorus to crops are of concern due to movement off-farm to streams and rivers. The situation in north Queensland is of increasing importance due to proximity to the Great Barrier Reef and the banana industry needs to demonstrate that it is able to manage its nutrient application minimising off-farm movement of nutrients. Nutrient imbalances and a decline in soil organic matter have been linked with a decline in the health of the soil and increased incidence of pest and diseases such as plant-parasitic nematodes. The deterioration in soil structure, due to compaction through the use of machinery increases erosion potential and may reduce crop production by restricting root growth. Conversely, practices that increase organic matter inputs can improve water infiltration, retain mobile nutrients and increase soil biodiversity, leading to suppression of soil borne pests and diseases.

Soil health has also been recognised as a priority by government as a means of reconciling agriculture production with environmental protection. Soil health is of particular concern in tropical regions due to the vulnerability of the soils to degradation and the need to protect World Heritage value sites such as the Great Barrier Reef. Soil health projects have been conducted with the Australian banana industry since 2002. The projects have tried to develop tests to determine the best indicators to relay the “health” of the soil to banana growers. The techniques used ranged from “do it yourself”, based on the model provided by USDA kits, to sophisticated laboratory testing. These projects have seen an evolution in the way soil health is tested and have stimulated growers’ interest in developing better farming practices. However, this work has not yet developed a satisfactory delivery mechanism of information to the banana growers in Queensland.

Further information and demonstrations of improved soil health practice are required for the Australian banana industry to stimulate widespread adoption of soil health practices. Recent research in Australia has highlighted the subtle loss in production with declining soil health, particularly a decline in the biological indicators, in long term monocultures of bananas, where organic matter is not replenished. More research is required in the development of biological soil health indicators and how they relate to soil management practices, to enable information to be disseminated to growers. Furthermore, more information is required on the role of soil organisms in the development of healthy soils and how this benefits sustainable banana production to prevent soil degradation. Innovative farmer practices, such as minimum tillage, cover cropping and companion planting, need to be validated for their impacts on soil health and ability to overcome soil constraints to meet increasing demands placed on the banana industry for environmental protection.

The banana industry in Queensland provides an ideal platform for the work in the Pacific in view of the tropical environment (with similar issues of high rainfall, temperature and disease pressures) and because Australian banana growers already have some awareness of soil health, as well as the desire to improve it. Furthermore, there remain external pressures on the banana industry, as with other horticultural industries in Pacific island nations, to demonstrate that they are using best management practices to grow crops to ensure they are having minimal impact on the surrounding environment.

2.2 Research and/or development strategy and relationship to other ACIAR investments and other donor activities

Because of the similarities in the challenges facing the production of tropical crops in the Pacific islands and Australia and the priority recognised in addressing soil health management issues at the grower level in both regions, the project proposes to use a participatory 'action research' model. Previous research and recent farmer interactions have suggested a range of 'best bet' options for improving soil health (especially based on restoring or increasing soil organic matter), so on-farm research can proceed immediately to evaluate the most effective and adoptable of these. In parallel, detailed research can take place to better understand specific pest and disease problems (and, if necessary, develop complementary strategies to manage them) and to develop and validate the 'tool kit' of indicators used to monitor soil health. Also in parallel will be the training of farmers and extension workers in soil health concepts and the development of appropriate extension materials and techniques to support this effort.

In addition to building on the participatory prioritization and problem-solving approach of DSAP, this research strategy builds directly on a number of previous projects on soil health that have given the team (all soil health practitioners) experience with the specific research and extension approaches to be followed in the project. The most directly relevant include:

- ACIAR HORT/2008/040 - *Integrated crop production of bananas in Indonesia and Australia*. This project is currently developing a number of indicators, such as soil biochemical tests (labile C, fluorescein diacetate and β-glucosidase, nematode community analysis) that will have direct relevance to this project. The project is also investigating physical, chemical and biological indicators related to suppression of soil borne diseases.
- ACIAR PC/2004/049 - *Improved farming systems for managing soil-borne pathogens of ginger in Fiji and Australia*. This project has investigated the effects of organic amendments, crop rotations and tillage on soil-borne pathogens in various ginger farming systems with the aim of creating more productive, disease-suppressive soils.

- HAL VG06100 - *Vegetable plant and soil health*. This project developed a system of identifying soil constraints, selecting soil health indicators and determining the appropriate management practices that was able to address the identified soil constraints.
- ACIAR SMCP/2002/085: *Utilising basic soil data for the sustainable management of upland soils in Vietnam and Australia*. The SCAMP process allows the identification of soil constraints using field, in-field and laboratory tests, and sets guidelines for the improvement of the soil constraints.
- HAL FR02025: *Banana root and soil health*. This project identified key soil health indicators for the Australian banana industry and the impacts of different management practices, such as organic amendments and inter-crop vegetation, on soil health indicators, sustainability of crop production and suppression of plant-parasitic nematodes.

An SRA (PC/2010/038 *Identifying pilot sites and research methods for soil health research in the Pacific*) undertaken as part of the development of this project, allowed the project team to consult with researchers, extension officers, growers and other stakeholders in high-value crop production in the Pacific islands. A number of high-value cropping systems were considered as candidates for further research; however, there was a high level of consensus that two intensified systems had reached a state of crisis, associated with soil health problems, to the level that farmers would be prepared to consider fundamental changes to their production system. These were export taro production (with target sites in Taveuni, Fiji, and Upolu, Samoa), and vegetable production in Tarawa, Kiribati (this latter with a strong link to soil health research at the Centre of Excellence for Atoll Agriculture in Kiribati, established by SPC with funding from the International Fund for Agricultural Development). As the project develops and indicators become available it is foreseen that the project's approach could be developed and validated in some of the other cropping systems proposed in the course of the stakeholder consultations including: banana production for processing in Fiji (supported by the SPC-FACT project - Facilitating Agricultural Commodity Trade); exports of organic Misi Luki bananas from Samoa (supported by Women-in-Business Development Inc., Samoa); exports of red papaya from Fiji (linking with research already supported by ACIAR through PC/2008/003 *Strengthening the Fiji papaya industry through applied research and information dissemination*); and exports of ginger (where some soil health management approaches were already developed by ACIAR under PC/2004/049 *Improved farming systems for managing soil-borne pathogens of ginger in Fiji and Australia*).

Taro production in Fiji is already strongly market-oriented with numerous smallholder farmers selling to national urban markets and to exporters supplying especially the New Zealand and, to a lesser extent, Australian markets. Incautious intensification has already led to a crisis of sustainability linked to declining soil health, especially in Taveuni where 80% of export taro is produced. Some 30% of corms are currently rejected as failing to meet adequate size/quality standards for exports (up from about 5% when exports from this island got under way); at least ten shipments of taro from Fiji to Australia, worth some $400,000, have been 're-exported' during 2010 due to interceptions of corm rots, believed to originate in the field; and clearing of forest to provide new, more fertile land for taro production is regarded as a crisis for biodiversity conservation.

AusAID, as part of a cyclone relief package, is already supporting more sustainable taro production in Taveuni and has established links between SPC, the Ministry of Primary Industries (MPI) research and extension staff and a dynamic farmers' association, Tei Tei Taveuni. Current support covers planting materials and trials of *Mucuna* as a green manure cover crop, supplemented by inorganic fertiliser applications. Meanwhile, Tei Tei Taveuni has obtained the support of UNDP for training of farmers in biological farming principles and will secure the services of an Australian Volunteers International (AVI) volunteer to assist with farmer training, through the ongoing 'soil schools' and on-farm follow-up visits. AusAID's bilateral mission to Fiji will further reinforce this collaboration by providing supplementary funding (equivalent to approx. 20% of the project budget), for additional equipment and materials to support the joint research and training effort.

Samoa was previously the Pacific's main exporter of taro but this industry was devastated by a taro blight epidemic; the industry is now in a recovery phase following major investments by AusAID (under the Taro genetic resources: conservation and utilization - TaroGen - project), other donors and the government in taro breeding, as well as more modest investment by ACIAR in resolving virus problems (e.g. PC/2006/053 *Evaluation of the impact of Dasheen mosaic virus on and other viruses on taro yield*). Samoa has resumed exports on a pilot level but is already encountering difficulties in meeting quality standards. A dialogue established during the SRA between the project team and the Samoa Farmers' Association, Women in Business Development Inc., the Taro Improvement Project, and individual exporters, indicates an awareness of the link between quality issues and soil health problems. A visit to a pack-house managed by the Ministry of Agriculture and Fisheries also provided the project team with direct evidence of soil-borne pest problems linked to high rejection rates and, as in Taveuni, stakeholder discussions cited the search for more fertile soil for taro production as a driver in the movement of farmers to new land on hillsides, resulting in deforestation and the risk of erosion problems.

