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Final report

project

Enhancing economic opportunities offered by community and smallholder forestry in Solomon Islands

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1 Acknowledgments

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2 Executive summary

Solomon Islands is a small island developing state that carries the burden of a scattered, mainly rural, population with poor infrastructure, and limited access to external markets. Teak was planted by smallholder farmers during a period when it had a disproportionate importance as a high value crop but it was planted without any appreciation of the work and the systems required to produce the size and form of trees that would be attractive to buyers. As a result there are thousands of smallholder woodlots scattered throughout the country that have not been correctly maintained with a wide range of quality and form.

The project was established to: improve the quality of the germplasm available to growers; increase knowledge of the quality and location of the existing resource; and to assist growers to better understand the systems that are needed to grow high quality trees suitable for the export market.

The establishment of a laboratory for the non-destructive testing of wood quality at the Munda Forestry Office is long-reaching asset that will help inform forestry research into the future. Prior to this, the only way to test the timber for qualities such as the ratio of heartwood to sapwood, or the colour of the heartwood (linked to several important wood properties such as durability and extractives) was to fell the tree, which then rendered it useless for genetic improvement. With the transverse coring programme it is now possible to establish seed production areas based on the physical form of the tree and on the quality of the timber.

Making an inventory of the existing resource has proved challenging over a country that consists of over 900 islands and where most rural families have planted at least a few trees, and some several hectares. Whilst satellite imagery can identify young plantations with reasonable accuracy, older plantations (the majority in Solomon Islands) are indistinguishable from the surrounding forest using normal imaging techniques. Multi- and hyper-spectral imaging techniques will be required to isolate plantations from the surrounding secondary forest and the project has made recommendations as to how this could be achieved.

Smallholder growers face significant challenges when establishing tree plantations. There is no traditional knowledge or group wisdom about how to grow trees that are specifically planted for an export market. There is no experience that comes from subsistence farming that prepares growers to deal with such a long-term crop. Social research was undertaken to evaluate the impact of trying to introduce novel systems and how that is perceived by all members of the community. As a result several changes have been made in the approaches that have been undertaken with community meetings and field days to explain and give practical demonstrations of the approach. Rural Training Centres also play a role and the project has established nurseries for the communities within the RTCs and encourages improved access to training through the RTCs.

Underpinning the developments are the scientific trials that are now of an age where they are being used as a practical demonstration of the correct systems for growing trees. The project has also run trials of novel cropping systems to give growers a financial return whilst waiting for the trees to mature. Alternatives to plantation establishment have also been tested with natural regeneration shown to be a valid system for the rehabilitation of logged forests that encourages trees of value and allows them to be grown at a far higher density than occurs naturally.

Some of the work described in the report is being continued through the follow-on project FST/2014/066 and to gain maximum value from the research should be maintained to the end of the rotation.

3 Background

Background

Community and smallholder forestry has the potential to increase foreign earnings in the Solomon Islands and bring the opportunity for economic security to the large proportion of the population that live in rural areas. The estimated 8-10,000 ha of these plantings that currently exist are in plantation style, monocultures, dominated by Teak with a small proportion of Mahogany. There are significant problems associated with these plantings that severely limit their economic potential. In particular plantings are generally over-stocked due to reluctance by growers to thin their trees to the final stocking rate needed to produce high value timber and even when growers are willing to thin, there is no infrastructure available to get the timber to market. ACIAR project FST/2007/020 pioneered a novel, mixed species system to help growers overcome these problems. The system involved planting teak with an indigenous, locally useful species, Flueggea flexuosa that is progressively thinned for use or sale. Teak is only felled at the end of the rotation when it has reached a size that is valued in the marketplace. Initial trials had shown that food crops could be successfully grown between the trees at the establishment phase. The initial results from the scientific trials were encouraging.

Aims and Objectives

The aim of the project was to further develop the economic opportunities offered by community and smallholder forestry in the Solomon Islands through more widespread application of high value agroforestry and improved management of secondary forests.

Specific objectives were:

To improve the quality and availability of germplasm resources for community forestry programmes

To enhance information resources to facilitate development of marketing and processing systems for smallholder timber resources.

To increase landowner and community knowledge about and adoption of agroforestry systems

Some of the work built on previous research and utilised the plantings established mainly in Western province. The excellent relations established with the Rural Training Centre network formed the basis for extending agroforestry trials and the development of community-based nurseries within appropriate RTCs. All of these activities were supported by an evaluation of the social impact upon village communities and individuals, again building upon the excellent relationships established with village groups during the previous project.

Research Questions and Methods

The research questions for this project fell in to 3 main areas:

How could the quality of the trees used for agroforestry be improved and made readily available to smallholders at an affordable price?

How could the information that was needed to make strategic investments in tree marketing and processing infrastructure in the Solomon Islands be improved in a cost effective manner?

How could smallholders knowledge of agroforestry and community forestry systems be improved in order to increase adoption of these systems and promote better economic and environmental outcomes?

The projects aim was to ensure the quality of the germplasm available to growers through selecting for growth and form and then testing selected trees for superior wood qualities. These trees would then form the basis for seed production areas that would provide growers with high quality germplasm through the network of community-based nurseries.

The project examined a range of activities to gather the information needed for future planning; training forestry officers in resource inventory and GPS; examining historic data on soils and landscapes captured from the archives of the British Protectorate to assess the utility for being incorporated into GIS layers; and remote sensing using both drone and satellite imagery allow Ministry of Forestry personnel to have access to the information they need to plan for future infrastructure development.

This project used data from mixed species and thinning trials for use in educational materials and field days to inform growers on aspects of management, species mix, spacing and intercropping. Underpinning this was research into the longer-term sustainability of the system and the nutrient cycling processes that drive productivity.

A series of trials were established to look at methods for the assisted natural regeneration of logged forests. This is a low-cost alternative to plantation style forestry that allows the high value trees to naturally regenerate in logged areas whilst controlling the growth of weeds and undesirable species. This research also has the potential to benefit communities through giving future access to carbon and biodiversity credits as part of the clean development mechanism.

The acceptance and adoption of novel systems such as agroforestry is often related to social and traditional values, as well as the purely economic, and the social research team sought to understand the pathways and the barriers to adoption of these ideas, the role that women play, given their historical positioning as primary providers of food and maintenance of subsistence agricultural crops, and the benefits they might derive from their uptake. There is an, as yet, untapped opportunity for rural communities to benefit from schemes such as the Clean Development mechanism and REDD+, the social research team examined communities understanding of, and attitude towards, these schemes. They also looked at the role of the Rural Training Centres in knowledge transfer with particular focus on the interactions between RTCs and their local communities.

Project Justification

Improving germplasm benefits all sectors of a developing plantation industry and the establishment of facilities and training of personnel in non-destructive timber testing has longer-term benefits for further improvement programmes on a wider variety of species.

The community-based nursery programme had the longer-term goal of making the improved germplasm available to a greater proportion of the country and with nurseries operational in 5 of the provinces; the infrastructure has been established for that to happen. This programme was also part of a greater involvement with the Rural Training Centre programme that saw a bigger role played by project staff in the educational programme.

Developing an understanding of the location, size and quality of the smallholder plantation estate in Solomon Islands was seen as the first step in allowing government to organise the infrastructure that would be needed to allow growers to access international markets for their timber.

Extensive data on soils and vegetation were gathered when Solomon Islands was a British Protectorate and, should that have been compatible for transfer to GIS layers, would have provided a valuable addition to enable matching of trees, as well as other commercially important crops, to location.

The use of remote sensing technologies has the potential to overcome many of the problems associated with remote and fractured landscapes with little or no infrastructure and inadequate levels of staffing to undertake inventory work. Remote sensing occurs at

varying levels of intensity from broad-acre swathes of imagery at low resolution to high intensity, high-resolution imagery. Understanding which is best suited to the landscape and the capabilities of Solomon Islands was considered a first step in the uptake of these technologies.

Scientific advancements have to be accessible to the communities they are designed to help and it is the role of the social researchers within the project to understand how community attitudes and understanding interacts with the scientific research programme. This includes: how traditional attitudes towards land ownership and resource access can be reconciled with modern forestry systems; what expectations people may have towards schemes such as Forest Stewardship Council accreditation and its associated costs and strictures: ability to access schemes such as REDD+ and how this affects community cohesion: and the relationship between RTCs and local communities.

The on-going monitoring of trials that had been previously established was seen as being of major importance. Plantations go through distinct stages as they develop toward maturity and the ability to monitor this development over long periods is rare. When the plantations are subject to novel approaches such as the mixed species trials that are aimed at improving the outcomes for growers, longevity in both managing and measuring the outcomes becomes even more important. Measuring the impact on soils through the use of microbial assessment techniques aids in understanding the impact of novel systems and may provide early warning mechanisms if above-ground systems start to have deleterious impacts on microbial communities.

As much as 70% of Solomon Islands original forest cover has been affected by the activities of logging companies, usually to the detriment of the forest and the communities that once relied on the forest for food, fibre and medicine. Finding suitable methods for re-establishing the quality of secondary forest, especially if this can contribute to longer-term income generating activities was seen as an important goal.

4 Objectives

The aim of the project was to develop the economic opportunities offered by community and smallholder forestry in the Solomon Islands through more widespread application of high value agroforestry and improved management of secondary forests.

The project had the following specific objectives:

Objective 1: To improve the quality and availability of germplasm resources for community forestry programmes

- Identify the most promising trees of four commercial species.
- Undertake transverse core testing programme to select trees with superior heartwood, physical and chemical timber properties.
- Establish seed production areas for each commercial species.
- Establish community based nursery programmes.

Objective 2: To enhance information resources to facilitate development of marketing and processing systems for smallholder timber resources.

- Establish a planted forest inventory and monitoring programme
- Review existing data on aspects of agricultural and forestry research including soil type, land use and species suitability.
- Establish GIS overlays of locale, soil, aspect, slope, species, age, site index relevant to community forestry.
- Examine the use of remote sensing and GIS technologies for planning and monitoring of community forestry.

Objective 3: To increase landowner and community knowledge about and adoption of agroforestry systems

- Develop an understanding of resource access rights, use and management and how these affect adoption of novel forestry systems
- Evaluate the effectiveness of the role of the RTCs and of community collaboration on forestry
- Examine smallholder expectations from involvement in schemes such as REDD+ and the CDM.
- Monitoring and analysis of mixed species trials
- Continue and expand the collaborative thinning trials.
- Expand agroforestry educational programme with RTCs community forestry extension workers.
- Examine soil-plant interactions in mixed species agroforestry systems
- Examine the use of an agroforestry approach to rehabilitate secondary forests.

5 Methodology

Objective 1: To improve quality and availability of germplasm resources for community forestry programmes

GPS Training

Following training in the use of handheld GPS units (Garmin Oregon 550), 4 officers from the MoFR Munda office were tasked with identifying, photographing and geo-locating the trees showing best growth and form of the 4 species that had been identified as having commercial value. Locations were in the Roviana and Vonavona lagoons, Kolombangara and Rendova Islands and the New Georgia mainland. Data was recorded in a book developed for the purpose and regularly downloaded from the GPS units themselves.

Transverse Coring for Wood Quality

Scientists from Agri-science Queensland, Department of Agriculture, Fisheries and Forestry (QDAFF) trained 2 forestry officers (Willing Zekele and Peter Maelagi) from Munda in transverse core testing at the facility at Salisbury in Queensland. The same two officers also received training in the handling and analysis of the samples and secure storage of the data.

A laboratory was established at Munda and 2 of the QDAF officers attended to set up the testing facility and to run training and field tests of the equipment. A follow up visit 6 months later ensured that procedures were being followed and the analysis was being correctly undertaken.

Phenotypes of seven species were selected based on the GPS data collected by Munda officers. A portable tree corer was used for the extraction of transverse, diametric cores. Extracted cores were then processed and analysed using the DAF facility, which was developed for this project and established in the Munda Forest Station. A total of 138 cores, which were processed into over 1,000 core segments, were analysed by the staff in the Munda Forest Station laboratory. Data arising from this analysis was to form the basis of the selection process for establishing seed production areas for the species chosen.

Workshop manuals for the use of the drilling equipment and a laboratory manual were produced.

Establishment of Seed Production Areas for each Commercial Species

A Flueggea improvement area had been established at Poitete on Kolombangara during the previous project. The project took over the maintenance and continued development of this area, which was successively thinned to remove all trees that did not exhibit good form.

Another trial of vegetative propagation of flueggea took place using a hormone rooting liquid but the success rate was very low (<10%).

Rootstock was planted for the other species and grafting took place at a site adjacent to the Scientific Area at Ringgi on Kolombangara. However, a misunderstanding with KFPL operational staff led to this area being overplanted as part of the company's normal operations. It was therefore decided to move the grafted orchard to Poitete where it was easier for the Poitete Office staff to maintain.

Community-based Nursery Programme

The underlying thought behind the establishment of community-based nurseries was as an outlet for good quality germplasm that could be sourced through the Ministry and eventually through the project seed production areas. Following discussions with the

Solomon Island Association of Vocational and Rural Training Centres (SIAVRTC) it was decided to incorporate the RTCs that we already had an established relationship with, into the programme. RTCs would obtain seed from the MoFR, grow the seedlings and sell on the seedlings or stumps to the public. It was also felt that the RTCs could have demonstration days to teach the local communities about nurseries. Permanent nurseries were established at Tetere and Kaotave (Guadalcanal) and Airahu (Malaita) in 2016. Since then nurseries have also been established at Garanga (Isabel) Navote (Makira) and Tabaka and St Dominic's (Western Province). Afutara RTC on Malaita has also joined the programme and have developed nursery facilities and standout beds with 0.5 ha of teak planted near the airstrip.

The establishment of these nurseries was seen as an educational opportunity for RTC students, but also for the staff. Following the initial introductory workshops, which brought together project staff, local forestry officers and the staff of the RTC, the project took on a "team teaching" approach with the project Education Coordinator supported by 2 of the Munda and Poitete Forestry officers. The team usually stayed at the RTC for a week, taking over the afternoon practical sessions to cover topics ranging from the construction of both formal and bush nurseries, seed handling, watering, maintenance and marking out and establishment of forestry plots.

In 2017 the project decided to try to establish a community-based nursery away from the RTC programme and actually based within a community. While this may seem an obvious choice, issues around land ownership, community engagement and daily maintenance of the facility all have to be dealt with. The project established a community-based nursery at Bibolo, a settlement near Lambete, Munda. It has been adopted by the 2 local schools but, as yet, a management committee has still to be formed.

Objective 2: To enhance information resources to facilitate development of marketing and processing systems for smallholder timber resources.

Establish a Planted Forestry Inventory and Monitoring Programme

Knowledge of the quality and extent of plantations in any given area is essential for planning for the infrastructure to get the timber to market. This is especially the case for teak, which does not have a local market and is seen almost exclusively as an export timber.

The initial step was community consultation for all the communities in the geographical area where we planned to work. Lagoon communities often have their houses in one area, either close to the water or on islands within or fringing the lagoon. Their plantations may be some distance away on customary land the community has on the New Georgia mainland. We specifically excluded plantations that were the communal property of the Christian Fellowship Church but we did work with growers who were part of the CFC community but had their own private plantations. Plantation owners invariably wished to attend when an inventory team was working on their land which meant they had to be picked up, and dropped back again at the start and finish of the day.

