

Mangrove Management Plan for Vulani Islands

Stage 1: General Mangrove Management

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Support

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Stage 2: Detailed plan for physical parameters of Vulani Islands property,
Selection of conservation, landscaping and nursery sites

Nomenclature convention:

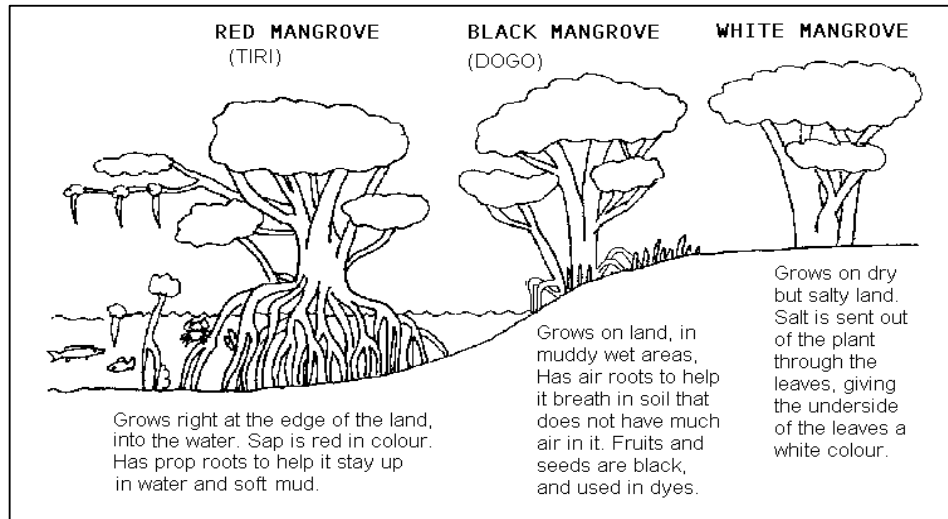
- Scientific species names given in *italics*,
- Common English names in regular font,
- Common Fijian names in "quotation marks".

A) Introduction

A.1) Background information on Fiji's mangroves

The word “mangroves’ does not describe a single species of tree, but rather a type of forest which is able to grow in wet and salty conditions. Fiji’s mangroves are made up of seven main species of trees, and several associated plants. The trees can be categorised into three functional groups depending on growth habits.

Figure 1: Mangrove zones according to growth habit.



Red Mangroves (“Tiri”) grow at the water’s edge, with “prop” roots that stabilise trees in soft mud and wave zones. In Fiji there are two species of trees which live in this manner, and one sterile hybrid when both species are present.

Red Mangroves in Fiji are:

- *Rhizophora stylosa* (*R. stylosa*) “Tiri tabua” - usually directly fronting the sea
- *Rhizophora samoensis* (*R. samoensis*) “Tiri wai” – usually closer to rivers
- the Hybrid *Rhizophora selala* (*R. selala*) - taller trees found in mixed forest

Black Mangroves (“Doggo”) are usually found behind Red Mangroves, in muddy areas that flood at high tide. They may have “prop”, or “elbow” roots that stick up out of the mud, sometimes both. In Fiji there is only one species Black Mangrove:

- *Bruquieria gymnorhiza* (*B. gymnorhiza*) “Doggo”

White Mangroves are often not recognised by the layman as part of the mangrove community. They are very salt-tolerant trees that grow on dry land immediately behind the wet mangrove areas, and can survive occasional salt-water inundation, and salty soil. In Fiji there are four species of trees which live in this environment.

White Mangroves in Fiji are:

- *Lumnitzera littorea* (*L. littorea*) “Sagali”
- *Heritiera littoralis* (*H. littoralis*) “Kedra viv na yalewa kalou”
- *Excoecaria agallocha* (*E. agallocha*) – Milky Mangrove “Sinu gaga”
- *Xylocarpus granatum* (*X. granatum*) – the Puzzlenut tree “Dabi”

Mangrove Associates are plants often found in the same area as the White Mangrove, but also in non-mangrove areas such as beaches. In Fiji these include:

- *Acrostichum aureum* - Mangrove Fern
- *Hibiscus tiliaceus* - Beach Hibiscus “Vau”
- *Hernandia nymphaeifolia* - Chinese Lantern “Evuevu”
- *Barringtonia asiatica* - Poisonfish tree “Vuturakaraka”
- *Pandanus pyriformis* – Screwpine “Vauvau”

A.2 Mangrove status in Fiji

It is estimated that Fiji has over 38,000 hectares of mangrove forests, most of which are found on the two main islands of Viti Levu and Vanua Levu, and that more than 60% of Fiji's commercially important food fishes use the mangrove at some stage of their life cycle. In 1983 the value of Fiji's mangrove forests to the fishing industry was estimated at over FJ\$20 million. The mangroves are also important in sewage disposal, providing a natural filtration of water and effluent.

