RESCCUE

Afforestation of degraded hill land: An overview of the benefits and costs of implementation for practitioners

Pam Booth, Suzie Greenhalgh, Patrick Walsh, Isoa Korovulavula and Lekima Copeland

March 2018

Pacific Community
Communauté du Pacifique

Manaaki Whenua
Landcare Research

AFD

FFEM
FONDS FRANÇAIS POUR L'ENVIRONNEMENT MONDIAL

USP
FACULTY OF SCIENCE TECHNOLOGY AND ENVIRONMENT
Institute of Applied Sciences

Preferred citation:

Booth P, Greenhalgh S, Walsh P, Korovulavula I, Copeland L. 2018. Afforestation of degraded hill land: An overview of the benefits and costs of implementation. Prepared as part of the RESCCUE-SPC Fiji project. University of South Pacific – Institute of Applied Sciences, Suva, Fiji.

Acknowledgements:

Our thanks goes to the communities in the Ra province. We would like to give our special thanks to the members of Naraviravi, Vunisea and Nalalawa who spent time to outline the benefits they derived from afforestation. Last we would like to thank Ben Wiercinski for his review, Anne Austin for editing and the team at USP for layout.

Table of Contents

Purpose....4

Background....4

The value of afforestation....6

Benefits of afforestation....6

Afforestation benefits....6

Agroforestry benefits: mixed-planting and selective harvesting methods....8

Costs of afforestation....10

Costs of implementing and maintaining afforested land....10

Consultation and planning....11

Training and planting....12

Maintenance and follow-up....13

Appendix 1: Data sources....i

Appendix 2: Assumptions....ii

Appendix 3: Examples of how to adjust prices between years....iv

Appendix 4: Examples of how to calculate Present Value....v

References....vi

Purpose

The purpose of this report is the provide information to Provincial Office staff and other practitioners in Fiji and elsewhere on the benefits of reforesting degraded hill land, benefits of using mixed-planting and selective harvesting land management, and costs of afforesting and managing degraded hill land.

The information provided is not intended to be an economic valuation of afforestation, mixed-planting or selective harvesting. It is intended to provide information for use by Provincial Office staff to identify the potential benefits and the value of these potential benefits to affected communities or households.

Background

Fiji has experienced significant land use change as the country has developed and used its natural resources more intensively. Unfortunately, many land use practices such as clear-cut logging, gravel bed extraction and burning to clear land has resulted in environmental degradation and decreased resilience to the effects of climate change (Waqainabete-Tuisese, Rounds and Kennedy 2016). These unsustainable land use practices have direct and indirect costs (e.g. erosion) often borne by surrounding communities. Changing these land use practices and reinvesting in the environment can reduce these costs.

This report outlines the benefits and costs of afforesting and reforesting degraded hilly land using agroforestry methods. The benefits and costs discussed in this report are not intended to be exhaustive, but reflect the on-the-ground experiences of communities in Ra Province participating in the afforestation programme with RESCCUE-SPC Fiji. Many of these discussed benefits overlap with and enhance the benefits from other RESCUUE-SPC Fiji programmes like riparian restoration and freshwater management.

Afforestation and reforestation (called “afforestation”) activities aim to improve and enhance the economic and environmental conditions for communities and the environmental resilience of native plants and animals (or “biodiversity”) in the Ra Province. As with many places in the Pacific, the resilience of communities is integrated with the resilience of their natural environment. Afforestation activities can be used to achieve multiple benefits for communities. For instance, using agroforestry methods of mixing timber with fruit trees and using selective harvesting reduces erosion impacts while providing food and timber resources for the community.

Afforestation activities have direct and indirect benefits for the managing community, surrounding community and downstream areas. There are also some costs associated with afforestation that should be considered and managed for as well as implementation costs. Table 1 provides an overview of the benefits and costs of afforestation. These are discussed in more detail in the following sections.

Table 1: Direct and indirect benefits and direct costs of afforestation (using agroforestry approaches)

Benefits and costs	Description	Direct/Indirect
	Benefits	
Erosion reduction:		
Fish/prawn health	Greater abundance and size of fish and prawns	Indirect
Reduce river sedimentation	Less time spent retrieving bogged livestock and rewashing clothes	Direct and Indirect
Lower land slip risk	Reduced risk of land slips impacting buildings/crops	Direct
Food	Additional fruit from planted trees	Direct
Timber and firewood	Additional timber from planted trees	Direct
Medicines	Greater medicinal uses of planted trees (tree species dependent)	Direct
Honey	Better habitat for bees – better pollination and honey production	Indirect
Better forest habitat	Increased abundance of doves, pigeons and bats	Indirect
Lower river water level	Reduced flooding with lower water levels	Indirect
Provides new skill-sets for villagers	New skills learnt from training to manage the forest	Direct
Better invasive species buffer	Reduces available land for invasive species (e.g. African Tulip Tree) to establish	Indirect
	Costs	
Opportunity cost[a] of land	Other uses of land (e.g. leasing to others outside the community) are no longer available	Direct
Lower river water level	Less water in river during dry season for household use	Indirect
Opportunity cost[a] of time:		
Enforcement/patrolling	Time spent enforcing no-burning and patrolling for illegal harvesting	Direct
Training	Time spent upskilling to manage forest	Direct
Land management	Time spent managing forest	Direct

a: opportunity cost is what is given up to do something else. For example, if the land was not afforested, it could have been leased to someone else for a financial return. A time example is the time spent training could have been used to do something else, e.g. gardening, other paid work.

