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Contents

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2 Executive summary

The many benefits of agroforestry have been widely identified, yet the area under agroforestry in Fiji and Vanuatu has in fact declined in recent decades, for example due to a push for growing export products during the colonial era, and the progressive urbanization of the population. While sugarcane growing and coconut production remain highly important land uses and sources of revenue in Fiji and Vanuatu respectively, there is considerable underutilized land in both countries. There is major scope for expansion of agroforestry, to produce timber as well as fruit and nuts from traditional tree species, with root crops and other vegetable species as intercrops. Expansion of planting could take place on sloping land and with little competition with agricultural production including sugarcane growing.

This SRA was designed to explore the financial, legal, planning and policy issues associated with transitioning to sustainable agroforestry in senile coconut plantations and marginal sugarcane lands in Fiji and Vanuatu. The project sites selected were north-western Viti Levu in Fiji and the island of Efate in Vanuatu. An appraisal of current land-use policies and practices and their limitations was undertaken, with a view to identifying potential strategies to create greater incentives for more profitable and sustainable land-use systems and farming practices in the identified study areas.

The research steps for this SRA included: literature review; analysis of existing policies, laws, land-use plans and land management practices; identification of promising agroforestry systems for unproductive land; analysis of the likely financial performance of particular tree species and agroforestry systems; workshops and discussions with researchers, government officials and industry representatives; and surveys of smallholders using semi-structured questionnaires.

A major achievement of the project has been the production of 16 working papers – abstracts of which are provided at the end of this report – providing review and original research outputs addressing the various research objectives. These include: a macroeconomic overview of agroforestry benefits in Pacific Islands (WP1), a survey of approaches which have been adopted for modelling the performance of agroforestry systems (WP2); outlines of the set of steps required for modelling the financial performance novel tree species (WP3) and for carrying out a broader modelling approach to include environmental and social benefits of forestry and agroforestry in Fiji and Vanuatu (WP4); assessments of the constraints to and opportunities for establishing agroforestry in the Western Division of Fiji (WP5 and WP6); a survey of the various lists of tree species which have been identified as having priority for growing in Fiji and Vanuatu and the criteria used for their selection (WP7); details of financial models of selected individual and crop species and mixed-species agroforestry systems and estimates of financial performance of both groups (WP8 and 9); an assessment of the most suitable financing and other measures to promote agroforestry in the two countries (WP10); and findings from a small landholder survey on the potential for agroforestry adoption in Vanuatu (WP11). Working papers 12 and 13 comprehensively examined legal and policy framework of Fiji and Vanuatu for promotion of agroforestry. Working papers 14 and 15 presented case studies on agroforestry practice in two areas in Fiji and two in Vanuatu.

Various constraints on mixed-species agroforestry were identified, including lack of knowledge of agroforestry techniques; lack of high quality germplasm (planting materials); degraded planting sites which require rehabilitation measures; lack of finance for establishing agroforestry plantings; shortage of labour for intensive landuse at particular times of the year (e.g. during cane harvest); difficulties in crop protection (including from wildfire); and uncertain land tenure for long-term land uses. Various *novel* or Pacific island tree and crop species suitable for agroforestry were identified, including species which

can be grown in areas with relatively dry winters including the rainshadow western area of Viti Levu. Priority tree species identified in one or both countries include, amongst others, sandalwood, whitewood, vesi (kwila), flueggea (poloumi), Pacific kauri, Pacific or tropical almond, breadfruit, canarium and cocoa.

Various measures to facilitate adoption of mixed-species agroforestry on underutilized land in Fiji and Vanuatu are identified, including increasing landholder knowledge, improving degraded planting sites, increasing wildfire control, facilitating finance and assuring a supportive policy environment.

Financial models were estimated for a wide range of individual tree and crop species. Thirteen of these individual species financial models were used in the development of multi-species agroforestry (MSA) system models. A further eight individual species models were not included in the MSA models, but are available as modules for further MSA modelling. In this latter group, the analysis (reported in WP8) indicates that particular timber species (including whitewood and flueggia but not vesi) will generate positive net present values, as will nut species (Polynesian chestnut and Tropical almond), avocado, banana and taro.

Considerable experimentation was required to develop a method of financial modelling of MSA systems. A Microsoft Excel workbook approach was finally adopted, with information being passed between a *summary sheet* to define the particular MSA system and integrate the findings from *individual species sheets*. The performance criteria (reported in WP 9) include NPV, site value (estimated returns from a perpetual rotation), sensitivity and scenario analysis, breakeven analysis, and estimates of annual labour requirements. A financial analysis was conducted for five MSA systems, three for Fiji and two for Vanuatu. Although confidence in these models would be increased by further validation, the analysis provides strong evidence that adoption of agroforestry systems based on priority Pacific Island tree and crop species would be financially viable and MSA models can be designed to generate early cash flows and spread labour demands to enhance the feasibility of adoption.

Overall, the financial analyses indicates an acceptable level of financial performance from growing the selected tree and crop species and mixtures at the focus locations in Fiji and Vanuatu, higher returns from the mixed-species plantings, and more marginal returns and relatively greater uncertainty of performance for forestry and agroforestry systems involving long rotations.

Key recommendations from the project include:

1. Increase production of traditional food species (fruit trees, vegetables and root crops) to substitute for food imports, through promotion of adoption of community-based agroforestry on underutilized sloping land in locations for which this practice is the ‘highest and best use’ of the land.

2. Facilitate further research into the design and implementation of agroforestry (agroecological intensification) systems including silvopastoral systems, and their financial evaluation, with accompanying documentation for extension purposes.

3. Design financial support measures for agroforestry adoption, combining a mix of incentives and facilitation measures, including measures for crop protection and ensuring that land lease arrangements provide security of tenure for landholders adopting agroforestry systems which include long-term tree crops.

4. Examine the prospects for development and new governance measures for promotion of agroforestry in Fiji and Vanuatu, having a lead agency or closer interagency arrangements for agroforestry, or formulation of a national agroforestry policy (as done in India).

5. Legal and policy reform for ensuring the security of land tenure for framers in agricultural areas and for building confidence of framers about livelihood security.

3 Background

This project is concerned with promoting sustainable agriculture and agroforestry to replace unproductive land-use in Fiji and Vanuatu. Fiji and Vanuatu are both small island economies with low population densities and low national incomes (Table 1). Agriculture is important in both countries, but particularly in Vanuatu. There has been a high rate of deforestation in both countries, and some timber plantations have now been established. Both countries have national forest policy statements, although these make only minor mention of agroforestry. Both also have recently compiled agriculture sector policies – namely *Fiji 2020: Agriculture Sector Policy Agenda* (Bacolod and Natasiwai 2014) and *Vanuatu Agriculture Sector Policy* (SPC, USAID and GIZ, c 2014) – in which importance of agroforestry is mentioned.

Table 1. Some population and landuse statistics for Fiji and Vanuatu

Statistic	Fiji	Vanuatu
Total land area (km^2)	18,270	12,200
Number of islands	332	83
Population (no.)	903,000 (2014 estimate)	257,000 (2015 estimate)
GDP (US$/person)	4,877 (2015 estimate)	2,993 (2014 estimate)
Agriculture share of GDP (%)	11.7% (2014 estimate)	22.4% (2015 estimate)

Source: Land areas and number of islands and population size from country data available in Wikipedia, and GDP estimates and agriculture share from Global Finance (2015a,b).

Fiji and Vanuatu have low human populations and areas of underutilized land and land which could be used more intensively. In their list of 'specific desirable elements' of their 'rural land use vision' for Fiji, Leslie and Ratukalou (2002, p. 6) included that the area of sugar cane grown on slopes exceeding 11° 'is greatly reduced and alternative sustainable farming systems, including agroforestry and pine plantations, are developed on the vacated marginal cane land'. Many sugarcane farms have some sloping land, and this would be an area suitable for agroforestry. Field trips to western Viti Levu also revealed other areas of underutilized sloping land. The Fiji Agriculture Sector Policy Agenda (Bacolod and Natasiwai, 2014, p. 2) noted that 'The second principal operating system to be employed in mass based modernization of the agriculture sector in Fiji is agroforestry in the upland areas where the forestry and agriculture sectors converge'.

SPC, USAID and GIZ (c 2014, p. 9) in their Vanuatu Agriculture Sector Policy noted that 'More than 90% of the land is customarily held land while about 10% is Government owned or leased land on which there is an opportunity for strategically increasing production. Nonetheless, only one third of the cultivable customary land area is presently being farmed'.

In spite of the relatively low population pressure on land use, CoA (2011, p. 21) found that Fiji and Vanuatu have negative balances for food trade (i.e. import a greater value of food products than they export), 'with a ratio of imports over exports for Fiji of more than 2:1 and for Vanuatu or about 6:1)'. As far back as 2007, it was estimated that 62% of the calories consumed by Fijians come from imported food (Food and Nutrition Centre 2010, cited by Martin, 2011). Martin further noted that locally produced root crops, including cassava and taro, provide only 11% of Fijians' daily calorie intake while largely imported rice and wheat provide 34%.

Various policy documents of the Republic of Fiji emphasise the importance of environmental protection, sustainable management and utilization of natural resources, economic development, and food security. However, these policy documents also mention the complexities in promoting sustainable agriculture. As observed in the Rural Land Use Policy for Fiji (Ministry of Agriculture, Sugarcane and Land Resettlement, 2002), attainment of sustainable land use may involve institutional and legal issues. Despite promulgation of the Rural Land Use Policy in 2002, some of these issues are still not fully addressed. This warrants further research with a view to identifying implementable strategies.