A team from Private Forestry Services Queensland (PFSQ) with extensive knowledge of native forestry and plantation inventory were brought to Munda to work in collaboration with the Munda Forestry Officers and with a group of students studying GIS at the University of the South Pacific (USP) under Dr John Lowry. In a week of activities two teams were formed and visited field sites in Roviana Lagoon to assess individual plantations. The data was then entered into a GIS overlay for Google Earth (Image 1). The teams plotted the boundaries of each plantation using Garmin Oregon GIS units and then undertook a detailed assessment of height, diameter and breast height and form using a transect method.

Each team consisted of at least 6 people and while this was a training exercise and therefore slower than would normally be expected. It was rapidly evident that this was a difficult and time-consuming operation. Each team completed a maximum of 4 plantations per day. Each community has numerous plantations that are scattered across the landscape. In a typical village, each of the families within the community may have at least one plantation. There may be as many as 50 plantations associated with one community, all situated within the customary land of that community.

With dwindling numbers of staff available to undertake these high intensity activities, it was decided to examine the use of remote sensing technologies but also to develop a method of rapidly assessing plantations that would be available for growers.

During the physical inventory process it became clear that plantations had shared characteristics. In general, they were planted between 1990 and 2005, the majority had no maintenance and had never been thinned. Using the data collected during the first inventory and followed by a subsequent visit involving PFSQ, a Rapid Assessment Tool (see Section 8.4) was developed to speed up the inventory process but also to act as a guide for growers themselves. Plantations were graded from category 1 (thinned, good length and dbh) to category 5 (unthinned, no commercial value). The tool is a visual guide based on photographs of plantations typical for the category and on the measurements taken by the team. This is still a work in progress and will be updated as ACIAR project FST/2014/066 gathers information on yield from the processing work being undertaken.

Review Existing Data from the British Protectorate

A survey of the soils and vegetation of Solomon Islands had been undertaken while the country was still a British Protectorate and it was decided to review this data to see if it could be used to establish GIS layers that would assist in matching soil types to vegetation. We identified 3 major sources for the information:

- The British Library, London, UK
- The National Library of Australia, Canberra, Australia
- The World Soil Survey Archive and Catalogue (WOSSAC) https://www.wossac.com/.

The soils data prepared by Hansell and Ward held at the British Library and the National Library of Australia includes both maps and detailed descriptions of soil profiles. However, in reality the scale is far too coarse to be of practical application in land use planning. A recent exercise on Kolombangara Island has revealed that for data to be useful in matching soil types to trees, it needs to be undertaken at a resolution approaching a 100m grid. This is also the resolution that would be required to be effective as a GIS layer.

A bibliography of relevant material that is still publicly accessible on Solomon Islands soil and vegetation as well as other material that has bearing on aspects of all the activities that have been undertaken through the projects is under preparation and will be available on the project website. This will include details of access/location.

Examine the Use of Remote Sensing and GIS Technologies

Commercial satellite Imagery

Due to the extreme difficulty and high level of staffing required for physical inventory, it was decided to look at the utility of commercial satellite photography. At the time of looking at this option it was decided on using WorldView2 imagery (8 spectral bands, 2 meter multi-spectral resolution, and 0.5 meter panchromatic). DigitalGlobe makes this imagery available at a special price for developing countries in the Pacific region through

SPC-SOPAC. The cost in July 2013 was $9.49 USD per sq. km. with a minimum of 50 sq. km. for imagery they have archived, and minimum area of 100 sq. km. for imagery they would have to newly acquire. This was around 60% of the full price charged to Australian customers.

The project purchased a 100 square km swathe of Roviana Lagoon, which was used by staff and students at USP, Suva led by Dr John Lowry. Whilst one of the images was clear, the other was too cloudy to be of use. The level of cloud cover that is normal within Solomon Islands will always be an issue and while it may be possible to get 'cloud free' images, the need to filter the imagery would probably increase costs. More importantly, Dr Lowry concluded at the end of the process that at 0.5m pixel resolution, the imagery was still too coarse for an accurate assessment of plantations.

Freely Available (non-commercial) Satellite Imagery

Desktop exercises were undertaken to look at the utility of using the freely available imagery from Google Earth and other satellite imagery. We looked at the areas we had previously surveyed and were able to identify the plantations we had measured and then similar plantation areas in the vicinity. Using the measurement capabilities of Google earth we could gain estimates of area and of distance that timber would have to be hauled to the nearest landing point.

This approach was dependent upon several factors:

- The age of the imagery, some of the imagery currently available for rural areas of Western Province are 12 years old. Since then plantations have grown, tracks have disappeared back into the bush and other plantings have been established.
- Cloud cover is still a problem, Google earth selects pictures that are cloud free as far as possible but there are still areas under cloud
- Some areas do not have high enough resolution imagery

Unmanned Aerial Vehicles (UAVs)

Given the problems with satellite imagery it was decided to assess the use of a UAV for plantation inventory. The UAV chosen was a Sensefly eBee fixed wing drone. This choice was made because of the greater endurance of fixed wing drones compared to multi-rotor styles that would allow larger areas to be mapped. The accompanying software (Pix4D) stitches together the photographs taken from the UAV and the resulting orthomosaic can then be entered into a GIS programme allowing accurate measurements of location, area and distances.

The software relies on its ability to recognise unique identification points in at least 6 of the images in order to successfully stitch the photographs together. When faced with the homogeneity of the secondary forest and plantations the resulting orthomosaic had large areas that were either blank or the image smeared where the software failed to find enough unique points and these compromised areas in the orthomosaic included all the plantations and secondary forest. The way to overcome these issues is to fly higher and therefore reduce the noise in each image that had overwhelmed the software. However, the images were taken at the legal height limit for flying UAVs (120m), which is the same in Solomon Islands as in Australia.

Over a series of test flights there were a number of other issues identified that would limit the use of UAVs. Birds of prey regard the UAVs as competitors and have often attacked and damaged them in flight. There are large numbers of territorial raptors throughout Solomon Islands and these pose a very real threat to the equipment. Whilst the fixed wing has the best coverage and battery life, they require reasonably clear areas, especially for landing. In the dense undergrowth of Solomon Islands this can be problematic. It is also a legal requirement for UAVs to be kept in line of sight of the operators. Flying over forest and plantations means the line of sight is restricted by the height of the trees and the areas that can be legally flown at any one time are therefore below the optimal. In the right

conditions an eBee can cover 100 ha per flight. With limited sightlines this was often reduced to 10 ha.

Objective 3: To increase landowner and community knowledge about and adoption of agroforestry systems

Here we provide approach and methods related to each of the research areas as part of Objective 3.

3.1 Develop an understanding of resource access rights, use and management and how these affect adoption of novel forestry systems

Access to land for forestry in Solomon Islands is dictated by a complex web of ownership mode including customary law, alienated land (former colonial holdings) and modern freehold and leasehold arrangements. Most smallholder forestry holdings are based on customary entitlements, usually managed by individual families under the umbrella of customary tribal rules. In these villages there was little consolidation of forestry effort and during extended discussions and workshops it became clear that families would probably remain independent in any commercial negotiations and transactions. This situation seemed to be the result of both a desire for independence and an inability to easily resolve the hierarchy of responsibility and representation that would be required for a cooperative growing and marketing effort. The exception to this land controlled by tribal adherents to the Christian Fellowship Church, located primarily in the Western Province. The leadership of the CFC 'trumps' customary arrangements and all land use is tightly controlled by the church leadership who decide what can be planted, how it is managed and the distribution of income. However, this has given the CFC the ability to consolidate land (2000 ha) for significant teak plantation in Duvaha in the northern part of New Georgia. The fate of the timber from this plantation is unknown but we had been told by a number of sources that the trees in this plantation were in no better condition than those in many of the village small holdings.

We provide detail of two villages where in-depth social research was undertaken, to demonstrate village level characteristics – including patterns of land use and resource access, social structure and decision making, and social and economic dynamics at the village level. This in-depth base line data is vital to understand the relative uptake of the ACIAR agro-forestry project.

Research Methods

3.1 a. A social science research team has conducted three field visits to Baraulu and Saika (Western Province), following a preliminary visit and pilot study. The research team, Lyons and Walters, accompanied by various post graduate students, and along with Gideon and Rose Bouro, and Larren Gomez as translators, have conducted interviews, focus groups, resource mapping and transect walks. Resource mapping involved community members mapping their village so as to identify infrastructure, natural and other resources, and access and ownership of these resources. Transect walks with community member's enabled in-depth discussion of resource and land ownership, land management and other issues.

Research and analysis focused on five themes:

1. Patterns of land use and resource access;
2. Village level social structure and decision-making patterns;
3. Social and economic dynamics;
4. Workload impacts associated with system uptake, including the gendered impacts; and

5. Processes of learning and education related to land management and use

3.1 b. Additional Study Sites for Willingness and Barriers to Adoption Social Research

There were four additional study sites selected for inclusion in the social research related to factors affecting willingness and barriers to adoption, and these were: Mauru; Mandali; Dunde; and Kindu. These were selected based upon the advice of the broader ACIAR team.

Our role was to assess the outcomes of such training, including community response and uptake of workshop content, as well as broader attitudes towards teak, teak maintenance and other community and cultural dynamics of relevance to the on-going PARDI/ACIAR project. Specifically, this research was focused upon identifying: (1) challenges associated with maintaining plantation forestry; and (2) issues and concerns associated with integration into the market for the sale of teak and other timber. We start by providing a brief background to the four selected villages for this study where focus groups were conducted with women and men (in addition to Saika, as detailed above), and offer some conclusions and recommendations to support the on-going development of this project.

Mauru

The Mauru village is spread across two islands, Ughele and Bagho. Here, villages have been growing teak, eucalyptus, cidrela, and other tree species for between ten and twenty years, with villagers explaining the impetus to begin tree planting came from the Ministry of Forestry via provincial Forestry staff. The village has around 50 hectares of timber tree species planted, with individual holdings of between one and three hectares. For some villagers we spoke with, there was frustration that after Forestry's initial enthusiasm – and championing of teak for economic development – they had received little in the way of support that could enable them to maintain their plantations properly, thereby ensuring they would receive a fair and reasonable price for the sale of their saw logs and/or timber. One plantation owner we met described the irony of being acknowledged by the National Government as planting the most trees on Rendova Island, yet receiving no incentive or reward for this achievement, despite the benefits this might deliver to the Government in the form of taxes related to timber sales. The majority of villagers at Mauru are members of the Seventh Day Adventist Church. On the day we visited a total of 17 people attended the focus group discussion (15 men, 2 women).

Mandali

Villagers at Mandali arrived in 1958 from Malaita, to work on an expatriate-owned coconut plantation. A total of 335 hectares is registered land, held in one local villagers' name. This villager, who was present at the meeting, has veto over land use decisions, including negotiations related to timber prices, and who is expected to take a 10% royalty from the future sale of teak. Each family has a small land allocation within the registered land. There are around 10 hectares of teak (the only timber species) grown in Mandali, the earliest of which were planted in 1996, and with more recent plantings from 2002. Most teak is grown in small family plantations, and similar to stories from Mauru, most villagers described the Ministry of Forestry as being responsible for motivating them to establish their plantations. Between 30 and 35 people, mostly men, attended our focus group discussion.

Here trees have been given only minor pruning - many trees have been neglected and as a result, are probably only worth a fraction of their potential worth. Men cited lack of tools for this lack of maintenance. At the moment all they had were bush knives - no ladders and no pruning saws. No thinning has been carried out although apparently some trees have been marked for thinning - we could not get confirmation of this. The reason for lack of thinning was the familiar reluctance to cut down 'perfectly good' trees. Some men were aware of the rationale for thinning, but none were prepared to do it. If a viable market existed for thinned trees however, then consideration may be given for thinning. However,

it must also be remembered that if a market for thinned trees could be established, there was every likelihood that all trees would be sold. Some made this intention clear. Some did say they might leave trees for the future, but this was something they would discuss among themselves when the time came; but also bearing in mind that individual families were free to make their own business decisions (an Anglican community, unlike the CFC). Would men come together to work cooperatively to get a better price for teak? Yes, although families would need to be paid individually. Villagers were not particularly worried about being cheated by a sawmill representative; they had experience in timber measurement from selling to loggers. There is also a qualified timber grader in the village.

Whilst we heard many stories related to experiences with the logging industries across all four villages, villagers from Mandali shared a recent experience (from 2005) which can be expected to be formative in shaping their concerns and approach to participation in plantation timber markets in the future. Here, local disputes have arisen as an outcome of what some described as the 'theft' of approximately 700 round logs by an illegal buyer. While this buyer provided a verbal commitment to purchase logs, this did not eventuate. Trees were felled, but the buyer never collected them, and the 700 logs were left beside a wharf on the island to rot. This experience contributed to significant social and economic disruption, including land disputes, conflict between family members and a heightened mistrust both within the village and of outsiders. A number of villagers we met raised concerns that these same issues might play out in negotiations related to the sale of teak and other timber plantation species.

Dunde

The village of Dunde is located on New Georgia Island. Here, over 10 hectares of teak have been planted. We met with five men who have plantations in this village, from a mix of denominations (including Christian Fellowship Church, Uniting Church and Seventh Day Adventist). The villagers included one 'champion': who actively advocates plantation timber production amongst the village, which has undertaken two rounds of thinning (and is planning a third), and has established a local nursery. This individual's background – including employment at Solomon Islands largest timber plantation Kolombangara Forest Products Limited (KFPL) – appears to have prepared him with a valuable background that could be harnessed to champion 'best practice' plantation management to other local growers.

This grower was of the view that his village would consult with each other if approached by a buyer, but individual decisions would be left to individual growers.

Experiences with logging companies had also been negative in Dunde. Logging companies had dealt with trustee landowners, who had excluded the community. This had created significant communal tension, economic costs and environmental damage.

Kindu

Also located on New Georgia Island, Kindu has around 20 hectares of teak and other species (including eucalyptus, mahogany, flueggea and callophyllum) under plantation. Villagers at Kindu are affiliated with both the Christian Fellowship Church and the Uniting Church. For those who are members of the CFC, there is a requirement to contribute labour to the CFC 'community' teak plantations. For CFC members there are no option to sell individually grown teak - all decisions of this nature are the prerogative of the Spiritual Authority.

3.2 Evaluate the effectiveness of the role of the RTCs and of community collaboration on forestry

During the life of this project, selected Rural Training Centres have taken on programs to educate young people in the methods of agro-forestry. Agro-forestry is taught as part of the 'agriculture' discipline in RTCs and is taught predominantly to young women. While the training appears effective, our research at these RTCs revealed that there remain

particular obstacles to uptake of this knowledge in villages as the gender and age of students often prevents them from taking part in decision making about land use and division of labour in the village context. Further research is required to engage with RTC alumni once they have returned to their villages to better understand the various processes that constrain and enable uptake of skills acquired at RTCs and whether these processes vary significantly across different cultural and language groups in Solomon Islands.

During this visit, and in line with the broad focus of the ACIAR Project on Rural Training Centre's (RTCs) as extension hubs for knowledge transfer across rural communities, the SRT focused on gaining a better understanding of the RTCs of Solomon Islands. The RTC initiative in the Solomon Islands began during the 1960s as a grassroots response to the limits of formal educational and paid employment opportunities, especially for rural young people. Five churches (Anglican, Catholic, United Church, Seventh Day Adventist and South Seas Evangelical Mission) undertook to transform some of their mission schools into vocational training institutions; with outcomes oriented towards offering livelihood alternatives to young people. Following the lead set by faith-based organisations, a number of rural communities also started creating their own educational centres. Demonstrating the growth in RTCs nationally, in 1993 the Solomon Islands Association of RTCs (SAIRTC) was created; with the purpose of creating an associated peak body that formally represents RTCs and promotes their growth in number and capabilities. Reflecting centre expansion, there are currently 47 RTCs operating as part of the association.