The value of afforestation

The benefits and costs were identified by members of Naraviravi, Vunisea and Nalalawa villages in Ra Province, Fiji in participatory ecosystem service assessment workshops and supplemented with information from other studies in the Pacific and globally. The views of afforestation expressed in the workshops aligned with other literature but provided more details on the scope of the benefit (or cost). The data sources are listed in Appendix 1

The 'financial benefits' (those benefits with monetary values) outlined below are likely to be highly variable and their estimation involves a number of assumptions. These assumptions are listed in Appendix 2. Appendix 3 also outlines how to convert monetary values from one year to another year so that all monetary values are compared for the same year. There are many benefits that could not be expressed in dollars, so in many cases the full set of impacts is likely much larger.

Benefits of afforestation

The benefits of afforestation are split into two groups:

- General benefits of reforesting degraded hills
- Additional benefits of the specific afforestation designs.

Afforestation benefits

1. Reduced erosion

Erosion issues facing communities fall into two main categories: a) damage from landslides; and b) damage from continuous sedimentation in the river system. The likelihood of erosion and landslides varies substantially depending on many factors, e.g. soil type, steepness of hill, concentration of water within the soil, earthquakes, and intensity of rainstorms. However, establishing vegetation on erosion-prone slopes reduces the risk of both events occurring (Forbes et al. 2011). The risk of landslides also reduces with tree age (Marden 2012).

The potential damage to infrastructure (e.g. houses and gardens) avoided by establishing and maintaining vegetation on erosion prone slopes varies with the risk of landslides, the severity of any landslide, and the type of infrastructure damaged. Where housing is at risk of being damaged, the magnitude of avoided costs can be estimated using the cost of replacing housing. The estimated average replacement cost for a wooden house in the Ba and Ra provinces was $22,200 (minimum cost of $7900 and maximum cost of $56,300) (Brown & Daigneault 2013). These values can be used as an upper amount of the possible cost of losing a house below degraded hilly land in the event of a landslide. A similar approach can be taken with gardens, where the costs involve the preparation and planting of a new garden as well as the loss of the food in the damaged/destroyed garden.

Sedimentation is both gradual and event specific as landslides also contribute to sedimentation in the river system. The benefit of reduced sedimentation comes from greater abundance of fish and prawns in the river, less time spent freeing bogged livestock, and less time spent washing clothes and/or finding alternative sites for washing, bathing, and recreation.

Fish and prawn abundance and size are negatively impacted by sediment-filled water. In the absence of healthy populations of fish and prawns for eating, a household can choose to replace their lost protein by purchasing fish or meat from the market, spending more time searching for fish in other parts of the river or slaughtering any livestock they may own. To replace the fish that are no longer present due to sediment in rivers with purchased fish was estimated to cost between $1825 and $2373 per household per year. To replace prawns that are no longer present due to sediment in rivers with purchased prawns was estimated

to cost between $4108 and $14,600 per household per year, depending on how often households consume prawns (i.e. once a week versus every day).

Increased river sediment also increases the silt on river banks, increasing the likelihood and severity of livestock bogging. The cost to a household of more bogging of their livestock is the time people spend digging their livestock out of the mud. This is time that could be spent doing something else, like wage work or gardening. The estimated benefit of reduced livestock bogging because there is less sediment in rivers is estimated to be between $49 and $196 per household per year. This estimate is based on the time taken to free bogged livestock being between 15 and 60 minutes per week at an average wage of $3.77 per hour.

The difficulties of washing clothes in water with lots of sediment is similar to bogging, as extra time is taken to successfully wash clothes (either re-washing laundry and/or finding cleaner water to wash clothes in). Again, this is time that could be spent doing something else, like wage work or gardening. The estimated benefit of not having to re-wash clothes is between $49 and $196 per household per year. This estimate is based on the time taken to successfully wash clothes being between 15 and 60 minutes per week at an average wage of $3.77 per hour.