In both Fiji and Samoa, this project will link directly to, and work closely with, another SPC-led and ACIAR-funded project, PC/2007/118 on *Developing cleaner export pathways for Pacific agricultural commodities* which is in the final stages of project development and approval. This project has also selected taro exports from Fiji and Samoa as a priority for attention and will pick up the supply chain 'from the farm gate'. Close operational links between the two projects will ensure that problems of biosecurity concern that can be addressed in the production system (such as infestation by plant parasitic nematodes) will be tackled by the present soil health project.

The project will be managed by the Secretariat of the Pacific Community (SPC), building on their experience of managing DSAP, a major multidisciplinary project funded by the European Union, as well as numerous other projects funded by ACIAR and other donors. DSAP focused on strengthening the linkages between stakeholder groups in order to enhance the capacity of local communities and to strengthen national technical capabilities in agricultural production and in the use of a variety of extension communications approaches.

Partnerships with soil researchers already established under DSAP will provide a foundation for the present project while the Pacific Islands Extension Networks (PIEN) will both contribute expertise and promote the uptake of project outputs. The project will strengthen the Centre of Excellence for Atoll Agriculture, established in Tarawa, Kiribati, in 2008, with support from the International Fund for Agricultural Development (IFAD) and will benefit from the long-standing partnership with the University of the South Pacific (USP), especially the agriculture campus at Alafua, Samoa that counts soil research among its priorities. A number of students in the 2010 intake of students under the ACIAR-USP scholarship scheme (HORT/2007/072) have already indicated their desire to undertake thesis research in conjunction with the present soil health project. For support to soil analyses, the project will draw on two of the most important soil laboratories in the Pacific Islands, that of Fiji MPI at Koronivia Research Station and USP-Alafua, which provide analytical services through the South Pacific Agricultural Chemistry Laboratory Network (SPACNET).

3 Objectives

Within the broader development goal of improving the economic and environmental sustainability of intensive smallholder crop production in the Pacific Region, the purpose of the project is to develop strategies for improving soil health in selected Pacific cropping systems (including extension approaches and indicators to monitor progress) and underpinned by a sound understanding of biological processes.

Specific objectives of the project will be to:

1. **Elucidate crop production and environmental soil problems at specific pilot sites and develop physical, chemical and biological indicators underpinning an integrated approach to soil management.** Building on the experience of DSAP, project efforts will be focussed on the key concerns of producers at each pilot site and to provide baseline data on the current situation. Based on the experience of the Queensland team and on further research as needed, indicators will be selected from the existing 'tool-kit' or developed to address the key concerns identified. Specific pest and disease problems (such as mealybug and nematode problems already noted in the SRA) will also be investigated and supplementary control tactics developed where necessary.

2. **Evaluate 'best-bet' soil improvement practices for sustaining intensive Pacific crop production.** Participatory methods will be used to identify 'best-bet' strategies for improving soil health that are adapted to local needs and conditions; these will then be tested in on-farm trials with lead farmers and used in 'training of trainer' exercises**.** Impacts of soil improvement efforts will be monitored through the use of the project's soil health indicators, as well as through changes in crop yields, reject rates (for export taro), and other economic and environmental parameters. The economic costs and benefits of best-bet soil improvement strategies will be assessed.

3. **Increase the understanding of soil health concepts (including physical, chemical and biological processes) among smallholder horticulture producers and their service providers and enhance their capacity to apply these concepts for sustained productivity.** This objective involves both developing more effective extension methods for communicating soil health messages and applying them at a pilot level, via capacity building among extension officers, in order to see improvements in soil management at the farm level.

4 Planned impacts and adoption pathways

The proposed project is expected to have scientific, capacity and community impacts benefiting the Pacific scientific and extension community, improving capacity to deliver information that meets the needs of landholders and to improve livelihoods of communities through more sustainable and secure food production.

A major focus of the project is centred on pilot sites and their farming communities and a capacity building and communication strategy will be formulated to achieve wider impact and adoption. We aim to draw on the support of existing activities in these areas that have a soil health focus. Even so this project is considered a Category 2 project in that the adoption of ‘best-bet’ management practices beyond the initial target area could begin within a 5-10 year time frame and we would expect at least a 40% adoption of practices within the target area by the end of this current project.

4.1 Scientific impacts

New developments will be made in scientific capacity to investigate soil health systems. Soil systems rely on physical, chemical and biological soil properties interacting to perform vital soil functions to sustain crop production and the environment. This project will test the utility of a variety of techniques for measuring and quantifying soil health systems in tropical environments and the impacts that farming practices may have on soil health.

Soil chemical testing for nutrients is routine and often performed by government and commercial laboratories, though work remains to be done in the Pacific to ensure the reliability and affordability of testing systems. Testing for soil physical properties is not done routinely although there are several well established methods available. However, the methods, knowledge and understanding of the soil biology and its importance in sustainable crop production systems are currently lacking. This project intends to use currently available techniques to measure soil biological activity and apply them to selected intensive crop production systems used in the Pacific and Australia. These methods will include nematode community analysis, soil biochemical tests and soil molecular testing and how they interact with the physical and chemical soil environment to help soils function to sustain crop production.

The biophysical research is expected to generate innovations in participatory extension techniques relevant to soil health management and possibly other dimensions of natural resource management. From an Australian perspective this project will help deliver practical technologies into the hands of the banana industry, but importantly, will develop mechanisms for communicating information to the banana growers in Queensland that has been lacking in the past. The knowledge gained from this project will have applications for other horticultural industries.

With sound methodology and measurement of soil properties, the results obtained from pilot scale studies should be readily extrapolated to the wider farming community. Furthermore, by developing a sound extension program and understanding the farming community’s knowledge, aspirations, skills, attitudes and culture and developing a relevant framework by understanding the soil constraints, findings from the pilot studies should be readily extrapolated beyond the pilot site areas.

4.2 Capacity impacts

The scientific development from the project will be used in Australia to develop soil indicators and guidelines that can be used in a soil health testing service for the banana industry. The indicators will be linked to soil constraints and management options so that when indicators fall outside an optimal range it will be possible for land managers to apply management intervention or change soil management systems to improve soil functions appropriate measures to sustain crop production and protect the environment. There is a current need for a soil health testing service for banana growers and the informal pilot system established between DEEDI laboratories, agribusiness and banana growers will be strengthened by the project.

The 'toolbox' of extension materials and approaches can be put to use immediately (and further refined) in the 'soil schools' being conducted by TeiTei Taveuni, which will be further strengthened during the current project by the involvement of a full-time AVI volunteer. Training materials and methods can also be incorporated in the more general training offered by Tutu Rural Training Centre, operated in Taveuni by the Catholic church.

Similar capacity building is envisaged at SPC, MPI, USP-Alafua and the Centre of Excellence for Atoll Agriculture as the project develops, with a view to ensuring that growers and their service providers have access to an accurate and affordable system for monitoring soil health in Pacific cropping systems. The capacity of extension services to understand soil health concepts and practices, as well as their ability to use participatory methods to communicate these messages to farmers will be strengthened. Indeed, the capacity building of government and community services people through work in progress at pilot sites, and supported by organised meetings and workshops, will be the first to benefit. However, it can be expected that further adoption within the farming community will be hastened by ‘change champions’ that will be identified through the information and training systems put in place. Through this process, adoption will be tailored to community needs and values and skills should be retained post-project. In general, the empowerment of farmers in soil health concepts and practices is also expected to contribute towards the evolution of a more needs- and demand-driven extension service.

4.3 Community impacts

4.3.1 Economic impacts

The development of soil health systems to overcome soil constraints is expected to improve livelihoods of smallholders as better knowledge is developed on how to manage the soil constraints and increase agricultural production without eroding the natural resource base. Furthermore, agricultural systems will be tested that will lead to more efficient use of resources, such as nutrients and organic amendments, to develop best management practices. The development of systems to suppress soil borne pests and diseases will also be investigated, reducing the need for soil applied pesticides.

Likely impacts are hard to estimate in the Pacific in view of the lack of baseline data. As an example of the kind of benefits that can be expected, however, it has been noted that the proportion of taro roots rejected as under-sized and unsaleable in commercial operations in Taveuni, Fiji, has risen over recent years from 5% initially to over 30% at the present time. Improved soil management is expected to restore the rejection rate to its previous level. New Zealand is the main export market for taro from the Pacific Islands, with Fiji supplying 80% of the current imports of 6000 tonnes/annum and with Taveuni’s 3,600 taro farmers receiving approximately FJ$1.50-$2/kg at the farm gate for export-grade taro. Rejects have so far cost the Taveuni taro export industry Fj$ 5-6 million each year, in what was previously a FJ$ 16 million dollar export industry. As Samoa re-enters the export taro trade, we would hope the project can help avoid similar problems with low yields and rejects.

The DSAP project revealed that a major constraint to improved productivity was poor soil health. Options for improving soil health will be based on a PRA process, and combined with methods to analyse costs and benefits, a measure of the economic impact of improved soil health measures can be ascertained.

