RESCCUE

Mangrove restoration:
An overview of the benefits and costs of restoration

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Purpose

The purpose of this report is to provide information to Provincial Office staff and other practitioners in Ra Province, more broadly in Fiji, and elsewhere on the benefits derived from mangroves, the costs associated with mangroves, and a breakdown of the costs of undertaking mangrove restoration activities.

The information provided is not meant to be an economic valuation of mangroves, rather it is aimed to provide information that could be used by Provincial Office staff and others to identify the full range of potential benefits as well as what some of these benefits could be worth to the communities or households affected.

Background

Mangroves provide many benefits for communities, many of which are taken for granted and are not recognised until mangroves have been removed or damaged. As mangroves are being removed or damaged by human activities or natural disasters, the importance of healthy mangroves systems is becoming increasingly important.

Fiji has the third largest mangrove area in the Pacific and was estimated at approximately 517 km^2 in 1985 (Ellison and Fiu 2010), most of which were on Viti Levu and Vanua Levu. More recent estimates of mangrove cover are not known but the area will have decreased for a number of reasons. The biggest threat to mangroves is coastal development (Sloan 2017; Movono 2018), with firewood harvest (Nakeke 2008), pollution (through waste disposal, sewage, aquaculture, pesticide runoff), watershed alteration and increased sedimentation, overfishing, sea level rise, and invasive species all contributing to the degradation of mangroves (Ellison and Fui 2010). In some instances, mangroves have also been removed simply because community members did not like them, e.g. because they believed they breed too many mosquitos (Nabukadra village member, pers. comm., November 2017).

Mangroves species in Ra Province and their condition

There has not been a comprehensive of survey of mangrove species distribution and condition for all mangrove areas in Ra province. However, the mangrove species identified in the 2014 survey of 5 villages (Togovere, Malake, Nayavuira, Navuniivi, Naockbau) in Ra province identified 9 different species (including a hybrid species) (Naikatini et al 2014):

- *Rhizophora samoensis* (Red mangrove; Samoan mangrove; local name – Tiri Wai)
- *Rhizophora stylosa* (Red mangrove; Spotted mangrove; local name – Tiri Tabua)
- *Rhizophora x selala* (Red mangrove; Hybrid mangrove; local name – Selala)
- *Bruguiera gymnorhiza* (Black mangrove; Large-leafed mangrove; local name – Dogo)
- *Excoecaria agallocha* (White mangrove; Blind-your-eye mangrove or Milky mangrove or Poisonfish Tree or River Poison Tree; local name – Sinu gaga)
- *Xylocarpus granatum* Koenig (White mangrove; Cannonball mangrove or Puzzlenut Tree; local name – Dabi)
- *Lumnitzera littorea* (White mangrove; Teruntum merah; local name – Sagali)
- *Heritiera littoralis* Ait. (White mangrove; Looking glass mangrove; local name – Kedra ivi na yalewa Kalou)

These species are the common species found in Fiji and will be representative of species found in other areas in Ra Province and Fiji in general.

The condition of mangrove sites that were surveyed varied from poor to excellent (Table 1) based on criteria listed in Appendix 1. As well as the human influence noted above, location characteristics can also affect condition. For example, mangrove areas directly facing the sea and not along river mouths or bay areas are exposed to harsher conditions and this exposure will affect the condition of the mangroves.

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Table 1. The condition of mangroves in the five villages surveyed in 2014

Sites	Condition
Togovere	Fair–Good
Malake	Poor–Fair
Nayavuira	Poor–Fair
Navuniivi	Fair–Excellent
Naocobau	Fair–Good

Table 1 highlights the variable condition of mangroves in Ra Province and the scope for restoration activities. There are 21 coastal villages in Ra province (Table 2) and all have mangrove stands of varying condition.

Table 2. Coastal villages in Ra Province, Fiji.

Village	Estimated mangrove stand condition
Drauniivi	Fair – excellent
Togovere	Fair – good
Vunitogoloa	Fair–Good
Narewa	Fair–Good
Rakiraki	Fair–Good
Navolau	Fair – excellent
Namuaimada	Fair–Good
Malake	Poor–Fair
Nanokonoko	Poor–Fair
Nanukuloa	Fair–Good
Naocobau	Fair–Good
Barotu	Fair–Good
Navuniivi	Fair – excellent
Nayavuira	Poor – fair
Nasau	Fair–Good
Veidrala	Fair–Good
Namarai	Fair–Good
Verevere	Fair–Good
Nayavutoka	Poor–Fair
Delaiyadua	Fair–Good
Matainanu	Poor–Fair
Saioko	Poor–Fair
Nabukadra	Poor–Fair

The value of mangroves

In many parts of the Pacific, including Ra Province, local communities are the direct beneficiaries of the benefits (and costs) provided by mangroves; and many households have subsistence livelihoods. The average rural household income in Fiji in 2013/2014 was $15,946 (Fiji Statistics 2017), approximately 56% of an average urban household income. Therefore, any financial and use benefits (and costs) provided by mangroves are important to these communities.

A summary of the direct and indirect uses of mangrove areas is outlined in Table 3, and classified as benefits and costs. These benefits and costs are described in more detail in subsequent sections.