In Vanuatu, about 80% of the population is involved in agriculture, the traditional farming systems being shifting cultivation with long fallows (food gardens) and cultivation of coconut palms with a mixture of other species, and about 60% of the cultivated area in Vanuatu is occupied by coconut plantations. The large area under coconut plantations and the downward trend in copra prices also reinforce the urgency of land-use change.

The *Vanuatu Forest Policy 2013-2023* identified maintenance and enhancement of food security through agroforestry systems as a national objective. The policy also encourages the active participation and engagement with communities on forestry initiatives and design and implementation of programs and projects for integrated and sustainable forest management jointly with community stakeholders. The policy also places major emphasis on the need for harmonization of legislation on land, forests, agriculture and environment.

While sugar production in Fiji and coconut production in both countries remain highly important, there has been concern over falling export prices for raw sugar and copra. Further, the decline in agroforestry in recent decades associated with various factors – described for example by Elevitch and Wilkinson (2000) – together with urbanization and greater reliance on food imports has been considered to have negative economic and community health impacts, e.g. CoA (2011). Various studies have identified major economic, social and environmental reasons for promoting *multi-species agroforestry* or MSA in Pacific Island Countries (PICs), e.g. Thaman et al. (2000), Kumar and Nair (2006),

Nair and Garrity (2012), Atangana et al. (2014) and Connell (2015). The benefits identified for agroforestry are described in Working Paper 1 (WP1).

With their relatively low population densities, PICs including Fiji and Vanuatu have scope for more intensive land utilization, and this can be achieved in a relatively sustainable way by agroforestry, also called *agroecological intensification* (e.g. Silici, 2014). Achieving more productive land use may warrant some changes to existing policies and regulations in order to provide incentives for all stakeholders, including landowner groups and individual farmers, to promote initiative, commitment and investment for improved land use, together with technical and financial assistance.

4 Objectives and activities

Research Objective 1: Review the recent significant land-use changes in Fiji and Vanuatu, and the economic, environmental and policy circumstances driving these changes.

Activity 1.1: Examine the broad patterns of food production and self-sufficiency in rural areas.
Activity 1.2: Review the transitions which have taken place or are currently taking place, between estates or plantations and small-scale agriculture, forestry and agroforestry.
Activity 1.3: Review the planning environment (legislation, regulations and policies) in relation to significant land-use change in the project focus areas.

Research Objective 2: Assess the strengths and weaknesses of present land uses in the focus areas in Fiji and Vanuatu, and the potential for improved land uses through introduction of new agroforestry systems.

Activity 2.1: Identify the current land uses for selected elevation and slope sites in the focus areas of the two countries, through literature review, site inspections and landholder case studies.
Activity 2.2: Make a preliminary assessment of the welfare (socioeconomic circumstances) of landholders in the focus area.
Activity 2.3: Identify promising agroforestry systems to replace unsustainable land use in the focus areas, in terms of tree and other plant or animal species, products and markets, and ecological impacts.
Activity 2.4: Examine the applicability of potential agroforestry support or incentive measures in target sites of the two countries, such as provision of free seedlings of timber and fruit trees, planting grants, technical (extension) support, and more comprehensive community agroforestry programs.

Research Objective 3: Identify the attitudinal, financial, legal and policy issues associated with transitioning to sustainable agriculture and agroforestry in senile coconut plantations and marginal sugarcane lands.

Activity 3.1: Investigate landholders' willingness to change to more productive land-use practices.
Activity 3.2: Identify any legal and institutional constraints to transition to agroforestry.
Activity 3.3: Conduct financial analysis of the introduction of selected agroforestry systems in the focus areas, in terms of capital outlays, operating costs and revenue generation, through discounted cash flow analysis.
Activity 3.4: Assess the amount of financial assistance and other support measures likely to be required to encourage land-use change.

Research Objective 4. Identify any policy changes and further information needed, to support transitioning to sustainable agriculture and agroforestry in senile coconut plantations and marginal sugarcane lands in Fiji and Vanuatu

Activity 4.1: Synthesize policy findings of Objectives 1 to 3 concerning constraints and opportunities for increased agricultural development.
Activity 4.2: Explore policy options for land-use change, and identify information gaps.
Activity 4.3: Develop suggestions for further research to generate information which will support land-use transition.

5 Methodology

The research method followed the steps set out in the Executive Summary, with some variations. It was originally planned to develop about four working papers, but finally 16 working papers were produced, allowing sharing of information between project members. These working papers were prepared by literature review, field visits and discussions with partner-country participants, consultation with colleagues (including some in other ACIAR projects), and interviews of smallholders in Fiji and Vanuatu.

Preparation of working papers was assisted by the overlap in team membership between the two SRAs – ADP/2014/013 – *Promoting sustainable agriculture and agroforestry to replace unproductive land-use in Fiji and Vanuatu*, and ADP/2014/012 – *Improving livelihoods and economic progress through agroforestry schemes in degraded tropical catchments*.

An extensive literature search was conducted on land use, food production and government legislation, regulations and polices relating to forestry and agroforestry in Fiji and Vanuatu. Detailed observations were made during a total of eight field trips to Fiji or Vanuatu, including those when the inception and final project workshops were held.

Site visits were made to farming areas, forestry and agroforestry planting sites, village gardens, seedling nurseries and produce markets. Wide-ranging discussions were held with in-country research collaborators in the islands of Viti Levu in Fiji and Efate in Vanuatu, including officers from the Secretariat of the Pacific Community (SPC), Government forestry and agriculture departments, staff of the University of the South Pacific (USP) and Fiji National University (FNU), and Conservation International personnel conducting a project in the Sovi Basin. In Vanuatu a visit was made to Epi Island to view agroforestry and silvopastoral systems. Access was provided to some of the Fiji financial data and models relating to forestry and agriculture, and correspondence with ACIAR project members in the Philippines. Detailed trip reports from fieldwork were developed, to share information between project members. Opportunities to discuss project topics were also assisted by visits of Tevita Kete and Sanfred Smith to Australia.

The landholder survey work was limited to small groups of landholders in specific villages (essentially collections of case studies), for cost reasons. The assessment of existing institutional and legal arrangements was undertaken to identify challenges related to the land lease system, policy imperative for cooperation between the various government departments, and participation of other stakeholders. An assessment was made concerning where legal or policy reform is needed.

The inception workshop in Fiji (not held until 20 October 2015) allowed presentation of preliminary research findings by Australian SRA team members, as well as informative presentations by Fiji participants from the SPC, government agencies and NGOs. A set of abstracts was prepared from the inception workshop.

A key source of information about tree species (though with limited financial data) was the series on *Species Profiles for Pacific Island Agroforestry*: *Ecological, Economic, and Cultural Renewal* edited by Elevitch, C.R. ed. (2006). Progress was accelerated when the Leslie (2013) collection of *Gross Margins for Selected Fruit, Vegetable and Root Crops for the Sugar Cane Belt in Fiji* was discovered, although a considerable effort was required to convert these data into annual net cash flows, adjusted to 2015 prices. The individual species models were then adapted for use as modules in financial modelling of five promising mixed species agroforestry (MSA) financial models.

6 Achievements against activities and planned outputs

The activities and planned outputs were in general achieved, as set out in detail in Section 7 on *Key results and discussion*. In this section, comments are focussed on Research Objectives and activities for which some variations relative to the plans set out in the initial project document took place.

The treatment of Research Objective 1 concerning 'recent significant land-use changes in Fiji and Vanuatu, and the economic, environmental and policy circumstances driving these changes', was less comprehensive than that of the other research objectives. A major reason is that, while sugarcane and copra production have decreased due to price falls, these continue to be major land-use activities, and land-use change has only been gradual. Under Activity 1.2 it was found that relatively little transition has taken place between large-scale landuse (estates or plantations) and small-scale agriculture, forestry and agroforestry in recent years, so limited attention was paid to this activity.

Under Research Objective 2, Activity 2.1, concerning current land uses in the project focus areas, it was soon recognized the Lautoka/Ba area which had been suggested for focus was not well suited for agroforestry because of the relatively dry winter and hence limited species choice. As well, there had not been 'substantial abandonment of sugarcane fields', and maintaining the sugar industry remains an important national priority. Notably, agroforestry is only seen as a competitor for sugarcane on the steeper land (with slope greater than about 11 degrees) for which the current policy is not to grow sugarcane. Well into the project it was realized that Ra province (also a sugar-growing area) was more suited to agroforestry, and in fact Conservation International has been carrying out important agroforestry research in this province. As a result, the project focus area in Fiji was finally resolved to be the Ba and Ra provinces of the Western Division of Fiji, in Viti Levu.

Emphasis has been placed on opportunities, constraints and the design and evaluation of agroforestry systems, with working papers addressing these aspects. A more detailed study was conducted in Fiji than in Vanuatu, with the two workshops and more visits in the former, in part due to the SPC project partners being based in Fiji.

Under Research Objective 3, it became realized that surveys into landholders' willingness to change to more productive land-use practices, for national or regional areas and using random samples, would not be financially achievable within a SRA budget. However, several small surveys were conducted and findings reported in working papers.

Under *Research Objective 4*, underutilized land was identified in both countries so only limited attention was placed on land-use change in facilitation of agroforestry. On the other hand, it became apparent that there is much which could be done in terms of further research to support agroforestry development, so additional attention was placed on this issue.