Between 1933 and 1975 mangroves were designated Reserved Forests under the Forestry Department, but since then they have been de-notified and are currently under the jurisdiction of the department of Lands and Survey as an integral part of the foreshore. A National Mangrove Plan was formulated in 1986 but as yet has not been made law, and there is currently little protective legislation concerning mangroves. However, under this plan, the main mangrove areas across Fiji were described in several zones:

Reserves:

- Resource Reserve
- National Reserve

Small scale use not involving clearance:

- Wood Production
- Traditional Use
- Shoreline Protection
- Sewage Processing

Clearance and conversion to dry land:

- Urban
- Tourism
- Agriculture (not clear felled along water courses)

In 2005, the Environment Management Bill was passed, recognising mangrove swamp as *"an ecosystem of national importance"* and requiring projects to seek approval from the Environment Impact Assessment Administrator for *"a proposal that could alter tidal action, wave action, currents or other natural processes of the sea, including... reclamation of ... mangrove areas..."*

The Nadi Bay area of Fiji has a dwindling area of entire mangrove forests and the remaining ones have been described as having significant conservation value in previous surveys. As a policy, large-scale clearing of mangroves is not recommended. There is no reason why development cannot be carried out in areas of mangrove forest without involving large-scale clearing. Careful design can result in sustainable usage of mangrove areas, and is to be strongly encouraged in the regions where mangroves remain.

In addition, within tourism developments, mangroves can have a positive value in educative programmes, coastal and river bank stabilisation, and scenic development. They are much more attractive than mud flats, and more efficient at coastal protection than sea walls.

Figure 2: Photographs of mangrove use and loss in the Fiji Islands

a) Beach erosion as a consequence of uninformed mangrove cutting

Rotting roots after mangroves cut down



Resulting beach erosion & sea wall loss



b) Beach conservation behind preserved mangroves

Beach point preserved around mangrove shrub



Beach preserved behind mangrove hedge



c) Two approaches to jetty placement:

Wide scale clearance and destruction



Limited cutting for scenic boardwalk



d) Two low tide river banks

Unattractive cleared mud flat



Low mangroves concealing mud



B) Overview of status of existing mangroves on Vulani Islands

B.1 Zonation

There are three mangrove types on the property.

1. Wet riverbank areas largely consisting of Red Mangroves with prop roots extending into the water and rooted in deep, soft mud.
2. Extensive muddy areas behind the riverbank which flood at high tide but are dry for most of the time. In these areas there is a mixture of Red and Black Mangroves with prop and elbow roots. The soil is deep mud, but drier and firmer than the river bank area.
3. Drier areas near to the centre of the property, and along the road, with a few Black Mangroves, and many White Mangrove trees and Mangrove Associates.

These can be split into “Associations” according to proportions of species and environment. During surveys as part of the EIA process for Vulani Islands, seven main Associations were identified:

1. Stunted Red Scrub, mix of *R. stylosa* and *R. samoensis*
2. Tall Red Forest including *R. selala*
3. Short Red & Black Forest with an even mixture of *Rhizophora* and *Bruguiera*
4. Tall Red and Black Forest dominated by *R. stylosa* and *R. samoensis*
5. Tall mixed Forest including Red, Black and White Mangroves
6. Tall mixed Forest of Red and White Mangroves
7. Dry Forest – non-mangrove trees

Figure 3: Location of the different Mangrove Associations (boundaries approximate)



B.2 Biological importance

Mangroves are essential habitats for juvenile fish and crustaceans. Large-scale clearing of mangrove forests can permanently alter fish and invertebrate populations of the surrounding reefs.

The mangrove forests around Vulani Island are mature, well established and bio-diverse environments supporting a high amount of animal and plant life, as well as providing high nutrient levels which support marine life in the rivers and estuaries. Past surveys have identified them as having very high fisheries productivity, particularly related to fish and crustaceans. While the roots of the Red Mangroves are important as breeding and juvenile habitats, the dead leaves and other detritus from the mature forests are vital nutrients for the entire marine life food chain.