The benefits and costs were identified by members of the Nabukadra village in Ra Province, Fiji in a participatory ecosystem service assessment workshop and supplemented with information from other studies in the Pacific and globally. The views of mangroves expressed in Nabukadra village aligned with other literature but provided more details on the scope of the benefit (or cost).

The financial benefits or those benefits with monetary values outlined below are likely to be highly variable and to estimate these financial benefits a number of assumptions were made. 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. Any financial benefits that are provided are to highlight the magnitude of a benefit. Comparing the various financial benefits to the average rural household income shows the importance of the benefits that come from mangroves. When other benefits that have not been estimated financially (or monetised) are also included then the scale of the benefits provided by mangroves further increases.

Table 3. Direct and Indirect uses of mangrove areas

Benefits and costs	Description	Direct/Indirect Use
Benefits		
Food	Crabs, fish, shellfish, and lobster for household consumption	Direct
Firewood	Firewood from mangrove species	Direct
Charcoal	Charcoal made from mangrove species	Direct
Timber	Timber from mangrove species	Direct
Fish smoking	Smoked fish using mangrove leaves	Direct
Bait fish	Bait fish caught in mangroves area	Direct
Medicines	Medicines made from mangrove leaves and bark	Direct
Traditional artefacts	Masi cloth made using mangrove bark	Direct
Potential tourism opportunities	Tourism activities related to mangroves, such as canoe trips	Direct
Nursery for reef/ocean fish	Mangroves acting as a nursery for juvenile reef or ocean fish, as well as providing feeding and breeding grounds	Indirect
Coastal protection	Protect the shoreline from waves, winds, and erosion	Indirect
Sediment removal	Remove sediment from rivers and streams that flow through mangrove areas	Indirect
Removes carbon	Absorb or sequester carbon dioxide from the air	Indirect
Removes wastes	Human and animal waste can be captured by mangroves and recycled	Indirect
Costs		
Smell	The mud in the mangroves area can smell unpleasant	Direct
Access	Mangrove areas can be difficult to walk around	Direct
Aesthetics	Mangrove areas, especially at low tide, can be considered by some to be unattractive	Direct
Mosquitos	Mangroves can be a breeding ground for mosquitos	Direct

The benefits of mangroves

The benefits that mangroves provide to humans and to our environment are wide-ranging. Some of these are financial benefits or can have financial implications if those benefits are no longer being provided by mangroves. Other benefits do not have a market price and so are not as easily quantified. They are, however, just as important. Outlined below is a description of the main benefits provided by mangroves.

Direct benefits of mangroves

1. Food: crabs, fish, shellfish, lobster

As noted by those in Nabukadra village, many households in coastal villages obtain four out of five meals from their surrounding mangrove areas. Households get food from the mangroves as access is easy and they do not have to pay for fuel as they do when ocean/reef fishing. Damu (mangrove red snapper), matu (small fish), kuka (small mud crab), qeqe (bivalve), oysters, and mud lobster are the most common species caught in mangrove areas. The species caught in the mangroves area are used for eating and bait; they are not caught for commercial sale.

If a household was to purchase the same amount of fish and shellfish caught in mangroves for eating, the cost would be approximately $7,098 per household per year.

2. Firewood

Mangroves provide A-grade firewood that burns longer and hotter than other types of firewood. Food that is cooked over mangrove firewood is believed by communities to taste better than other types of firewood. When mangroves are not harvested for firewood, the firewood is either sourced from the forest (mango and guava trees are commonly used) or purchased. The distance to other sources of firewood will vary by forest location and availability of timber for firewood in the forest.

If a household had to purchase, rather than collect, their own firewood, for use in cooking and heating it is estimated to cost between approximately $325 and $540 per household per year. This value only captures the cost of purchasing firewood and does not account for the taste or heat difference between mangrove firewood and other sources of firewood or any potential transportation costs associated with purchasing firewood.

3. Charcoal

Charcoal from mangroves is used for dyes, medicine, and heating. As with firewood, substitute sources of charcoal are available and could be purchased in the market.

4. Timber

Mangroves are a source of many building materials, and its high tannin content makes it a durable timber (Kathiresan 2012). The timber is used for fences as well as houses. Many people like the reddish colour of the timber. Because mangrove timber is flexible it is also favoured for fishing poles.

5. Fish Smoking

Smoking fish is a way to preserve fish for longer; mangrove leaves are often used to smoke fish. Smoked fish (vesa) are sold at market for similar or higher prices than other fish (~$6 per smoked fish compared with $6–9 per kg of fish).

6. Bait fish

Popular bait fish, the matu and qeqe, are found in mangrove areas. These bait fish are used for either reef or ocean fishing. The ease of catching these fish makes them more desirable than having to launch a boat, which involves more time and cost (fuel).