The purpose of our reporting is to describe the role of RTCs in community education, and to offer some preliminary assessment of their use value as extension agents in the ACIAR project.

Specifically, the focus of this research objective has sought to increase understandings of the effectiveness of contemporary approaches to community education in the delivery of community forestry and agro forestry content and materials. To do this, we conducted a case study of Rural Training Centres (RTCs) across a number of sites to generate insights into the value and effectiveness of rural education related to forestry training in the Solomon Islands. In 2015, and in relation to Research Objective 3.2, the SRT made visits to RTCs to investigate the linkages between RTCs and local communities, the effectiveness of RTCs in knowledge building and information exchange, the learning dynamics at RTCs, and the impacts of community based nurseries. To do this, the SRT visited three RTCs as advised by the broader ACIAR team, where collaboration was already underway:

- Don Bosco Tetere Technical Institute Rural Training Centre: Located in Guadalcanal Province, Don Bosco RTC was established 11 years ago by the Salesian community of the Catholic Church. Today it houses about 150 students aged 20 years or older. Staff working at the centre included 3 Silesians, 8 teachers and between 16 and 20 assistants.

- Garanga Village Rural Training Centre: Located in the North of Ysabel Province, in a remote setting close to the Garanga River. This is a residential rural training centre, owned jointly by the Ysabel Provincial Government and the Church of Melanesia, Diocese of Isabel. The Garanga RTC has been running for 15 years. Today it houses 260 students aged between 18 and 36 years old. It offers training in carpentry, agriculture, life skills and mechanics.

- Airahu Rural Training Centre: located in West Kwara'ae, Malaita Province, 30 minutes' drive south of Auki. This RTC was also founded by the Church of Melanesia. It houses 176 students who study life skills, agriculture, mechanics or carpentry.

As part of this fieldwork, a range of qualitative research methods were used, including:

Semi-structured interviews with a key staff member of Solomon Islands Association of RTCs (SIARTC); one of the founding members of the RTC movement; a political leader of the Malaita province; and all principals of the visited RTCs.

b) Focus groups with RTC teachers, eight (female) agriculture students; and RTC students (approximately 60 students divided in groups).

c) Transect walks, where participants were encouraged to show the researchers the results of their work, particularly their agricultural and forestry work, while we discussed relevant themes with them.

d) on-going policy and desk top studies.

3.3 Examine smallholder expectations from involvement in schemes such as REDD+ and the CDM.

In the final year of the ACIAR project, the social research team visited Honiara and Choiseul to research the progress of both REDD+ and other carbon credit schemes in operation. In Honiara we met with various senior officials from the Ministry of Forestry, to discuss progress with Solomon Islands implementation of REDD+. The program is still in its early stages, but SI is particularly committed to climate change adaption and mitigation as it is vulnerable to climate change.

In Choiseul, the Natural Resources Development Foundation, a Solomon Islands NGO focussed on mitigating the negative environmental outcomes of commercial logging has been working on a program with several villages in Choiseul to prepare them for carbon trading. The program is holistic and focusses on environmental stewardship, livelihood creation and the legal recognition of customary land to provide security. NRDF are working with NAKAU, a “Pacific Islands regional ‘Payment for Environmental Services’ (PES) program” to prepare land for carbon offset. While the NAKAU program has a far shorter timeline to realisation than the SI government managed REDD+, the NRDF has been diligent in managing the expectations of tribal groups about the possibility and scale of any eventual payments, focussing instead on forest stewardship and livelihood creation.

Specifically related to this research objective, in 2017 the SRT conducted fieldwork for 2 weeks in Honiara and Choiseul Province to examine the expectations and realities arising from environmental certification schemes such as FSC, REDD+ and the CDM.

To do this, the SRT visited Choiseul Province, where the only established carbon offset projects in Solomon Islands were underway at the time of fieldwork, thereby providing a case study approach to generate insights and lessons that may be applied to sites where the ACIAR project is working, and where communities have expressed interest to learn more about carbon offset initiatives.

Villages included in this research included Sasamunga, Tanabo, Boeboe, and Voza, all in Choiseul Province. Each of these villages is involved in the implementation of carbon offset projects, alongside a range of other complementary livelihood initiatives, including sustainable logging, bee keeping, organic food gardens and a women’s savings club.

As part of this fieldwork, a range of qualitative research methods were used:

(a) Semi-structured interviews, including with representatives from key government and non-government organisations (e.g. the Ministries of Environment, Land and Forestry, The Nature Conservancy (TNC) and Natural Resources Development Foundation (NRDF)). Interviews were also conducted with tribal leaders.

b) Focus group

c) Transect walks and participatory observation in all villages.

d) on-going policy and desk top studies.

Through fieldwork, the SRT acquired a rich qualitative data set that facilitated an in-depth analysis of the expectations of multiple stakeholders in relation to REDD+ and CDM schemes; specifically, the expectations of local smallholders and other relevant groups. On this basis, the SRT was able to meet the objectives and achievements outlined in research objective 3.3.

3.4 Monitoring and analysis of mixed species trials

Established in 2009 for research into the optimal spacing of a novel mixture of teak and flueggea, the mixed species trials at Poitete and Ringgi continue to be maintained with annual measurements of diameter at breast height over bark (dbhob) and height. The trials had 4 replicates of 5 treatments: 1) teak as a monoculture at 4m x 3m spacing, 2) Teak and flueggea in alternating rows at 4m x 3m spacing, 3) teak at 12m spacing between rows but with 2 rows of flueggea planted between the teak rows at 4m x 3m spacing, 4) teak at 12m spacing between rows but with 2 rows of flueggea planted between the teak rows at 4m x 4m spacing and 5) teak at 12m spacing between rows but with 2 rows of flueggea planted between the teak rows at 4m x 6m spacing,

The trials were progressively thinned with teak of poor form removed but the major thinning effort concentrating on the flueggea. These trials will continue to be maintained and measured to the end of 2019 when the current ACIAR forestry project in Solomon Islands ends.

Saika High Density Trial

Based on early observations of the comparative growth rates between the species in the mixed species trials, it was decided that a trial with a higher density of flueggea between rows of teak may be beneficial. As with the mixed species trial, teak was planted in rows 12m apart but with 5 rows of flueggea at 2m spacing between the rows of teak. It was felt that closer spacing of flueggea would encourage the flueggea to put more effort into height, keeping better pace with the teak and reducing the likelihood of early branching.

The high-density trial at Saika continues to be maintained and measured an annual basis

Thinning Trials

Established to look at the effect of late age thinning on plantation teak in Solomon Islands, these trials were established at Mauru, St Dominic's and Saikile in Western Province and Harasita on Malaita. At each site, the trial area of 0.25 ha was chosen for the uniformity of the trees taking into account slope and aspect. Half of the area was thinned with 3 out of every 8 trees being removed. The criteria for removal was to leave the trees showing best form and diameter but also taking into account proximity of other trees to ensure release would be obtained. This is the standard approach used by Ministry of Forestry Officers. For the unthinned area, using the same criteria as the thinned areas, trees that would have remained had the rest of the area been thinned were marked and these were the trees that would be measured for comparison of growth. Trees were measured for diameter at breast height over bark (DBHOB).

The trials were measured for 2 years on a 6-monthly basis and then on an annual basis. Two of the trials, (Mauru and Harasita) were harvested and measurement ceased after 4 years on the remaining 2 trials when it became obvious that there was no response to thinning at any of the trials.

Nelder Wheel

The Nelder design is a spacing trial that shows the effects of spacing on diameter, height, form and survival of the species involved. The trial is laid out much like a bicycle wheel with trees planted along the spokes that emanate from a central hub. As the planting

proceeds along the spoke, the trees are spaced further apart from the preceding tree and also are more widely spaced from trees in the neighbouring spokes. At the centre of the wheel, the trees are at a stocking rate of 6,000 stems per hectare (sph), at the furthest distance along the spoke, the stocking rate is down to 76 sph.

Nelder wheel is on annual measurements. This has been one of the most useful tools for the field days as it demonstrates clearly the effect of not thinning on growth, branching, and form and plantation health.

Agroforestry Trial

Established to demonstrate that food crops could be successfully grown in the establishing plantations, this was also a mixed species trial with teak and flueggea planted in alternating rows at 4m x 3m spacing. Vegetable farming ceased following the first harvest due to the distance of the trial from the homes but the crop was considered to be highly successful.

Coffee

Agroforestry systems are not just about growing trees and food crops in the same area, other crops such as vanilla and cocoa have been successfully grown in agroforestry systems. Coffee is commonly grown within agroforestry systems around the world as the trees derive benefit from the shade which has been shown to give measurable gains in berry production. The agroforestry trial area has been subject to the same thinning regime as the mixed species trials and most of the flueggea removed. Because this was planted on an alternating row basis, the removal of the flueggea has resulted in an 8m space between rows of teak. The resulting space and light levels are suitable for the growth of lowland coffee.

The trial is now the site of coffee as an intercrop, having been planted with a mixture of Arabica and Robusta seedlings derived from a former coffee trial established on Kolombangara in the 80's or 90's and other locally obtained genetic material. Coffee has been planted at 2m x 2m spacing. The trial is maintained to keep the weeds away from the coffee seedlings and is on an annual measurement of dbhob and height for the teak.

Flueggea Improvement Trial

The area was originally established as a flueggea provenance trial with seeds gathered from all of the provinces of Solomon Islands with the exception of Isabel. Laid out as line plantings of eight trees in a line, the trial covers approximately 1 ha and was initially planted at 4m x 2 m spacing.

The flueggea provenance trial has been rogued and thinned to a final stocking and is now a seed production area. This area is also one of the trial sites for lowland coffee and has been planted out using a variety of propagation techniques and genetic material.

The trial is measured annually

Rural Training Centre Demonstration Plots

The demonstration plots at Vanga, Tabaka and Airahu continue with extra areas being planted out at Airahu. The trial at Kaotave has been maintained and Afutara has established a teak plantation.

3.5 Continue and expand the collaborative thinning trials

The projects had previously established thinning trials at Harasita (Malaita), St Domonic's RTC, Mauru and Saikile (Western Province). Data from these trials has been analysed and it has been concluded that teak plantations do not respond to thinning once suppression has been established and this can be as early as 6 years following establishment. This finding has been supported by other studies (see Report 7: Thinning Trials). Following this lack of response to the late age thinning trials and the marked

reluctance of growers to thin their plantations without financial compensation, it was decided not to pursue this objective.

3.6 Expand agroforestry educational programme with RTCs community forestry extension workers.

The RTCs that we work with were initially chosen by the management committee of the Solomon Islands Association of Vocational Rural Training Centres (SIAVRTC). We wanted a workable geographical spread and now work across 5 provinces: Guadalcanal (Kaotave RTC and Don Bosco); Malaita (Airahu and Afutara RTCs), Makira (Navote), Isabel (Garanga); and Western Province (Tabaka and St Dominic's RTCs). This programme was inter-linked with the Community-based Nursery programme described above. The original concept had been to involve the Community-based forestry extension officers in the project but the CBFEO system has effectively ceased. We do make sure that the local forestry officers from the areas that the RTCs are based in are involved in project activities and they are always the first call when arriving in each area.

The original focus of the educational programme was the introduction of the mixed species agroforestry system to the students. This was based on the mixed species trials described above and involved both classroom and practical lessons. The project also developed a booklet "Agroforestry, a better way to grow trees" that is constantly updated as a result of feedback and experience. The layout of the booklet was used as the basis of lessons starting with seeds, through to planting out, plantation maintenance, thinning and harvesting.

Food crops such as beans, tomatoes, capsicum, sweet potato, cassava and even dry land rice were introduced into the plantation areas and tended by the students. The crops that will grow are dependent upon the amount of shade cast by the trees and the management of light levels through pruning and thinning and the introduction of more shade tolerant crops were part of the teaching programme.

RTC agriculture teachers from each of the RTCs involved in the project were funded to attend the Western Province Field Days put on by the project to highlight the project's activities which included: the mixed species trial, Nelder Wheel and Agroforestry trial at Ringgi; Vasavasara natural regeneration trial: milling at a local village site and drying at Lokuloku; Tabaka RTC nursery and the community nursery at Bibolo.

3.7 Examine soil-plant interactions in mixed species agroforestry systems

The first of two studies examined nitrogen (N) cycling and microbial functional genes associated with N cycling in different tree plantation systems, to evaluate the impact of interplanting teak and flueggea on the soil, especially the microbial community. Tree mono-plantations are susceptible to soil nutrient impoverishment and mixed-species plantations have been proposed as a way of maintaining soil fertility while enhancing biodiversity and increasing soil carbon (C) and N pools.

Objective: To determine the abundance of bacterial functional genes involved in N cycling under teak mono-plantations, flueggea mono-plantations and mixed-species systems and evaluate differences in N cycling due to tree cover.

Three samplings were carried out (December 2012, April 2013 and December 2013) at Poitete, Kolombangara. We collected soil samples from a teak mono-plantation, a flueggea mono-plantation and a mixed-species system (4 x 3 m spacing) (Fig. 1). The soil samples were sieved on site and transported in a cooler to Australia, where soil DNA was extracted in a quarantine-approved laboratory at Griffith University. After DNA extraction, the abundance of microbial functional genes associated with N fixation, denitrification and nitrification were quantified. In parallel, soil samples were analysed for pH, total C, N, NH_4^+ and NO_3^- and $\delta^{15}N$ (a good indicator of N cycling rates and microbial activities).

The second study focused on naturally regenerating logged forests, and examines the changes in soil microbial diversity and species composition during a two year succession. Soil microbial communities and soil processes belowground are influenced by changes in vegetation aboveground, and these occurring shifts in soil microbial communities during vegetation succession have consequences not only for belowground soil biodiversity, but also for ecosystem services. These expected changes in soil microbial communities may be related to the vegetation itself, but also to soil abiotic characteristics, especially pH.

Objective: To assess shifts in soil properties and in soil microbial diversity in naturally-regenerating Vitex stands that have been previously logged and where active management is carried out (weeding, thinning).

The study was undertaken on Vasavasara Island. The vegetation is a tropical rainforest that has been recurrently logged until December 2013 (Fig. 2). The forest is dominated by Vitex cafassus, with occurrence of other tree species such as Flueggea flexuosa, Elaeocarpus sp., Pometia sp., Callophyllum sp. and Malaina sp. Three circular plots of 0.1 ha were established in naturally regenerating forest areas. Soil sampling was carried out in July 2014, February 2015 and July 2016. Five composite samples were obtained per plot and five composite soil samples were collected outside of the circular plot, in the control areas, where no management was applied. Soil samples were then immediately sieved (2 mm) and refrigerated until analysis in a quarantine-approved facility at Griffith University. Soil DNA was extracted and the 16S rDNA region from the DNA extracts were sequenced. Moreover, soil samples were analysed for pH, total C, N, and δ15N.

3.8 Examine the use of an agroforestry approach to rehabilitate secondary forests

The original concept was the use of agroforestry as a means of promoting the rehabilitation of logged over forests. However, it became clear that people keep their gardens reasonably close to the villages and regard forestry and gardening as separate areas. The project therefore decided to concentrate on the management of natural regeneration as a path to the rehabilitation of secondary forests.