Of the seven Mangrove Associations identified from surveys during the EIA process, the ones with the most importance to the marine habitat are:

2. Tall Red Forest including *R.selala*
3. Short Red & Black Forest with an even mixture of *Rhizophora* and *Bruguiera*
4. Tall Red and Black Forest dominated by *R. stylosa* and *R. samoensis*

These represent the mangroves along the river banks and in the western section of the forest. They include a full range of *Rhizophora* species and a large population of *Bruguiera gymnorhiza*.

Most of the trees are tall (8 m and over) and mature, with little room for new growth, and little light penetration through the leaf canopy. There is little undergrowth of mangrove associate plants. In the deeper sections of the forest, the roots reach up to 1.5 metres from the surface, and the foliage starts between 6 and 8 meters, with a large area of bare tree stems in the centre.

It is the roots and foliage that are important to the marine environment, and these large, old trees, prevent the growth of new seedlings. Smaller, younger trees which had the same area of roots and foliage growth would be just as biologically important, and more aesthetically acceptable for a resort development.

Mangrove Landscaping and Management is recommended as a way of preserving sufficient mangrove environment to minimise adverse impacts on the marine communities, whilst allowing scenic development of the area to take place.

Figure 4: Examples of tall and small mangrove trees



C) Concepts in Mangrove Landscaping

C.1 Shaping and trimming

In mature mangrove forests, the trees can grow to over 10 metres tall, blocking views and creating tangled, impassable forests. It is for this reason that many developers seek to remove mangroves. However, mangroves do not have to be allowed to grow to their full height and natural shape any more than a land-based tree. As previously discussed, from the standpoint of value to the marine environment, it is important that mangroves have mature root systems and plenty of foliage, but there is no need for the forest to be allowed to attain its maximum growth.

Trimming the growth point of a young mangrove tree as it grows will encourage it to remain short and bushy rather than tall and straggly. If this is done as part of a normal landscape gardening programme, mangroves can be kept small enough to retain their biological functions, and yet become part of a scenic landscape.

Pruning can take place once trees are one or two years old. Pruning can be designed to shape the tree to the requirements of the landscaper: tall trees with straighter trunks can be achieved by trimming lower branches. Smaller, bushy trees can be formed by continually trimming off the taller growing points. Over-pruning of more than 30% of the foliage crown will stunt growth altogether. Stubs of cut branches should be painted with tar to prevent fungal attack.

“Bonsai mangroves”

Mangroves have even been subjected to “Bonsai” treatment and made to be very decorative, and there is no reason why ornamental mangrove trees cannot be cultivated in public areas.

Figure 5: Growth-limited “bonsai” mangroves



(Picture credit: Horace F. Clay / Mid-Pacific Bonsai Foundation Ukiyoe Collection)

In the case of small seedlings that may be used for decorative shaping, leaf buds can be cut off right above their base, and leaves snapped off by hand. Not more than two leaves should be removed per day from small seedlings.

Note that mangrove seedling roots should not be trimmed, as they have very specific functions, and cutting them may damage the tree’s health.

Naturally growth-limited mangrove in Fiji



(Picture credit: David Fukumoto / www.fikubonsai.com)



C.2 Selective cutting and thinning

Pruning may be a management solution for small areas of mangrove, but not a practical answer over large areas of tangled, mature forest. In these areas, very old mangroves prevent new foliage growth by blocking out sunlight from the forest floor, and the ecosystem can benefit from selective cutting of old trees and replanting with young ones. Techniques used in this practice are selective cutting and strip clearing. (Melana D et al)

Selective cutting is a method of cutting specific trees within a forest, creating increased space and light, which in turn encourages natural regeneration of young trees in the space created. This is suitable to remove large, unhealthy or unattractive trees from a small area, to increase the scenic value of the remaining forest.

Strip clearing is more suitable for a larger area (greater than 10 hectares). A strip 10-20 meters wide by 50-100 meters long is cut through the forest. If the trees face wave action, these strips should be at a 45 degree angle to the waves, to lessen the impact. The cut strips can either be allowed to regenerate naturally, or can be replanted with cultivated seedlings (“Enhancement Planting”). This is a useful tool to open up and revitalise moribund old-growth forest, and to increase biodiversity by planting specific mixtures of species.

C.3 Transplantation of trees from clearance areas.