2. Reduced Flooding

Afforestation has an impact on surface runoff and groundwater recharge and can significantly reduce water levels in rivers and streams. In the short term, during heavy rain trees and other vegetation slow the rate at which the rain reaches the ground and the rate at which the rain flows down the hill. This reduces the amount of water that drains into the river at any given time (Farley et al. 2015), potentially reducing both the likelihood and the severity of flooding next to the river.

Over longer periods, where surrounding land has been afforested, river levels may drop permanently (Brown et al. 2013; Farley et al. 2015). Several environmental factors, such as the level of the water table relative to the river, influence the magnitude of river level drops, with some rivers seeing lower levels throughout the year, some seeing lower levels during the dry season, and some seeing lower levels just during drier days (Brown et al. 2013).

The benefit of reduced flooding relates to any reduction in costs from replacing and fixing infrastructure and/or crop losses from flooding. These benefits will vary with the type of infrastructure and crops that are damaged and how regularly flooding occurs. Community members in Naraviravi and Nalalawa noted they were experiencing fewer floods now that areas around their village had been afforested but that the magnitude of flooding that did occur remained unchanged. The flooding these villages mentioned occurred as a result of regular precipitation and was not necessarily connected with cyclones and other severe rain storms.

3. Habitat

Afforested areas could provide additional habitat for birds (e.g. pigeons), bats, and other animals, while still providing benefits to villages, including fruit and timber (Lamb 2002). The extent and type of benefits for other species will depend on many factors such as distance to other habitats, whether the area is on a migratory route, and what species can live in the newly afforested areas. These species could be a food source for the local community, contribute to the overall environmental health of the area, and potentially providing tourism opportunities (e.g. hiking trails). Any tourism activities that may develop will depend on the accessibility of the area, other tourism activities in the area that may draw visitors to the area, and the ability to set up tourism-related businesses.

4. Invasive species buffer

Invasive species tend to do better than native species in areas that have been cleared and are not closely

managed. However, there is some evidence to suggest that actively managing land with native and preferred tree plantings may slow or reverse the spread of invasive plants (Martinez 2010). Species, such as Africa Tulip trees, for example, are agricultural pests so reducing the likelihood of these species dominating the area will reduce the time and money spent on controlling these species (Daigneault et al. 2013).

Agroforestry benefits: mixed-planting and selective harvesting methods

In addition to the benefits of afforestation noted above, the mixture of trees (fruit, nut and timber) chosen by the village to plant can have additional direct and indirect benefits to the village. Within a few years of planting, any fruit and nut trees will start providing communities with a new food source. Using a range of timber species that are ready at different times for harvesting will allow communities to harvest timber over longer time frames. If communities replant harvested timber species, this benefit will continue into the future.

There are several tree and plant species used in current plantings in the Ra Province. These species, along with their benefits and uses, are outlined in Table 2, with the uses and benefits being those noted by communities during the participatory workshops. There may, therefore, be additional uses or benefits identified for these species in the future. The actual scope and magnitude of benefits a community may receive from afforestation will depend on the species chosen by the community and the suitability of these species for the area being afforested.

Table 2. Uses and benefits of timber, fruit, and other plants available for afforestation plantings

Plant (*scientific name*)	**Use in benefits estimations**
Vetiver grass (*Chrysopogon zizanioides*)	Erosion control
Lemon (*Citrus limon Osbeck)*	Food
Tahitian chestnut (*Inocarpus fagifer*)	Food
Coconut (*Cocos nucifera*)	Food
Mango (*Mangifera indica*)	Food, firewood
Pineapple (*Ananas comosus*)	Food, firebreak
Kavika (*Syzygium malaccense*)	Food, erosion control
Tavola (*Terminalia catappa*)	Medicine, food, erosion control
Pine (*Pinus carribea*)	Timber, erosion control
Sandalwood (*Santalum album*)	Timber, erosion control
Teak (*Tectona grandis*)	Timber, erosion control
Mahogany (*Swietenia macrophylla*)	Timber, erosion control

1. Food

The potential benefit to a community from planted fruit and nut trees is a combination of the:

a) Avoided expense from no longer having to purchase the food from the market, and

b) Potential fruit/nut surplus produced which the village can sell at the market.

The exact preferences for each individual community will determine which and how many of these fruit and nut trees are planted and thus the magnitude of the benefits. Table 3 outlines the financial benefits of planting different fruit or nut species. The estimated amount produced per tree is an average production value and may vary in either direction dependent on age of tree (i.e. lemon trees produce more with age), environmental conditions and management of plants as it matures.

Table 3. Estimated benefits and years until the benefits begins

Plant	Amount produced	Benefit[a] (per plant per year)	Time until first harvest
Lemon	100 fruit per tree per year	$50	4 years
Tahitian chestnut	3,500–5,000 nuts per tree per year	$525 – $750	4 years
Coconut	30 per tree twice a year	$30 – $40	6 years
Mango	100 fruit per tree per year	$38	4 years
Pineapple	1–3 per plant	$3 – $15	1.5 years
Kavika	350–1,400 fruit per tree twice a year	$263 – $1,063	4–6 years
Tavola	5 kg nuts per tree per year	Unknown market value	10 years

a: these benefit estimates are based on average production rates and 2017 prices (see Appendix 2). Actual production will differ with tree age, weather and land conditions, and the management of the trees by the community.