7. Medicines

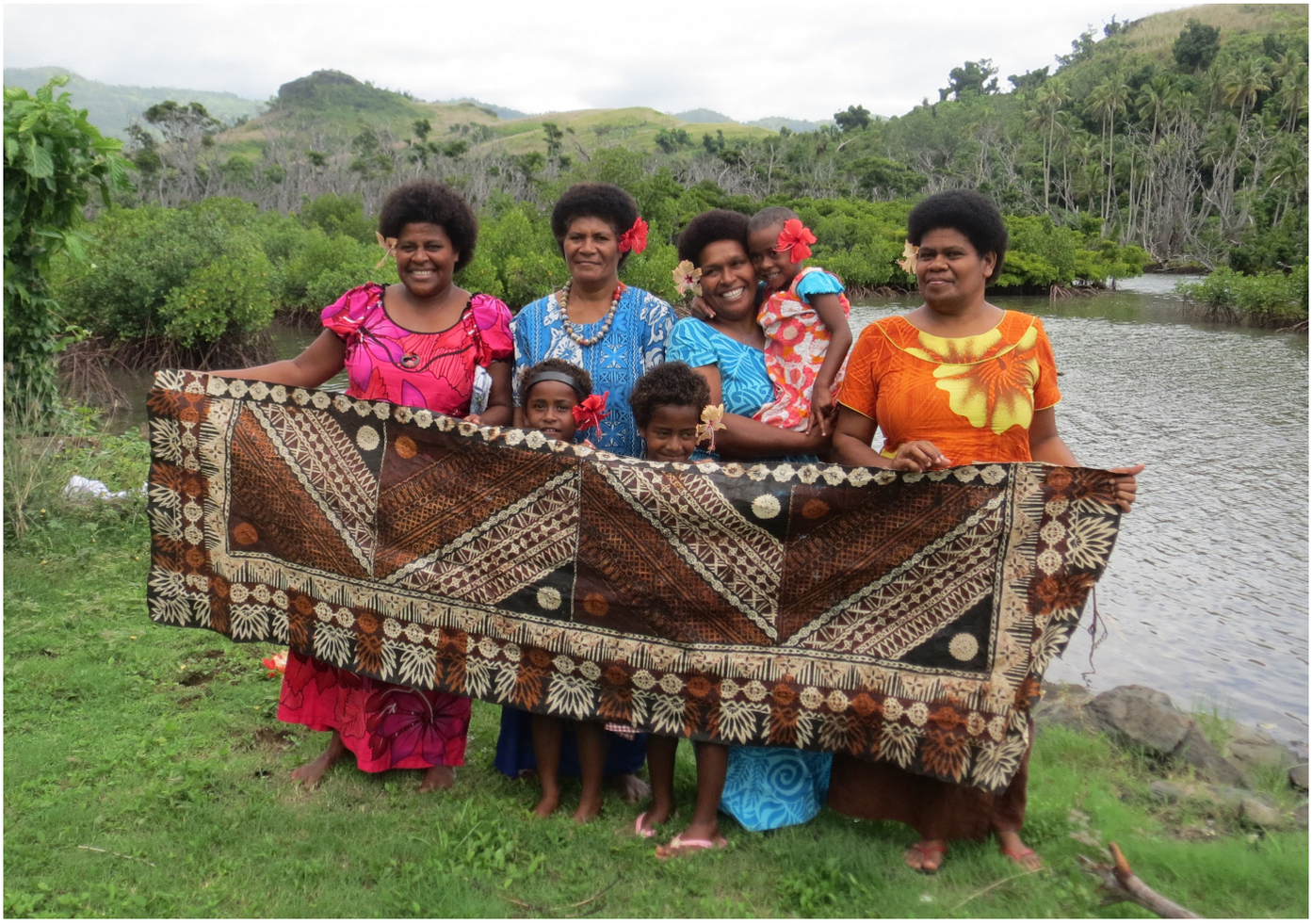
The leaves of mangroves have a number of medicinal uses, including relieving children with stomach cramps, helping with muscle cramps, and helping treat pneumonia and broken bones.

Of the species found in the areas surveyed in Ra province after Cyclone Winston (Naikatini et al 2014), the medicinal properties include:

- *Rhizophora* spp.: the bark has astringent, antidiarrheal and antiemetic properties
- *Bruguiera* spp.: the leaves are used for reducing blood pressure
- *Excoecaria agallocha:* is used for the treatment of leprosy and epilepsy
- *Xylocarpus* spp.: has antidiarrheal properties (Kathiresan 2012).

8. Traditional artefacts

Many artefacts are made with products from mangroves, e.g. woven baskets, garlands made from bark. Most of these are for household use. In the Ra Province, a traditional cloth made from mangroves is used for weddings and other ceremonies. This is a highly valued cloth and is made to order by village women. The cloth dye (masi) is from mangrove bark and carbon from burnt charcoal. A small cloth sells for about $60, while a big cloth is worth about $1,000. The income generated is highly variable, with sales ranging from around 10 cloths in a bad sales year to more than 20 in a good sales year. This equates to $600 to $20,000^{+} per village per year depending, on the number of cloths sold.



9. Provide tourism opportunities

Some areas could develop tourism activities within mangrove areas, e.g. canoe trips. This opportunity will depend on the accessibility of the mangrove area and other tourism activities in the surrounding area that could attract visitors. Areas without good road access or at least road access to a point close to the mangroves are less likely to be used for tourism purposes. This type of opportunity will also depend on either the local community having the ability to set up such a business or someone from outside the community developing the business.