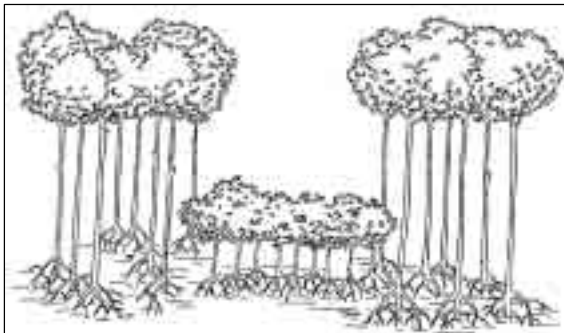
In an area where mangrove clearance is being considered, it may be possible to transplant seedlings and smaller trees to areas where refurbishment is required. This requires careful handling and excavation of a mud ball of a large enough diameter that the roots are not broken or damaged. However, it can be a useful way to quickly landscape an area, and to preserve some of the trees from a clearance zone.

C.4 Enhancement planting

Replanting mangroves is widely done across the globe, usually as a means of increasing coastal protection or of regenerating mangrove areas that have been destroyed for a variety of reasons. This has been done for several years in the Fiji Islands, largely by OISCA, a Japanese-funded NGO.

“Enhancement Planting” as part of “Assisted Natural Regeneration”, is more suitable for areas that require regeneration for biological or scenic reasons. This involves encouragement of natural new growth, and augmentation with deliberately planted seedlings, coupled with controlled pruning and thinning, and forest floor cleaning.

Figure 6: Strip Clearing and Enhancement Planting. (Melana D et al)



This is also very useful to conserve biodiversity, as different species can be planted in desirable proportions rather than allowing haphazard regeneration, which may lead to an unfavourable single-species dominance. Different balances of species can be planted according to different environment zones.

Within a mature mangrove forest, seedlings can be planted in spots where selective cutting has taken place, or in strips between mature trees. They can then be pruned or thinned according to landscaping requirements.

C.5 Management of landscaped areas

It is not sufficient to start a mangrove landscaping project and later allow the trees to revert to their wild growth forms. In the same way as regular landscaping and ground-keeping, there must be ongoing maintenance in the form of weeding, pruning, removal and replacement of dead trees etc. Full-time staff need to be trained in mangrove landscaping and the process incorporated into the regular gardening schedule.

The most intensive part of mangrove management is establishment and upkeep of a suitable nursery site. Again, this can be included in a regular grounds-keeping routine, but requires special placement and staff training. (See following section E).

D) Selection of areas for Conservation and Landscaping

D.1 Areas for conservation as “Wild State” mangrove forest

It is not advisable to change all mangrove forest into a regulated and “gardened” area. It is important that there are large tracts of wild-state forest to preserve natural biodiversity, seeding areas, and habitats for a full range of animal inhabitants from crustaceans to birds.

It is strongly recommended that any area considering mangrove landscaping also makes a strong commitment to preserving an equivalent-sized area of wild state mangrove forest. It is also important that such areas be continuous rather than patches isolated from each other by altered environments.

Before any clearance and landscaping takes place, suitable areas should be identified and designated as wild state preserves.

D.2 Areas for preservation and landscaping of mangroves

Similarly, before any clearance takes place, areas for landscaping through selective or strip clearing, enhancement planting, and/or pruning and thinning, should be clearly identified and designated.

This should take into account environmental suitability, sufficient variety of habitat to maintain a similar or improved balance of species to that in place before landscaping, and development requirements. Alterations in drainage caused by development requirements may change the suitability of the area for different species, and so full disclosure of development plans is essential.

River banks are particular areas where preservation of mangroves is recommended, from both environmental and bank stabilisation standpoints. Belts at least 10 metres, and preferably 15 metres, deep should be preserved along river banks, with occasional deeper stands where areas of biological importance are identified. In these areas, controlled pruning, strip cutting and enhancement planting could be used to lower the overall height of the forest, allowing landscaping, while preserving ecological function. Areas bordering small creek beds are important to maintain with mangrove root systems to avoid siltation into rivers and ocean.