2. Timber

In addition to fruit and nut trees, communities have planted many timber-producing trees. Timber production is a long-term investment and is usually planted along with fruit and nut trees so that communities have a range of short- and long-term benefits. Mixed planting also means that when some trees are harvested there are other trees (fruit and/or timber) on the hillside maintaining soil stability and the erosion benefits outlined above. The estimated financial value of timber production is outlined in Table 4 and is shown as the Present Value (or PV). The PV in Table 4 represents the future harvested value of timber in 2017 dollars (see Appendix 4 for how to calculate PV).

Table 4. Estimated benefits and years until harvest of 4 common timber species in Fiji.

Plant	Volume per tree (average)	PV benefit (per tree)[a]	Time until harvest
Pine	11.5 cubic meters per tree	$1,143	30 years
Sandalwood	30 kg per tree	$946	15 years
Teak	1.5 cubic meter per tree	$450	15 years
Mahogany	12 cubic meters per tree	$1,184	30 years

a: these benefit estimates are based on average production rates and 2017 timber prices (see Appendix 2). Actual tree volume will differ with tree age, weather and land conditions, and the management of the trees by the community. Future timber prices may also vary.

3. Medicines

Plant species can also be planted that have medicinal uses. For instance, the Tavola tree (Terminalia catappa) is used for many medicinal purposes in the community. The leaves and bark of the tree are used to remedy lethargy after illness, stomach aches, and headaches and migraines; as an astringent for dysentery and thrush; as a diaphoretic, to treat mouth infections, and to assist the healing of bone fractures (Thomson & Evans 2006).

4. Honey

The plant species chosen may also support honey production, and could present new income opportunities for a community. Honey production can be profitable, depending on the market demands and productivity of the hive. An estimate of a village-run honey operation with a hive producing approximately 100 kg of honey per year is about $1,000 per year. In addition, bees are beneficial to a village's flowering garden and cash crops, such as chillies and pawpaw, which are reliant on pollinators as the additional flower resources attract greater numbers of pollinators.

5. New skill-set

An important aspect of afforestation activities is building awareness of unsustainable land use practices – mentioned in erosion reduction section – and training people to manage the new forest area. Agroforestry techniques, once learnt, can be applied elsewhere in the community to improve the resilience, sustainability, and profitability of the land.

Costs of afforestation

1. Lower river levels during dry season

While the decrease in water runoff during and after storms and decreased groundwater discharge in the afforested area should reduce the frequency of flooding, it may also mean that there is less water in the river during drier periods. The frequency of lower river levels during dry times could also be further worsened with climate change (Brown et al. 2013).

2. Opportunity cost of land

Many communities lease land to commercial forestry companies. However, by afforesting this land, the land is no longer suitable for leasing and the community could no longer receive a lease income. In areas that are not leased, this opportunity cost does not relate to an actual cost to the community; rather, it represents the loss of a potential income source that should also be considered. Depending on the type of tree planted, the estimated present value of this loss per ha ranges from $26,655 to $70,933 for a 15–30 year lease.

3. Opportunity cost of time

Burning brush to clear land for farming and/or new plantations is a practice often used in Fiji. While burning is a low-cost method to clear land, it has an economic and environmental cost to the surrounding communities. Fires can easily get out of control, especially in dry conditions and on grasslands, and destroy houses and crops. The bare land is also more susceptible to erosion.

To reduce the negative effects on communities of burning, communities may need to develop means of enforcing no-burning, regularly monitor the area for fires, and raise general awareness about the dangers of burning land. The actual time taken to monitor, enforce, and raise awareness will depend on a community's use of fire to clear land and incidence of arson. If it took a person 1–2 hours a week for these activities, the estimated cost would be between $196 and $392 per year for the community.

As with the increased washing of clothes and dealing with bogged livestock with sediment, monitoring, training, and increased land management take time that could be spent doing other activities. The opportunity cost of training and land management will depend on how long these activities take. These opportunity costs were estimated at about $30 per person per day.

Costs of implementing and maintaining afforested land

The implementation costs of afforesting land can be divided into:

- Consultation and planning,
- Training and planting, and
- Maintenance and follow-up.

The costs for these activities will vary from site to site as the area to be afforested changes; labour costs may also differ depending who is undertaking the work. To help estimate the cost of undertaking afforestation activities, the estimated time and costs are provided below. These costs are based on the costs associated with afforestation activities undertaken through the RESCCUE-SPC project in Ra Province, Fiji, between 2016 and 2018. In some instances the costs below could be shared with other activities such as riparian restoration and freshwater management, which could be undertaken in the same area.