The Australian banana industry, where data is available, is currently worth around $400 million annually. Improvements due to the adoption of new soil health management systems are likely to result in a reduction in soil applied pesticides and nutrient applications, which will have an impact within 5 years. This is expected to result in a $5 million annual saving to the banana industry. However, greater long term benefits are expected as soils develop greater nutrient recycling, pest and disease suppression, and a greater resistance to erosion. Therefore, the benefits are expected to rise to as much as $20 million (5% of the value of the industry) 10 years after the completion of the project. Similar benefits have been achieved through the suppression of plant-parasitic nematodes in the banana industry (Stirling & Pattison, 2008)

4.3.2 Social impacts

Social benefits will include the reduction in the amount of pesticide needed (especially for the banana industry in Australia), making agricultural practices safer for producers. There are community expectations that agricultural production will not impact on the pristine environment surrounding tropical agricultural production regions, which this project will help to achieve. In Kiribati, the project aims to improve food security for smallholder growers and vegetable production has been identified by the government and a number of donor organizations as important in improving the health and quality of life of the Tarawan community. The experience of DSAP already suggests that communities are empowered in a number of ways by participatory approaches that enable members to better manage their natural resources.

4.3.3 Environmental impacts

The project will aim to protect the environment surrounding agricultural production areas by reducing the farming impact on the off-farm environment. This will be an important focus of the project by assessing the risks that farming practices may have on the surrounding environment. In Taveuni and Upolu, growers in search of land that is not exhausted by current farming practices are moving into forested areas, a practice that must be stopped. In Kiribati, clean ground water is of paramount concern, and a sustainable organic production strategy is the goal of the project. To reduce these risks the project will aim to develop ‘best-bet’ management practices. These will include optimising the use of organic residues (both green wastes and composted materials) to develop soils that are better able to suppress soilborne pests and diseases, as well as retain water and nutrients. A major gain, both in Australia and the Pacific islands, is reduced soil erosion and nutrient run-off related to both the use of appropriate plants and to increasing the stability and resilience of soils; this in turn helps to maintain the health of reef systems that are vitally important for both the multi-million dollar tourist industry and for inshore capture fisheries and harvest of a range of sea-food products.

4.4 Communication and dissemination activities

Developing communication and extension approaches is recognised as a key activity within the project. While a participatory research approach is central to the project, it will need to be developed in the context of local communities. Different levels of tools and information resources will need to be developed to meet the needs of diverse stakeholders, such as landholders, agricultural service providers and research and extension personnel.

A key strategy will be to collaborate closely with existing local government extension staff and support them in using their farmer networks and proven local communication strategies for message dissemination. In Samoa, we will also collaborate with USP staff who work closely with taro growers and exporters/wholesalers.

For communication to be effective we will need to identify our various audiences and adapt the message and communication method to suit. Target audiences will include:

- Pilot site farmers
- Landowners, lease-holders and other village community members, including village leaders and mentors.
- Local government research and extension officers
- Staff of SPC, USP, NGOs and other extension service providers
- Government planners and policy makers
- Soil testing services staff at Koronivia, Fiji and USP-Alafua

Key messages will need to be identified for each target audience. This will be done by working closely with target audience members to determine what information they want and need, and for reviewers selected from the target audience to provide comment on draft communications before they are finalised. Developing the most appropriate tools for communication will again be target audience-dependent, and we will consult each target audience to determine the most appropriate way to communicate most effectively.

Issues to consider will be available communication technologies, accepted forms of communication by the target groups, reading ability of target groups and application of adult learning principles. For example, adults learn more quickly and effectively if they are actively involved in the learning process, so we intend holding learning sessions on pilot sites and facilitating farmers and service providers to practice activities such as soil assessment and field testing under guidance, and encourage them to draw and build on their own practical experiences.

The most likely forms of communication will be visits for informal chats, field days, and training workshops, printed information with an emphasis on diagrams and photos and telephone. Awareness communication would include using newspapers, leaflets, radio, television and computer, depending on availability and common use by the target audiences.

In addition, in the overall context of developing a communication strategy, it is important to conduct some evaluation of acceptance and effectiveness of our communications, particularly at the grower and local service provider level. Finally, a strategy for continuing information flow after the end of the project will be developed during the project. Key aspects of developing the strategy will be:

- Building the knowledge and skills of local service providers in relevant technologies, effective learning facilitation and information transfer.
- Encouraging improved networks between growers and grower groups by demonstrating the benefits of learning together and from one another.

It is anticipated that this project will also deliver soil health training systems that will complement current nutrient testing services to help landholders manage soils.

It is recognized that the primary beneficiaries of this project will be smallholders, with communication and information packages targeted to meet their needs. However, it will be important to include industry service providers to ensure consistent information is being extended to smallholders and to strengthen their information networks. It is anticipated that information packages will be made available based on formats from previous projects for banana and vegetable growers, but the culturally most appropriate methods for communicating information and building knowledge will also be pursued within the project. The information will be updated and re-focused to ensure its relevance to growers in the Pacific islands and in a format that will facilitate uptake and adoption.

Dissemination of the project activities is anticipated through scientific forums and conferences such as Australasian Soilborne Disease Symposium and Soil Science Society meetings. It is also anticipated that scientific results will be published in peer reviewed journals. The Pacific Islands Extension Network and other projects and activities of SPC will provide numerous pathways for uptake of the project's outputs.

In addition, Pacific project staff will benefit by attendance at special conferences and workshops (e.g. Composting Conference in Adelaide in 2011), as well as visits with Australian project staff.

5 Operations

The project will be centred around a participatory 'action research' approach to evaluate, on farmers' fields, the most appropriate strategies for improving soil health and sustainably increasing soil fertility (Objective 2); evaluation, by researchers and farmers, will involve the use of the project's 'tool kit' of soil health indicators, as well as measurements of crop yields and other biophysical indicators, and assessment of costs and benefits of such actions.

To prepare for the action research, some detailed consultation will be required with the farmer groups (Objective 1) to select representative experimental plots and lead farmers. Discussions, literature reviews and direct observations undertaken during the recent scoping study (PC/2010/038) indicate that the over-riding priority for improving soil health is to increase soil organic matter (in both taro export systems on volcanic soils and vegetable production in atoll soils). Identifying adequate sources of organic matter that can be accessed at reasonable cost, however, can be a major challenge in island environments; although some ‘best-bet’ materials and strategies have been provisionally identified in the course of the scoping study (see below), these will also need to be further refined in the course of initial farmer (and extension worker) consultations (Objective 1). These initial consultations will also provide an opportunity to benchmark current knowledge of, and attitudes towards, soil health. Finally, Objective 1 will provide the opportunity to carry out some diagnostic research on specific issues (such as the nematode damage, rots and mealybug infestations noted during the scoping study).

Some relevant extension materials are already available from existing work on soil health in banana systems in Queensland and other experiences elsewhere. However, extension materials and approaches will be refined during the project (Objective 3) to provide growers and extension workers with both an understanding of soil health concepts and the practical means to monitor and improve soil health.

5.1 Methodology

5.1.1 Initial Scoping (Objective 1, in part)

Building on the SRA, the project team will further explore, through a Participatory Rural Appraisal (PRA) process, the soil constraints faced by land holders, their current management and information systems and barriers to adoption of improved soil health practices. The project team will also work with landholders to identify potential ‘best-bet’ management practices.

Questionnaires will be developed to determine: social and environmental characteristics of the land holdings; the current knowledge, constraints and aspirations of land holders in regards to soil management; and barriers to adoption of soil health practices. Importantly, the interactions will be used to determine the information needs and the best methods of delivering soil health information to the growers and how they would respond to different soil management scenarios. Simultaneously, soil samples will be taken to set a benchmark of physical, chemical and biological soil properties and to evaluate the characteristics of the productions system currently being used. The soil and environmental constraints on agricultural production will be determined using a Soil Constraints And Management Package (SCAMP) process during the initial scoping work.

The selection of lead farmers and experimental plots will also use a PRA model; however it will be necessary that the sites should be representative of soil type and land form (e.g. slope). They should also be representative of most farmers’ practices in the region, including crops grown, rotations, cultivation, fertilising, water application, and pest and disease control. Moreover, sites should be located centrally so that neighbouring farmers can easily travel to the sites, ideally so that other farmers will regularly pass the sites in their travels (e.g. on their way to town, for supplies and services). The project team will work closely with regional government extension teams to implement a locally acceptable and participative strategy for selecting the number and location of pilot farmers and experimental plots. The aim would be to involve the local farming community as much as practically possible in the selection process.

In Taveuni, the local Ministry of Agriculture extension team will conduct community meetings allowing the farming community to select likely pilot site farmers by vote, and, as is the way in these communities, other farmers would then be involved in preparation, planting and maintenance of the sites.