7 Key results and discussion

These are discussed in the sequence of the four research objectives, with greater detail provided in the working papers, extended abstracts of which are included as Appendix 1.

Research Objective 1: Review the recent significant land-use changes in Fiji and Vanuatu, and the economic, environmental and policy circumstances driving these changes.

Activity 1.1: Examine the broad patterns of food production and self-sufficiency in rural areas.

As identified by Thaman et al. (2000), various phases in the evolution of landuse systems in the Pacific Islands, including Fiji and Vanuatu, can be identified. These phases commence with the first human settlement 1000 or more years ago, through 'colonial agrodeforestation' during the 19th and 20th century, when colonial governments promoted 'monocultural export cropping and livestock grazing' of coconuts, cocoa, sugarcane, and other crops. These were followed by *Post-World War 2 agroforestry* of growing cash crops and unsustainable logging, with discouragement of traditional agroforestry practices accompanied by increasing rates 'nutritional disorders', and then late *21st century agroforestry re-enrichment* when there was 'active promotion of MSA' or mixed-species agroforestry.

Literature review and fieldwork in the SRA revealed that although much has been written about priority tree species and agroforestry systems in recent years, little progress has been made in expanding plantings. A major trend in urbanization is notable, with increased reliance on food imports.

Survey work (reported in WP11, WP12 and WP13) and field visits indicate that smallholders in Vanuatu farm only small areas of land, for home consumption and with the aim of selling some produce in local and more distant larger markets, but find marketing their produce difficult. In rural areas, fruit (including breadfruit, citrus, mango) and vegetable (including root crop) gardens are common around villages in lower watercourses and some upland areas, and produce much of the food for village residents. In Fiji sugarcane production for export of raw sugar remains important, and in Vanuatu coconuts are widely grown and cattle raising (on ranches and silvopastoral systems) is important.

Activity 1.2: Review the transitions which have taken place or are currently taking place, between estates or plantations and small-scale agriculture, forestry and agroforestry.

As noted in WP5, the area planted to sugarcane and harvest tonnage in Fiji are now less than half that of the late 1980s. The sugar industry remains important in Fiji, on Viti Levu and Vanau Levu islands, and the Fiji Sugar Corporation is now aiming for larger land areas per producer, greater mechanization, and some sugar refining prior to export. Coconut oil, copra, kava and beef have been major Vanuau export products in recent years. However, FAO (2013) observed a major decline in Vanuatu production and exports of coconut products, with aging of coconut palms and lack of recent planting. Tourism has now become a major industry in both countries. The rate of change in land uses is relatively slow.

Activity 1.3: Review the planning environment (legislation, regulations and policies) in relation to significant land-use change in the focus areas.

A potential impediment to agroforestry development in Fiji is that – unlike agriculture and forestry which have particular departments in government responsible for their activities – no single department is the champion for agroforestry, which 'falls through the cracks' in terms of administrative support. Clearly, the Fiji Department of Forestry (within the Ministry of Fisheries and Forests) and Department of Agriculture (within the Ministry of Agriculture, Rural and Maritime Development and National Disaster Management) have responsibility over various facets of agroforestry. But so would the Ministry of Lands and Mineral Resources (including the Department of Lands and Surveys which is responsible for the administration of all development on State Land in Fiji), Ministry of Local Government, Housing, Environment, Infrastructure and Transport (in which the Department of Local Government oversees activities of Fiji's 12 municipal local governments), and Ministry of Industry and Trade and Tourism. As well, the iTaukei Land Trust Board (TLTB), formerly known as the Native Land Trust Board, has a major stake and influence in land use**.** In Vanuatu also, there is no single authority to champion agroforestry.

A large number of land leases have reached expiry date in the last 20 years, and a considerable number have not been renewed, creating some uncertainty over land tenure. Further, leases for agriculture do not necessarily provide rights to grow forestry or agroforestry, both of which require long duration of land tenure.

In Vanuatu, there are a number of overarching issues relevant to this context. The first is, fundamentally, a lack of a joint agroforestry strategy by relevant government departments. This may come as little surprise, given that very few countries have such policies. Nevertheless, the lack of such a policy calls into question the effectiveness of existing policies that touch upon agroforestry, particularly those policies relating to agriculture and forestry. The second, which is inter-related with the first, is the significant overlap of agroforestry-related activities across several government departments. Co-ordination and co-operation between these departments is wanting. Finally, alienation of local community from their land is major hurdle in Vanuatu in agroforestry development. Government initiatives are needed to ensure proper management of agriculture leases, particularly leases to foreigners.

Research Objective 2: Assess the strengths and weaknesses of present land uses in the focus areas in Fiji and Vanuatu, and the potential for improved land uses through introduction of new agroforestry systems.

Opportunities and constraints for agroforestry in Ba and Ra provinces in Fiji and in Efate in Vanuatu are examined in WP5 and WP6 in particular, drawing on field trip reports to Fiji and Vanuatu. A substantial area of sloping land well suited for forestry and agroforestry but not horticulture and agriculture is available, as are suitable species (timber, fruit and nut trees and short-rotation and annual food crops). Agroforestry would supplement rather than displace present land uses. However, various constraints can be identified, including in relation to grower knowledge and information sources, access to high quality germplasm, difficulty of agroforestry establishment on degraded land, the need for 'crop' protection, lack of finance, limited market availability and uncertain long-term land tenure. Design of agroforestry systems can provide an early food or income source, making this landuse more financially feasible that forestry.

Activity 2.1: Identify the current land uses for selected elevation and slope sites in the focus areas of the two countries, through literature review, site inspections and landholder case studies.

A detailed investigation of land capability has been carried out, reported in particular in WP5, 6, 11 and 12. In the project focus area in Viti Levu in Fiji, which is an important sugarcane growing area, sloping areas were found to be difficult sites for agroforestry. The 'rain shadow' nature of western Viti Levu with relatively low rainfall, a dry winter, and frequent wildfires which result in crop loss and land degradation, greatly reducing the choice of tree and intercrop species, and considerable site improvement may be required before planting. Impressing agroforestry establishment success was observed in The Nakauvadra Community Based Reforestation Project of Conservation International, located in the far north of Viti Levu in the Ra Province, commenced in 2010.

Fiji has a comprehensive Land Use Capability (LUC) classification system, based on that of New Zealand but modified in 1977 to suit Fiji's conditions, and described by Department of Agriculture (nd). Land is divided into eight classes, based on slope, drainage, soil depth, water holding capacity, extent of erosion, fertility, stoniness, rainfall and altitude. Classes I to III are considered suitable for ploughing and cropping, IV for low intensity cropping, V to VII for pastoral and forestry use, and VIII only for protection purposes. Horticulture remains a priority land use on higher quality land in the Fiji Western Division, being in general the 'highest and best use' for land classes I to III. Forestry and agroforestry are more appropriate for more sloping land classes IV to VII. Much of this land is covered with mission grass and other unproductive grasses, and is subject to frequent wildfire. Small-scale surveys in both countries reveal the growing of a wide range of food crops and some timber and fruit species, though usually as separate blocks rather than integrated into mixed-species agroforestry.

Activity 2.2: Make a preliminary assessment of the welfare (socioeconomic circumstances) of landholders in the focus area.

Smallholders typically have only small landholdings (mostly less than 5 ha), grow food crops for home use and sale, and have few animals. Small surveys suggest they have little if any machinery, few have work animals, and they lack even basic farming tools. Further problems include access to markets and technology and lack of storage facilities for agricultural produce. These militate against higher farm productivity and profitability, and undermine sustainable livelihoods in villages. The livelihoods in the villages with less secure property rights appear less sustainable. Policy implications include providing an enabling environment for the farming communities by ensuring easier access to markets and technology and creating a more secure property rights regime.

Activity 2.3: Identify promising agroforestry systems to replace unsustainable land use in the focus areas, in terms of tree and other plant or animal species, products and markets, and ecological impacts.

This was a major component of the project, and is discussed in WP7 to 9, and also the conference paper by Harrison and Harrison arising from the project. Priority tree and crop species for Fiji and Vanuatu were identified. A total of 21 financial models for individual tree and crop species were developed, with a view to their inclusion in mixed-species agroforestry (MSA) models. Through considerable experimentation, a method of financial modelling of MSA systems was developed. This involved an Excel workbook approach, with data transferred between a summary sheet and sheets for species modules. Five promising agroforestry models (AFMs) were chosen, for comparison on the basis of net present value and site value. The MSA systems are as follows:

AFM1 – Mango (*Mangifera indica*) + cassava (*Manihot esculenta*)
AFM2 – Breadfruit (*Artocarpus altilis*) + pineapples (*Ananas comosus*) + cassava (*Manihot esculenta*)
AFM3 – Citrus (*Citrifolia sinensis*) + Sandalwood (*Santalum yasi*) + Pigeon Pea (*Cajanus cajan*)

AFM4 – Cacao (*Theobroma cacao*) + sandalwood (*Santalum austrocaledonicum* or hybrid) + sweet potato (*Ipomoea batatas*)
AFM5 – Canarium (*Canarium indicum*) + plantain (*Musa sapientum*) + kava (*Piper methysticum*) + Pacific kauri (*Agathis macrophylla*)

Activity 2.4: Examine the applicability of potential agroforestry support or incentive measures in target sites of the two countries, such as provision of free seedlings of timber and fruit trees, planting grants, technical (extension) support, and more comprehensive community agroforestry programs.