Indirect benefits of mangroves

10. Nursery, feeding and breeding ground for freshwater, inshore reef and oceanic fish

A number of reef fish (e.g. snapper, jack, trevally, and surgeonfish) use mangroves as a nursery, feeding and/or breeding grounds. Many of these fish species are caught for sale in markets or eaten – in the 1980s approximately 70% of the fish sold in Fijian markets were estuarine/coastal fish (Lal 1984). Based on the fish caught by households, the value of mangrove-dependent fish sold is estimated to range from approximately $9100 to $12,600 per household per year. Without mangroves, the numbers of these fish would be reduced, resulting in fewer being caught and available for sale.

The importance of mangrove areas as fish nurseries is influenced by the size of the mangrove area, its accessibility, and the health of surrounding habitats such as sea grasses (Lee et al. 2014). Where mangrove forests are exposed during low tide, for instance, fish need access to other areas until they can move back into the mangrove area.

11. Coastal protection

Mangroves protect shorelines against waves, storms, flooding, and coastal erosion. Depending on the location, mangroves could protect gardens, buildings and/or roads. For example, during Cyclone Winston, houses in Nasua village (Ra Province) that were protected by mangroves suffered only partial damage compared with the complete destruction of houses that were not protected and were thus fully exposed to wave forces and ocean winds (RESCCUE-SPC Fiji progress report 2017). Another area where mangroves have provided benefits is protecting sea walls, increasing the life of these walls, and reducing the cost of maintaining the walls (World Disaster report 2002). It was estimated that a fully grown mangrove forest can reduce wave energy by 20% per 100 m of forest (Mazda et al. 1997).

The damage that is avoided by having mangroves to protect housing and other infrastructure will vary substantially depending on many factors, e.g. wind speed and direction, timing of the tides, and wave height, as well as the characteristics of the mangroves (such as density, height, type of species, elevation, fragmentation, and health of the mangroves) (Kathiresan 2012; Lee et al 2014). However, the magnitude of the costs can be estimated using the cost of replacing houses. For instance, the average price of a wooden house in the Ba and Ra province was estimated at around $22,200 (with a minimum cost of about $7,900 and a maximum of about $56,300) (Brown and Daigneault 2013). This information could be used to provide an upper amount of the extent of housing losses if all or a portion of houses not protected by mangroves in a village were destroyed.

12. Sediment removal from rivers and streams that flow through mangrove areas

The removal of sediment from rivers and streams helps protect coastal areas such as reefs, which can be damaged by too much sediment. How well mangroves trap sediment depends on the type and health of mangrove species, the density of the mangroves, and how complex their root systems are, as well as the amount of sediment and the wave action (Kathiresan 2012; Lee et al 2014).

Where there is inland deforestation, the effectiveness of mangroves at trapping sediments can be reduced due to the mangroves silting up, which affects their health and their ability to regenerate.

13. Carbon dioxide removal from the atmosphere

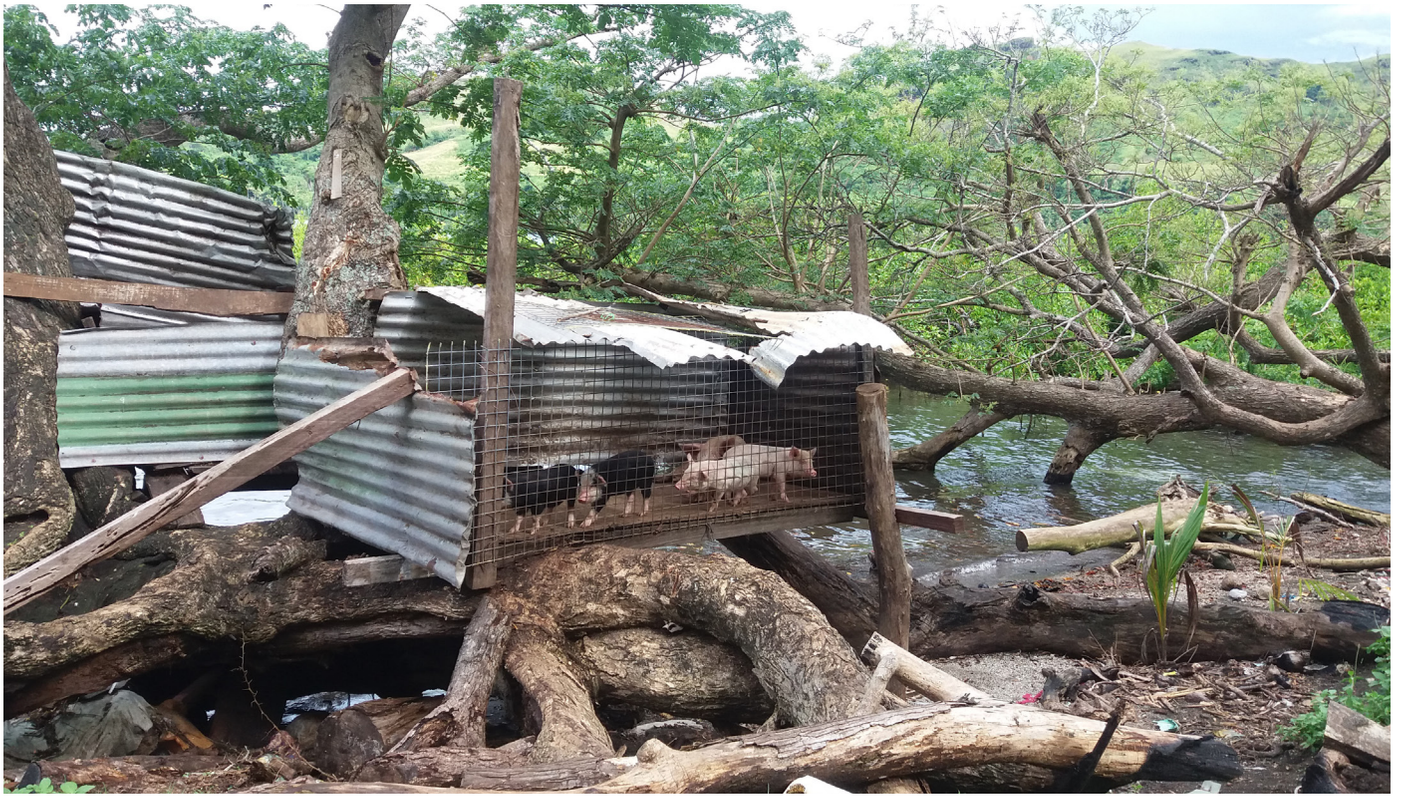
Mangroves, like other plant species, remove carbon dioxide from the atmosphere and store much of this within the plant (e.g. leaves, stems, roots) and soil. This process is called carbon sequestration and helps reduce the cause of climate change. In mangroves, the soil is the biggest carbon store.