Consultation and planning

Consultation with communities is important for getting buy-in for planning, planting, and the maintenance of afforestation activities. Communities should be fully aware of benefits from afforesting – and, if applicable, agroforestry – to protect degraded hill land and provide sustainable income sources for the community. The consultation process includes a) holding several meeting with the village chief and community to discuss the afforestation activities, b) working with the community to identify the objectives of any afforestation activities and map the area targeted for afforestation, and c) develop a work plan including the selection of plants. Consultation is typically undertaken by external organisations e.g. NGOs, Provincial Office, Department of Agriculture or Forestry, Conservation International (CI) and/or University of South Pacific (USP) staff. Estimated costs are in Table 5.

Table 5. Costs for community consultation and planning.

Activity	Who	Time involved	Approximate cost
Meeting with chief and community to outline activities	NGO, USP, provincial staff or Department of Forestry staff	~ 2 meetings/village (allow 1/2 day for each meeting) 1 staff expert minimum for this work	~ $180 based on: • $180/Field officer/day
Traditional protocol for community engagement (Yaqona – sevusevu, itatau)		Part of first community meeting	$60 based on: • $60/packet of Kava
Catering expenses	For community	$9-17/person for catering for participants (Morning tea/lunch, afternoon tea)	$540 - 1020 based on: • 60 participants
Travel to village	NGO, USP, provincial staff or Department of Forestry staff	~1 day/meeting (depends on distance)	~$50 based on: • Fuel costs
Objective setting and mapping of target afforestation area	NGO, USP, provincial staff or Department of Forestry staff	2 days (includes identifying key landscape features such as rivers, steepness of slope, access routes, soil conditions and current vegetation (e.g. Tulip Trees). ~3 staff experts required for this work	$900 based on: • $240/Forest Ecologist /day • $170/Field officer /day • $40/Technical assistant/ day
Develop work plan for afforestation activities, including species selection	NGO, USP, provincial staff or Department of Forestry staff	3 days to develop and refine the plan (includes outlines the objectives of the project, who to contact for each part of the project, the timeline for each component, and what the expected outcomes of each component) ~2 staff experts required for this work	$850 based on: • $240/Forest Ecologist /day • $170/Field officer /day
Approximate cost (staffing costs will depend on organisation, but will be similar regardless of area replanted)			**$2580 - 3060**

Training and planting

Once the work plan is agreed by the community, the plan needs to be put into action. This means training and awareness workshops, building a nursery, and clearing and planting the land. Estimated costs for training and planting are in Table 6 and estimated costs for building and starting a nursery are in Table 7. Trainings and establishment of the nursery should occur prior to preparing the land for planting.

Table 6. Costs for awareness workshops training, nursery development and planting land.

Activity	Who	Time involved	Approximate cost
Conducting Sustainable Land-use Awareness Workshops	NGO, USP, provincial staff, Department of Forestry, or Department of Agriculture staff	1 day for awareness and educational workshop 1 day/village ~4 Dept. of Agriculture staff ~1 CI Field Officer	$300 based on: • $30/person/day for Dept. of Agriculture staff • $180/CI Field Officer/day
Training community members for planting and managing the land	NGO, USP, provincial staff or Department of Forestry or Department of Agriculture staff	1 day for nursery planting and land management training ~1 staff required for this work	$180 based on: • $180/CI Field Officer/day
Travel to village for workshops & training	NGO, USP, provincial staff or Department of Forestry staff	~1 day/meeting (depends on distance)	$50 based on: • Fuel expense
Catering expenses (workshop)	For community	~$9-17/person/day	$ 360-680 based on: • 40 participants
Accommodation for staff and/or experts who help in training activities	NGO, USP, provincial staff or Department of Forestry staff	~2 nights for 5 staff	$0 - 300 based on: • $30 /night / person • $0/night if staff can stay at CI field office
Nursery development	NGO, USP, provincial staff Department of Forestry, or Department of Agriculture staff	~10 days (see Table 7 for details)	$2650 – 3900 (see Table 7 for details)
Clearing land in preparation for plantings	NGO, USP, provincial staff or community	~1 day per hectare for 5 people 1 supervisor	~$190 based on: • $30 /person/day • $40/supervisor/day
Planting land	NGO, USP, provincial staff or community	~1 day per hectare for 5 people 1 supervisor	~$190 based on: • $30 /person/day • $40/supervisor/day
Transportation costs of moving plants from nursery to site	NGO, USP, provincial staff or community	~1 day of planting	~$500 based on: • $500/day truck expense (from Suva to Rakiraki)
Approximate cost (staffing costs will depend on organisation)			**$4720 - 6040**

Table 7. Costs for building and starting a nursery.