E) Mangrove nurseries

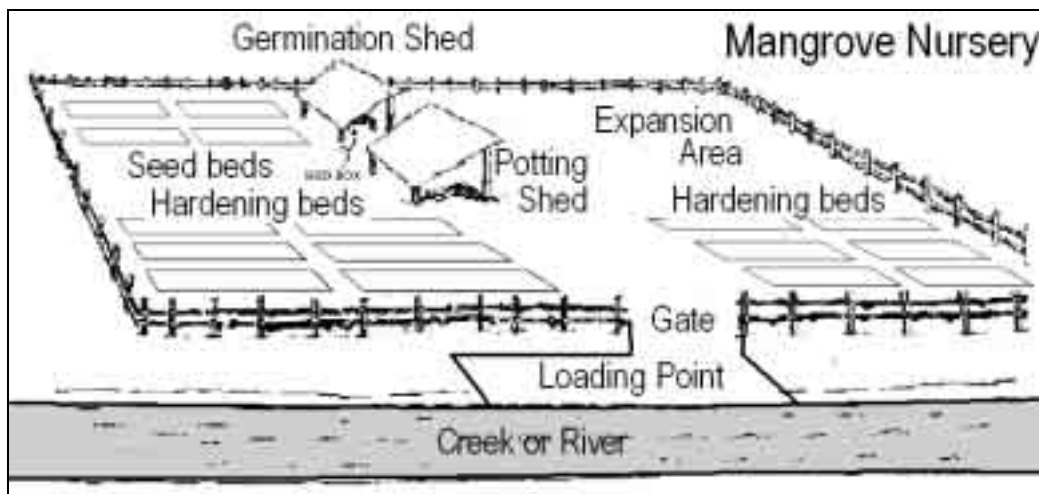
Replanting and Enhancement Planting cannot take place without a nursery where seeds can be germinated and seedlings cared for until they are large enough to plant out. In addition to the main nursery, there may need to be secondary nursery areas where larger seedlings can be placed close to their eventual planting-out location, to harden them off to their environment.

E.1 Determining suitable location

The main mangrove nursery area has the following requirements:

- Adequate water supply – Fresh or brackish (not salt) water, e.g near a river, but not subject to flooding.
- Accessible – Soil needs to be brought in and seedlings taken out, Staff need to be able to access site daily.
- Well drained, and flat – Seedlings should be raised in properly drained soil, not in waterlogged ground
- Large enough - The size of the nursery can be calculated using a simple formula (Melana D et al): for each hectare of mangroves to be eventually planted, 325 square metres of nursery space will be required, plus room for working space, storage sheds, etc.

Figure 7: Layout of Mangrove Nursery (Melana D et al):



Nurseries need to contain the following:

- Seed germination beds (with mesh coverings)
- Seed box
- Germinating shed
- Potting shed
- Bagging and storage shed
- Potting soil and sawdust stockpiles
- Compost beds
- Seedling hardening beds (with mesh coverings)

The secondary planting out nurseries are smaller and have much less elaborate needs, essentially just an area of natural soil with adequate sunlight (i.e., forest floor cleared of other vegetation, overhanging tree branches trimmed back)

E.2 Collection of fruit / seedlings

Figure 8: *R. stylosa* propagule

The Red and Black Mangrove species of Fiji do not germinate from seeds like most land-based plants, but instead grow long thin pod-like “propagules” which hang from the tree like green beans. These can be collected from the trees in the area at the correct time of year. According to OISCA, in Fiji the best time to collect *Rhizophora stylosa* propagules is March / April / May, and it is probable that the other species mature at the same time. Propagules harvested too early will not germinate successfully.



A 20 – 30% failure rate amongst seedlings can be expected, so if 1,000 seedlings are required, it is recommended to plant 1,400 to 1,500 to allow for replacement as needed. Propagules should not be planted too deeply – one third of the length of the propagules underground to two-thirds above the surface is recommended.

If it is not possible to collect all propagules needed from trees, it is also possible to collect floating seedlings after they have fallen from the trees – these often accumulate at the corners of bays after drifting according to currents. Any that are already sprouting leaves have a better chance of success than those without leaves.

Figure 9: *Rhizophora stylosa* seedlings in Fiji

Nursery and hardening off site



Seedlings ready to plant out



Wildlings

It is also possible to uproot small seedlings (30cm tall or less) which have already settled in unsuitable environments (“wildlings”) and replant them in the secondary nurseries, as long as sufficient care is taken not to damage the roots. The general rule of thumb for this is to carefully dig out the mud in a circle around the wildling the same size across as the wildling is tall, to prevent root damage. (Melana D et al)



E.3 Growing and timescale

The speed of the seedlings' growth depends on the nutrient levels of the soil they are planted in. Muddy, soil-rich substrate produces faster growth than sandy substrate, and drainage is important. Recommended potting mix is 50/50 mix of soil and a dry pulverised organic matter such as sawdust.

The experience of OISCA staff in Fiji is that it takes approximately 8 – 9 months to grow a propagule into a plantable seedling around 50 cm tall.