We undertook a series of meetings with communities on one of the islands that had undergone a third wave of logging in recent times to understand people's attitudes to the forests after the loggers had left. It was well known that this was often the time that people had chosen to establish plantations as access up the logging roads was easy and the land had been partially cleared by the loggers. Whilst most communities and families had established plantations in this way in the past, the lack of markets for teak discouraged them from continuing this activity. The logged areas rapidly become overgrown with weedy growth or as dense thickets of small trees. These areas were no longer any use for hunting as pigs and possums avoided them, were too difficult to walk through and were generally regarded as waste land.

However, during these meetings we also discovered that there were areas in the bush where natural regeneration of certain species was taking place. Typically these would be where the loggers had removed a large tree and the seedlings from the tree had sprung up to utilise the light. This is much the same as the response to cyclone damage.

Kohinggo and Parara Islands

One of the most common species for this was *Terminalia brassii* and we were shown 4 areas of such re-growth, 2 on Parara Island and 2 on Kohinggo. With the permission, and help, of the landowners we established trial plots at the four sites where the re-growth was very dense but the trees, while having good height and form, were of very small diameter, typically <4cm. In each area the trees were thinned to allow an approximate 4m between trees with preference being to those trees demonstrating best form and growth.

These areas are measured annually.

Nusa Hopei

Another area of *Terminalia brassii* on the New Georgia mainland had previously been thinned by the Munda Forestry team around 2004. We revisited the site in 2014 and undertook a second thinning, again concentrating on keeping the best trees. These trees are measured annually and an adjacent area that has never been thinned measured as a control.

Vasavasara

Vitex cofassus is a tree that is valued by both logging companies and by local people, who regard it as the premium timber for construction. The island of Vasavasara was logged in late 2013 and the project team first visited in February 2013. In April the project established 3 regeneration trials in areas that had been severely affected by logging. Each area was approximately 500 sq.m. and was systematically cleared of everything but sprouting seedlings of the commercial tree species that were regenerating naturally, mostly Vitex but also Pomatia and Flueggea. The trial was visited on a bi-monthly basis for weed control and measured at 6-monthly intervals. Selective thinning of the trial sites began in 2015 and green crown pruning to 6m was undertaken in 2017.

With the outstanding success of the trial it was decided to examine whether areas of logged forest that had been allowed to grow wild could still be regenerated. These area were typically covered with dense growth of mainly weedy species but with a few of the commercial species still existing but heavily suppressed by the surrounding growth. In 2017 the project established 3 more trial areas using the same principles as before. These areas were separate from, but adjacent to the original trial sites. The maintenance and measurement of these sites is ongoing but there were encouraging levels of regeneration from the new sites, though this tended to be patchy in places. There was a sufficient density of seedlings in the other patches that we were able to undertake enrichment planting moving seedlings from areas of abundance to the areas that were more sparsely populated.

The Vasavasara site is one of the sites used in the Field Days undertaken by the project and always excites interest and questions from the local community members.

6 Achievements against activities and outputs/milestones

Objective 1: To Objective 1: To improve quality and availability of germplasm resources for community forestry programmes……

no.	activity	outputs/ milestones	completion date	comments
1.1	**Identify the most promising trees of four commercial species** Tree selection and marking	Forestry personnel trained in GPS Superior phenotype trees of Teak, Flueggea, Rosewood and Terminalia identified, tagged and mapped	June 2013 August 2013	The project supplied 4 GPS units (Garmin Oregon 550) to Munda Forestry Office. 4 forestry officers have been trained in the use of GPS. Teak, Flueggea and Rosewood were identified and tagged with GPS location and photos recorded on Kolombangara Island Superior Terminalia brassii were identified, tagged and photographed on Parara Island and the New Georgia mainland
1.2	**Transverse coring for wood quality** Undertake transverse core testing programme to select trees with superior heartwood, physical and chemical timber properties. **Testing**	2 Forestry personnel given intensive training at QDAFF, Salisbury Workshop and Field exercises in SI 2 forestry staff to be trained in lab techniques at Salisbury Centre Basic wood testing facility to be established at Munda Report on review visit by QDAFF staff for quality control and extra training Report describing results of research on high quality genetic material for the 4 species of interest identified	March 2104 May 2015 March 2014 May 2015 March 2016 June 2016	The two Munda forestry officers, Willing Zekele and Peter Maelagi, who were chosen by the Ministry for the training spent a week in Brisbane in March 2014 and were trained to the satisfaction of the QDAFF officers. Field exercises and training of munda personnel carried out by QDAF officers, Gary Hopewell and Jock Kennedy Training in laboratory techniques held concurrently at Salisbury in March 2014 Laboratory established by Gary Hopewell and Jock kennedy. Further improvements made to overcome humidity problems by project staff Bill Leggate visited Munda for review of field and laboratory procedures. *See report: DAF Project visit 14 – 18 March 2016: Review of tree coring and laboratory procedures* A report based on the analysis of 138 cores taken from 7 tree species was prepared by QDAF. The cores had all been collected by the Munda Forestry team. The 7 species involved were: • Tectona grandis

				• Flueggea flexuosa • Pterocarpus macrocarpus • Terminalia brassii • Eucalyptus deglupta • Eucalyptus pellita • Calophyllum inophylum The last three were sampled as a result of a request from Kolombangara Forest Products Ltd, an important project partner who host many of the project trial sites. All cores were tested in the Munda laboratory for : • Density • Heartwood proportion • Colour • Stability *See: ACIAR Project FST/2010/043 Enhancing economic opportunities offered by community and smallholder forestry in the Solomon Islands* *Milestone 7 report: wood core analyses*
1.3	**Establishment and maintenance of seed production areas for each commercial species** Initial focus in Western Province but possibility of other locations on Malaita	Seed orchards of high quality genetic material for Teak, Flueggea, Rosewood and Terminalia on Forestry property at Ringgi and Poitete and Malaita Establishment of trials on Malaita did not take place	February 2015	The Flueggea improvement area has been thinned to final stocking and is now a seed production area. A trial of vegetative propagation of flueggea using EsiRoot hormone rooting liquid was established, but only 10 of the 50 cuttings survived. A grafted orchard was established in an area at Ringgi on Kolombangara Island for teak, rosewood and terminalia but was planted through by KFPL workers and the decision made to move it closer to Poitete where it would be easier for Forestry officers to maintain. The future of this is on hold pending decisions by the Ministry on continuation of that trial.
1.4	**Establish Community based nursery programmes**	Regional workshops involving CFEOs and RTC staff for developing community nursery program. (see also 3.6) Up to 6 Nurseries to be established at RTCs where no forestry nursery exists	2014-2017	Workshops to introduce the community nursery programme were held at Garanga RTC (Isabel), Navote (Makira), Airahu and Afutara (Malaita) with the attendance and participation of the local forestry officers. Munda and Poitete forestry staff have been involved in the workshops held in Western Province The project provides both tools and materials to the RTCs including poly bags, shade cloth, hoes, mattocks and forks. The project has also developed a

				booklet that is given to each student see: *"How to Make a Nursery and Grow your own Seedlings"* Permanent nurseries had been established at Tetere and Kaotave (Guadalcanal) and Airahu (Malaita) in 2016. Since then nurseries have been established at Garanga (Isabel) Navote (Makira) and Tabaka and Vanga (Western Province). Afutara RTC has also joined the programme and have developed nursery facilities and standout beds with 0.5 ha of teak planted near the airstrip. Permanent and student nurseries are built as part of a weeklong education programme involving staff, students and the ACIAR team including officers from Munda Forestry. Following the retirement of Philip Zekele, we have been able to use his skills as part of the nursery education programme. See report 1: *A Simple Business Model for RTC-based Community Nurseries*
		Develop business models for VTC/community nursery ventures Program to be monitored through life of project Report on operation of community nurseries		A community nursery has been established at Bibolo community to gauge the effectiveness of communities in managing their own facility without it being part of an RTC programme. This is still a relatively recent development and will continue to be monitored. See Report 2: *Bibolo Community Nursery*

PC = partner country, A = Australia

Objective 2: To enhance information resources to facilitate development of marketing and processing systems for smallholder timber resources….

no.	activity	outputs/ milestones	completion date	comments
2.1	**Establish a planted forest inventory and monitoring programme**	Training workshop for forestry staff in inventory techniques, GPS and data management USP staff and students involved in 3 workshops on data handling and GIS training Target areas identified by Forestry	2015	Four Munda Forestry officers have been trained in the use of handheld GPS units. The first workshop was held in Munda involving Munda Forestry Officers, Sean Ryan and David Menzies from Private Forestry Services QLD (PFSQ) who are experienced in forest inventory, 4 students from the GIS course at USP, Suva and Dr John Lowry, who teaches the course. Munda Forestry officers successfully identified superior trees of each of the target species. These were given waypoints, photographed and entered into the record books each officer carried.

		Community growers approached to take part in survey Final Report on Inventory to be delivered to Min Forestry	2016 2018	Community meetings were held with growers around Roviana and Vonavona lagoons. The purpose of the exercise explained to the growers and permission received to enter their plantations A hand-held visual guide (Rapid assessment Guide was developed based on assessments undertaken during the 2 visits from PFSQ. This will be further refined as the recovery data from the milling and processing project becomes available. See. *Rapid Assessment, Teak* See *Report 3:* *Report on the use of remote sensing technologies to gather information on smallholder and community-based plantation activities in Western Province, Solomon Islands:*
2.2	**Archive Data Mining**	Capture of existing data on soil and vegetation in a useable form	2017	Archives of relevant material have been identified at the British Library and the National Library of Australia. There is also a large collection of soils data held at Swinburne University in the World Soil Survey Archive and Catalogue (WOSSAC) https://www.wossac.com/. The soils data prepared by Hansell and Ward held at the British Library and the National Library of Australia includes both maps and detailed descriptions of soil profiles. However, in reality the scale is far too coarse to be of practical application in land use planning. See Report : *Report 12: Archive Data Mining* A bibliography of relevant material that is still publicly accessible on Solomon Islands soil and vegetation as well as other material that has bearing on aspects of all the activities that have been undertaken through the projects is under preparation and will be available on the project website. This will include details of access/location.

2.3	**Development of GIS overlays of community forestry in the Solomon Islands**	Collation of data collected by inventory teams, archive data mining and remote sensing	2016	This has proven to be enormously difficult to achieve using inventory teams (See 2.1). The archive data, whilst an impressive body of work that mapped the soils of the country is still at too coarse a scale to be of practical use for smallholder farmers (see 2.2). Remote sensing is the most promising approach but has to be done at the correct scale to balance resolution, cost and practicality. The data are too difficult to collect by traditional means and the areas to be covered are too large for small UAVs to make any real headway.
		GIS workstation established within SIG Forestry	2016	The condition of the current GIS units at Ministry Headquarters in Honiara led us to believe this was not the best use of resources. A web-based data-sharing platform was established by John Lowry of USP to give all partners access to project GIS data. The project also approached the staff in charge of developing a GIS laboratory at SINU. This was still under development and it was evident that the teachers had little experience in GIS beyond a preliminary training course.
		Seminar to SIG ministers to demonstrate results of the inventory program and highlight findings (also 2.4 below)	2017	This will not happen
		Final Report on development and coverage of GIS data sets and updating of inventory via remote sensing (below)		See Report 3: *Report on the use of remote sensing technologies to gather information on smallholder and community-based plantation activities in Western Province, Solomon Islands:*
2.4	**Examine the use of Remote sensing technologies** Satellite Imagery and Observation Drones	Report on the potential of remote sensing for forest inventory using available satellite imagery	2014	Multi-spectral satellite imagery of a swathe of Roviana lagoon was purchased from a commercial provider and examined by a remote sensing specialist at Griffith University. The major problem was the level of cloud cover that masked most of the terrain and made identification of plantations impossible. An exercise using Google Earth and images from the United States Geological Survey has tentatively identified plantation areas on Rendova island that are related to the communities around Ughele. These

				have yet to be ground-truthed but as this information is also relevant to project FST/2014/066 this will be undertaken as time and staff permit.
		Report on the cost effectiveness and utility of observation drones	2015	The project purchased a fixed wing drone (eBee Ag, Sensefly) to overcome the problems of cloud. The individual imagery obtained was very high quality with a pixel size of around 4cm. However, there are several problems with using the fixed wing drone. In part these are to do with the physical problems of having clear approach and landing areas in forests and the presence of large predatory birds, which consider the UAV to be a rival. However, the greatest problem is the inability of the software to stitch together pictures of the forest due to the homogeneity of the canopy. Without the resulting ortho-mosaic, the data cannot be entered in to ArcGIS in a usable form There is potential to use the resources of the British Antarctic Survey which become available during the no-fly season. The PL did approach a British university to make a joint submission to the BAS but this fell through. An approach from the Solomon Islands government may bear more fruit.
		Seminar to SIG ministers		This will not happen
		Final report as 2.3 above	2018	See Report 3: *Report on the use of remote sensing technologies to gather information on smallholder and community-based plantation activities in Western Province, Solomon Islands:*

PC = partner country, A = Australia

Objective 3: To increase landowner and community knowledge about and adoption of agroforestry systems….

No.	Activity	Outputs/ milestones	Completion Date	Comments
3.1	**Develop an understanding of resource access rights, use and management….**	Establishment of baseline data sets for at least 6villages Reports and recommendations		5 villages engaged during 2013-14 and revisited 3 times. Two villages selected for detailed baseline study on the basis of their long term involvement in ACIAR project completed, as detailed below, with

	Base line data collection from participating villages	on resource access rights, use and management Report on factors affecting willingness and barriers to adoption Report on impacts and changing roles of women as a result of uptake		specific focused on gendered implications of access, rights and labour relations Detailed reporting on willingness and barriers to adoption across 5 villages in Western Province See report: *Social Research Report 1: Resource Access Rights, use and management*
3.2	**Evaluate the effectiveness of the RTCs and of community collaboration….** Evaluation of community collaboration Evaluation of RTC scheme Examination of community based nursery scheme	Interim reports on effectiveness of community collaboration and RTC collaboration Report on effectiveness of approaches to community collaboration and RTC model in facilitating knowledge transfer and uptake of agroforestry Critical evaluation of the impacts of and management of community based nurseries		Final report on Effectiveness of community collaboration, effectiveness and approaches to collaboration. Future research required to measure impact and translation of training at the village level See Report: *Social Research Report 2: Evaluation of the effectiveness of Rural Training Centres and Community Collaboration* Community based nurseries not established at time for social research, therefore unable to complete this study
3.3	**Examine smallholder expectations from REDD+, CDM and similar.** Examination of the expectations and realities arising from environmental certification schemes such as REDD+ and the CDM	Reports on the disjunct between reality and expectation involving carbon and biodiversity schemes		Case Study of carbon market project in Choiseul Province to highlight details of the scheme, with insights that can be communicated to ACIAR village project participants. See Report: *Social Research Report 3: Smallholder Expectations from REDD+, CDM and Similar*
3.4	**Monitoring and analysis of existing agroforestry trials:** 2 fully replicated mixed species spacing trials,	Database of trial results	Throughout the project for all activities	Data is currently stored at Griffith University. It will be made available through the Project website but that currently needs upgrading to a paid model that does not have data limitations. The mixed species trials at Poitete and Ringgi continue to be maintained with annual measurements. The trials have

				been progressively thinned with teak of poor form removed but the major thinning effort concentrating on the flueggea. See Report 4 *Competition between species in the mixed species teak/flueggea trial* Interim Report 5 *Response of 5 year teak to stocking rates and mixed species plantings in Solomon Islands* Report 6: *Comparative root architecture for teak and flueggea grown in a mixed species system in Solomon Islands*
	community based high-density planting trial, 5 thinning trials, Nelder fan trial looking at both Teak and Flueggea with and without legumes, community agroforestry trial involving high intensity vegetable farming, Flueggea provenance trial, 3 RTC demonstration trials		Throughout the project	The high-density trial at Saika continues to be maintained and measured an annual basis Trials at Mauru on Rendova and Harasita on Malaita have been harvested. Vanga and Saikile trials were measured on an annual basis. See Report 7: *Thinning Trials* Nelder wheel is on annual measurements. This has been one of the most useful tools for the field days as it demonstrates clearly the effect of not thinning on growth and plantation health. See Report 11: *Interim Report on Nelder Wheel, Ringgi, Kolombangara Island, Solomon Islands* Vegetable farming ceased following the first harvest. The trial, which consisted of alternating rows of teak and flueggea on a 4 x 3 m spacing, has been thinned and most of the flueggea removed. This has allowed space and light levels suitable for the growth of lowland coffee. This trial is now the site of coffee as an intercrop, having been planted with a mixture of Arabica and Robusta seedlings derived from a former coffee trial established by Frank Wickham in the 80's or 90's and other locally obtained genetic material. The flueggea provenance trial has been rogued and thinned to a final stocking and is now a seed production area. This area is also one of the trial sites for lowland coffee and has been planted out using a variety of propagation techniques and genetic material. The demonstration plots at Vanga, Tabaka and Airahu continue with extra areas being planted out at Airahu. The trial at Kaotave has been maintained and Afutara has established a teak plantation.