In Samoa, an initial community and environment assessment will be needed to determine local extension partners and the most efficient and acceptable approach for pilot site selection to enable maximum diffusion of site results. However, the farmer network established by the Taro Improvement Program provides an advanced starting point with well-established communication in place, along with mapping of sites and some characterization of farmers' holdings and crops.

In Tarawa, the process would be conducted by extension staff from the Centre of Excellence for Atoll Agriculture. Candidates for participatory research and training would be selected at a community meeting following pre-meeting awareness activities by the extension staff. Initially sites would be restricted to the peri-urban regions of South Tarawa, with possible extension to other Tarawa and outer island sites later. In addition to working with spatially representative communities, groups to be targeted will include youth groups and the Womens’ Federation who have a centre in South Tarawa.

In each location, we would ideally be looking for farmers with the following characteristics:

- Recognised and respected as an average to good farmer.
- Having average wealth and resources (growers who have, or are perceived by the community to have considerable resources at their disposal will be unrepresentative of most farmers in the region, and therefore results from the site would not be readily disseminated).
- Culturally acceptable to most farmers in the community.
- Having good networking and communication skills.
- Willing to share their experiences and practices with others.
- Willing to cooperate with the project team and work closely with local research and extension staff.
- Willing to host field days at their farm.
- Willing to trial new practices and technologies.

Local extension staff will advertise the experimental sites with regional communities and conduct regular field days at these sites.

In Taveuni, existing MPI research trials on growers’ farms will inform the ‘best-bet’ approaches to soil management on the pilot sites and thereafter will be conducted concurrently with the pilot demonstration sites to fine-tune the ‘best-bet’ practices being demonstrated on the pilot sites.

5.1.2 Development of soil health indicators (Objective 1, in part)

Key physical, chemical and biological soil health indicators will be identified (from the existing 'tool kit') to address major soil constraints identified in the course of the PRA. Such indicators must be suitable for use by smallholder growers and their intermediaries in the Pacific to monitor progress. The aim would be to develop indicators at different levels of sophistication from simple qualitative tests to tests that could be conducted by service providers (or, in some cases farmers themselves) after training, through to emerging techniques that serve as useful research tools. In particular, the development of low cost methodologies for measuring soil health are being developed by DEEDI, such as soil biochemical tests, which would allow a continuation of the measurements beyond the life of the project by service providers in the Pacific. However, these techniques require validation and refinement for different laboratories and with current methodologies.

Physical indicators would include characteristics such as texture, bulk density, infiltration and aggregate stability. The tests would be conducted on samples collected from farms.

Chemical indicators would form part of a standard nutrient test that are commercially available, or from government/university laboratories in the Pacific, and would include extractable nutrients, organic C, pH, CEC. Special attention will be needed to identifying tests that can be conducted reliably and at an affordable price by service providers in Pacific countries.

Biological indicators would need to be selected that are sensitive to management changes and that are relevant to soil functions, such as disease suppression or nutrient recycling. The biological indicators could be selected from biochemical tests such as labile C, fluorescein diacetate (FDA), β-glucosidase; bioindicators such as weeds, earthworms, insects and analysis of nematode community diversity and structure; and molecular tests such as T-RFLP (terminal restriction fragment length polymorphism) to better characterize microbial communities.

A suitable foundation is provided by the Cornell University Soil Health Test (CUSHT) which includes a range of tests that have been found to be:

- reasonably priced,
- require minimal infrastructure to perform the tests,
- identify constraints in specific soil processes that go beyond nutrient deficiencies,
- provide practical management strategies specifically targeted at the soil constraints,
- allow farmers to monitor their soils over time and develop responsive strategies prior to degradation occurring and
- are easy to interpret.

This approach has already been found to have merit in the context of Australian banana and vegetable industries and could be modified for use in the Pacific.

5.1.3 'Best-bet' management practice (Objective 2)

'Best-bet' management practices for cropping systems that overcome identified soil constraints and improve soil, economic and environmental indicators will be developed and tested on farmers' fields through participatory 'action research' involving both formal researchers and the farmers hosting the trials.

Studies will be conducted initially at pilot sites with a limited range of crops and soil types common to the region (i.e. taro on weathered basalt slopes in Fiji and Samoa; and vegetables on a coral atoll in Kiribati) and will ultimately lead to applications in a wider range of sites and farming systems. One site in Australia, alluvial plains, using the banana industry as model, will also be used as a contrast to the Pacific situation. In Australia a site for the ‘best bet’ management practices will be established using practices such as minimal tillage, cover crops and retention of crop residues to prevent the decline in soil health indicators and promote improved agronomic characteristics of bananas. Furthermore, banana growers will be engaged to establish some or all of the components of the best-bet management practices on their farms, which will be monitored for changes in soil health indicators over the life of the project.

Sites for the pilot studies have been tentatively identified during the SRA and in consultation with local communities. The treatments to be evaluated at the sites will be determined in consultation with smallholders in a Participatory Planning Workshop (PPW), following closely on the PRA, to ensure that they are relevant; these are conceived as demonstration activities requiring community input into planning and planting. A key activity will be to review the organic residues available (both green manure and composts) and their characteristics and costs. The management strategies evaluated will aim to increase the economic and environmental sustainability of crop production and land management.

Treatments provisionally identified for further research in taro system are:

- management of residues from fallow and weeding (generated by herbicides or hoeing)
- *Mucuna* green manure cover crop (supplemented or not with inorganic fertiliser); this is the main focus of existing MPI/TTT/SPC trials and therefore accessible for monitoring using the project's indicator toolkit but may not need to be incorporated as specific treatments in the project's own on-farm research
- residues from multipurpose trees/shrubs (*Gliricidia*, *Inga* etc) grown on field margins, and used as a top dressing or shredded and incorporated
- 'cocopeat' from grinding of low-density coconut wood (available as a by-product of coconut replanting operations or milling of cocowood products)
- biochar from low density coconut wood chips or other organic matter (e.g. coppicing of *Gliricidia*, *Inga* etc).

Treatments provisionally identified for further research in atoll vegetable systems are:

- residues from weeding and fallen leaves (breadfruit etc) as mulch/top dressing, in trench before planting or composted
- residues from multipurpose trees/shrubs (*Gliricidia*, *Inga* etc) grown on property boundaries and applied as a top dressing or shredded and incorporated
- domestic/urban organic waste, shredded and/or composted.
- seaweed collected on shores (and suitably leached to reduce salt).

Measurements of physical, chemical and biological indicators will take place at the pilot sites and changes in soil properties documented. Erosion control, particularly in the Australian context as Pacific agriculture already involves minimum tillage, will also be an important factor in the development of best management practices. This information will also be used to determine the sensitivity of the indicators to soil management practices. It will also be used to demonstrate the holistic interactions which occur in soil health management.

Some simple Cost Benefit Analysis (CBA) will also be used in the evaluation of best-bet options. For instance, we would want to know:

- what is the economic cost to the farmer, measured in terms of reduced productivity or smaller sized taro corms (and the reject rates by the market), of poor soil health? and
- are the extra inputs (labour/organic matter) required to maintain good soil health, justified by an increase in productivity and therefore financial reward? i.e. is the additional financial return greater than the cost of the additional inputs (time and money)?

There will be some soil management techniques that might prove more labour intensive (i.e. producing composts and incorporating into the soil) and others that might be relatively easier (using weedy fallows), and therefore time/cost effective. These might not produce the very best results in terms of soil health, but may be more likely to be taken up by farmers because of their effectiveness from a CBA perspective. These issues will be explored and will inform best and most appropriate practice.

A more complete evaluation of the cocopeat vs. biochar options may be appropriate in Taveuni, in view of the substantial capital investment that these processes imply. This could include the evaluation of the 'carbon footprint' of these processes (in view of the fuel and machinery required to prepare the biomass) and exploration of the possibility of selling energy (biogas or electricity) produced as by-products of pyrolysis, to offset costs and increase the economic sustainability of these options.

Current practices in Australia, on the other hand, include rotations versus monoculture. It could also include replant bananas versus bananas that have a fallow period. Other soil health practices could include minimum-tillage versus full knock-down cultivation and rebuild the beds using a companion crop versus bare soil in the plant crop. The expected changes in Australia may well be increased use of fallow crops to build soil organic carbon, reduced cultivation and increased use of intercropping with companion grasses to reduce erosion and reduce soil degradation.

5.1.4 Strategy for information and training systems (Objective 3)

This objective involves developing an information system that allows landholders to receive information, increase their knowledge of soil health management and apply this knowledge for greater productivity and sustainability. Different information packages and delivery protocols will be tested at pilot scale to give growers an opportunity to determine the best means of receiving information to meet their needs. This should accelerate adoption and increase the knowledge of smallholders.

Training of landholders, farm advisors and agricultural service providers will take place at pilot scale within the project (and more broadly as an outcome, and as part of the impact pathway of the project) to build the capacity of the agricultural community to adopt and understand soil health practices. It will allow the information from soil health testing to be interpreted and extended through local communication networks.