The average annual rate of carbon sequestration from mangroves is variable but one global estimate is that mangroves remove about 6.32 (±4.8) tCO_2e/ha/year. These rates are at least two to four times greater than mature tropical forests (Murray et al. 2011) and their carbon stocks (or stored carbon) are up to 10 times higher than other tropical forest (Donato et al. 2011, 2012), making mangroves important for both carbon storage and removing carbon dioxide from the atmosphere.

The carbon sequestered by mangroves can be used to offset greenhouse gas emissions. This is where a company has a project that removes as much carbon dioxide from the atmosphere as they emit from their activities (such as emissions from using petrol in boats). An example of this in Fiji is 'Mangroves for Fiji', which is a privately funded project where Beqa Adventure Divers (on the Coral Coast) uses the carbon dioxide sequestered by mangroves to offset their tourism operations (Mangroves for Fji 2018). In the future, mangroves could provide opportunities for REDD+ implementation in Fiji. REDD+ refers to a country's efforts to 'reduce emissions from deforestation and forest degradation, and foster conservation, sustainable management of forests and enhancement of forest carbon stock'. In a 2009 scoping exercise for REDD+, the loss of mangroves to settlement and infrastructure development was noted as one of the main drivers of forest loss and degradation in Fiji (REDD+ Fiji 2010).

14. Removes waste

Human or animal waste can be captured and recycled by mangrove areas as mangroves are able to recycle nitrogen, carbon, and sulphur. Mangroves tend to disperse the flow of waste over larger areas: the mangrove itself can filter nutrients from water, and the soil beneath mangroves can absorb large amounts of pollutants (e.g. heavy metals), preventing their spread in coastal areas (Wong et al. 1995).



15. Honey

Benefits have been noted in other places that could also have future importance. Honey is one such benefit. In parts of East and South Asia, mangroves support apiculture activities (honey and wax). The mangroves species that have been noted for honey production in these areas include *Aegialitis rotundifolia, Cynometra ramiflora* and *Ceriops* spp. (Kathiresan 2012). These species are not native to Fiji so some work would be needed to determine if species in Fiji are also good for apiculture activities.

Costs associated with mangroves

The negative aspects of mangroves tend to reflect what people dislike about mangroves, rather than a financial cost. However, if tourism was to increase, the aspects listed below might deter tourists from visiting an area.

1. Smell and access

Some communities or people within villages find the smell of mangroves areas unpleasant. They also do not like walking in those areas to gather food or timber because it can be difficult to walk in the mud under the mangroves.

2. Aesthetics

Some people dislike the look of mangroves, particularly during low tide.

3. Mosquitos

One other observation by local communities is that sometimes mangroves can have more mosquitos, which are not only a nuisance but could also carry viruses that affect humans and/or livestock in the future.

The main mosquito-borne viruses in Fiji currently, dengue fever, chikungunya and zika (Vuibau 2016), are not carried by mosquitos that breed in mangroves. In the future, though, other mosquito-borne viruses (e.g. Ross River Fever) from areas where the mosquito host breeds in mangroves may enter Fiji (Dale and Knight 2008).

Maintaining tidal flushing is one way to help reduce areas where there is standing stagnant water that provides a breeding place for the mosquitos.