		Growth models and growth tables for 2 species	2018	Measurement of the trials continues. All trees in the trials are between 6-9 years of age and are still juvenile.
		Preliminary report on expected growth of grower returns	2018	When FST/2014/066 is completed the project will have the opportunity to provide realistic figures for grower returns, until then it will be estimates at best. The eventual returns to growers also depend on whether the timber is sold as round log or processed as timber
		Extension material		Project extension material is updated as data and experience dictates. See Section 8.4 for all project related publications including Agroforestry booklet, Nursery booklet, Teak Manual, Tree measurement manual and project posters
	Research into intra and interspecific interactions within the mixed species systems	Thesis	2016-2018	See doctoral Dissertation, John Allwright Fellow, Dr Vaeno Vigulu*
		Final report on growth from mixed species systems		The Final Report will be prepared at the end of FST/2014/066 when all of the systems have been measured for the final time
		Species mix and silvicultural management recommendation for growers		The species mix and silvicultural recommendations to growers have been prepared as a Manual for growers as it was felt this was the most accessible form it could take. We will be using this in the Adult Education programme for project FST/2014/066 and will be preparing a SI Pijin version. See “A Manual for Growing Teak in Solomon Islands” (Sec 8.4)
		Journal articles		See Section 8.4 for the list of Journal Articles arising from this activity
3.5	**Expand collaborative thinning trials** Extra thinning trials established under the control of the CFEOs	3 trials each in Malaita, Guadalcanal, Western Province Data fed into growth models Grower information on thinning benefits Report outlining results of thinning trials and	Not undertaken	The CFEO programme has apparently broken down to the point of being ineffective. For this activity to work would require the involvement of Provincial Forestry staff and the full cooperation of the Ministry. The trials that have been ongoing and data from other ACIAR programmes suggest that late age thinning does not give a significant growth response in teak See Report 7 *Thinning Trials*

		recommendations to improve the economic returns		
3.6	**Expand Agroforestry Educational Programme** Integration of RTC and Community Forestry Extension Officers (CFEOs) activities in agroforestry	Workshops to introduce agroforestry concepts and to establish common ground between RTC and CFEO operations (see also 1.4) Regional community forestry information sessions and Field Days	2014 2015 – 2017 2017	We received full support from the Ministry of Forestry and the executive of the Solomon Islands Association of Rural Training Centres for the integration of RTC and community extension officer activities. However the practicality was that the officers based at the local forestry office were the ones to attend the meetings, not the community-based officers. Introductory workshops, involving local forestry officers, were held at: Garanga, Isabel Province (09/2013) Tetere, Guadalcanal (02/2014) Navote, Makira Province, (04/2014) Subsequent visits by Munda Forestry team and project coordinator saw the establishment of nurseries at each location. Regional workshops and community information days were undertaken by the coordinator and forestry staff. Community Field days demonstrate the research that the project has undertaken. Sites include: the mixed species trial Nelder Wheel and Agroforestry trial at Ringgi; Vasavasara natural regeneration trial: milling at a local village site and drying at Lokuloku. Depending on timing and weather Tabaka RTC and the community nursery at Bibolo may also be included. Community field days were held in November 2017 over 6 days Day 1: Schoolchildren from the local schools Day 2: RTC teachers from partnering RTCs on Isabel, Malaita, Guadalcanal, Western Province Day 3 : Communities from Rendova Island attended Day 4: Communities from Munda Area Day 5: Vonavona lagoon communities Day 6: Regional Forestry Officers. Due to the success of the events and the enthusiastic response of the participants,

	Field Days for SICHE Forestry trainees during practical training on Kolombangara	Field days for students undertaking Certificate and Diploma Courses in Plantation management	2014	further Field Days are planned for 2018. The RTC teachers in particular wanted much more in-depth training and we are considering a week long course Larren Gomese the in-country coordinator, gave weekly lectures to students taking the Certificate and Diploma courses. The anticipated field trips to Kolombangara have only taken place twice under very limited circumstances and the project was unable to participate.
3.7	**Examine soil-plant interactions in mixed species agroforestry systems** Research into basic soil nutrient cycling Soil microbial and fungal research to examine longer term sustainability of mixed species systems	Establish a Lab capable of basic extraction procedures Report on nutrient dynamics in mixed species agroforestry systems Seminar to Forestry on long term sustainability Journal articles and conference presentations on strategies for maintaining sustainability of mixed agroforestry systems	2015	The project donated AUD 20,000 towards the establishment of SPE Analytics in Honiara. This move was agreed at the project Inception workshop as it was felt that Dr Shane Tutua had the expertise needed to make this project successful. The laboratory has the equipment to undertake basic soil nutrient analysis of the type most frequently needed. See Report 8: “Soil plant interactions in mixed species agroforestry systems: changes in microbial functional genes associated with nitrogen cycling in different forestry systems” Report 9: Shifts in soil microbial communities in naturally regenerating *Vitex cofassus* stands Reverchon F, Hosseini Bai S, Liu X, Blumfield TJ. 2015. Tree plantation systems influence nitrogen retention and the abundance of nitrogen functional genes in the Solomon Islands. *Frontiers in Microbiology* 6: 1439. (Impact Factor 2016: 4.076) These results were also presented at the Mexican Conference of Ecology in April 2015, and during a conference held at the Centre of Tropical Research, University of Veracruz, in June 2015.
3.8	**Examine the use of an agroforestry approach to rehabilitate secondary forests** Development of secondary forest management trials in community based	Workshop with RTC and CFEOs to examine the possibilities of SFM Establish 3-6 trials at CBTCs that have access to logged areas		Sustainable Forest Management and the rehabilitation of the native forest has been discussed at each of the workshops held to establish the RTC programme (see 1.4) There were 2 basic flaws in the assumptions in this section, one being that both community Forestry Extension Officers and the RTCs would be able and

	RTCs Secondary forest management trials within village communities			willing to expend the energy to establish these plots: the second was that the project coordinator would have the ability to visit remote RTCs often enough to keep the project momentum going. Neither proved to be the case.
		Establish 3-6 trials on individual family land identified by CFEOs	2013	Land belonging to Lato village on Kohinggo Island has been subjected to waves of logging resulting in broomstick regeneration of the dominant species *Terminalia brassii*. We have established 4 thinning trials (2 at Lato and 2 at Moumou, Parara Island) aimed at demonstrating how to restore the economic potential of the area through sustainable forest management practices.
			2014	A further area on the New Georgia mainland belongs to the community of Nusa Hopei. This was a similar TB broomstick regeneration area but was thinned by the Munda Forestry crew under Philip Zekele around 2007. The project has visited the area to mark and measure the trees and in 2014 undertook a further thinning. These areas are measured annually.
			2014	The island of Vasavasara was logged until January 2014, initially the project was simply going to establish photo plots to monitor regrowth and weed development but on seeing the amount of Vitex that was regenerating decided to establish 3 plots to demonstrate the practicality of natural regeneration through simple weed control and silvicultural management.
			2017	The three plots have been maintained and extended with the addition of paired plots to each of the 3 existing plots in 2017. The purpose of the additional plots was to investigate whether regeneration was possible years after the logging had finished and the site had become completely overgrown with secondary growth. The 3 paired sites continue to be maintained and form part of the Field Days.
		Report on evaluation of secondary forest rehabilitation trials		See Report 10: *Natural regeneration trials in Vonavona and Roviana lagoons, Western Province, Solomon Islands*

*Contrary to the statement in the End of Project Review, both thesis and journal articles arising from the research of John Allwright Fellow, Dr Vaeno Vigulu are valid outputs of this project. Without project funding for fieldwork and accommodation, during and after the scholarship period, and without the dedicated support of project staff, in particular Dr Blumfield, Dr Reverchon and Dr Hosseini-Bai, the thesis would not have reached conclusion and the journal articles would not exist. To state otherwise is, at best, mis-informed.

7 Key results and discussion

Community Based Nurseries

The project established nurseries at 7 RTCs in 5 provinces. The basic premise discussed and agreed at a meeting of the SIAVRTC Executive Committee, was that the RTCs are all surrounded by communities and they could become hubs that would be able to provide those communities with high quality seeds and seedlings as well as being able to run courses as required by the communities. It was also felt that the local forestry officers would provide valuable input, especially the network of community based forestry extension officers that had been established by the Solomon Island Forestry Management Project.

In reality, the nurseries were established but the main beneficiaries were the RTCs, not the communities. There were 2 notable exceptions:

Afutara RTC is a long established and stable RTC in a remote area of Malaita that is firmly rooted within the community. It has a very stable staff, many of whom have been at the RTC for 20 years compared to other RTCs that can rotate staff every 1 or 2 years. This stability is essential for community interaction.

St Dominic's RTC on Kolombangara has seen the benefit of teak being sold through the local commercial plantation operator, Kolombangara Forest Products Limited. This has boosted interest in planting from local growers and the nursery at St Dominic's is experiencing high demand for teak seedlings.

The project also established a community nursery within one of the local communities at Munda in Western Province. Despite having permission from the community Chief, this still became the centre of a land dispute and also did not generate the community interest beyond the few individuals who were involved from the outset. The nursery has been handed over to the 2 local schools as an educational facility. The use of RTCs as a basis for this type of activity is justified by the ever-present land issues in Solomon Islands.

Forest Inventory and the Use of Remote Sensing

There have been various attempts over the last two decades to undertake an inventory of the plantations in Solomon Islands. A partial one was completed by the AusAID funded Forest Management Project and another by the Ministry of Forest Research around 2012. The plantation estate is characterised by thousands of small plantations, many less than 1 ha in area, scattered on the tribal customary land. Many were planted following logging and were established in areas that had been partially cleared by the loggers, usually along logging tracks that have subsequently become overgrown and are indistinguishable from the surrounding secondary forest.

The attempts by the project to develop a system of plantation inventory has demonstrated that the level of personnel required to undertake the activity is beyond the capacity of the under-resourced Ministry of Forestry Research.

Remote sensing of plantations would seem to offer a potential method to overcome this problem. The project examined different levels of remote sensing starting with the purchase of commercial satellite imagery. Some of this was too affected by cloud cover to be of use and the rest was judged to be too coarse resolution for it to be useful in attaining accurate data.

The project investigated the use of a fixed wing drone. The image quality was high and cloud cover not an issue but the homogeneity of the canopy cover overcame the ability of the software to produce the orthomosaics that were needed for plantation estimation.

There were other issues related to maintaining visual line of sight in forested areas and vulnerability to birds of prey. Flying higher would overcome the software limitations and the line of sight issues but there are legal limits on the height that unmanned aerial vehicles may be operated in Solomon Islands.

The project then examined the use of freely available imagery such as Google Earth and was able to identify areas of known plantations around Roviana and Vonavona lagoons. However, the imagery may be more than 10 years out of date and would seem to be mainly useful for identifying young plantations that still had visible straight planting lines and boundaries. These characteristics disappear as the plantations mature and the surrounding forest grows back. High-resolution coverage of Solomon Islands is also patchy.

The project also contacted a company specialising in using multi spectral imagery, providing precise locations of teak plantations in Western Province. The hope was that they would be able to isolate the unique, multi-spectral signature of teak and then develop algorithms to enable computer-based identification of plantations. To date the company has not reported success.

One potential solution to overcome the issues identified would be to have sensors mounted on light planes that could fly high enough to enable orthomosaic stitching by the software and yet low enough to avoid clouds. This would also increase sensitivity on a multi-spectral scale. There are commercial companies offering these services but it may be possible to procure the services of the National Environmental Research Council (NERC) Airborne Research Facility (ARF). Normally deployed in Antarctic and Arctic surveys, the aircraft are available in the closed season for other environmental work and have been deployed in Africa and Australia. Capability includes radiometrically corrected hyperspectral data from the AISA Fenix and Owl instruments; ground height information from the Leica ALS50-II; and digital photography. It is recommended that the Solomon Islands Government approach NERC to undertake this work.

Resource Access Rights, use and management

Our field visit has confirmed some of our findings from 2013; including the apparent reticence that many villagers have towards maintaining their teak in ways commensurate with forestry management protocols, and in considering extending their teak plantations. Villagers juggle competing priorities, and spend many hours in their day engaged in work activities related to subsistence food crops, and crops that can be sold in local markets. Engaging in work related to teak (for example planting and forestry management) in some respects must be considered as asking villagers to take a leap of faith, given the on-going uncertainty of markets and buyers. In this context, it appears that only those with the economic means to wait, and to risk investing land and labour, are able to take this leap. Others explain their priorities related to labour are directed towards ensuring they maintain a subsistence lifestyle, as well as generating a small cash income for basic necessities through sales of vegetables, betel nut and other crops in the local markets. As such, many villagers have left their teak to deteriorate, or conduct minimal maintenance, and lament the area of land it occupies that could be otherwise used for food gardens or other short-term cash crops. While for the most part villagers do not resent the Ministry of Forestry, they are losing confidence that forestry will find a market for their teak. However, they still rely on Forestry workers for advice and, in the event of a market becoming available, they generally believe that the Ministry would be central to both securing this market, managing the sale of the teak and protecting growers' interests. While some villages are in close proximity to Munda, enabling villagers to access the Ministry to discuss matters with Forestry staff, other villages are distant and isolated from Forestry staff, a spatial aspect that has impacts for information, access and trust.

The "How to Measure Trees" workshop aimed to address some of the challenges teak growers face, by equipping them with the skills to measure and value their timber and, in

the process, to manage their expectations about the value of their teak. While this has been beneficial for some, others have been left further disheartened, as they have been introduced to new scientific metrics to value their trees; and for many the timber is of low value.

It is also instructive that we found it so difficult to actually meet with people who had attended the workshops, suggesting the limited extent to which Forestry has either documented, or maintains connection and/or provides supports to workshop participants. This strikes us as a missed opportunity to follow up with attendees; supporting them in ways that might assist to extend knowledge and best practice in forestry plantation management and to evaluate their training efforts for the future. It has also constrained us from conducting a thorough evaluation of the impacts of such exercises, thereby offering improvements for future similar workshop activities.