Activity	Who	Time involved	Approximate cost
Material for building nursery	NGO, USP, provincial staff or Department of Forestry staff	~7 days for ordering and delivery of material	$1000 - 2000
Building nursery	NGO or USP staff or community members	~5 people over ~ 1 day	$150 based on: • $30 per person per day
Seedlings for nursery	NGO, USP, provincial staff or Department of Forestry staff, for community, and/or for other nurseries in region	~1 day including • Ordering seedlings from Department of Forestry • 5 community members 1 collect from the forest Pine seedlings are available from SPC Deuba nursery	$900 - 1150 based on: • ~$1/seedling • $30/person/day • To afforest a 1 ha area expect to need 1500-2000 seedlings of various species
Pot/manage seedlings	NGO, USP, provincial staff or for community	5 people 1 day to pot 1000 seedlings	$300 based on: • $30/person /day • 2 days to pot 2000 seedlings
Approximate cost (seedlings and planting costs will depend on total planted land)			**$2650 - 3900**

Maintenance and follow-up

The main cost associated with maintenance of the land is community labour. The estimated annual cost of maintaining the afforested area is $300 per ha per year (based on the area needing maintenance four times a year at a labour cost of $75 per ha of afforested land). The actual time taken to maintain the area will depend on the species planted, the distance to the afforested area, and the topography of the area.

Appendix 1: Data sources

Several sources of data, both primary and supplementary, are used in this analysis, and various assumptions are made in the absence of some data. The primary source of information on the impacts of afforestation on which this analysis is based comes from workshops conducted in Ra Province in November and December 2017. Where values were unavailable, supplementary information was used and is cited.

Primary sources

Workshops were conducted in Ra Province between 13 and 16 November and on 8 December 2017 with seven villages that are currently participating in at least one of RESCCUE-SPC's environmental interventions: afforestation, freshwater management, mangrove restoration, and/or riparian zone planting. Information for this report on the costs and benefits of afforestation and crop and fish production, consumption, and prices come from Vunisea, Naraviravi, and Nalalawa. Information provided in these workshops was verified by at least one other village and/or via interviews with Conservation International and University of South Pacific. Crop and fish price data was supplemented and verified by a random sampling of available crops and fish at the Suva open-air market in November 2017.

Supplementary sources

There are several supplementary information sources: RESCCUE-SPC project reports, a household survey from the Climate Development and Knowledge Networks project conducted in Ba and Penang catchment by University of the Pacific and Landcare Research in 2012, and published literature. See References for a complete list of sources used.

Appendix 2: Assumptions

Several assumptions were made for the various estimations discussed. These assumptions are listed below and cited when applicable. The data, unless otherwise cited, are based on village workshops held in November 2017 in the Ra province. All monetary values are in 2017 Fijian dollars.

Fish and prawns

- 1 kg average consumption of fish and/or prawns per household per day
  - Scenario 1: Household consumes a mix of fresh and marine fish
  - Scenario 2: Household consumes a mix of fresh and marine fish 6 days a week and prawns 1 day a week for a special village event
  - Scenario 3: Household consumes only prawns
- Price of prawns is $40 per kg (Brown & Daigneault 2013)
- Price of freshwater fish is, on average, $5 per kg (November 2017 price)
- Price of 'not A-grade' marine fish is, on average, $6.5/kg (November 2017 price)

Time

- Bogging:
  - One average sized cow is bogged
  - Household spends additional 15 minutes to 1 hour per week getting cows out.
- Household activities:
  - Household spends an addition 15-30 minutes per week re-washing clothing and/or going further to find a less dirty part of the river
- Average hourly wage of $3.35 (2012 FJD) (Brown and Daigneault 2013)
- Prices were adjusted using Fiji CPI 2017 = 116.4 and Fiji CPI 2012 = 103.4 (Fiji Bureau of Statistics 2018)

Protection of infrastructure, e.g., houses

- Mean price of wooden houses in the Ba and Penang catchments in Fiji was $19,700 (2012 FJD) with a minimum of $7000 and maximum of $50,000 (2012 FJD) (Brown & Daigneault 2013)
- Prices were adjusted using Fiji CPI 2017 = 116.4 and Fiji CPI 2012 = 103.4 (Fiji Bureau of Statistics 2018)

Honey production

- One hive produces, on average, 25 kg of honey every 3 months
- Price of honey at the market is approximately $10 per kg (November 2017 prices)

Fruit and nut production

Plant	Quantity	Market price
Lemon	1 heap = 4 lemons	$2 per heap
Tahitian chestnut	1 bag = 10 nuts	$1.50 per bag
Coconut	1 dozen	$6 to $8 per dozen
Mango	1 heap = 4 mangoes	$1.5 per heap
Pineapple	1 bunch = 1 to 3 heads	$3 to $5 per bunch
Kavika	1 heap = 4 apples	$1.5 per heap