Over the course of the project, it will be important to develop a longer-term communication strategy (see Section 4.4) that will help landholders to receive information more efficiently and increase their knowledge of soil health management. Such a strategy will guide the research-and-development efforts of their service providers. A strategy will include the promotion of what benefits there are to growers from improved soil health, identification of soil health constraints on their land, identification of management practices that may be able to overcome soil constraints and identification of the appropriate indicators to monitor changes in soil health properties.

5.2 Activities and outputs/milestones

Objective 1: To elucidate crop production and environmental soil problems at specific pilot sites and develop physical, chemical and biological indicators underpinning an integrated approach to soil management.

The SRA has helped, provisionally, to identify some of the constraints posed by farming practices currently in use at the potential pilot sites. For instance in Taveuni, field visits and soil sampling backed up by laboratory studies at Koronivia Research Station, has revealed that parasitic nematodes, in particular *Pratylenchus coffeae* and *Meloidogyne* spp., have contributed to taro root damage observed in the field. This could go a long way towards accounting for poorer yields and small corm size leading to higher reject rates for export grade taro. Heavy infestations of mealybugs (currently being identified) were observed by the SRA team and corm rots (e.g. Erwinia) have been intercepted in taro shipments from Taveuni. Although similar field and laboratory studies are needed for Samoan taro, a close inspection of taro corms destined for export seemed to reveal similar soil-borne pathogen problems (especially related to nematodes). Experience in Australia and elsewhere has shown that improved nematode control can be achieved by managing organic carbon levels in the soil and increasing the abundance and diversity of soil microorganisms. Meanwhile, as root rots and related problems are investigated and brought under control, attention can be given to soil nutrition, as soils in Taveuni and Upolu are known to be acidic with low levels of potassium and phosphorus (Leslie 2002, Leslie 2009).

In Tarawa, soil health problems are mainly related to the inadequate levels of organic matter in the topsoil. This is not a new problem as Morrison (1986) found organic carbon levels $<0.5\%$ which in turn accounted for poor water retention, low phosphorus and low nitrogen. In addition, the soils are inherently high in calcium carbonate. A soil amelioration project is urgently needed with an aim of improving soil organic matter and lifting vegetable production.

No.	Activity	Outputs/ milestones	Due date of output/ milestone	Risks / assumptions	Applications of outputs
1.1	Partici-patory rural appraisal (PRA)	Lead farmers and experi-mental sites selected; understanding of knowledge, attitudes and practices (KAP) at sites developed and documented	6 mo	Social/political constraints allow suitable lead farmers and sites, representative of KAP, to be selected as project partners	Project team and partners all understand project and impact pathway; documented state of KAP provides baseline for targeting and assessing capacity-building efforts
1.2	Partici-patory planning workshop (PPW)	'Best-bet' tactics for soil improvement and method for evaluating them agreed	6 mo	Partners have sufficient grasp of soil health concepts and practices to select options. Practices are realistic and capable of adoption	Agreed best bets and methods will serve as basis for achieving objective 2
1.3	Bench marking	Crop history recorded; Current soil properties documented at beginning (and end) of project	12 mo	Pest/disease complex and nutrient limitations understood for each site	Understanding of soil health status at each site will guide research program; difference in status (beginning and end) will provide evidence of any impact

1.4	Diagnostic research (on pest and disease problems)	Correct diagnosis of the nature, causes and interactions of soil-borne pest and disease problems available	12 mo (also refined, 24 mo, 36 mo)	Major pest and disease problems are soil-related	A more complete diagnosis of pest and disease problems will be used to guide the choice of best-bet soil improvement options and the selection of the most relevant soil health indicators
1.5	Selection of soil health indicators	Balanced 'tool-box' of the most relevant soil health indicators selected	6 mo (refined or modified at 12 mo, 24 mo as necessary)	Soil an pest-and-disease problems are correctly diagnosed and susceptible to monitoring at reasonable cost	
1.6	Training in use of tools for monitoring soil health	Research teams trained in use of this tool-box	24 mo	Most appropriate tool-box selected with end-user in mind	Participatory research teams are able to conduct the evaluations (objective 2) effectively

Objective 2: To evaluate 'best-bet' soil improvement practices for sustaining intensive Pacific crop production.

Development and testing of 'best-bet' management practices for cropping systems that overcome identified soil constraints and improve soil, economic and environmental indicators.

No.	Activity	Outputs/ milestone	Due date of output/ milestone	Risks / assumptions	Applications of outputs
2.1	Assess 'best-bet' practices at each site	Understan-ding of the impacts of soil improve-ment tactics on soil physical, chemical and biological attributes available	12 mo; 24 mo; 36 mo; 48 mo	Practices are realistic and capable of adoption; practices are effective in changing soil variables	Results will inform further development of soil improvement tactics and the training program for farmers and intermediaries; eventually, following capacity building and adoption, pilot sites will have in place practices that will improve yield and reduce losses
2.2	Assess effectiveness of tools and indicators	Understan-ding of how results of simple indicators correlate with yield, and pest-and-disease incidence	12 mo; 24 mo; 36 mo; 48 mo	Yield and pest-and-disease incidence are closely related to soil variables; tools are appropriate for measuring relevant variables	Results will be used initially to inform the development of the toolkit and the content of the training program; subsequently, the tactic can be used to refine soil improvement tactics and monitor the progress in soil improvement
2.3	Cost-benefit analysis (CBA)	Evaluation of the costs and benefits of the best-bet soil improve-ment tactics available	12 mo, 24 mo, 36 mo, 48 mo	The most significant costs and benefits can be quantified	Results will be used initially to refine the soil improvement tactics and then to inform the capacity building actions
2.4	Compare perceptions of farmers with research assessments	Table of KAP with data collected at each site	24 mo; 48 mo	Farmers have understood teachings; results presented in the right format	Farmers more empowered to implement 'best-bet' practices

Objective 3: To increase the understanding of soil health concepts among smallholder horticulture producers and their service providers and enhance their capacity to apply these concepts for sustained productivity.

Develop an information and training system and a longer-term strategy that will allow growers and landholders to receive information and increase their knowledge of soil health management and guide the research-and-development efforts of their service providers. 'Development' of the training system in the context of this project involves 'road-testing' it at pilot level with small groups of farmers and their service providers and then further improving the content and methods. Wider use of the training system to build capacity among growers and their service providers will be undertaken by other partner and/or outside the current project. A strategy for this longer term and wider use of the training system will be a product of the project.

No.	Activity	Outputs/ milestone	Due date of output/ milestone	Risks / assumptions	Applications of outputs
3.1	Develop and test farmer information and training system.	Training materials relating to soil health concepts and soil improve-ment practices available	48 mo (with intermediate products at 12 mo and 24 mo)	Practices are realistic and capable of adoption	Initial outputs will be progressively refined and used in the training-of-trainers activity; eventually training materials will be used by project partners and beyond for wider capacity building
3.2	Conduct 'training-of-trainers'	“Toolbox” of proven extension resources and methods available	48 mo (with intermediate products at 24 mo)	Extension partners ready and willing to adopt training methods	Initial outputs will be progressively refined as they are used in training-of-trainers exercises; eventually extension strategies will be used in wider capacity building
3.3	Develop strategy for long-term collaboration in research and capacity building	Research, development and extension (RD&E) strategy in soil health agreed	48 mo	Partners recognise the value of developing long-term strategy in soil health RD&E	Strategy will be used by research, development and extension organizations to further develop knowledge of soil health in Pacific crops and to build capacity in using soil health concpets and practices to enhance sustained productivity

5.3 Project personnel

5.3.1 List of participants involved in the project

Commissioned organization

Name	Sex (m/f)	Agency and position	Discipline and role in project	Time input (%)	Funding
Tony Gunua	M	SPC –Team Leader, Plant Health	Plant Pathologist; Project leader and Theme Leader for Plant Health at SPC	30%	SPC
Emil Adam	M	SPC – Information, Communication & Extension	Extension; provide expertise on training materials; link to other extension efforts in Pacific	10%	SPC
Research Officer - TBA		SPC	Soils/extension; manage the field sites, collate data, day-to-day running of project	100%	ACIAR
Sushil Narayan	F	SPC – Div Administrative Officer	Project administration	10%	SPC
Rajhneal Deo	M	SPC - Economist	Costs-benefits analyses	10%	SPC
Sanfred Smith	M	SPC - FACT	Advice to taro export industry; labour budgets	5%	SPC

Australian commissioned and collaborating organisations (or IARC)