On the basis of our fieldwork, we conclude with the following recommendations:

- In addition to making a broad invitation for participation in workshops, it would be useful to consider selectively recruiting key participants in villages who are recognized as leaders (including those affiliated with non-government organisations or other community groups) who may then use their position of legitimacy/authority to advocate for teak plantation management. Our findings demonstrate that leaders with backgrounds in Forestry/Agriculture, or who have studied these disciplines, are most likely to be 'early adopters' of new forestry management techniques, thereby assisting to bring other members of the community on board. These leaders may also be more likely to communicate with one another, thereby establishing informal links to share workshop information;
- Given that women actively participate in teak management, consider suggesting to village leaders that women participate in workshops in the Western Province. This may be particularly beneficial given the high levels of informal networking and communication that is evident amongst women in the communities we visited, suggesting workshop materials may be shared readily amongst women participants. Comparing outcomes of workshops between Western Province and Isobel (where we understand there were up to 7 women participants) may provide comparative insights;
- Feedback also indicated villagers would prefer workshops that ran for a series of days (rather than one day). While this has resource implications, it is worth considering given the feedback that some participants requested more, and repeated, training was required for them to feel confident with techniques they had learnt, including being provided opportunities to verify learnings with experienced foresters and others around, as well as practicing methods within the workshop, before applying in their local context;
- To ensure appropriate content of workshops, it would be useful to consider designing and running a pilot workshop with a small group of participants, and on the basis of feedback, refine workshop materials for broader dissemination. This would assist to ensure content was informed by local knowledge and needs;
- To ensure effective evaluation of workshop outcomes, it is necessary to document attendees and their contact details. Follow up with participants will assist to gain in understanding the usefulness of content, and will inform future workshops (including both curriculum and selection of participants);
- Some villagers proposed the establishment of an association to assist in organising training, education and marketing of teak. There are clear advantages for growers in setting up some form of cooperative arrangement to sell teak. There may be more buyer interest in large quantities of teak, consolidated from many villages; transport and on-site milling costs could be shared and reduced; and a central buyers' association could effectively negotiate with buyers and lobby the government. Villagers seem to have a mostly trusting relationship with the

Department of Forestry, particularly with advising on market trades, and this trust might be profitably harnessed in setting up a cooperative or association. We are, however, mindful of the realities of intergroup politics in Solomon Islands and establishing a cooperative association of teak growers may be a tortuous process.

- There is a request for more information on carbon trading (including marketing arrangements, certification/compliance requirements), as well as future opportunities to participate in these markets;
- Further integration of local knowledge and practices into plantation and agro forestry management is likely to improve local level uptake. For example, if villagers are now turning to eucalyptus as a timber species; could this be integrated into agro forestry system?
- Many villagers expressed a desire for greater knowledge about plantation management, yet did not attend the workshop. There appears to be a disconnect between training available and local level participation. Reflecting on ways of bridging this gap – such as greater integration of local knowledge, promoting workshops at local events, and offering workshops at appropriate times – may assist, particularly if technology such as video was used;
- There are ongoing concerns about buyers and markets. People hear numerous different accounts of how sellers might be potentially treated by Forestry and saw mills. To avoid adding to the confusion and mis-information that can be spread by "coconut news" it is imperative to provide accurate information, about teak prices and prospects for markets; and
- There is a significant role for the Rural Training Centres (RTC) in education and cementing local knowledge of teak planting, maintenance and agroforestry practices. As such, ongoing support and relationship building with RTC's is advised, including the design of locally appropriate curriculum materials and a program of evaluation that would allow RTCs insight into the effectiveness of programs once RTC graduates return to their villages.

Evaluate the effectiveness of RTCs and Community Collaboration

RTCs are grassroots educational institutions in the Solomon Islands that give new livelihood skills and opportunities to youth left behind by the formal educational system. These organisations can be seen as having significance for the ACIAR project in achieving some of the project goals, particularly in disseminating agro-forestry knowledge to wider communities. RTCs are strategically located within rural communities, have legitimacy vested via church affiliation as well as through their trusted leaders (including religious leaders). As such, RTCs have the capacity to act as a conduit between ACIAR project staff and broader rural communities, addressing some of the earlier challenges related to extension and uptake.

Recommendations

- ACIARs agro-forestry curriculum is included in the agriculture training specialisation at RTCs. This is a specialisation area that mostly women select, resulting in mostly women only receiving the ACIAR agro-forestry training through the RTC. To widen access and availability to agro-forestry training, the SRT recommend consultation with RTCs about where course content might best be included, with a particular focus on ensuring both women and men have access to training.
- The introduction of agro-forestry curriculum from the ACIAR project draws upon both local and western scientific knowledge. Given the benefits of adopting an approach that incorporates both local/indigenous and Western approaches – the SRT recommend the ACIAR project take this approach in education and training going forward. This will avoid imposing what can be seen as 'expert and outside'

knowledge, and assist to ensure effective uptake of learning in a culturally appropriate format.

- The decentralised model of RTCs provides flexibility in developing and refining agro-forestry curriculum in the context of local needs, values and knowledges. The SRT recommend the ACIAR project work with the Principal, Agriculture teachers and other relevant stakeholders at each RTC they work, in the design of agro-forestry curriculum. Rather than rolling out standardised curriculum as developed by the ACIAR team, this collaborative approach will ensure locally specifically content that is compatible with local needs and interests. The decentralised model of RTCs provides a structural framework to do this.
- The SRT recommend the ACIAR project take due consideration of the increasing influence of external actors, including in driving RTCs into a more Westernised study-for-employment model of vocational education. A shift in this direction could significantly hinder the potential of these institutions to foster students capable of addressing Solomon Islands' urgent and unique livelihood and environmental challenges. It could also have impacts for the future role of RTCs in the delivery of agro-forestry training.

Examine Smallholder Expectations from REDD+, CDM and Similar

Our research found that:

The initial messaging that communities receive about carbon markets (including regulatory compliance and other requirements for participation, and any benefits that might be realised), is particularity important. Early communication will shape local understandings of, and willingness to participate in, such projects. Effective communication can also assist to manage local expectations in relation to these projects;

If messaging about REDD+ type projects is poor, communities may become disillusioned and impatient, which could result in a move towards unsustainable logging activities;

Articulating the value of REDD+ type projects can be an arduous process given that the benefits and processes of participation may be abstract, distant, or discussed using overly technical or scientific language. Preparing for entry into these projects therefore requires high levels of trust between local and extra-local actors and groups;

The technical requirements of carbon market participation need to be articulated in ways that local communities understand – this may require training and capacity building. The NRDF and The Nature Conservatory (TNC) – both locally operating NGOs – have provided training for local communities so they are better able to understand REDD type projects; and

Effective REDD+ type project messaging needs to be intergenerational and inclusive; young people may be reluctant to honour the commitments made by elders in relation to REDD+ participation and compliance, thus signalling the possible return of unsustainable logging activities. A lack of generational continuity is flagged as a potential barrier to the successful implementation of REDD+ type projects.

The Importance of Collaboration, Partnerships and Trust

The role of collaboration, trust and dialogue between and among local and extra-local stakeholders was identified as being key to the successful implementation of REDD+ type programs.

It was found that:

* There is a complex range of local and extra-local actors and stakeholders involved in carbon schemes in Solomon Islands;

* The successful implementation of carbon schemes (as well and other conservation and development projects) relies on collaboration, partnerships and dialogue between these stakeholders;

* The value of collaboration and dialogue between NGOs and community based organisations (CBOs) and community leaders was identified as being particularly important. When responding to the question of what holds carbon and other livelihood projects together, participants responded by stating that it was the relationship between local people and local organisations;

* These collaborations and dialogues are also important in ensuring local expectations related to carbon schemes are realistic and that the concerns and interests of local communities are foregrounded, and

* Although local communities have not yet received any payments from participation in the Nakau Programme, they trust the local actors and organisations involved in the project and are therefore willing to participate in the programme.

Recommendations

Based on this research, we conclude with a series of recommendations

The SRT recommend that any consideration of REDD+ type projects as part of the ACIAR project should weigh up the current low levels of readiness for entry into the global carbon market. In this context, a project-based approach appears to represent the most immediate pathway for participation in the market. This approach, with a key role for the NGO sector, is also not without challenges, and these should be considered carefully in any work in this area;

The SRT recommend that communication and education should start early on in the process, ensuring local villagers have reasonable expectations of what is required for entry into carbon markets. The communication strategy should ensure there is representation across age groups, to create the basis for intergenerational equity of carbon market projects;

There is a possible role for the ACIAR project team to play, ensuring that communities have realistic expectations about the opportunities and challenges associated with entry into carbon markets, including their prospects to complement already established agro-forestry projects;

Some villages the ACIAR project works with have expressed interest to learn more about carbon markets, with the option of entry into markets as an additional village level income stream. Based on our research, the SRT recommend that as part of preparedness for entry into carbon markets, the focus should be on implementation of compatible local livelihood activities. The introduction of new livelihood activities (including bee keeping, women's savings clubs and organic farming, for example) may assist to support preparedness for entry into carbon markets, while at the same time delivering immediate positive local level outcomes. This may support villages to maintain the long-term demands required for compliance with carbon market requirements. This diversified approach also minimises the economic and other risks for communities; and

The success of carbon market projects depends on collaboration and trust across stakeholder groups. The SRT recommends that the ACIAR project continue to deliberately foster collaborations – between government, non-government organisations, and villager leaders – in their work. This will assist villages considering entry into carbon markets with the building blocks for success.

Monitoring and analysis of existing trials

The project inherited a series of trials established by the previous project. These trials included spacing and mixed species trials that will continue to supply data until the close of ACIAR project FST/2014/066 in December 2019. These trials also formed the basis of the research undertaken by John Allwright Fellow, Dr Vaeno Vigulu that led to the award of his PhD.

The mixed species trial investigated growing teak and *Flueggea flexuosa* within the same plantation. Flueggea is a local species that is widely used for construction and fencing and it was felt that if the two species were grown together in the same plantation, the removal of the flueggea would effectively thin the plantation whilst providing the community with a timber that is widely valued. This would overcome the reluctance of the growers to thin their plantations, a reluctance based on the perceived value of the teak and lack of appreciation of teak as a locally useful timber.

An investigation of the root architecture of the two species showed that in the first 5 years the roots of the two species occupied essentially different parts of the soil volume and therefore were not competing for the same nutrients and water. This was supported by a tracer experiment that introduced an isotopically labelled source of nitrogen to pairs of the species that had been isolated by an impermeable barrier. Both species were seen to access similar amounts of the labelled nitrogen, showing that they were not in competition for ground-based resources. This experiment also demonstrated that flueggea recycled greater amounts of the nitrogen through litterfall, again demonstrating a high level of complementarity between the two species.

When growth in height and diameter between the mixed species system and teak grown in a monoculture where compared, there was no detrimental effect on the growth of the teak. In fact, whilst not statistically significant, Teak grown in companionship with flueggea consistently recorded greater diameter than teak grown in monoculture.

The trial also compared stocking rate at establishment. There was no difference in height between trees that had been planted at 415 stems per hectare (sph), 625 sph and 833 sph. There was a noticeable increase in diameter for the trees planted at the lower stocking rate but when the diameter of all of the trees within the stand (known as basal area) was calculated, there was considerably more timber in the 833 sph treatment. This confirmed that the standard stocking rate of 833 sph (4m x 3m spacing) was the correct one for teak growing in Solomon Islands.

Thinning Trials

The thinning trials have shown clearly that thinning of teak plantations in Solomon Islands must commence at canopy closure, which can be at 4 years after establishment, and that to delay thinning by even a few years will impact on plantation productivity. This is not necessarily in accord with the literature but that is dependent upon the length of rotation and the area where the teak is planted. Indian teak grows at a far slower rate than Solomon Island teak and late age first thinning (20 years) is considered to be desirable but when growth rates are compared, the onset of canopy closure is still probably the influencing factor. It is therefore not recommended to base thinning regimes on age, rather on the physical situation in the plantations.

Soil-Plant Interactions in mixed species systems

This part of the project was focused on investigating soil nutrient cycling and soil microbial processes in mixed species plantations and in secondary forests undergoing natural regeneration, in order to assess the longer term sustainability of these ecosystems. Since soil microbes participate in many processes that are occurring in the soil and are directly responsible for organic matter decomposition and nutrient cycling, they constitute good indicators of soil quality. Yet, the importance of soil microbial diversity is often overlooked. Land management practices and changes in vegetation cover are known to impact

microbially-driven processes in soils through the alteration of bacterial communities, thereby modifying nutrient availability to plants or nutrient losses from the ecosystem. It is therefore necessary to include soil microbes in research on soil – plant interactions, to obtain a better understanding of the ecosystem functioning.

Our results show that combining teak and flueggea can reduce soil pH, which could decrease soil microbial activity and N cycling rates, and therefore reduce N losses from the soil. They also showed that combining teak and flueggea can reduce soil δ15N, which implies a decrease in N losses through volatilization, denitrification or leaching in the long term. We found that, although inorganic N pools remained unaffected by plant cover, at least in the short-term, soil total C and total N were the lowest under teak mono-plantations. Mixed species plantations may be a way for the growers to increase soil fertility without losing productivity.

We also found an increase in the abundance of microbial genes associated with denitrification in soils from mixed plantations, which could lead to a potential reduction of nitrate leaching and N2O emissions. This is most likely due to the development of different bacterial communities in the soil of these different tree plantation systems, due to different root exudates and organic material inputs into the soil.

We therefore conclude that interplanting teak with flueggea represents an alternative to teak mono-plantations, which maintains soil fertility without affecting the growers' productivity. It represents a benefit for soil quality, as soil C and N pools increase and N losses from the system seem to decrease under mixed-species plantations. These conclusions support the research reported above on the complementarity of the two species.

Examination of agroforestry approach to rehabilitate secondary forests

The agroforestry trial that was established at Ringgi revealed that in areas where there is no great land pressure, the establishment of gardens in the same area that trees are growing is not practical. Plantations are generally established some distance from the village and gardens occupy the areas closer to the village. It became evident that using gardening (agroforestry) as a method of rehabilitation would not work.

However, in conversation with various communities it became evident that they were unhappy about the way that forests are left after logging has finished and that the forest no longer had any of the values it had previously held.

The regeneration trials that the project established were of two types:

- The Terminalia brassii trials were established in areas where seedlings had regenerated after the removal of a single dominant tree. The seedlings were tall but remained thin due to intense competition. The trials were similar to first and second thinning in a plantation undertaken to relieve competitive stress in established trees, keeping those trees that showed best form.
- The Vasavasara trial was established at seedling emergence stage with weeding and removal of unwanted species. Seedlings from densely stocked areas were moved to areas of lighter stocking (enrichment planting) and the areas was subject to a constant process of selection to give the trees exhibiting best growth and form the space to grow. This demonstrated a low-cost, low risk alternative to plantation establishment based on the dominant species of the area.

  The second phase of the trial at Vasvasara also demonstrated that this technique was open to communities even some years after the logging operations had ceased. Whilst the initial establishment phase may be physically more demanding, the subsequent maintenance phase is similar.

8 Impacts

8.1 Scientific impacts – now and in 5 years

A soil analysis laboratory has been established in Honiara (SPE Analytical) supported by the project which donated $20,000 in equipment. The laboratory is run by Dr Shane Tutua, who was in-country coordinator to a previous ACIAR project. This facility allows for the basic analysis of soil nutrients, organic matter and pH. Prior to this these samples had to be sent overseas for analysis at great expense. As the Ministry of Forestry Research develops its own research capabilities, this facility will play a key role.