Cost of Restoring Mangroves

The restoration costs for mangroves can be divided into 3 main categories:

- Consulting with the community and planning
- Establishing a mangrove nursery
- Planting of mangrove seedlings and monitoring

The costs for these activities will vary from site to site as the area to be replanted changes; labour costs may also differ depending who is undertaking the work. To help estimate the cost of undertaking mangrove restoration activities, the estimated time and costs are provided below. These costs are based on the costs associated with mangrove restoration activities undertaken through the RESCCUE-SPC project in Ra Province, Fiji between 2016 and 2018.

Consulting with the community and planning

Community consultation is an important aspect of any replanting programme. Consultation is important to get buy-in from the community and also to gain enthusiasm for the project as local labour or community members (e.g. village youth) will be important for the collecting, planting, and monitoring of any mangrove replanting programme. The costs for this aspect of the restoration are listed in Table 4. Consultation is undertaken by NGOs, Provincial Office, Department of Fisheries or Forestry, and/or University of South Pacific (USP) staff.

Table 4. Costs for community consultation and planning (costs based on engagement and planning with 5 villages)

Activity	Who	Time involved	Approximate cost
Meeting with chief and community to outline project	NGO, USP, provincial staff or Department of Fisheries or Forestry staff	~ 3 meetings/village (allow 1 day for each meeting) Total 15 meetings for the 5 villages for one person	~ $1200 based on: • $80/person/day
Traditional protocol for community engagement (Yaqona – sevusevu, itatau)		Part of first community meeting Total of 5 packets of kava needed	~$200 based on: • $40/packet of Kava
Travel to village	NGO, USP, provincial staff or Department of Fisheries or Forestry staff	~1 day/meeting (depends on distance) Total 15 meetings	~$6000 based on: • ~$200/each way by vehicle
Mapping of mangroves and area to be replanted	NGO, USP, provincial staff or Department of Fisheries or Forestry staff	~4 days (including assessing the area, groundtruthing, taking GPS locations). 3 staff required for this work	~$5300[a] (with $80/person/day for staff)
Develop work plan for replanting activities, including species selection	NGO, USP, provincial staff or Department of Fisheries or Forestry staff	~5 days to develop and refine the plan (includes contacting community & other partners) ~4 staff required for this work	~$5400[a] (with $80/person/day for staff)
Approximate cost (will be similar regardless of area replanted)			**$18,100**

a: See Table 5 below for a more detailed breakdown of costs

Table 5. Detailed breakdown of mapping and planning costs (based on costs for 5 villages)

Category	Mapping and Planning Activities	Cost[a]
Engagement	Community engagement and consultation on the objectives of mangrove replanting	$7,400
Mapping of mangroves and area to be replanted	Mapping the coastline and a profile of coastal area	$500
	Identification of high energy and low energy areas to determine areas that will be revegetated	$500
	Identifying in situ seed source (mangrove and coastal vegetation) and collecting of seeds	$2,000
	Carry out a participatory historical profile of the vegetation	$400
	Gathering community information on appropriate or inappropriate places for replanting mangroves and coastal native plants (e.g. areas access to sea, etc.)	$400
	Demarcate the areas to replanted	$1,500
Develop work plan for replanting activities, including species selection	Mobilizing of communities in the replanting (transport and planting equipment)	$3,500
	Mangrove monitoring community capacity strengthened: Developing a mangrove monitoring plan	$400
	Establishment of a mangrove protected area: Community consultation to establish a tabu area within their existing mangrove area and developing a tabu management plan	$1,500

a: based on activities being undertaken in 5 villages. Costs per village will be cheaper if there are multiple locations/villages involved.

Establishing a mangrove nursery

The main cost related to the establishment of a mangrove nursery is the collection of the seedlings and transport to the nursery area (Table 6). Seedlings are typically collected from wild sources near villages. This, of course, will depend on access to wild sources. If there are no wild sources near the village then there will be additional costs associated with the collection of seedlings from further away. The mangrove species sourced should also be appropriate for the location being replanted.

The estimates below are based on a 20 m x 50 m restoration area and are provided as a guide for the cost of the actual restoration. The costings that underpin these calculations can be used to estimate different sized restoration areas. Appendix 3 also provides some recommendations for how to improve seedling survival rate.

Table 6. Approximate costs to establish a nursery to replant a 20 m x 50 m area

Activity	Who	Time involved	Approximate cost
Collection of seedlings	Community members/ youth (~10 - 20 youths needed)	1 ½ days to collect 3000 seedlings (~ 2000 seedlings collected per day)	$375 based on: • ~$250/day for community members/ youth[a]
Construction of nursery	NGO, provincial staff, Department of Fisheries or Forestry staff	~ 2 days for 2 people	~$320 based on: • $80/person/day
Potting of mangroves	Community members/ youth (require 10 – 15 people) NGO, provincial staff, Department of Fisheries or Forestry staff	~ 4 days (Based on needing 1000 seedling bags and 300 seedling bags potted/day)	~$920 based on: • Potting bags $10/pack (with 50 potting bags in a pack) • $100/day for community members/ youth • $80/day for staff
Approximate cost for transplanting ~3000 mangrove seedlings (1000 bags) (to replant 20mx50m area)[b]			**~$1615**

a: this is often a fixed community cost regardless of the number of youth/community members involved.

b: number of seedlings needed for transplanting is based on a 1m x 1m planting density (i.e. require 1000 seedling bags) with 3 seedlings per bag.