Support measures which could be provided to promote agroforestry include provision of information (including increased extension services and use of demonstration plantings), making high quality germplasm more readily available, supporting crop protection (including from wildfires), market facilitation, financial support for tree planting and maintenance, and increasing the security of land tenure. Various financial support measures for forestry and agroforestry – including traditional measures and innovative funding approaches – have been examined (reported WP10). The evidence from small local surveys (effectively case studies) suggests that these kinds of assistance measures would make a substantial contribution to encouraging adoption of MSA systems. In that land preparation and plantation establishment would impose major labour demands, and divert effort from regular income-earning activities, some financial support may be critical in the first few years of establishment of agroforestry systems.

Research Objective 3: Identify the attitudinal, financial, legal and policy issues associated with transitioning to sustainable agriculture and agroforestry in senile coconut plantations and marginal sugarcane lands.

Activity 3.1: Investigate landholders' willingness to change to more productive land-use practices.

Limited survey findings (including these reported in WP11, WP12 and WP13) indicate that landholders have a strong interest in growing particular tree species, including sandalwood and whitewood, the former which is necessarily grown in an agroforestry system. Further, they would be prepared to adopt or expand agroforestry – or more intensive landuse in general – with even a relatively small amount of assistance. Uncertain tenure was not cited as a major impediment, but need to access more land was noted. Lack of knowledge and lack of even basic tools and equipment were reported as constraints, as was difficulty in obtaining markets. For some species, and notably sandalwood but also probably avocado and improved mango varieties, obtaining planting materials was obviously a constraint. It is likely that risk of wildfire risk would also be a discouragement for landholders on relatively dry sites. Overall, it would seem to be in the interests of the iTaukei land stewards to encourage land leasing, as a source of revenue from underutilized land.

Sugarcane being the way of life in Tunalia (Fiji), these problems also threaten environmental sustainability by degrading the cane growing land, as the farmers do not replace their sugarcane crop every five or so years as recommended by the Sugarcane Research Institue of Fiji. This also militates against adoption of new and improved cane varieties and makes sugarcane monoculture more deeply entrenched. The farmers in the cane growing areas of Tunalia did not support agroforestry to replace sugarcane. Instead they preferred continuation of sugcane-based farming systems with support for an enabling environment for the farming communities by ensuring easier access to markets and product storage, new technology including mechanisation, creation a more secure land tenure regime, exlanded research and extension services, and more affordable transportation of produce. Policy response may imply consolidation of holdings so that bigger farms can employ mechanical technology more effectively in sugarcane cultivation.

Smaller farmers currently growing sugarcane require support for adaptation to growing other crops including vegetables, fruit and staples to diversify their farming activities.

Activity 3.2: Identify any legal and institutional constraints to transition to agroforestry.

In Fiji, in that there has been non-renewal of some leases in recent years, tenure security for a long-term land use may be a concern for many landholders. However, in the case of community-based agroforestry by indigenous communities, this may not be a major constraint, particularly for MSA systems with a rotation life of not more than about 20 years. Some uncertainty seemed to arise about the cost of land leasing and the rental payments required, the levels of which appear to vary with land quality and with negotiation outcomes in particular cases. Extent of upward revision of land rental fees during the term of individual leases was also identified as a source of uncertainty. The shared administrative responsibility for agroforestry across government departments (hence lack of any particular agency to champion this land use) was also raised as a concern.

In Vanuatu, a major issue is alienation of land from traditional land-owners due to leasing to foreign investors. In many instances agricultural leases have been converted to other types of leases. Serious institutional reform is needed to ensure equitable and sound operation of the leasing system.

Activity 3.3: Conduct financial analysis of the introduction of selected agroforestry systems in the focus areas, in terms of capital outlays, operating costs and revenue generation, through discounted cash flow analysis.

A review was conducted of methodologies previously used to evaluate agroforestry systems (WP3). It was decided that a spreadsheeting approach using Microsoft Excel would the the simplest evaluation method and would have the capacity to deal with the amount of information in the agroforestry system models. WP2 was written to develop a shared understanding to the concepts and procedures of financial modelling by the research team.

Spreadsheet financial models of 21 tree and crop species were developed, for use as modules in mixed-species agroforestry (MSA) system models. As indicated in Activity 2.3, five MSA systems were identified, three most appropriate for Fiji and two for Vanuatu. These were modelled as Excel workbooks, with a summary sheet containing parameter values, overhead costs, cash flows, financial performance criteria, and stability analyses. The parameter values were read by module sheets for each particular species, and annual cash flow and labour requirements for each species transferred to the summary sheet.

Aggregate cash flows for all species in MSA systems and hence net present value (NPV) were obtained for each system. Internal rate of return (IRR) estimates were also obtained, but were found to be unrealistic and meaningless, due to the design of MSA systems to generate early cash flows. Sensitivity, breakeven and scenario analyses were demonstrated for some models. Sensitivity analysis (with 20% adjustments in the pessimistic and optimistic directions) provided information about the impact on aggregate system NPV of variation in yields and prices of individual species, and for impact of wage rate and discount rate on NPV. Breakeven analysis proved to be uninformative, in that some species could carry zero or even negative returns of others, within MSA systems. However, scenario analysis – in which all selected parameters are simultaneously adjusted by 20% in the pessimistic and then optimistic direction – were a useful guide to the robustness of the financial predictions.

Because rotation length varied between MSA systems, site values (land expectation values) were derived for each of the five systems. Site values effectively adjust NPVs upwards for short MSA system lives, to produce a more reliable comparison. It was found that all aggregate NPVs and site value were positive. The financial modelling process is reported in WP7 8 and 9, and a summary is provided in the conference paper of Harrison and Harrison listed in the publications in Section 11. The financial performane estimates were as follows:

Agroforestry system	AFM1	AFM2	AFM3	AFM4	AFM5
Species	Mango, cassava	Breadfruit, pineapple, cassava	Citrus, sandalwood, pigeon Pea	Cacao, sandalwood, sweet potato	Canarium, plantain, kava, Pacific kauri
Project life (yrs)	15	20	20	30	40
NPV/ha – local currency	98136	47105	230473	2693918	2775365
NPV/ha in A$	60844	29205	142893	32327	33304
LEV/ha ($A)	88855	37182	181925	35894	34911

Separate spreadsheet models have been prepared to estimate the financial performance of eight individual species as listed in the table below. These species have not been included in the MSA system financial models, but the spreadsheets are available as modules for further MSA system models. All these financial models are presented in terms of Fiji dollars, but relatively simple adjustments could be made to apply them to Vanuatu. The analyses are for a 1 ha planting, and an 8% discount rate is adopted.

Performance indicator	Whitewood (*Endospermum medullosum*)	Vesi (*Intsia bijuga*)	Poumuli (*Flueggea flexuosa*)	Polynesian chestnut (*Inocarpus fagifer*)	Tropical almond (*Terminalia catappa*)	Avocado (*Persea americana*)	Banana (*Musa spp*)	Taro (*Colocasia esculenta*)
'Project' life (yrs)	20	40	7	30	30	15	4	3
First harvest age (yrs)	20	20	7	6	3	6	1	1
NPV ($/ha)	5418	-2054	1505	11734	5084	48175	43337	20160
LEV ($/ha)	6898	-2153	3614	13028	5645	70353	163556	97785
IRR (%)	14.5%	5%	21%	16.5%	20%	>25%	>25%	>25%
Peak deficit ($/ha)	2957	4022	1709	4135	1321	2983	4765	5516
Payback period (yrs)	20	Never	7	14	13	7	1	1
Labour, yrs 1-3 (days)	75	70	53	62	32	39	260	291

Net present value and site value is positive for all species except vesi, which has a particularly long rotation. Avocado, banana and taro appear th have particularly high NPVs, though the latter two also have particularly high labour requirements. Whitewood, Polynesian chestnut and tropical almond have relatively long payback periods.

Financial modelling proved to be a highly time-consuming activity, with parameter data compiled from various sources. Only limited data validation was possible within the time and budget constraints of the SRA.

Activity 3.4: Assess the amount of financial assistance and other support measures likely to be required to encourage land-use change.

The cumulative cash flow (project balance) series generated in the single species and multi-species financial models provide an indication of the amounts by which landholders would be 'out of pocket' over time for each selected species or system, and the peak deficit or maximum amount of assistance which they would need to avoid being placed in an adverse financial situation during forestry and agroforestry system establishment. Typically, timber species have a long payback period (the harvest age) while food crops

and tree-crop combinations have a relatively short payback period. For example, the payback period of the mango-cassava agroforestry system is predicted to be one year..

The models assume that labour from the farm household is used in MSA establishment, and this labour is priced at the statutory minimum daily wage in both countries. The annual labour cost is in effect treated as an income for the household to replace that which would be lost from having to reduce off-farm work. In that intercropping is designed to generate revenue in the short term (within a year for some species but not for several years for others), agroforestry typically provides much less financial stress than single-species forestry projects.

Research Objective 4. Identify any policy changes and further information needed, to support transitioning to sustainable agriculture and agroforestry in senile coconut plantations and marginal sugarcane lands in Fiji and Vanuatu.

Activity 4.1: Synthesize policy findings of Objectives 1 to 3 concerning constraints and opportunities for increased agricultural development.