Name	Sex (m/f)	Agency and position	Discipline and role in project	Time input (%)	Funding
Mike Smith	M	DEEDI - Senior Principal Scientist	Plant physiologist and Australian project leader	20%	DEEDI
Sharon Hamill	F	DEEDI - Principal Scientist	Biotechnology and microbial ecology	5%	DEEDI
Emily Rames	F	DEEDI – Technician	Biotechnology and microbial ecology	40%	ACIAR
Tony Pattison	M	DEEDI - Principal Nematologist	Soil biology and soil health systems	20%	DEEDI
Tegan Kukulies	F	DEEDI - Technician	Soil biology and soil health systems	40%	ACIAR
Jenny Cobon	F	DEEDI – Nematologist	Soil biology and soil health systems	10%	DEEDI
Wayne O'Neill	M	DEEDI - Plant Pathologist	Soil biology and soil health systems	5%	DEEDI
John Bagshaw	M	DEEDI - Senior Extension Horticulturist	Extension, environmental and food safety management systems	20%	DEEDI

Partner country institution(s) or collaborating IARC

Name	Sex (m/f)	Agency and position	Discipline and role in project	Time input (%)	Funding
Rohit Lal	M	Fiji MPI – Extension Officer (Taveuni)	Extension and liason with taro farmers	40%	Fiji-MPI
Malakai Vukinavanua	M	Fiji MPI – Research Officer (Taveuni)	Research and trial work at taro pilot sites	40%	Fiji-MPI
Ami Sharma	M	Fiji MPI – Soil Technician	Laboratory work on Fiji pilot sites	30%	Fiji-MPI
Mereia Fong	F	Fiji MPI – Plant Pathologist	Pathology and nematology support	30%	Fiji-MPI
Poase Nauluvula	M	Fiji MPI – Principal Research Officer	Taro agronomist and postharvest physiology	10%	Fiji-MPI
Peter Kjear	M	TTT farmer association	Farmer, liaison with TTT training efforts	5%	Self/TTT
AVI	M/F	AVI hosted by TTT	Extension, conduct farmer 'soil schools' (for TTT), test training materials (for project)	40%	AusAID/ TTT
David Hunter	M	USP-Alafua, Senior Lecturer	Soil Scientist and Statistician; oversight of USP input to project	10%	USP
Daya Perera	M	USP-Alafua, Senior Soils Technician	Laboratory work on Samoan pilot sites	5%	USP
Tolo Iosefa	M	USP-Alafua, Senior Agronomist	Taro agronomist and link with farmers	10%	USP
Rupeni Tamanikayiaroi	M	USP-Alafua, Plant Pathologist	Pathology and nematology Support	5%	USP
Philip Reti	M	USP-Alafua, Soils Technician	Laboratory work on Samoan pilot sites	10%	Samoa-MAF
Tokintekai Bakineti	M	Kiribati MELAD – Principal Agricultural Officer	Research and extension; MSc student with USP-Alafua	20%	MELAD, Kiribati
Roota Tetoake	F	Kiribati MELAD – Extension Officer	Extension	10%	MELAD, Kiribati
Tianeti Beena	M	Kiribati MELAD – D/Director Research	Soil Scientist	5%	MELAD, Kiribati

5.3.2 Description of the comparative advantage of the institutions involved

Secretariat of the Pacific Community (SPC) was established by the 22 Pacific Island countries and territories in 1947 and is now well established as the region's leading technical, advisory, training and research organization. SPC has a regional mandate for agricultural development and this is implemented though it's Suva-based Land Resources Division (where the ACIAR Pacific Crops office is located). Among the many projects implemented by SPC is DSAP (Development of Sustainable Agriculture in the Pacific), started in mid-2003 and that has conducted participatory surveys and established pilot sites for technology adaptation and adoption in 16 Pacific Island countries. DSAP aims to demonstrate how farmers, researchers and extension officers can collaborate to solve agriculture production problems and several of its pilot sites (and many of the project's activities) focus on soil fertility issues. SPC will also take over coordination of the South Pacific Agricultural Chemistry Laboratory Network (SPACNET), which aims to improve the quality of soil, plant and water analysis carried out in the Pacific Region. The Network was previously funded by NZAID with some support from SPC and managed by Landcare Research New Zealand. SPC LRD will coordinate it with potential funding from FAO Food Security and Sustainable Livelihood Program (FSSLP).

DEEDI (Department of Employment, Economic Development and Innovation), QPIF (Queensland Primary Industries and Fisheries) has been investigating soil health systems in tropical and subtropical agriculture for the past 10 years. This has led to the development of a network of research and extension staff with practical knowledge of crops involved and the delivery of outcomes to growers. DEEDI has research stations and laboratories located in regional areas which allow staff to establish effective collaborative relationships with stakeholders. It also means the constraints faced by growers can be simulated on research stations. Access to equipment and skills within DEEDI ensure project milestones can be met.

5.3.3 Summary details of the role of each participant involved

Tony Gunua is Coordinator of the Plant Health Thematic Group of SPC. He will be overall team leader of the present project and will ensure the project can achieve its objectives in the Pacific.

Emil Adam is ag. Coordinator Information and Extension at SPC. He has more than 10 years experience in extension and agricultural education. He will bring expertise in communication for development and training materials and will assure linkage to the Pacific Islands Extension Network.

Rajhneal Deo is an economist at SPC; under the guidance of Tim Martyn (Development Economist) and Jonathan Bower (ODI Research Fellow in Economics), he will assess the costs and benefits of the best-bet soil improvement options being trialled with farmers in Taveuni; Sanfred Smith, field officer with the SPC FACT and a person already thoroughly familiar with the taro industry in Taveuni, will assist by helping the project team to develop 'labour budgets' for the various soil improvement tactics.

Mike Smith is a Senior Principal Scientist based at Maroochy Research Station with experience working in the Pacific since 1987, most recently controlling soilborne pathogens of ginger in Fiji using a farming systems approach. He will be the Australian project leader and provide advice with regard to plant health and productivity.

Sharon Hamill is a Principal Scientist based at Maroochy Research Station. Sharon has extensive experience in application of clean plant material for improved crop production. Her current research with beneficial bacteria and other amendments aims for sustainable production practices targeting reduced fertiliser inputs, improved plant health and disease resistance.

Emily Rames is a Technician (Molecular Biology/ Microbiology) based at the Maroochy Research Station and has extensive experience in molecular biology. She will use her experience to measure various soil microbial parameters as they relate to yield and disease suppression.

Tony Pattison is a Principal Nematologist based at South Johnstone in north Queensland. He will provide information on soil biology, selection of indicators and analysis of agricultural systems.

Jenny Cobon is a Nematologist based at Indooroopilly. Jenny has experience in developing and applying nematode community and biological indicators to agricultural production systems and research experiments during her recent involvement in soil health projects in vegetables and bananas.

Wayne O'Neill is a Plant Pathologist based at Indooroopilly with extensive research experience in the areas of Fusarium wilt diseases, plant-parasitic nematodes and soil health. He has been involved in several recent soil health projects in vegetables and banana, including ACIAR projects with collaborative field work in Indonesia.

John Bagshaw is a Senior Extension Horticulturist based at Bundaberg. John has 25 years of experience in horticultural extension and has been a member of previous soil health projects. John's expertise extends into farm management systems including post harvest, quality assurance, food safety and environmental management.

In Fiji, Ami Sharma is a Senior Research Officer in the soil and water testing laboratory at Koronivia Research Station. He has been involved with SPC LRD in fertilizer trial works on taro.

Rohit Lal is a Field Extension staff at Taveuni. He is currently involved in the soil management work there involving the establishment of pilot sites using 'best bet'.

Mereia Fong is a Plant Pathologist with experience working with soilborne pathogens of root crops in Fiji.

In Samoa, David Hunter of USP Alafua Campus is a soil scientist as well as a biometrician, with many years of experience of research leadership and training, specializing in experimental design and analysis, and soil fertility and plant nutrition studies.

Daya Perera of USP Alafua is a soils technician with many years of technical experience in the analysis of physical and chemical parameters of soil, plant and feed samples.

Tolo Iosefa is an agronomist/crop breeder of USP Alafua with extensive experience in taro breeding and participatory rural appraisal activities and has very strong linkages with taro farmers in Samoa via the Taro Improvement Programme.

Rupeni Tamanikayiaroi of USP Alafua is a plant pathologist with extensive research experience in plant protection work on taro, sugarcane, vegetables and other root crops.

Philip Reti is a soils technician of USP Alafua with five years of technical experience in the establishment and maintenance of field experiments, and collection and analysis of soil and plant samples for various physical, chemical and biological properties.

In Kiribati, Tokinitekai Bakineti is currently a Principal Agricultural Officer and also the national coordinator of the Centre of Excellence for Atoll Agriculture. He is a former DSAP staff.

Tianeti Beena is Deputy Director of Agriculture and in charge of research. His back ground is in soil science.

5.4 Intellectual property and other regulatory compliance

All information used is currently in the public domain and no proprietary intellectual property is anticipated to be developed as a result of this project.