A laboratory for the analysis of transverse cores taken from the commercial tree species of interest in Solomon Islands has been established at the Munda Forestry office. The laboratory contains all the equipment needed for the coring of the trees and simple analysis of the cores. As the second phase of teak improvement goes ahead, this facility will allow for the non-destructive sampling of the phase 2 trees and the establishment of a seed orchard which will supply the countries needs for high quality teak seeds into the foreseeable future.

The project has affirmed the importance of the use of remote sensing technologies to overcome the practical difficulties that are faced when trying to understand the spread of smallholder plantations across Solomon Islands. Further developments in the use of multi-spectral sensors and automated scanning of imagery should overcome the currently insurmountable hurdles to producing an accurate inventory of plantations.

During the course of this project, the mixed species trials that were previously established have come to a stage where they are yielding results that demonstrate the viability of the approach taken. This only comes with time and the longer that trials are available for measurement and analysis, the more valuable the results become. Research into competition between species in a novel, mixed species system has shown the teak and flueggea are complementary species for the first 4-5 years following establishment. This is an important finding as teak grows rapidly in the environmental conditions of Solomon Islands and our research has shown that it does not respond to thinning once it has been held in suppression. Gradual removal of the flueggea in response to canopy structure allows the teak to thrive whilst providing growers with a valued timber resource. The ongoing development of this resource as it is finally cleared of all flueggea and maintained through to maturity will yield invaluable data and provide a model for growers that is valid not just within the confines of Solomon Islands.

Research into microbial community changes under these systems has also shown a favourable response with an increase in beneficial microbial communities under the mixed species system. Using microbial functional groups as an indicator of sustainability acts as a soils-based early warning system of problems that may not become apparent through other indicators such as tree growth for several years. This system can also be applied as the development of agroforestry practices, such as growing commercial crops in the inter-row develops.

There is scant data on teak being grown in the humid tropics away from its natural range and the research that has been undertaken is a valuable addition to the body of knowledge that will be beneficial to other counties, particularly pacific island countries and Small Island developing states, that intend to develop high value timber plantations.

8.2 Capacity impacts – now and in 5 years

The project supported the research of John Allwright Fellow, Vaeno Vigulu, toward the attainment of his PhD. Dr Vigulu is now the Permanent Secretary of the Ministry of

Forestry Research and in a position to promote forest research activities which previously had been neglected.

Training in the use of handheld GPS was given to 4 Munda Forestry Officers who each have responsibility for the care and maintenance of the units.

2 Forestry Officers trained in transverse coring and laboratory techniques for the analysis of cores. Training took place at the QDAF Salisbury Timber Testing Facility in Brisbane. The establishment of the coring laboratory at Munda (see 8.1 above) has greatly increased the capacity of the Ministry to improve the genetic resources available to growers.

The sponsorship of the soils testing laboratory in Honiara has introduced a capacity into the country that was not there before. Prior to this, all soil samples had to be sent overseas for analysis.

As part of activity 1.4, staff and students of RTCs are taught to construct shade houses, germination beds and standout beds as part of the Community-Based Nursery programme. Students are taught how to construct their own nurseries from bush materials as well as those constructed using sawn timber and shade cloth. This activity has taken place at least twice at each of the RTCs involved with each RTC having on average 30 agriculture trainees per induction, impacting an estimated 400 students.

The project has tried a range of different crops to be grown within the mixed species system, mainly in the demonstration plots belonging to the Rural Training Centres. We have recently decided that lowland coffee has a good chance of being the low volume, high value inter-crop that will give growers an income through the length of the rotation. However, developing new cropping systems takes time and the period from planting to fruit bearing for coffee is 4-5 years. The project has therefore planted around 1 ha of lowland coffee on Kolombangara (and continues to do so) that will mature and give the capacity for a research programme looking at the management of the crop and the development of guidelines for growing Robusta in Solomon Islands and potentially developing a new industry for Solomon Islands.

8.3 Community impacts – now and in 5 years

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8.3.1 Economic impacts

The primary objective of all the smallholder activity in Solomon Islands is the sale of teak for export. Growers are failing to realise the potential of the plantations through poor silvicultural practices and a lack of accessible markets to stimulate any real interest in the development of the industry. The project has demonstrated that it is possible to grow high value trees within a mixed species system that addresses many of the issues preventing growers from managing their plantations properly. The field days around the various trial sites have been very successful in showing growers that there are alternate systems and with the beginnings of market access, there is a genuine possibility that growers will adopt novel systems that will give them far better returns on their investment than are currently possible.

The agroforestry trial demonstrated that vegetables could be successfully grown in areas where plantations are establishing. This is tempered by the fact that there is little resource pressure in Solomon Islands and there is generally room for extensive garden plots near the village, whilst plantations are planted at some distance. However, the more densely populated areas such as Malaita province, genuine agroforestry may be an option for people who wish to grow trees.

Whilst teak is regarded as an export timber and people have no real appreciation of teak for local consumption, flueggea is held in high regard as a valuable timber for various domestic purposes. Flueggea grown within the mixed species trials is a valuable commodity for sale or barter and the 4-5 years growth makes it a good size for posts and local house construction.

The project has established demonstration trials of lowland coffee between the trees. Coffee is widely grown in agroforestry systems around the world and is a suitable high value, low volume crop for rural areas where transport infrastructure is limited. In conjunction with the growing of food crops in the earlier stages of plantation establishment, this demonstrates a 'whole of cycle' approach to providing growers an income from their land. Typically, food crops can be grown for the first 2 years following establishment of a mixed species system described above. Following the progressive removal of the flueggea, sufficient space is available between the rows of teak for coffee to be planted at 5 years following establishment. The coffee plants produce berries from 4 years giving at least 10 years of production before the teak is harvested and the cycle repeated.

The natural regeneration trials have clearly demonstrated that it is possible to enhance the value of logged areas beyond the value that it had prior to logging. Using the techniques pioneered by the project it is possible to grow high value native trees at a higher density than they naturally occur with minimal costs normally associated with plantation establishment such as nurseries, germination and stand-out beds and intensive site preparation.

8.3.2 Social impacts

The Social Research Team has collected in-depth base line data across a number of villages to identify resource access, use and decision making at the local level. It has also undertaken targeted research at key village sites where the ACIAR project team has worked to identify the opportunities and challenges in dissemination of agro-forestry training, alongside targeted research with TRCs where the ACIAR team has worked, to assess impacts of curriculum delivery. Importantly, a key output from the SRT has been 5 Masters Theses on specific aspects of this research, all of which have been made available to the ACIAR project. On the basis of our social research, we have identified the following social impacts associated with this project:

- Villages in Solomon Islands demonstrate complex local level governance structures, which shape decision making related to land and resource access and use. This has impacted the relative uptake of the agro-forestry program. In some instances, for example, the agro-forestry system – including thinning and pruning – is understood as out of step with local needs and aspirations as defined by villagers themselves and their ruling elites, and on this basis uptake of agro forestry practices has been constrained;
- Gender is highly significant in shaping land and resource access and availability, and gender is a key variable in shaping the labour process at the village level. The introduction of agro forestry practices has had significant impacts on women in particular, and yet women do not demonstrate high levels of involvement related to the uptake of agro-forestry. Further engagement with gender issues into the future will be vital to ensure the social sustainability of this project;
- A number of villagers have now been trained in methods related to agro-forestry. This has increased knowledge on specific skills to enable villagers to calculate the value of the timber in their trees, a vital pre-requisite for ensuring fair conduct in national and international markets. And yet there are limits on the uptake and implementation of such practices. Further consideration of the barriers to systems

uptake is required, to ensure training is specific to local needs. Specific considerations are detailed in the Social Research Report 1, attached.

- Rural Training Centres represent an important site for the dissemination of information related to agro-forestry. The ACIAR team has built strong relations as the basis for an enduring collaboration. Further options to consolidate and extend this collaboration are recommended, along with further research to determine the translation (or otherwise) of student training at the village level; and
- Villagers are interested to learn more about the options for entry into carbon markets, and their possibilities for increased income earning. Our findings demonstrate there are opportunities and constraints on the expansion of carbon markets in Solomon Islands. There is an important role for the ACIAR project to communicate these findings to local villages it works, and to ensure that any developments in carbon markets are pegged to tangible positive local livelihood projects (including growing food, honey and other income generating activities).

8.3.3 Environmental impacts

Smallholder plantation activity normally takes place in areas that have been previously logged, in some cases for the second or third time in as many decades. Destruction of pristine forest for plantation activity does not occur therefore any activities related to teak plantations have minimal negative environmental impact.

Growing teak, which is not native to Solomon Islands, with flueggea, which is, lessens the potential impact that may arise from growing a monoculture of teak. This was seen in the increased beneficial microbial functional groups that were noted in the mixed species areas when compared with the monoculture teak.

For many communities, logged areas are regarded as a waste land that are too dense to undertake the activities that were done prior to logging such as hunting, gathering food, collection of building materials and fibres and the gathering of medicinal plants and parts of plants. The project has demonstrated that it is possible to regain control of areas of logged forest without great expense or effort.

The active thinning regime promoted through the mixed species trials produces both timber for housing and fencing, but firewood as well. While this has little impact in areas with no resource pressure, in other areas such as Malaita where mangrove systems are used as a source of firewood, the alternate timber supply is an important environmental bonus.

8.4 Communication and dissemination activities

Solomon Islands National University

The in-country coordinator, Larren Gomese, gave weekly lectures to the Forestry Students (approx., 35) at the Solomon Island National University during 2014 teaching terms and was involved in the field activities.

Rural Training Centre Activities

The project is involved with 7 of the Rural Training Centres across 5 provinces. Training is carried out using a team teaching approach involving the project Education Coordinator and members of the Munda Forestry team. The activities generally take place during the course of a week with the students having their formal lessons in the mornings and then working with the project team in the afternoons. Activities include construction of bush material nurseries, training in the handling and appropriate treatment of different types of

seed, germination and pricking out of seedlings, stumping and plantation planning and layout. Students are given project booklets such as “Agroforestry: a better way to grow trees” and “Booklet and “How to Make a Nursery and Grow Your Own Seedlings”.

Community Activities

Community Meetings are held on a regular basis in all of the communities where we interact. Meetings are generally tri-lingual with English, Pijin and Roviana (the local language) used with translation of the English into Roviana. These meetings follow a standard pattern of introductory meetings to explain the purpose of a particular activity and seek the permission of the community. The usual arrangement is for the team to come back after a few days to hear the communities’ decision. Meetings are then held to update the communities on the progress of the activity and always held when a direct request comes from a community member. Often these meetings are for clarification of activities.

Field/Demonstration Days

Community Field days demonstrate the research that the project has undertaken. The sites also include activities from project FST/2014/043. Sites include: the mixed species trial. Nelder Wheel and Agroforestry trial at Ringgi; Vasavasara natural regeneration trial: milling at a local village site and drying at Lokuloku. Depending on timing and weather Tabaka RTC and the community nursery at Bibolo may also be included.

Community field days were held in November 2017 over 6 days

Day 1: Schoolchildren from the local schools
Day 2: RTC teachers from partnering RTCs on Isabel, Malaita, Guadalcanal, Western Province
Day 3: Communities from Rendova Island attended
Day 4: Communities from Munda Area
Day 5: Vonavona lagoon communities
Day 6: Regional Forestry Officers.

Due to the success of the events and the enthusiastic response of the participants, further Field Days are planned for 2018. The RTC teachers in particular wanted much more in-depth training and we are considering a week long course

Newsletter

The project produces 2 newsletters a year that are sent via email to around 100 recipients and distributed in-country as hard copies.

Posters

The project has a poster series that is distributed through the Rural Training Centre network in A1 format and is given in A4 format to people who attend field days and workshops. There are currently 8 posters in the series, see Section 10 Publications

Fact Sheets

Three Fact Sheets have been prepared by the Social Research Team, and these will be distributed to in-country partners, and made broadly available to interested parties.

Booklets

The project produces booklets in A5 format that are distributed to students through the Rural Training Centres as mentioned above and are given to people who attend field days and workshops. A silvicultural manual “A Manual on Growing Teak Trees in Solomon

Islands" has been produced in A5 format as well as a manual "How to Measure your Trees"

Website

The project has a website that holds copies of newsletters and reports for people to download at will. It is currently at the capacity allowed by the host and will be moving to a paid server in the near future:

https://sites.google.com/site/solomonislandsagroforestry/

9 Conclusions and recommendations

The project has seen a severe depletion in personnel since inception and this has limited some of the achievements. Project Scientist Dr Frederique Reverchon who had responsibility for the soil and microbial research component had to take a position in Mexico 18 months after the project started and her contribution was limited to sampling trips and laboratory analysis (aided by Dr Shahla Hosseini-Bai). This reduced the Griffith University personnel active in-country to the project leader.

The Education Coordinator, Larren Gomese took one year's study leave reducing the in-country staff to one person for that year. Larren was subsequently replaced after the year when he needed more time to study and Gideon Bouro took his place. Alick Haruhiru, the in-country Coordinator was offered a permanent position by the SIG Dept of Meteorology and was replaced by Moris Jatobatu.

The Munda Forestry staff has been depleted by three deaths and the retirement of Philip Zekele, Chief Forester, and this has seen the personnel available to be involved in project activities reduced from five to three, and the remaining three have to assist other Departments in the Munda office as required.

9.1 Conclusions

Despite the staffing issues, there have been some significant achievements:

- The establishment of the transverse coring and wood-testing laboratory at Munda and the soils testing laboratory in Honiara are a lasting legacy from the project. Both are available to assist Ministry staff to improve the germplasm available to both commercial and private growers and to aid in a better understanding of the relationship between soil properties and species success.
- The project tested a variety of methods for making an accurate inventory of the plantation estate in Solomon Islands that took into account available staffing levels and expertise. Through a process of elimination it has been possible to show what does not work and why and to make recommendations for future developments. A rapid assessment tool for use by growers and assessment teams will aid in the ground-truthing for what must be an essentially remote-sensing approach to inventory. This tool is being refined in light of work still in progress under FST/2014/066
- A network of RTC-based nurseries across 5 provinces has been established that are available for the public to access and to obtain superior quality seeds and seedlings. The nurseries also form an important part of the educational programme aimed at RTC students and undertaken by the project, which involved officers from the local forestry office, officers from the Munda forestry team, and the project Education Coordinator.
- The mixed species trials have clearly demonstrated that growing teak with flueggea is a successful method for obtaining both high quality teak and a supply of locally useful timber. Further, the linear aspects of the alternating row system makes possible both food crop production and longer-term income generating crops such as coffee, thereby providing the potential for a whole of cycle approach to income generation from teak plantations.
- The scientific research programme has shown that teak and flueggea demonstrate a high level of compatibility as companion species in a mixed species planting. The programme looked at root architecture, competition for resources and growth rates at different species ratios and stocking rates. All confirmed that this is a workable system for Solomon Islands. Soil microbial research also confirmed that

the mixed species system was beneficial to microbial functional groups that were essential for maintaining nutrient cycling and soil fertility.

- Results from thinning trials have corroborated findings from other ACIAR projects that teak does not tolerate suppression and that thinning at the appropriate stage of canopy closure is essential to maintain plantation productivity.
- The Nelder wheel spacing trial has been used to successfully demonstrate this to growers and field day participants.
- Forest rehabilitation through the use of selective natural regeneration has been demonstrated in 5 sites in Vonavona and Roviana lagoons. In particular, the Vitex regeneration trial on Vasavasara has shown the value of early intervention following the cessation of logging but also that regeneration is possible some years after logging even when the area is densely overgrown. It has also demonstrated a low-cost, low risk alternative to plantations for growing high value timber.