Various constraints impede more intensive land use including agroforestry, notably lack of knowledge by landholders, the need for site amelioration for establishment of trees and crops, low winter rainfall limiting species choice in some locations (especially western Viti Levu), lack of tools and equipment, lack of finance for tree and crop establishment, difficulty in crop protection (including from livestock, cyclones and wildfire), limited markets given the low population density, and uncertainty about land tenure for long-rotation species. On the other hand, some underutilized land is available, and there is in general a wide variety of high-value indigenous tree species which can be intercropped with traditional food crops, with potential to displace imports.

A wide variety of policy instruments which could be used to supporti forestry and agroforestry were identified, as outlined in WP10. These may be classed as: command and control measures (mainly used for environmental protection rather than new investment); market-based instruments; education and provision of information; joint investment ventures and managed investment schemes; improved forest and agroforest governance; land use planning; moral suasion; voluntary land stewardship approaches; national and regional NRM programs; green bonds and other commercial investment funds; and national and regional reforestation programs.

Specific support measures could be made available, with respect to provision of information, supply of high quality germplasm, financial assistance during the tree and crop establishment period, market facilitation including export promotion, and governance initiatives including providing a lead agency for agroforestry and ensuring secure land tenure of long-rotation landuses.

It is difficult for developing countries to finance measures to support forestry and agroforestry. In this context, the strategies for increasing financing flows for SFM' or sustainable forest management identified by Sue (2010) are highly relevant for both forestry and agroforestry. These include: formulate a National Forest Finance Strategy; increase collaboration with other Pacific agencies including in attracting conservation grants; encourage support from the private sector (e.g. with tax rebates); encourage SRM certification; move forestry license and service fees towards a user-pay system; provide incentives for forest establishment; encourage development of non-timber and non-wood products; levy a green fee on foreign visitors; place a levy on sales of native forests logs to fund SFM activities; promote intercropping and silvopastoral systems in young plantations; promote forest-based ecotourism; and implement the REDD+ policy.

Activity 4.2: Explore policy options for land-use change, and identify information gaps.

Land availability is not a major issue, in that both Fiji and Vanuatu have low human populations and areas of underutilized land and land which could be used more intensively (discussed in Section 3, Background). Policy options for bringing underutilized land into more productive uses can be viewed in terms of facilitation measures to overcome constraints. Perhaps the major constraints concern establishing trees on degraded sloping land, crop protection, lack of finance, and constraints on land access and security of tenure. Establishment of trees and crops may be a particular problem in the Fiji study area, where using vegetative fallows for one to three years before plantation establishment has been suggested as a solution. Financial support would be most critical in the early years of tree and crop establishment, and cash payments to support planting and early weeding – frequently employed internationally in reforestation programs – may be an effective form of facilitation. Promotion of community-based agroforestry may be desirable for the control of wildfire, land access and security of tenure. The financial modelling suggests that agroforestry establishment is likely to be financially viable from a private investment perspective. In that intervention to support land-use change is likely to involve public sector spending, an extension of the analysis to an economic (social cost-benefit) assessment would be desirable.

Activity 4.3: Develop suggestions for further research to generate information which will support land-use transition.

The limitations of a short-term SRA for investigating complex land-use issues are recognized. While substantial information has been generated in the SRA, further validation and augmentation of this information would increase the relevance and value for policy-support. This could involve further development of MSA financial modelling, more comprehensive survey work on landholder practices, attitudes and support requirements for agroforestry adoption, and further policy analysis including on the potential for a regional or national agroforestry policy.

There is considerable scope to extend and refine the financial modelling activities, beyond the 21 individual-species models and five overall mixed-species agroforestry system models now developed. This could include:

- development of more financial models for individual timber, fruit and nut tree and food crop species;
- development of financial models for silvopastoral systems, e.g. raising tethered beef cattle and goats on improved pastures.
- further research into the design of financially viable MSA systems, and development of additional MSA system models;
- comparison of the financial performance of indigenous or traditional Pacific Island tree species versus exotic tree species such as conifers, eucalypts and acacias (which may greater ability to grow on degraded sites and greater wildfire tolerance), and of MSA systems containing these species;
- providing more details of the pattern of annual cash flows, including project balances, peak deficit and payback period, to provide a clearer picture of financial support required for agroforestry adoption;
- carrying out further validation testing of the financial models (including Delphi surveys on parameter values, tests of model face validity by ‘experts’, and generally increasing confidence in financial models through their further applications).
- improving the estimates of overhead costs, including the cost of land access (e.g. lease establishment and annual rental charges), of site clearing and land preparation, and of acquiring containers, tools and equipment;
- investigating the impact of site and management quality on financial performance of MSA systems (using the facility already developed in the current MSA models); and

- making the MSA financial models more user-friendly, e.g. by adding user menus, data entry error trapping, help files and report production routines.

A number of other research activities could be undertaken in relation to improved landuse:

- Conduct a larger and more detailed landholder survey into current landholder resources and land-use practices (including forestry and agroforestry practices), attitudes to agroforestry, and support measures considered necessary to adopt or expand agroforestry. Such a survey could also investigate the tree and crop yields achived by smallholders, and farm-gate prices received for produce (which may be muct lower than market prices).
- Broaden the agroforestry focus to consider agroecological intensification and resultant benefits, which are now receiving major international research interest, and provide a wider environmental perspective on agroforestry.
- Adopt a broader cost-benefit approach to the evaluation of MSA systems to be established in sensitive sites, e.g. riparian, coastal and tourism areas. This would require estimating not only the private financial costs and benefits of agroforestry expansion but also the environmental and social costs and benefits to the wider community. Such non-market costs and benefits could be estimated by the benefit-transfer method (adapting monetary estimates from other studies) or environmental choice modelling (a stated preference method involving estimates of landholder preferences between alternative choice sets). In this way the justification for forestry or agroforestry establishment could be examined in terms of total economic value (TEV), to allow comparison with other national priorities, to support policy-making.
- Develop an illustrated briefing paper on ‘crop’ protection strategies for large downside cost events including major pest and disease damage, windstorms (cyclones) and wildfire, as an aid to agroforestry extension. Also, develop an illustrated briefing paper on financial analysis of mixed-(or multi-) species agroforestry systems, to explain the approach which has been developed by experimentation in the SRA, and promote further MSA financial and economic evaluation.
- Conduct field trials in communities on agroforestry establishment and management, perhaps using new graduates or industrial-placement students as trainee facilitators and also providing some high-quality germplasm for plantation establishment.
- Examine the prospects for development of a national or regional agroforestry policy statement for Fiji, along the lines of the National Agroforestry Policy (NAP) recently introduced in India, the ‘overarching national policy’ for agroforestry proposed for Vietnam, and the ‘USDA Agroforestry Strategic Framework, Fiscal Year 2011–2016’ which states the intention to ‘Issue a policy statement in support of agroforestry’.

8 Impacts

It is difficult to predict the impacts of this SRA, given it's relatively short duration and small budget, hence limited extension component. In terms of scientific impacts, although the SRA is not a science project, we feel that some impact has been made through the working papers, in terms of agroforestry system design, and site preparation and crop protection on degraded sites. The method developed for financial evaluation of mixed-species agroforestry systems would be expected to make a contribution to capacity building, with respect to evaluating the financial returns, extent of risk and labour requirements of these systems.

The community, economic and social impacts will depend on the extent to which the land-use intensification advocated by the project is taken up by government, in-country agencies (including the Secretatiat of the Pacific Community, Department of Forestry in Fiji, and Department of Industry, Ministry of Trade, Commerce, Industry and Tourism in Vanuatu), NGOs and landholders. It has been demonstrated in the project that posive financial returns can be generated from individual tree and crop species, with 21 financial models for individual species developed, which could encourage the growing of these species on underutilized farm land. Integration of species models into agroforestry system models is also demonstrated, but further analysis and demonstrations at trial sites may be required to promote uptake. The project findings also emphasize environmental benefits from growing Pacific Island tree and crop species, and provide suggestions in relation to policy analysis.

A strength of the project has been the communication and dissemination activities. Two workshops for various agencies, and direct communications with SPC and government officers and NGO staff, have made research findings more widely available. The working papers have been made available to SPC officers.

Apart from the activities listed in the original project proposal, an internship program has been created in SPC from this project with special permission of the research project manager. Two students from Fiji National University will undertake internships for six months under this project. One student has already commenced the internship and another student will soon be selected by SPC. These internees will carry out some survey and other data collection work over the next six month for further development of working papers developed form this project. They will also help to disseminate the findings of the project at the local level. These internships will be helpful for further implementation of findings of this project and capacity building of local researchers. The project leader will make a follow-up visit in Fiji after the completion of the project to train the interns for further surveys and dissemination of information developed by this research project.

9 Conclusions and recommendations

Expansion of mixed-species agroforestry (MSA) in Fiji and Vanuatu offers many potential benefits, in terms of livelihoods and social and environmental improvement. Underutilized land is available for planting. Financial analysis of a number of MSA system designs indicates that these can generate high returns for adoptors. Further, by intercropping and producing food crops or generating early income, agroforestry can have much greater financial feasibility than forestry, and require less financial assistance, yet generate a valuable future asset for farmers.

On the downside, a number of constraints are apparent, and various facilitation measures will be required. The major recommendation is that steps be implemented to overcome these constraints and promote agroforestry development. This promotion could include provision of increased extension advice, support for access to improved germplasm (including support for community seedling nurseries), promotion of improved crop protection measures (including for prevention of wildfire), provision of financial assistance for initial establishment of agroforestry, and a supportive policy and governance environment.