5.5 Travel table

PART A Commissioned Organisation or IARC

Trip no.	Person or position	Estimated date of travel	From / to	Purpose	Duration (days)
1	Tony Gunua	September 2011	Suva/Brisbane	Project reporting	5 d
2	Research Officer	April 2012	Suva/Brisbane	Project reporting	5 d
3	Tony Gunua	September 2012	Suva/Brisbane	Project reporting	5 d
4	Research Officer	April 2013	Suva/Brisbane	Project reporting	5 d
5	Tony Gunua	April 2014	Suva/Brisbane	Project reporting	5 d

PC = partner country, A = Australia

PART B Australian Collaborating Organisation/s

Trip no.	Person or position	Estimated date of travel	From / to	Purpose	Duration (days)
1	Mike Smith, John Bagshaw		Maroochy, Bundaberg, Cairns		3 d
2	Tony Pattison	April 2011	Australia/Fiji/Samoa /Kiribati	Monitoring, Evaluation & Engagement	17 d
3	John Bagshaw	April 2011	Australia/Fiji/Samoa /Kiribati	Monitoring, Evaluation & Engagement	17 d
4	Mike Smith	April 2011	Australia/Fiji/Samoa /Kiribati	Monitoring, Evaluation; Engagement & Partnerships	17 d
5	Tony Pattison	October 2011	Australia/Fiji/Samoa	Monitoring, Evaluation & Engagement	10 d
6	John Bagshaw	October 2011	Australia/Fiji/Samoa	Monitoring, Evaluation & Engagement	10 d
7	Tony Pattison	March 2012	Australia/Fiji/Samoa /Kiribati	Monitoring, Evaluation; Engagement & Partnerships	17 d
8	John Bagshaw	March 2012	Australia/Fiji/Samoa /Kiribati	Monitoring, Evaluation; Engagement & Partnerships	17 d
9	Mike Smith	October 2012	Australia/Fiji/Samoa	Monitoring, Evaluation & Engagement	10 d
10	Tony Pattison	October 2012	Australia/Fiji/Samoa	Monitoring, Evaluation & Engagement	10 d
11	John Bagshaw	October 2012	Australia/Fiji/Samoa	Monitoring, Evaluation & Engagement	10 d
12	Tony Pattison	March 2013	Australia/Fiji/Samoa /Kiribati	Monitoring, Evaluation; Engagement	17 d
13	John Bagshaw	March 2013	Australia/Fiji/Samoa /Kiribati	Monitoring, Evaluation; Engagement	17 d
14	Mike Smith	March 2013	Australia/Fiji/Samoa /Kiribati	Monitoring, Evaluation & Engagement	17 d
15	Tony Pattison	October 2012	Australia/Fiji/Samoa	Monitoring, Evaluation & Engagement	10 d
16	John Bagshaw	October 2013	Australia/Fiji/Samoa	Monitoring, Evaluation & Engagement	10 d
17	Tony Pattison	March 2014	Australia/Fiji/Samoa /Kiribati	Monitoring, Evaluation & Engagement	17 d

18	John Bagshaw	March 2014	Australia/Fiji/Samoa /Kiribati	Monitoring, Evaluation & Engagement	17 d
19	Mike Smith	October 2014	Australia/Fiji/Samoa /Kiribati	Reporting & Post-Project Planning	17 d
20	Tony Pattison	October 2014	Australia/Fiji/Samoa /Kiribati	Reporting & Post-Project Planning	17 d
21	John Bagshaw	October 2014	Australia/Fiji/Samoa /Kiribati	Reporting & Post-Project Planning	17 d

PC = partner country, A = Australia

PART C Overseas Partner Organisation/s

Trip no.	Person or position	Estimated date of travel	From / to	Purpose	Duration (days)
1	Tokintekai Bakineti	April 2011	Kiribati/Australia	Attend International Soil Composting Conference and visits with DEEDI staff	15 d
2	Rohit Lal	June 2011	Fiji/Australia	Visit with DEEDI staff and field/lab visits	15 d
3	Philip Reti	June 2012	Samoa/Australia	Visit with DEEDI staff and field/lab visits	15 d
4	Ami Sharma	June 2012	Fiji/Australia	Visit with DEEDI staff and field/lab visits	15 d
5	Malakai Vukinavanua	June 2013	Fiji/Australia	Visit with DEEDI staff and field/lab visits	15 d

6 Appendix A: Intellectual property register

Inquiries concerning completion of this form should be directed to **contracts@aciar.gov.au**

6.1 Administrative details

Project ID	PC/2009/003
Project title	Improving soil health in support of sustainable development in the Pacific
Assessment provider	Dr Mike Smith
If not Australian project leader, provide title	
Date of assessment	19/04/2010

6.2 Categories of intellectual property and brief description

Plant or animal germplasm exchange

Does the project involve:	**Yes**	**No**
Provision of germplasm by Australia to a partner country?		X
provision of germplasm from a partner country to Australia?		X
provision of germplasm from or to an IARC or another organisation and a project participant?		X
use of germplasm from a third party		X
material subject to plant breeders/variety rights in Australia or another country?		X

If “yes” to any of the above, for each applicable country provide brief details of the material to be exchanged:

- If the germplasm exchange can be finalised before the project commencement, provide a Materials Transfer Agreement.
- If the specific germplasm to be exchanged cannot be identified until after project commencement, indicate the type of material likely to be exchanged.

Country	**Details of plant or animal germplasm exchange**

Proprietary materials, techniques and information

Does the project involve provision (from one party to another) of:	**Yes**	**No**
research materials or reagents (e.g. enzymes, molecular markers, promoters)?		X
proprietary techniques or procedures?		X
proprietary computer software?		X

If "yes" to any of the above, for each applicable country provide:

- brief details of the materials or information, the organisation providing, and the organisation receiving the materials
- a copy of any formal contract between the parties.

Country	**Details of proprietary materials, techniques and information**

Other agreements

Is any aspect of the project work subject to, or dependent upon:	Yes	No
other materials-transfer agreements entered into by any project participant?		X
confidentiality agreements entered into by any project participant?		X

If "yes" to any of the above, for each applicable country provide:

- brief details of the agreements and conditions
- a copy of any such agreement before project commencement.

Country	Details of other agreements

6.3 Foreground, background and third party Intellectual Property

This includes, but is not limited to patents held or applied for in Australia and/or in partner countries and/or in third countries. For example, Foreground IP includes any new germplasm, reagents (such as vectors, probes, antibodies, vaccines) or software that will be developed by the project.

Foreground IP (IP that is expected to be developed during the project)

Ownership of or rights to Foreground IP other than as detailed in the ACIAR Standard Conditions must be approved by ACIAR.

	Yes	No
Is it expected that there will be Foreground IP?		X

If "yes",

- for each applicable country provide brief details of the IP and who will have rights to use the IP (e.g. Commissioned Organisation, Australian collaborating organisation/s partner countries).
- If a patent, give details of patent status (provisional, application, granted), priority date and designated countries.

Country	Details of foreground IP

Background IP (IP that is necessary for the success of the project but that has already been created and is owned by parties to the project)

Any agreements in place regarding Background IP should be provided to ACIAR prior to project commencement.

	Yes	No
Is it there Background IP?		X
If “yes”, are there any restrictions on the project's ability to use the Background IP?		
would there be any restriction on ACIAR or the overseas collaborator claiming their rights to IP for the project based on the Background IP (refer ACIAR Standard Conditions)?		

If "yes", for each applicable country provide brief details of:

- the source of the Background IP.

- whether the Commissioned Organisation and/or Australian collaborators and/or developing country collaborators own it.
- any conditions or restrictions on its use.

Country	Details of background IP

Third Party IP (IP that is owned by or licensed from other parties)

Agreements governing the use of third party IP can be related to research materials, research equipment or machinery, techniques or processes, software, information and databases.

	Yes	No
Is there any relevant Third Party IP that is essential to the project?		X
If “yes”, would there be any restriction on ACIAR claiming its rights to IP for the project (refer ACIAR Standard Conditions)?		

If "yes", for each applicable country provide brief details of:

- the source of the Third Party IP.
- the applicable country/ies, the circumstances/agreement/arrangement under which the IP is to be obtained or used by the project partners (for example, material transfer agreement, germplasm acquisition agreement, confidentiality agreement, research agreement or other arrangements).
- any conditions or restrictions on its use.

Country	Details of third party IP

Other contracts, licences or legal arrangements

	Yes	No
Are there any other contracts, licences or other legal arrangements that relate to the project?		X

If "yes", for each applicable country provide brief details.

Country	Details of other contracts, licences or legal arrangements

7 Appendix B: Budget in Attached Spreadsheets

8 Appendix C: Research and development work in Taveuni - arrangements for collaboration and co-sponsorship.

Problem statement

Farming - and especially the production of taro for export - is vital to the life of Taveuni, in the Fiji islands, contributing to both the national economy and the livelihoods of local communities. Taveuni contributes some 60% of Fiji's taro exports - which have recently totalled some 10,000 tonnes per year, valued at approximately Fj$20 million. It has been estimated (McGregor et al. 2010) that as many as 17,000 people in Taveuni are at least partly dependent on taro for their livelihoods.