Planting of mangrove seedlings and monitoring

The planting of the seedlings involves taking the seedlings from the nursery to the planting site and the transplanting of the seedling bags (Table 7).

Table 7. Approximate costs for planting the mangrove seedlings (20 m x 50 m area)

Activity	Who	Time involved	Approximate cost
Training on planting and monitoring plants	NGO, USP, provincial staff or Department of Fisheries or Forestry staff	~ ½ day (1 staff person needed and can be undertaken during a high tide period when access to the nursery is limited)	~$40 based on: • $80/person/day for staff
Transport of seedlings	NGO, USP, provincial staff or Department of Fisheries or Forestry staff Community members	Depends on distance. Assumed it will be approximately 1 day for most replanting sites near villages.	~ $500 based on: • Vehicle use at $100/day (1 day) • Boat transfer for places that are not accessible by vehicle at $200/one way (depends on distance) – used 1 return trip • Plastic rack for transport (holds ~30 potted seedlings). Trays can be supplied by Department of Forestry at no cost
Planting of seedlings	Community members	~ 3½ days (for 10 people) (~ 300 potted seedlings planted per day x 10 people and there are 1,000 bags to transplant)	~ $3500 based on: • ~$100/day/person x 10 people
Monitoring of seedlings[a]	Community members	1 ½ hours x 10 people.	Community did this without being paid
Approximate cost for replanting 20mx50m area (~1000 mangrove seedling bags)			**~$4040**

a: the monitoring should be undertaken until the mangrove stands are mature. While the monitoring will be undertaken by the community at no cost, there could be further costs associated with any issues that might arise, for instance, a storm destroys the newly planted seedlings and they need to be replanted.

Appendix 1. Criteria to assess condition of mangroves

Table 1A outlines a set of criteria to assess the condition of mangroves. This assessment can be used to determine which areas are best to target for mangrove restoration.

Table 1A. Criteria to assess the condition of mangroves (Deguit et al. 2004)

Condition	Criteria
Excellent	>76% crown cover 1 plant regeneration per m^2 Above 5 m in average tree height Undisturbed to negligible disturbance
Good	51–75% crown cover 0.76-1 plant regeneration per m^2 3 - 5 m average height of trees Slight disturbance and few cuttings
Fair	26–50% crown cover 0.5–0.75 plant regeneration per m^2 2 - 3 m average height of trees Moderate disturbance and noticeable cuttings
Poor	0–25% crown cover 0.50 plant regeneration per m2 <2 m average height of trees Heavy disturbance/cuttings pollution, rampant conversion to other uses, nearly destroyed

Appendix 2. Assumptions made for the financial estimates of the benefits of mangroves

Outlined below are the assumptions that underpin the monetary numbers in 'Benefits of Mangroves' section. The data, unless otherwise cited, are based on village focus groups held in November 2017 in the Ra province. All monetary values are in 2017 Fijian dollars.

Benefit	Assumption
Food	• 80–90% of a household's meals come from mangroves (4 out every 5 meals) • Average family size is 5 (median size of household was 4.79 in 2007 (Fiji Bureau of Statistics 2007)) • 1.25 kg fish/meal is consumed for a family of five • Household eats 3 meals/day • 'other fish' not the class A fish is consumed by families • Price of 'other fish' is $6.5/kg (November 2017 price) Example calculation: Purchase of fish by households if no mangroves = percent of meals that comes from mangroves **x** kg of fish consumed by a household **x** number of meals a household eats per day **x** price of fish ($/kg) **x** number of days in a year
Firewood	• Households collect, on average, 9 bundles of firewood per month (Brown and Daigneault 2013) • All firewood is collected from mangroves • No adjustment was made to potentially using less mangrove firewood compared to other species given mangrove firewood burns for longer. This was due to no information being available on the species collected for firewood in the survey by Brown and Daigneault (2013) • The price of firewood bundles was between $3 and $5 per bundle. Example calculation: Purchase of firewood by a household if no mangroves = Bundles of firewood purchased each year x price of firewood ($/kg)
Traditional Cloth	• The lower bound estimate is based on the sale of 10 small clothes (approximately 200 x 50 cm wide) at $60 each (November 2017 price) • The upper bound estimate is based on the sale of 20 large (or wall size) clothes at $1,000 each (November 2017 price) Example calculations: Sale value = number of clothes sold x price of clothes