Timber production

- Present value calculated using an 8% discount rate

Plant	Production	Commercial value	Time of harvest
Pine	11.5 cubic meters (Tikoibua 2017; Sue 2010)	$996 per cubic meter (August 2017 prices)	30 years (Sue 2010)
Sandalwood	30 kg (Tora 2011; Tikoibua 2017; Simmons 2017)	$100 per kg (Tora 2011; Simmons 2017)	15 years
Teak	1.43 cubic meter (Tikoibua 2017)	$996 per cubic meter (August 2017 prices)	15 years
Mahogany	11.97 cubic meter per tree (Tikoibua 2017)	$996 per cubic meter (August 2017 prices)	30 years (FAO 2002; Norghauer et al. 2011)

Opportunity cost of lease

- $12 per hectare + 12% stumpage royalty (Sue 2010)
- Present value calculated using an 8% discount rate

Plant	Distance between trees	Production (per ha)	Commercial value	Time of harvest
Pine	6 meters	3207 cubic meters (Sue 2010; Tikoibua 2017)	$996 per cubic meter (August 2017 prices)	30 years (Sue 2010)
Sandalwood	4 meters	18,750 kg (Tora 2011; Tikoibua 2017, Simmons 2017)	$100 per kg (Tora 2011; Simmons 2017)	15 years
Teak	4.5 meters	707 cubic meters (Tikoibua 2017)	$996 per cubic meter (August 2017 prices)	15 years
Mahogany	4.5 meters	5909 cubic meters (Tikoibua 2017)	$996 per cubic meter (August 2017 prices)	30 years (FAO 2002; Norghauer et al. 2011)

Opportunity cost of time

- Assume monitoring, enforcement, and awareness raising takes 1 to 2 hours per week for one person
- Assume that people work an 8 hour day
- The average hourly wage is $3.35 (2012 FJD) (Brown & Daigneault 2013)
- Prices were adjusted using Fiji CPI 2017 = 116.4 and Fiji CPI 2012 = 103.4 (Fiji Bureau of Statistics 2018)

Appendix 3. Examples of how to adjust prices between years

When estimating costs and benefits price information often differs for different years, for example, prices from 2012 may differ from the current year. To ensure prices are comparable, all prices need to be stated in the same year.

Convert prices from one year to another year by using the Consumer Price Index (CPI). An example:

- A house price was 19,700 in 2012 dollars
- Average annual CPI for 2017 is 116.4
- Average annual CPI for 2012 is 103.4

To convert the 2012 price to 2017 dollars using the following formula:

= 2012 house price * (CPI 2017/CPI 2012)

= $19,700 * (116.4/103.4)

= $22,177

Table 3A lists the CPI values that can be used for these calculations

Table 3A. Annual average CPI from 2008 to 2017 (Fiji Bureau of Statistics 2018)

Year	CPI (average annual)
2008	87.1
2009	89.9
2010	93.2
2011	100.0
2012	103.4
2013	106.4
2014	107.0
2015	108.5
2016	112.7
2017	116.4

Appendix 4. Examples of how to calculate Present Value

Present value is a method for comparing the monetary value of a future cost or benefit to the monetary value of a cost or benefit today. The value of money changes over time, for example, $20 today buys more than $20 10-years from now, so comparing prices today versus 10 years from now without scaling the future prices won't be taking this change into account. To calculate this future monetary value in today's prices, we scale the estimated future value by a discount rate (Buncle at al. 2013).

To calculate the present value (PV) of a cost or benefit we need the estimated value of this future cost or benefit, the number of years in the future we expect to get this cost or benefit, and a discount rate. An example using timber harvest is:

- Q: quantity, e.g. 30 kg of Sandalwood
- T: time, e.g. Harvested in 2032 (15 years from 2017)
- p: price, e.g. 2017 market rate Sandalwood is $100 per kg of wood
- r: Discount rate, e.g. 8%

To calculate the PV we use the following formula:

PV = (Q x p) / ((1+r)^T) where (1+r)^T is equivalent to (1+r) times itself T number of times

Using the above example, the PV is:

PV = (30 kg x $100 per kg) / ((1+0.08)^15)

= ($3000) / 3.1722

= $945.73 in 2017 FJD

This means that the value of the sandalwood harvested in 2032 is estimated at $946 in 2017 dollars.

References

Brown P, A Daigneault. 2013. Household survey for CDKN project. Unpublished data. Data can be requested from Manaaki Whenua Landcare Research NZ Ltd.

Brown AE, AW Western, TA McMahon, L Zhang. 2013. Impact of forest cover changes on annual streamflow and flow duration curves. Journal of Hydrology 483: 39–50. Doi: 10.1016/j.jhydrol.2012.12.031

Buncle A, A Daigneault, P Holland, A Fink, S Hook, M Manley. 2013. Cost-benefit analysis for natural resource management in the Pacific: a guide. SPREP/ SPC/ PIFS/ Landcare Research and GIZ.