This industry is, however, currently in crisis, for a number of inter-linked reasons. At the root cause is the lack of sustainable, intensified production techniques for taro, capable of supporting large-scale commercial production of the kind currently being practiced. Traditionally, taro farmers have cultivated the crop on naturally fertile soils (especially in valley bottoms and on lower slopes) and after a relatively short period of production have allowed the land to recover under 'bush fallow' for several years. In response to economic incentives to produce taro for 'export' to urban communities and overseas, farmers have simply increased the area under production or prolonged the cycles of cultivation on the same land, without sufficient investment in mineral fertilisers and organic matter to replace the nutrients removed with the crop. This has led to a 'vicious circle' of falling yields, shorter fallow periods, increased areas under taro production and incrreasing deforestation, as farmers move to steeper slopes (with heightened risks of erosion) in search of more fertile land.

Within the crop, falling soil fertility and biological health is leading to reduced size and quality of taro 'roots' - with an increasing proportion failing to meet export standards (the proportion 'rejects' rising from around 5-10% initially to 30-40% today) and with a rising incidence of soil-borne pests and diseases, especially nematodes and mealybugs. Interceptions of nematodes on arrival of the taro in New Zealand are often treated with methyl bromide fumigation, reducing shelf life and root quality and increasing costs. Interceptions on arrival in Australia of rotting corms (perhaps infected with primary soil-borne pathogens, or associated with the mealybug damage) has led to the 're-export' of several consignments during 2010, corresponding to losses of some Fj$400,000 and seriously threatening the viability of the industry. An additional 'stress factor' was the damage caused by Cyclone Tomas in March 2010.

Seeking a solution

The chronic nature of the taro production problems has been recognized by a group of leading farmers, comprising the TeiTei Taveuni (TTT) farmers' association. When funds were available from AusAID to mitigate the devastating consequences of Cyclone Tomas, the taro producers indicated that these resources could be most effectively deployed to assist the farming community in adopting more sustainable production practices, based on improving soil health. In collaboration with the Secretariat of the Pacific Community (SPC) and the Fiji Department of Agriculture (DoA), technologies being formally trialled include the use of a green manure cover crop - velvet bean, *Mucuna pruriens* - in combination with different levels of inorganic fertiliser. Other technologies being considered include leguminous agroforestry trees and the use of 'Biobrew' organic liquid fertiliser.

The TTT group have also placed a great deal of emphasis on the need for farmer education in soil health principles and practice, to encourage the adoption of more sustainable production practices. They have successfully applied to the Global Environment Facility of the United Nations Development Programme, with support from NZ Aid, receiving a grant of US$46,000 to support:

- farmer 'soil schools', initially for 175 farmers, in biological farming principles
- demonstration fields/plots
- on-farm visits
- soil testing and use of soil kits
- tree planting and conservation awareness

These actions will be conducted in collaboration with SPC, DoA and Organic Matters Foundation (OMF) of Australia.

To further reinforce the farmer training and technical support effort, TTT have applied to Australian Volunteers International (AVI) for a volunteer to assist in this work. The response has been positively received and selection of a volunteer will be undertaken in early 2011, with a view to the person starting work in mid 2011.

Collaboration with ACIAR 'soil health' project

In parallel with the above developments in Taveuni, the Australian Centre for International Agricultural Research (ACIAR) has been developing a project, PC/2009/003 on *Improving soil health in support of sustainable development in the Pacific*. This 'soil health' project is led by SPC with technical support from the Queensland Department of Employment, Economic Development and Innovation (DEEDI) and the University of the South Pacific (USP), in collaboration with the Fiji DoA, the Ministry of Agriculture and Fisheries, Samoa, and the Centre of Excellence in Atoll Agriculture in Kiribati. It builds on the work of an earlier SPC-led project on Developing Sustainable Agriculture in the Pacific (DSAP), which, using participatory methods to consult with farmers and other stakeholders, identified soil-related problems as a priority for Pacific island communities in numerous locations; the project also initiated trials of appropriate technologies, including the use of *Mucuna* and agroforestry techniques, to address these problems.

A scoping study and consultations conducted during 2010 led the new ACIAR-funded project to focus on intensive taro production in Fiji and Samoa as a 'system in crisis' for further attention. As set out in earlier sections of the present document, the soil health project will take an integrated approach to research and development in this area. This will involve taking into account the physical, chemical and biological dimensions of the soil health concept and developing 'indicators' that will help researchers, extension workers and farmers, to diagnose soil health-related problems and the progress they are making in tackling these problems; it includes the trialling, with farmers, of strategies to improve soil health in intensified production systems; and the extension to farmers of soil health concepts and practices.

The ACIAR soil health project will use experience of promoting soil health concepts in banana production systems in Queensland as a platform for R&D to tackle problems in intensified taro production (Fiji and Samoa) and vegetables (Kiribati).

The ACIAR soil health project thus has objectives and approaches that are closely aligned with those of the TTT initiatives, in association with SPC and DoA, and representatives of TTT have been involved, together with these partners, in planning for the ACIAR-funded project. What the ACIAR project offers the Teveuni group is a partnership with world-class field- and laboratory-based researchers who have had long experience of addressing soil health problems in intensive agricultural systems, in the context of ecologically sensitive environments; they bring with them a range of techniques, technologies and experience in both practical soil amelioration techniques and experimental design to validate these techniques under local conditions. Access to this expertise will both reinforce the existing efforts of the Taveuni group and offer new ideas and options, for soil fertility improvement and the means to monitor it. A special strength of the soil health project is the experience of the DEEDI project team in the extension of soil concepts and practices to farmers; these will synergise with the training efforts already under way with UNDP support and foreseen for the AVI. Indeed, the soil schools and on-farm training to be conducted by the AVI will provide an immediate testing ground for the training materials and approaches generated by the project - and immediate feedback for their further improvement.

AusAID complementary support: a decisive contribution

The project partners developing the ACIAR soil health project have identified the over-arching need to increase *soil organic matter content* as the first priority in restoring the fertility, physical structure and biological function of soils. While many strategies can contribute to this objective - including the use of compost, leaf litter from agroforestry trees and green manure cover crops (such as *Mucuna*), which are already being trialled in the cluster of projects proposed or under way - the challenge of finding sufficient organic matter to make a significant difference can be an overwhelming one in tropical island environments. Although primary biological productivity is typically high under humid tropical conditions, the rate of breakdown of organic matter in moist tropical soils can also be very rapid. Add to this the consideration that primary productivity will be lowest on the infertile soils that are most in need of amelioration, and the high cost (in labour and/or fuel) of transporting organic matter from more abundant sources to the fields where it is needed, and it is easy to see why farmers find this challenge a very difficult one to tackle.

The provision of supplementary AusAID funds in the start-up phase of the soil health project will decisively increase the effectiveness of the project in two ways:

1) by providing access to the abundant organic matter locked up in the trunks and fronds of senile coconut trees, which can be converted (using the equipment provided by the AusAID grant) into 'cocopeat' or 'biochar'; and

2) by reinforcing the extension work of the AVI and collaborating extension workers, through the provision of a 4WD vehicle, training materials, audiovisual equipment, additional soil testing and coordination with other research-and-training activities.

Items covered by the AusAID grant are tabulated below.

Note that the research and extension activities supported by the grant are entirely integrated into the R&D proposal to which this forms an Annex, in terms of technical justification, planning, review (according to established ACIAR procedures), coordinated implementation, and monitoring and evaluation.

Specifically the AusAID grant covers the following items:

Item	**Amount Aus$**
Planning and coordination workshop (hosted by SPC) to develop training materials and training strategy	13,500
4 WD vehicle and accessories (for use of AVI and extension collaborators)	45,000
Fuel costs for vehicle and machinery (first year only - thereafter covered by ACIAR funds)	5,000
Soil testing and shipping of samples to Sunshine Coast University (first year only - subsequently covered by ACIAR funds)	8,000
Stereo dissecting microscope and teaching/filming attachments	4,500
Lap-top computer and small transportable generator	4,000
Powerpoint projector - robust model for field extension use	3,000
Preparation and printing of training materials	12,000
Costs of establishing TTT field trials of soil carbon amendments (subsequent maintenance of trials covered by ACIAR funds)	2,000
ACIAR management fee (5%)	5,000
First payment	**102,000**
Horizontal wood chipper/grinder (to produce cocopeat from senile palms and other organic residues - e.g. from agroforestry trees)	60,000
BigChar 1000 biochar unit (including installation and initial instruction; to produce long-lasting soil carbon from palm and other residues)	70,000
Tractor with front-end loader (for handling organic matter)	25,000
ACIAR management fee (5%)	8,000
Second payment	**163,000**
TOTAL	**265,000**

9 Appendix D: Supporting documentation

This section is only required for FULL PROPOSAL

Documents attached:

- Letters of support
- Letters of approval
- Curricula vitae