Benefit	Assumption

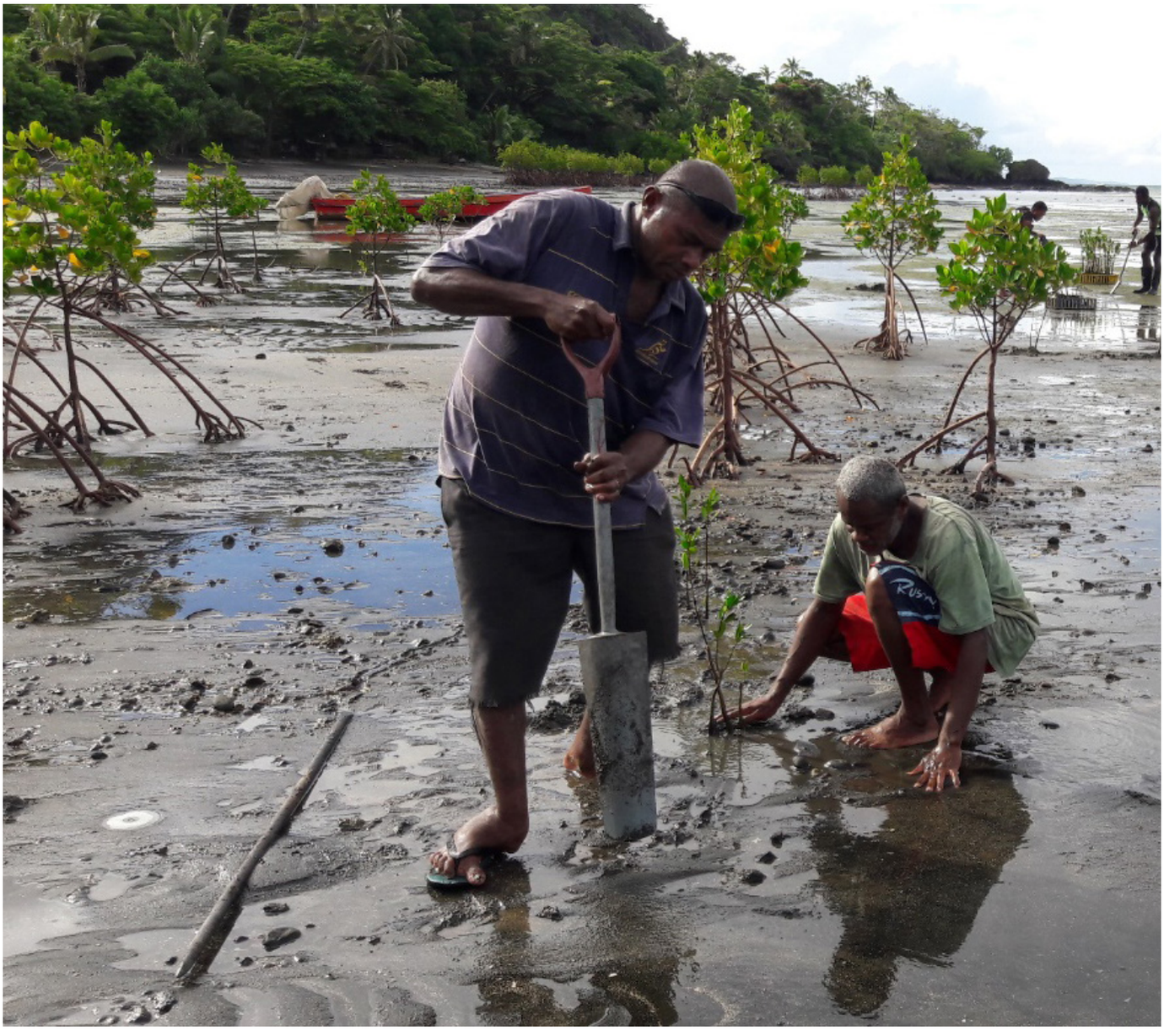
Nursery, feeding and ground for freshwater, inshore reef and oceanic fish	• Household catch is approximately 50 kg fish per week
	• Price of class A fish is $9/kg (November 2017 price)
	• Price of 'other fish' is, on average, $6.5/kg (November 2017 price)
	• 70% of fish species sold to market use mangroves (Lal 1984)
	• Fish is sold in the market 40 weeks of the year
	• No account has been made of
	  • more fish that do not use mangroves could be caught or
	  • any an increase in fishing effort as a result of potentially diminishing fish stocks
	Example calculation:
	Value of mangrove-dependent fish a household sells in the market =
	Kg of fish household catches to sell **x** percent of fish species sold in markets that depend on mangroves x price of fish sold ($/kg) x number of weeks a household sells fish

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 $7,000 and maximum of $50,000 (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) (see Appendix 4)

Appendix 3. Recommended actions to improve survival rate of replanted mangroves

From the RESCCUE-SPC mangrove restoration efforts there are some recommendations to help restore mangrove areas successfully:

- Use transplanted seedlings rather than directly planted seedlings. Transplanting seedlings seem to improve root stabilisation, making them better able to withstand harsh coastal conditions
- Use plastic bags for potting rather than plastic cups
- Plant 2–3 seedlings per bag
- Use a 95% survival rate for the transplanted seedlings. This assumes that healthy seedlings are selected for collection and then potting



Appendix 4. Example 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 the prices need to be stated in the same year.

Prices can be converted 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 4A lists the CPI values that can be used for these calculations.

Table 4A. Annual average CPI from 2008-2017 (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

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