In terms of providing information for current and potential agroforestry adoptors, extension advice is needed on technical and financial aspects. Technical information would be helpful on on: seedling production; species-site matching and priority tree and crop species; and silviculture, including crop protection from pests, diseases, windstorms and wildfire. Establishment of more demonstration sites could also increase landholder interest. Further financial information is desirable on individual tree and crop species and on species mixtures, as well as on product marketing. In terms of financial assistance to growers, traditional support measures and innovative methods for generating funds are needed.

In that investment in any long-term landuse requires confidence in tenure security, a priority for community-based agroforestry management rather than individual farmer (individual property rights) plantings seems desirable. The community approach has advantages in negotiation of long-term property rights and providing a more regular workforce when needed, and has a greater capacity for crop protection (including prevention of wildfire).

This has been a productive SRA, but there are many areas where more detailed investigation into smallholder agroforestry or agroecological intensification in Fiji and Vanuatu is desirable, to shed more light on how to promote productive and sustainable landuse in these countries. Suggestions for further research are summarized in Section 7 under results for Activity 4.3.

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11 List of publications produced by this project

Working papers – extended abstracts of the following 16 working papers are provided in Appendix 1:

1 The Contribution of Agroforestry to Economic Development in Fiji and Vanuatu – Steve Harrison, Saiful Karim, Mohammed Alauddin and Robert Harrison

2 Modelling Approaches for Multi-species Agroforestry Systems – Steve Harrison and Robert Harrison

3 Evaluating the Financial Performance of Individual Tree Species for Forestry and Agroforestry in Fiji and Vanuatu – Steve Harrison

4 Non-market Values of Agroforestry Systems and Implications for Pacific Island Agroforestry – Steve Harrison, Robert Harrison, Caroline Sullivan and Saiful Karim

5 Opportunities and Constraints to Agroforestry Expansion on Underutilized Land in Western Viti Levu, in Fiji – Robert Harrison and Steve Harrison

6 Rehabilitation of Degraded Land for Agroforestry Establishment in Western Viti Levu, Fiji – Steve Harrison and Robert Harrison

7 Priority Tree Species and Potential Agroforestry Species Mixtures for Fiji and Vanuatu – Steve Harrison and Robert Harrison

8 Financial Models of Multi-Species Agroforestry Systems in Fiji and Vanuatu – Steve Harrison and Robert Harrison

9 Multi-Species Financial Models and Explanatory Notes – Steve Harrison and Robert Harrison

10 Assistance Measures for Smallholder Forestry, with Particular Reference to Fiji and Vanuatu - Steve Harrison and Robert Harrison

11 Prospects for Agroforestry in Vanuatu: Findings from a Survey in Two Villages in Vanuatu – Steve Harrison and Lazarus Aising

12. Policy and Legal Framework for Promoting Sustainable Agroforestry in Fiji: An Overview – Md Saiful Karim, Samuela Lagataki, Mohammad Alauddin, Sairusi Bulai, Tevtia Kete and Alexander Button-Sloan

13 Policies and Laws for Promoting Sustainable Agroforestry in Vanuatu – Md Saiful Karim, Mohammad Alauddin and Alexander Button-Sloan

14 Agroforestry and Sustainable Livelihoods in Vanuatu: Insights from Two Case Studies – Mohammad Alauddin, Md Jahangir Kabir and Md Saiful Karim

15 Agroforestry and Sustainable Livelihoods in Fiji: Two Case Studies – Mohammad Alauddin, Md Jahangir Kabir and Md Saiful Karim

16 Capturing the benefits of ecosystem services to support poverty alleviation: how agroforestry can provide opportunities for Fiji and Vanuatu – Caroline A. Sullivan and J. Maiden

Conference paper

Harrison, S. and Harrison, R. (2015), Financial Modelling of Mixed-species Agroforestry Systems in Fiji and Vanuatu, Based on Traditional Tree Species, paper presented at the conference on ‘Small-scale and Community Forestry and the Changing Nature of Forest Landscapes’, University of the Sunshine Coast, 11-15 October, Maroochydore, Queensland.

12 Appendices

12.1 Appendix 1: Abstracts of the Working Paper Series Developed in the Project

1 The Contribution of Agroforestry to Economic Development in Fiji and Vanuatu – Steve Harrison, Saiful Karim, Mohammed Alauddin and Robert Harrison

Multi-species agroforestry has been for centuries a widely practiced landuse in the Pacific Islands, including in Fiji and Vanuatu. Various forms of agroforestry are practiced, the most widely recognized being mixed-species plantings involving timber, fruit or nut trees intercropped with root crops and other food crops, and silvo-pastoral systems such as 'cattle under coconuts'. During and after colonial times, a major decline in agroforestry practice has taken place. Home and village gardens now have a reduced role as a source of food for households in Fiji and Vanuatu. Current trends of urbanization, cash cropping and heavy reliance of food imports together with reduced prices for previously major export crops have made the need to encourage multi-species plantings particularly apparent. A comprehensive literature review reveals that an impressive range of benefits can be attributed to multi-species agroforestry. These include: agricultural diversification and genetic conservation; carbon capture; catchment protection and rehabilitation; strengthening of agricultural infrastructure; increased self-sufficiency in timber and fuelwood; reduced need for food imports; poverty reduction; improvement in the nutritional status of the people and associated health benefits; improved utilization of degraded and marginal cropping land; improved wildlife habitat; and landscape amenity. While agroforestry is a more complex type of landuse than monoculture timber plantations, it also offers greater benefits. However, agroforestry is not generally the responsibility of any individual government department, and new forms of governance may be needed to provide a more supportive environment for renewed adoption.

2 Modelling Approaches for Mixed-species Agroforestry Systems – Steve Harrison and Robert Harrison

Given their complexity, the design and evaluation of agroforestry systems has been a challenging task for researchers. A 'tripple bottom line' evaluation in terms of financial, social and environmental impacts is called for. This working paper was developed to select a logical and consistent modelling approach for multi-species agroforestry (MSA) systems, with particular emphasis on predicting financial performance. A number of potentially suitable modelling approaches and software packages are reported in the literature. These have typically used third and fourth generation computer programming languages and modern software packages (notable spreadsheet packages). The *Australian Cabinet Timber Financial Model* (ACTFM) was developed to predict potential returns from small-scale plantations of north Queensland high-value mixed species rainforest cabinet timbers for which there was little experience of plantation commercial production. The New Zealand *Agroforestry Estate Model* (AEM) was designed to evaluate agroforestry in combination with other farm activities. The *Agroforestry Modeling Environment (AME)* was designed as an object-oriented modelling tool to graphically visualize, construct, integrate and exchange agroforestry models. The AME was subsequently developed into the *SIMILE* simulation package designed for building general ecology models. Nowadays, with the continued development of spreadsheet packages (notably Excel), increasing use is being made of this software for forestry modelling. While spreadsheets are widely used in the timber industry and in forestry research projects, their

use for design and evaluation of complex multi-species agroforestry systems is less well exploited. An intuitively powerful approach is to develop multispecies agroforestry financial models in an Excel workbook, with separate spreadsheets within the workbook for individual species. In support of this approach, a suite of financial models for individual species could be developed as modules which can be combined relatively quickly to evaluate various multispecies agroforestry designs.

3 Evaluating the Financial Performance of Individual Tree Species for Forestry and Agroforestry in Fiji and Vanuatu – Steve Harrison

Growing a small woodlot or agroforestry stand can be considered as a type of investment project. In that tree species can take many years to generate income, application of discounted cash flow (DCF) analysis is appropriate. This paper concerns the application of DCF analysis from the perspective of private investment project assessment (IPA), as distinct from social cost-benefit analysis (CBA). In IPA, relevant cost and revenue items for the landholder are identified, and annual net cash flows (annual project revenue less capital outlays and operating costs, for the difference between the with-project and without-project cases), are computed over the project life, which depends on the longest species harvest age. In evaluating the financial acceptability of a forestry or agroforestry project, the performance criteria of net present value (NPV), internal rate of return (IRR), peak deficit and payback period are useful. Some topics treated in detail include constant versus current price analysis, the concepts of opportunity costs and sunk costs, determining the discount rate, cash flow variables most difficult to estimate (including work rates, labour costs, plant protection costs, estimating market and farmgate product prices, deriving yield estimates or yield curves, determining post-harvest processing needs and costs), and testing the financial model (verification, validation and sensitivity analysis). A distinction is made between returns to capital and to other resources (particularly labour and land). An example or an Excel spreadsheet for a particular forestry species (*Flueggea flexuosa* or *poumuli*) is presented and some of the important spreadsheet formulae explained. A reliable evaluation of the costs and returns to growers from investment in agroforestry is critical for developing policies to support agroforestry. Conversely, cost-benefit analysis would be appropriate to determine what level of expenditure is justified to support agroforestry expansion from the *social* or national perspective. This would require estimation of the broader social costs and benefits of agroforestry expansion for timber and food production but also social and environmental benefits (e.g. protection or improvement of riparian and coastal areas)..