Conservation International. 2018. RESCCUE Progress Report January 2018.

Daigneault A, Brown P, Greenhalgh S, Boudjelas S, Mather J, Nagle W, Aalbersberg W. 2013. Valuing the impact of selected invasive species in the Polynesia-Micronesia hotspot. Landcare Research Contract Report LC1227. Prepared for the Critical Ecosystems Partnership Fund.

Farley, KA, EG Jobbagy, RB Jackson. 2005. Effects of afforestation on water yield: a global synthesis with implications for policy. Global Change Biology 11(10): 1565–1576. Doi: 10.1111/j.1365-2486.2005.01011.x

Fiji Bureau of Statistics 2018. Consumer price index. http://www.statsfiji.gov.fj/statistics/economic-statistics/summary-of-consumer-price-index12 [accessed 9 March 2018].

Food and Agriculture Organisation (FAO). 2018. Mangoes, mangosteens and guavas yield in Fiji years 2016-2010. Retrieved from FAOSTAT crops database March 2018. Rome: FAO. http://www.fao.org/faostat/en/#data/QC

Food and Agriculture Organisation (FAO). 2002. Hardwood programmes in Fiji, Solomon Islands, and Papua New Guinea. Forest and plantations Working Papers, Working paper FP/21. Forest Resource Department Service, Forest Resource Division. Rome: FAO,

Forbes K, J Broadhead, GB Bischetti, F Brardinoni, A Dykes, D Gray, F Imaizumi, SL Kuriakose, N Osman, D Petley, A Stokes, B Verbist, TH Wu. 2011. Forests and landslides: The role of trees and forests in the prevention of landslides and rehabilitation of landslide-affected areas in Asia. FOA RAP 2011/19. 42 p.

Grimwood BE, F Ashman. 1975. Coconut palm products: The processing in developing countries. Rome: FAO.

Lamb D. 2002. Large-scale ecological restoration of degraded tropical forest lands: the potential role of timber plantations. Restoration Ecology 6(3): 271–279. Doi: 10.1046/j.1526-100X.1998.00632.x

Marden M. 2012. Effectiveness of reforestation in erosion mitigation and implications for future sediment yields, East Coast catchments, New Zealand: a review. New Zealand Geographer 60: 24–35. doi: 10.1111/j.1745-7939.2012.01218.x

Morton JF. 1987. Malay apple. In: JF Morton, Fruits of warm climates. Miami, FL. [retrieved from https://www.hort.purdue.edu/newcrop/morton/index.html] Pp. 378–381.

Morton JF. 1987. Pineapple. In: JF Morton, Fruits of warm climates. Miami, FL. [retrieved from https://www.hort.purdue.edu/newcrop/morton/index.html] Pp. 18–28.

New Zealand Chestnut Council (NZCC). 2018. Frequent asked questions. [retrieved March 2018 from http://www.nzcc.org.nz]

Norghauer J, CA Nock, J Grogan. 2011. Table 3. Tree characteristics of mahogany trees grouped into four size-fecundity classes at the Marajoara forest in Para, Brazil. Table, The Importance of Tree Size and Fecundity for Wind Dispersal of Big-Leaf Mahogany. PLoS One 6(3): e 17488.

Sue D. 2010. Facilitating financing for sustainable forest management in Small Islands Developing States and low forest cover countries. An analytical report prepared for Indufor for the United Nations forum on forests. Country case study. Fiji. Helsinki. http://www.un.org/esa/forests/pdf/aheg/aheg1/fiji.pdf

Simmons M. 2017. At the heart of the matter. The Fiji Times Online. 22 January 2017. http://www.fijitimes.com/story.aspx?id=386320 [accessed 28 February 2018].

Thomson LAJ, B Evans. 2006. Terminalia catappa (tropical almond). Version 2.2. In: Elevitch CR (ed). Species profiles for Pacific Island Agroforestry. Permanent Agriculture Resources (PAR), Holaloa, Hawaii. Available from www.traditionaltree.org.

Tikoibua T. 2017. RESCCUE Project activity update report – Ra province. Coastal rehabilitation and riparian work activity. 6 September 2017.

Tora I. 2011. Forestry promotes sandalwood farming. Fiji Sun Online. 30 June 2011. http://fijisun.com.fj/2011/06/30/forestry-promotes-sandalwood-farming/ [accessed 28 February 2018].

Waqainabete-Tuisese S, I Rounds, B Kennedy. 2016. Ecological restoration and erosion control in Ra Province: diagnosis and Action Plan. Institute of Applies Sciences. University of the South Pacific, RESCCUE Progress Reports.