The Value of a Trans-disciplinary Research Approach

The ACIAR project is based on a cross-disciplinary collaboration; whereby forestry, soil science, social science, economics and other approaches are brought to bear in offering new understandings related to enhancing the opportunities for smallholders in the community forestry sector in the Solomon Islands.

To ensure effectiveness in this cross-disciplinary project, the SRT has reflected on transdisciplinary research practice. Transdisciplinary research practice has become a core element of global sustainability science, and is therefore suitable to this project scope.

Transdisciplinary research expects that people with different backgrounds and interests will learn *together* through *collective problem solving* and *innovation*. In particular, 'transdisciplinary communities of practice' – drawing upon both situated learning theory and transdisciplinary practice – can create new opportunities for research practice. This can deliver new, and rich findings of direct benefit to the project participants.

To achieve this end, however, requires researchers from across different disciplines to work with – not for, or below each other – in the conduct of research. (Cundill et al. 2015).

Trans-disciplinarity and/or inter-disciplinarity is now recognised to be vital for creating innovative solutions that move beyond reductionist approaches to science, decision-making and communication (Fleming and Howden, 2016).

On this topic, Dick *et al*. state:

"Contemporary conservation problems are typically positioned at the interface of complex ecological and human systems… conservation science teams must adopt multiple disciplinary approaches that bridge not only academic disciplines but also the political and social realms and engage relevant partners" (Dick *et al.*:67).

In other words, social research, combined with scientific understandings, is integral for an analysis of, and solution to, complex ecological problems.

While we experienced moments of a transdisciplinary community of practice in this ACIAR project, especially in the mid-term review, we see great opportunities for further project effectiveness through deeper consideration of this approach.

9.2 Recommendations

Staffing problems at Munda Forestry office have diverted staff resources from the use and implementation of the wood coring facility to the detriment of staff morale and the currency of training and usage. This is an important facility, which is available to both government

and commercial forestry operations for the non-destructive testing of important wood qualities.

Recommendation

- That the MoFR assigns permanent staff to the Munda research section with responsibility for the wood coring facility, if needed these staff can be sent to Brisbane for training or QDAF staff can be brought over to Munda to provide refresher courses.

The field days undertaken through the project demonstrated that the general public still do not grasp the essentials of silvicultural management of plantations and hence have consistently poor results from their plantations. This project has shown that there are alternatives to teak monocultures that may overcome the reluctance of growers to undertake the difficult tasks required to produce good quality and productive plantations. Further, the development of income generating opportunities from the plantations would encourage a useful thinning regime and maintain interest in the health and productivity of the system.

Recommendation

- That greater effort is put into public education using the resources that are now available in the mixed species, Nelder and agroforestry trials. The value of these resources lies in their age and documented history and they provide graphic proof to growers of the effects of both good and bad silvicultural practices.
- That developments in a whole of cycle approach to income generation from the plantations are continued with research into suitable cropping systems such as coffee or vanilla.

Even a reasonably accurate inventory of smallholder plantations remains elusive in Solomon Islands due to the difficulties of physically accessing thousands of scattered plantations. While satellite imagery remains too coarse for accurate estimations and UAVs are faced with technical challenges, the best solution would seem to be the use of light aircraft equipped with suitable sensors that could gather data from both standard colour imagery and multispectral sensors. The costs associated with this on a country-wide scale would be very high using a commercial operation but there are research facilities available through the UK government that would provide both the data and the expertise in interpretation.

Recommendation

- We recommend that the Solomon Islands Government makes a formal approach to NERC ARF for flights over the entire country and training of government officers in the photogrammetric interpretation of the images.

  Normally deployed in Antarctic and Arctic surveys, the aircraft are available in the closed season for other environmental work and have been deployed in Africa and Australia. Capability includes radiometrically corrected hyperspectral data from the AISA Fenix and Owl instruments; ground height information from the Leica ALS50-II; and digital photography.

The ACIAR teak forestry programme commenced in 2008 and is due to continue until December 2019. During that time, important trials have been established that continue to yield valuable data and staff at Munda are well versed in the techniques and principles of research data and sample collection. However, the staff are all approaching retirement

and when they do, the accumulated experience and knowledge they have gained will retire with them. It is essential that a genuine research unit is established at the Munda Forestry office that can take advantage of the experience and knowledge of the Munda officers and can take over the established research sites with full understanding of the principles and practices involved.

Recommendation

- We recommend that a Research Unit, staffed with graduate officers, be established at Munda Forest Station before the end of 2018. That would allow a 1-year hand-over period with ACIAR project staff. This unit would have proximity to existing research sites, have the Kolombangara Scientific areas available to establish new sites and be able to benefit from the experience of the existing research staff.
- We **DO NOT RECOMMEND** the establishment of a research unit at the head office in Honiara. This would be counter-productive as the access to sites, to experienced staff and to the ACIAR project depend upon having Munda as a base.

The existing trials are providing data that will be of value to future growers both in Solomon Islands and anywhere in the humid tropics where teak is being grown in plantation style settings. The true value of these trials lies in the longevity of data collection, it is exceedingly rare to have continuous data from establishment potentially through to harvest and even rarer in fully replicated 5 treatment trials established on two sites. Similarly, the natural regeneration trials will continue to yield data and experience in how best to manage these developing stands.

Recommendation

- That the trials established through the ACIAR projects continue to be maintained and measured through to end of rotation.

While the ultimate solution to growing marketable trees is a scientific one, the journey to that solution, if it is to involve donor participation, requires a multi or trans-disciplinary approach The involvement and assimilation of social scientists into both the planning and execution of a project can provide vital context to science, particularly an awareness of culture, politics and economics and the need to incorporate changing indigenous understandings of what is appropriate development.

This requires a greater awareness from funders that this process takes time, and perhaps the surrender of a degree of control. This will require a change in the expectations that are levied on aid delivery teams, with reporting to include clear accounts of how interventions are being understood, received and shaped by villagers. The role of well-trained indigenous project team members will be vital (the PhD training of Solomon Island researchers is a valuable start).

Recommendation

- Recognise and work with local level governance and decision-making processes to actively enrol community members in the ACIAR project, including demonstration plots.
- Support the expansion of reliable and trustworthy information sources on forest management practices, including their benefits. This might include increased community visits by Forestry workers, increasing opportunities for community members to visit Rural Training Centres, as well as media coverage of the ACIAR project (including radio and newspapers).

- Recognise the value of experiential learning, and find innovative ways to better integrate local community members in demonstration plots and other activities related to the project;
- Active inclusion of women and young people in agro-forestry extension activities;
- Acknowledge the diverse needs and aspirations community members articulated – including related to service provision, infrastructure, education, employment etc. Part of the medium and long term monitoring and evaluation of the agro-forestry development project will require assessment of the extent to which these identified community needs might be met via the income generated from the sale of teak (and other timber and food crops associated with the mixed species planting), and how the project might be altered to assist in delivering on these needs.

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McDougall, D. (2008) 'Religious Institutions as Alternative Structures in Post-Conflict Solomon Islands? Cases From Western Province', State Society and Governance in Melanesia. Discussion paper 2008/5. Pp. 1-21.

Makim, A. and Dart, P. (2002) 'Community Forestry and the 'Arc of Instability': An Under-Utilised Opportunity for Redefining the Terms of Australia's Engagement with the Pacific? *Development Bulletin,* 58, pp. 81-84.

Hviding, E. (2003) 'Contested Rainforests, NGOs, and Projects of Desire in Solomon Islands', UNESCO, pp. 539-553.

10.1 List of publications produced by project

The following reports and publications have been produced during this project:

Collaborators Reports

Prepared by:
Forest Product Innovations
Department of Agriculture and Fisheries, Queensland (QDAF)
Salisbury Research Facility
50 Evans Road Salisbury Q 4107

- Review of tree coring and laboratory procedures (March 2014) DAF Project visit March 14 – 18 2014 (Report)
- Processing tree cores a lab manual for measuring density, colour and shrinkage (2015) (Manual)
- the Drill corer a field manual for taking tree cores using the large-bit drill corer (2015) (Manual)
- Milestone 7 report: wood core analyses (2016) (Report)

Prepared by:
Private Forestry Services Queensland
8 Fraser Rd,
Araluen QLD 4570

- Rapid Assessment Guide

Publications by Project Team Members:

- How to measure your trees (Booklet)
- How to make a Nursery and Grow your own Seedlings (Booklet)
- Agroforestry: A better way to grow trees (Booklet)
- Project Poster Series:
    - Agroforestry
    - Managing your Trees – Pruning
    - Managing your Trees – Thinning
    - Natural Regeneration
    - Community Nurseries
    - Selling My Trees
    - Mixed species plantings: a different way to grow teak
    - Mixed species plantings: why do we use mamafua
- A Manual on Growing Teak Trees in Solomon Islands (Booklet)
- Agroforestry News (Newsletter)

Reports by Project Team Members

1. A Simple Business Model for RTC-based Community Nurseries
2. Bibolo Community Nursery
3. The use of remote sensing technologies to gather information on smallholder and community-based plantation activities in Western Province, Solomon Islands
4. Competition between species in the teak/flueggea mixed species trial
5. Interim Report: Response of 5-year teak to stocking rates and mixed species plantings in Solomon Islands
6. Comparative root architecture for teak and flueggea grown in mixed species system in Solomon Islands
7. Thinning Trials
8. Soil plant interactions in mixed species agroforestry systems: changes in microbial functional genes associated with nitrogen cycling in different forestry systems”
9. Shifts in soil microbial communities in naturally regenerating *Vitex cofassus* stands
10. Natural regeneration trials in Vonavona and Roviana lagoons, Western Province, Solomon Islands
11. Interim Report on Nelder Wheel, Ringgi, Kolombangara, Solomon Islands
12. Report 12: Archive data

Social Research Team Reports

1. Agro-Forestry and its Social Impacts, Social Science Report, (2013) Dr Kristen Lyons, Dr Peter Walters, Erin Riddell, Prof David Burch and Henry Boer, University of Queensland
2. The Uptake of Agro-Forestry Training, Social Research Team Summary Report (2014), Kristen Lyons, Peter Walters, Catherine Hall, Nicole Garofano, University of Queensland
3. Enhancing Economic Opportunities Offered by Community Small Holder Forestry in the Solomon Islands – Final Report (2017) Associate Professor Kristen Lyons, Dr Peter Walters & Annabel Shewring
4. Social Research Report 1: Resource Access Rights, use and management
5. Social Research Report 2: Evaluation of the effectiveness of Rural Training Centres and Community Collaboration
6. Social Research Report 3: Smallholder Expectations from REDD+, CDM and Similar
7. Fact Sheet 1: Factors Affecting Willingness and Barriers to Adoption of ACIAR Village Level Agro-Forestry Training
8. Fact Sheet 2: Rural Training Centres and Argoforestry
9. Fact Sheet 3: Smallholder Expectations from REDD+, CDM and Similar Carbon Market Initiatives

Theses

Vaeno Vigulu (2018) Mixed Species and Agroforestry System Interactions in Solomon Islands Griffith University Doctoral Dissertation (Dr Vigulu is the recipient of a John Allwright Fellowship)

Mallet-Wallace, A. (2017) Carbon Credits and Sustainable Livelihoods: A Case Study of Conservation, Gender and Local-Level Development in Choiseul Province, the Solomon Islands. unpublished Masters thesis, The University of Queensland.

Benevides, A. (2015) Re-imaging technology and knowledge transfer: incorporation of external knowledge to local epistemological systems through grassroots educational initiatives. The case of Rural Training Centres in the Solomon Islands, unpublished Masters thesis, The University of Queensland.

Garofano, Nicole. 2014. "How the Use of Value Chains in Family-Based Reforestation Projects in Solomon Islands Can Support Claims of Effective Aid." Master of Development Practice, School of Social Science, The University of Queensland, Brisbane.

Hall, Catherine. 2014. "Navigating the Role of the Visible Researcher: Using a Reflexive Research Ethic to Articulate Investigative Validation in Qualitative Development Research." Master of Development Practice, School of Social Science, The University of Queensland, Brisbane.

Riddell, E. (2013). "Competing Claims: Perceptions, Disjunctures & Programme Efficacy in the Solomon Islands", Master of Development Practice, School of Social Science, The University of Queensland, Brisbane. (Supervised by Lyons and Walters).

Journal Articles

Vigulu. V.W., Blumfield, T.J., Reverchon, F., Xu, Zhihong and Tutua, S., (2017) Competition for nitrogen between trees in a mixed-species plantation in Solomon Islands, Australian Forestry

Vaeno Vigulu, Timothy J Blumfield, Frédérique Reverchon, Shahla Hosseini Bai, Zhihong Xu (2018) Growth and yield of five years old teak and flueggea in single- and mixed species forestry systems (Submitted to New Forests, January 2018)

Vaeno Vigulu, Timothy J Blumfield, Frédérique Reverchon, Shahla Hosseini Bai, Zhihong Xu (2018) Comparative root architecture of Tectona grandis and Flueggea flexuosa in mixed species systems in Solomon Islands (Submitted to Agroforestry Systems, January 2018)

Vaeno Vigulu, Timothy J Blumfield, Frédérique Reverchon, Shahla Hosseini Bai, Zhihong Xu (2018) Nitrogen and carbon cycling associated with litterfall production in monoculture teak and mixed species teak and flueggea stands (Submitted to Journal of Soils and Sediments, January 2018)

Timothy J Blumfield, Frédérique Reverchon , Vaeno Vigulu (2018) The Importance of Market Access for Timber Growers in Small Island Developing States: a Solomon Island Study (Submitted to Land Use Policy, January 2018)

Reverchon F, Bai SH, Liu X and Blumfield TJ (2015) Tree Plantation Systems Influence Nitrogen Retention and the Abundance of Nitrogen Functional Genes in the Solomon Islands. Front. Microbiol. 6:1439. doi: 10.3389/fmicb.2015.01439

Walters, P., Benavides, A. Lyons. K. (2018 in press) ‘Education for a vocation or a society? The dialectic of Western and customary epistemologies in Rural Training Centres in Solomon Islands”, Comparative Education.

Lyons K, Walters P and Riddell E (2016) The Role of Faith-based Organizations in Environmental Governance: the Case of Forestry in Solomon Islands
Journal of Environmental Policy & Planning Vol. 18, Iss. 3

Walters P, Lyons K (2016) Community teak forestry in Solomon Islands as donor development: When science meets culture Land Use Policy, V57, Pages 730-738

11 Attachments

11.1 Collaborator's Publications

- Review of tree coring and laboratory procedures (March 2014) DAF Project visit March 14 – 18 2014 (Report)
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    - Managing your Trees – Pruning
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12. Archive Data

11.4 Reports by Social Research Team

1. Resource Access Rights, use and management
2. Evaluation of the effectiveness of Rural Training Centres and Community Collaboration
3. Social Research Report 3: Smallholder Expectations from REDD+, CDM and Similar
4. Fact Sheet 1: Factors Affecting Willingness and Barriers to Adoption of ACIAR Village Level Agro-Forestry Training
5. Fact Sheet 2: Rural Training Centres and Argoforestry
6. Fact Sheet 3: Smallholder Expectations from REDD+, CDM and Similar Carbon Market Initiatives