4 Non-market Values of Agroforestry Systems and Implications for Pacific Island Agroforestry – Steve Harrison, Robert Harrison, Caroline Sullivan and Saiful Karim

In general, financial analysis of forestry and agroforestry investments do not take into account the broader social, environmental, cultural, traditional and other benefits of these systems. Hence this paper examines methods of estimating *non-market* values to provide policy support. Such values would have relevance with respect to carbon sequestration, sea level rise, watershed protection, preserving mangrove areas and coastal fisheries, improving the supply of healthy food products to improve public healt, and in general a wide range of policy areas. Under social cost-benefit analysis, if the overall benefits – private, social and environmental – are found to exceed the costs (or the benefit-to-cost ratio is greater than 1.0), a project is considered to be justified on *economic* grounds. Because some important benefits are not reflected in market transactions, various methods have been developed to estimate values of non-market goods and services, a few of the better known including: *travel cost method* (TCM) for valuing recreation

benefits; *contingent valuation method* (CVM) for estimating consumer willingingness-to-pay (WTP) for a wide package of benefits; and *environmental choice modelling*, which breaks WTP down into a number of components. The *hedonic price method* (HPM) is used to estimating values associated with market transactions, such as the values of attractive landscapes, low noise and proximity of public transport, with these estimated by their impact of property prices (i.e. as *revealed* rather than just stated preferences). In practice the *benefit transfer method* (utilizing values adopted from previous research rather than conducting new and costly evaluation efforts) is often used as a convenient expedient for non-market values. Many databases of environmental values have been developed, which allow values from a source site to be inferred for a target site. The importance of watershed protection or remediation is well recognized in Fiji and Vanuatu. Flooding is often associated with cyclones, and can have serious impacts on tourism sites, cropping areas and watercourses. Various Pacific Island tree species have wide-spreading root systems and are well suited for streambank and coastal land stabilization. Revegetation of these areas can have considerable non-market benefits. Estimation of values of such benefits – say by CVM or benefit transfer – could be used to place dollar values on riparian and coastal tree plantings, and to guide government policy as to whether such investment would be justified on broad socio-economic grounds.

5 Opportunities and Constraints to Agroforestry Expansion on Underutilized Land in Western Viti Levu, in Fiji – Robert Harrison and Steve Harrison

Fieldwork in western Viti Levu reveals that a substantial area of land is underutilized, including in the sugar cane belt. In many cases the allotments leased contain some sloping land that is not suitable for cane production but would be suitable for agroforestry. Opportunities for agroforestry arise from: a large number of useful tree species (including high quality timber species) and food crop species; a chance to generate potentially large private and social benefits; and history and skills base in growing agroforestry. The constraints appear to include: relatively low rainfall in winter months limiting species choice; degraded land due to deforestation and frequent wildfire; insufficient resources of landholder for establishing agroforestry plantings; high management complexity of mixed-species agroforestry systems, including for crop protection; relatively low domestic timber demand and prices; supply and value chain issues for non-timber agroforestry products; land tenure uncertainty for long rotation land uses; and lack of a lead agency for promoting this land use. Wildfire appears to be a major disincentive to establishing forestry and agroforestry, with numerous reasons for lighting fires being identified, including clearing land for planting, removing rubbish and stinging insets for cane harvesting, removing tall grass (notably mission grass) to gain short-term grazing for livestock, to clear walking tracks, to help hunt wild pigs, and to control insects and diseases of crops. The constraints identified suggest scope for policies to create a more favourable situation for forestry and agroforestry investment. Some relevant facilitation measures include: trials on improving degraded land at planting sites; a coordinated effort on wildfire control, probably at community level and including a fire surveillance system; improving the institutional environment for agroforestry planting, for example by developing a regional or national agroforestry statement or plan; increased use of demonstration sites and provision of extension service; provision of more financial information on the expected costs and returns from agroforestry plantings; and carefully designed financial assistance measures.

6 Rehabilitation of Degraded Land for Agroforestry Establishment in Western Viti Levu, Fiji – Steve Harrison and Robert Harrison

The benefits from establishing mixed-species agroforestry in Pacific Island countries are widely recognized. Some underutilized land exists in western Viti Levu in Fiji, including in areas where sugarcane growing has ceased due to low profitability and where unproductive grasses subject to regular burning are found. Two major problems are investigated in this paper, viz. establishing agroforestry on degraded sites, and protecting planted areas from subsequent damage due to fire or other causes. The literature on reforestation of degraded areas provides insights into methods for 'regreening the bare hills', particularly concerning choice of tree species or mixtures and establishment methods. For fire prevention, a combination of policy measures (e.g. community awareness raising, use of fire wardens, training of canegrowers on green harvesting) and establishment of firebreaks and fuelbreaks (using fire-resistant tree species and silvopastoral areas) would appear to offer potential. Community or group action appears to offer greater potential for success than action by individual landholders. Setting up of trial and demonstration sites of agroforestry establishment and crop protection would allow the agroforestry strategies identified to be tested and landholder knowledge about agroforestry establishment and protection to be increased.

7 Priority Tree Species and Potential Agroforestry Species Mixtures for Fiji and Vanuatu – Steve Harrison and Robert Harrison

A major challenge for the promotion of agroforestry expansion in specific locations in Fiji and Vanuatu is to identify species mixtures which are technically suitable and viable in terms of resource demands and financial performance. In ACIAR project ADP/2014/013 – *Promoting sustainable agriculture and agroforestry to replace unproductive land-use in Fiji and Vanuatu*, an attempt has been made to identify mixed-species agroforestry (MSA) systems suitable for adoption on underutilized land in the Fiji Western Division in Viti Levu, and in unproductive coconut plantation land on Efate Island in Vanuatu. In this context, information has been obtained about site requirements of priority Pacific Island tree species, and other tree and crop species suitable for use with these in agroforestry systems. This has involved a major literature review, as well as site visits, discussions with officials concerned with natural resource management, and landholder surveys. Based on information about priority species in the two countries, together with information on species-site matching, a suite of financial models for single tree and crop species has been developed for the focus areas of the ACIAR project. The financial models for individual species can be used in carrying out financial analysis of overall MSA systems, to assist in identifying promising systems and support measures which would be required to promote them, from a land-use policy perspective. Needless to say, some validation of the individual-species models, and of the overall MSA system models, is needed before these can be promoted for specific areas.

8 Financial Models of Multi-Species Agroforestry Systems in Fiji and Vanuatu – Steve Harrison and Robert Harrison

This paper brings together many of the considerations on multi-species agroforestry examined in the earlier working papers. The complexities in designing multi-species agroforestry (MSA) mixtures for particular settings are examined. Some parallels and differences are drawn between designs of mixed-species plantation systems that were adopted for rainforest cabinet timbers in tropical north Queensland and MSA systems for ACIAR project focus locations in Fiji and Vanuatu. It is demonstrated that for various reasons the design and financial analysis of MSA systems is much more complex than that of mixed-species timber plantations; various biophysical and socioeconomic factors must be taken into consideration in designing coherent mixtures. In developing MSA

system financial models for Fiji and Vanuatu, considerable effort was required to carry out species-site matching for priority tree species, determine technical aspects (such as site amelioration, species compatability, shading requirements and equipment needed), examine labour requirements and cash flows over time, and sketch field layout diagrams for species mixtures including the pattern of intercropping and how this would change over time. Finally, five MSA models which have a relatively high likelihood of being successful in Fiji and Vanuatu according to biological and financial criteria were identified and their rationales described. Detailed financial performance estimates for these models are provided in Working Paper 9. As well, financial performance has been estimated for eight priority tree and crop species not included in the MSA models, but available as modules for further agroforestry system designs. A table of financial performance for these eight species and interpretation of the findings is provided in this working paper. Calculations have been made in Fiji dollars per hectare of planted area. These species and estimated net present values, and land expectation values as a better criterion for comparison of species, are as follows: whitewood $5,418 ($6,898), vesi -$2,054 (-$2,153), flueggia $1,505 ($3,614), Polynesian chestnut $11,734 ($13,028), tropical almond $5,084 ($5,645), avocado $48,175 ($70,353), banana $43,337 ($163,556) and taro $20,160 ($97,785). The latter two species have particularly high labour requirements.

9 Multi-Species Financial Models and Explanatory Notes – Steve Harrison and Robert Harrison

This working paper provides screenshots of the financial models of the five mixed-species agroforestry models selected in Working Paper 8, together with notes to explain the structure and interpretation of these models. The Excel *workbook* for each multi-species agroforestry system consists of a set of spreadsheets, including a first or *summary sheet* and a sheet for each individual *species module*. For each MSA system, the summary sheet contains the key parameter values of the system, and these are referenced by the spreadsheets for individual species. Conversely, the summary sheet for each system references the cash flow sequences for each individual species module to compile a summary of financial performance for the overall agroforestry system. Each species module is for a standard area unit of 1 ha, and all use a discount rate of 8%. Estimates of annual capital outlays, operating costs and revenue generated are presented for each individual species, to derive the annual net cash flows. Annual labour requirements are also estimated. The currency units are those for the country to which the MSA is best suited (Fiji dollars or Vanuatu vatu). In the summary sheet, the overall net present value (NPV) is computed for each species mixture. Sensitivity analysis, breakeven analysis and scenario analysis (where optimistic or pessimisting values for all parameters are considered simultaneously) are demonstrated. Notably, these have not been performed for individual tree and crop species, the financial analyses being designed to evaluate overall agroforestry systems, not individual components of them. Because the overall rotation length varies between MSA systems, the financial performance of all systems are compared on the basis of *site value* or *land expectation value* (the sum of NPVs for a *perpetual rotation*). It is found that given the parameter values and other assumptions of the analyses all the selected species mixtures would generate positive returns. NPV estimates per hectare for the five multi-species agroforestry systems in local currencies (Fiji dollars and Vanuatu Vatu) and Australian dollars are summarized in the following table. MSA species mixtures 2, 4 and 5 have very similar LEVs, considerably lower than those for mixtures 1 (dominated by mango) and 3 (dominated by sandalwood).

Species	Mango, cassava Fiji	Breadfruit, pineapple, cassava, Fiji	Citrus, sandalwood, pigeon Pea' Fiji	Cacao, sandalwood, sweet potato Vanuatu	Canarium, plantain, kava, Pacific kauri, Vanuatu

Project life (yrs)	15	20	20	30	40
NPV – local currency	98136	47105	230473	2693918	2775365
NPV in A$/ha	60844	29205	142893	32327	33304
LEV ($/ha)	88855	37182	181925	35894	34911

10 Assistance Measures for Smallholder Forestry, with Particular Reference to Fiji and Vanuatu – Steve Harrison and Robert Harrison

A wide variety of approaches have been adopted to support forestry and agroforestry, to ensure future timber supply, household livelihoods and environmental benefits of vegetation in the landscape. This working paper reviews the measures to promote forestry at the national, regional and individual smallholder level, in various countries, but with particular emphasis on those trialled, proposed or potentially suitable for Fiji and Vanuatu. In general, measures include command and control instruments (most often concerned with environmental protection), market-based instruments (various subsidies and grants, e.g. free seedlings, assistance with planting, payments for early weed control), moral suasion, provision of information (e.g. field days on how to establish a nursery and produce seedlings, plant trees or wildlings, carry out pruning and thinning, and generally to progress to best management practice), plantation joint venture or shared equity schemes, more supportive land-use policy, governance and planning schemes (including removal of impediments to planting and selling produce), and introduction of national and regional greening programs with substantial funding support. Some innovative approaches for funding large-scale programs to support forestry and agroforestry are identified. In general, a mix of instruments is likely to be the most effective approach. On the basis of this evidence, policy implications are drawn for promotion of agroforestry in Fiji and Vanuatu.

11 Prospects for Agroforestry in Vanuatu: Findings from a Survey in Two Villages in Vanuatu – Steve Harrison and Lazarus Aising

A small survey was conducted to explore smallholders' attitudes to agroforestry in the villages of Epau and Etas on Efate Island in Vanuatu. Land areas of farmers were found to be small (not more than about 5 ha), and the lack of farming equipment was notable. Strong interest was found in growing whitewood and sandalwood, which are relatively short-rotation species with high value timber. Various food crops were also grown, including citrus, vegetables, and notably 'sea cabbage', and were sold locally and in Port Vila. Some integration of timber trees and food crops was noted, although no particular mixtures could be identified as favoured. Major constraints over expansion of mixed-species agroforestry included lack of land, lack of finance, and concern about availability of markets for farm-grown produce. The lack of more than very basis tools and equipment, which would make tree planting and maintenance difficult, was also apparent. It would appear that even a small amount of assistance would encourage greater agroforestry adoption. Assistance measures identified as encouraging increased agroforestry included provision of finance, improved market access, access to more farming land, and funding for purchase of hand tools and other equipment (e.g. chainsaws), and fencing. Mention was also made of extension and provision of planting materials.

12. Policy and Legal Framework for Promoting Sustainable Agroforestry in Fiji: An Overview – Md Saiful Karim, Samuela Lagataki, Mohammad Alauddin, Sairusi Bulai, Tevtia Kete and Alexander Button-Sloan

This paper identifies and discusses some of the key legal and policy issues in developing sustainable agroforestry on unproductive land in Viti Levu. Much of this land has become unproductive predominately because of the decline in Fiji's sugar industry, on which the country has long relied. Interest in other land uses has thus emerged. It is pertinent to examine the opportunities and constraints facing the promotion of sustainable agroforestry development. Unfortunately, however, recent reports indicate that only a very minimal amount of agroforestry is being practised in Fiji. The review of relevant laws and policies shows that for promotion of agroforestry and land conservation some major policy initiatives will be necessary in Fiji including *inter alia*:

- A national strategy of agroforestry for better cooperation between different government departments should be developed clearly identifying responsibilities for each relevant department.
- Initiatives should be taken for ensuring the security of tenure for framers in the agricultural lands and for building confidence of framers about livelihoods security thereby encouraging them for long-term investment and commitment for sustainable agricultural practices including agroforestry.
- Reform and revitalisation of the Land Conservation Board to ensure proper functioning of the Board including provision for adequate human and financial resources.
- The *Fiji 2020 Agriculture Sector Policy Agenda* states "The MOA [Ministry of Agriculture] is currently responsible for over 33 pieces of legislation. It is foreseen that all the acts specified under the ministerial assignment must be reviewed and be ensured that there is no conflict between policy interpretations of existing acts. The consolidation of the law into an omnibus legislative act provides a better structure for common understanding so that anything that is in line with agriculture development can be put together in just one piece of legislation." The proposed omnibus legislative act should include provisions for promotion of agroforestry.
- In some countries a legal framework has been developed for managing and promoting community agroforestry/social agroforestry development in partnership with government and farmers groups. Fiji may explore this option through a feasibility study to encourage indigenous landowning units for community agroforestry projects on the public private partnership (PPP) basis.

13 Policy and Legal Framework for Promoting Sustainable Agroforestry in Vanuatu – **Md Saiful Karim, Mohammad Alauddin and Alexander Button-Sloan**

Enabling legal and policy formwork is important for development of agroforestry. This paper identifies and discusses some of the key legal and policy issues arising with respect to Vanuatu's move to develop sustainable agroforestry. There are a number of overarching issues relevant to this context. The first is, fundamentally, a lack of a joint agroforestry strategy by relevant government departments. This may come as little surprise, given that few countries have such policies. Nevertheless, the lack of such a policy calls into question the effectiveness of existing policies that touch upon agroforestry, particularly those policies relating to agriculture and forestry. The second, which is inter-related with the first, is the significant overlap of agroforestry-related activities across several government departments. Co-ordination and co-operation between these departments is wanting. Finally, alienation of local community from their land is major hurdle in Vanuatu in agroforestry development. The government should take immediate initiatives for management of agriculture lease particularly lease to foreigners. As noted earlier, an enabling legal and policy framework is needed for promotion and

sustainable development of agroforestry in Vanuatu. In this regard the following can be undertaken:

- A national strategy of agroforestry for better cooperation between various government departments should be developed clearly identifying responsibilities for each relevant department.
- The Vanuatu government should take immediate initiatives for management of agricultural leases, particularly lease to foreigners.
- An effective land use planning system should be established.
- Creation of an enabling legal and policy framework for agro-based industry is needed.
- Recognition of agroforestry as a specialised sector in the future agricultural legislation.
- In some countries legal framework has been developed for managing and promoting community agroforestry/ social agroforestry development in partnership with government and farmers' groups. Vanuatu may explore this option through a feasibility study to encourage indigenous landowning units for community agroforestry projects on the public private partnership (PPP) basis.

14 Agroforestry and Sustainable Livelihoods in Vanuatu: Insights from Two Case Studies – Mohammad Alauddin, Md Jahangir Kabir and Md Saiful Karim

This paper provides a brief overview of the agroforestry systems in Vanuatu through case studies on two contrasting villages in the Efate Island, Vanuatu. One village is more settled and is characterised by secure property rights while the other is a newly settled village with a less secure property right regime. Common problems facing the both villages relate to access to markets and technology and lack of storage facilities for agricultural produce. These militate against higher farm-productivity and profitability, and undermine sustainable livelihoods in both villages. Policy implications lend support for providing an enabling environment for the farming communities by ensuring easier access to markets and technology. This calls for strengthening the agricultural research and development and extension services and stronger marketing and storage agencies. The livelihoods in the village with less secure property rights appear less sustainable.

15 Agroforestry and Sustainable Livelihoods in Fiji: Two Case Studies– Mohammad Alauddin, Md Jahangir Kabir and Md Saiful Karim

This paper presnts two case studies on agriculture and agroforestry systems in two contrasting farming settlements in the Veti Levu Island, Fiji. The settlements differ in terms of cropping systems and land tenure regimes. One settlement has its livelihoods based on diversified cropping systems including agroforestry while the other practises sugarcane-based farming systems. One settlement is characterised by secure property rights while the other has a less secure property right regime. Common problems facing the both villages relate to access to markets and improved technology, obtaining fair prices for agricultural produce, high transportation cost, vulnerability to natural disasters, and access to credit and research and extension services. Problems specific to the sugarcane-based farming systems relate to land tenure security, non availability of sugarcane farm workers during harvesting season and lack of labour-saving technology. This argues that support for providing an enabling environment for the farming communities by ensuring easier access to markets and storage, technology including mechanisation and creating a more secure land tenure regime, research and extension services, and affordable transportation cost is needed. Policy response may imply consolidation of holdings so that bigger farms

can employ mechanical technology more effectively in sugarcane cultivation. Smaller farmers currently growing sugarcane require support for adaptation to growing other crops including vegetables, fruits and staples to diversify their farming activities.

16 Capturing the benefits of ecosystem services to support poverty alleviation: how agroforestry can provide opportunities for Fiji and Vanuatu – Caroline A. Sullivan and J. Maiden

The problem of land degradation is widespread across the world. In small island states, where land resources are already limited, this is of particular concern. One option to address this is through the expansion of landscape stability, by increasing tree density through agroforestry. This paper discusses how the goods and services supplied by tropical forest ecosystems in Pacific Island states like Fiji and Vanuatu, can be harnessed through an expansion of agroforestry. If this can be achieved, it will have a beneficial effect both in addressing land degradation, and in strengthening local livelihoods.