Once seedlings are of an adequate size they can be prepared for planting out. This requires a 4 week period of "hardening off" where seedlings are gradually exposed to more salt water and more sunlight. This is generally done in a specially prepared area of the nursery where there is access to more salt water than has been previously used, or seedlings can be transferred to secondary nurseries where the water is more salt.

Seedlings should not be taken straight from a shaded fresh water nursery and planted out in an open, salt water environment without hardening.

Once planted out, the trees require regular and intensive maintenance (See later section) for about two years, after which they are fairly self sufficient.

Thinning can take place at 5 years if required.

E.4 Use of nursery areas to condition sea water for lagoon use

In salt-water aquariums, mangroves and artificial wetlands have been incorporated into filtration systems to help control nutrient levels. In Fiji, such a system has been in place at Kula Eco Park for the past four years, and Marine Ecology Consulting currently has a USP Post Graduate Student studying the effectiveness of this.

It is suggested that a properly situated mangrove nursery or hardening off ground could be utilised to reduce nutrient levels in an artificial lagoon system, helping to reduce algal growth. In the aquarium situation mangrove seedlings have been grown entirely hydroponically (i.e., roots in water, not in substrate) which raises the possibility of floating decorative islands which could be moved around as required.

E.5 Planting out

After hardening, seedling can be planted out. Planting areas should be prepared by clearing out surface plants, dead wood, and any other debris, and trimming back over-hanging branches. Avoid areas with a lot of barnacles on existing roots, as these may damage young trees. If the area has been cleared of old trees, the majority of large roots should be removed.

Extremely soft mud, waterlogged areas, or areas with sulphurous smells should be avoided, and the area should be dry or less than 10cm underwater at low tide. Areas with strong wave action are not suitable, or require special preparations such as denser planting, and special shapes designed to break wave force.

In calm areas seedlings can be planted out at a density of 1 seedling per square metre. If denser growth is required, this can be increased to 4 seedlings per square metre. In areas of strong wave action, denser planting is recommended up to a maximum of 16 seedlings per square metre, but this may stunt growth.

This means that 10,000 to 40,000 seedlings are required per hectare to be replanted.

Figure 10: Photographs of planted out *Rhizophora stylosa* seedlings in Fiji



E.6 Maintenance of seedling trees

For the first two years, the young trees will require constant and intensive gardening maintenance. Weekly visits to the planted sites are recommended. This includes:

- Removing debris
- Removing barnacles
- Removing dead seedlings
- Replacing dead or lost seedlings with new seedlings from the nursery
- Removing algae etc.
- Gentle pruning as required in landscaping

After 2 years the young trees are more self-sustaining and maintenance can be reduced. At this point, more aggressive pruning of growth points and branches can be carried out.

When trees are 5 years old, further thinning out can be carried out if required.

F) Long term management and sustainability

F.1 Staff requirements and training

It is recommended that initial propagule collection and planting be carried out by an experienced team, whilst training the staff who will have the long-term care of the mangroves. Such expertise is available in Fiji, utilising Marine Ecology Consulting personnel and OISCA programmes.

After the nurseries are set up, the regular landscaping and ground-keeping staff should be able to carry out routine maintenance, with occasional support from Marine Ecology Consulting and OISCA as required, and at critical times such as hardening off and planting out.

The mangrove landscaping will be a full-time project for at least one dedicated gardener for the first two years of the project, and it is recommended that more than one staff member be trained in the techniques needed, to ensure continuity.

F.2 Staff supervision

As mangrove gardening is not a common skill, it should not be presumed that ground-keeping staff will be able to maintain a mangrove landscaping programme without supervision, especially if there is a high staff turnover. It is recommended that there be regular monitoring of the nursery and planted areas to ensure sustainability. This could be done by full-time engagement of a specialist, or on a consultancy basis.

Marine Ecology Consulting and OISCA could provide such supervision, or it may be possible for the developers to engage and support a post-graduate student.

F.3 Continuing monitoring and adaptation of management plan

Mangrove Restoration such as is suggested here has been carried out in several places in the world, notably in the Philippines, and to some extent in the Fiji Islands. However, this would be the first large-scale Mangrove Management Plan in Fiji designed specifically for tourism development, and so inevitably will require an adaptive management approach.

A detailed survey of trees within the areas of the proposed development has already been carried out as part of the EIA process. This would be used as the basis of species ratios in enhancement planting in each area, to ensure that the new plantings reflect the original species spread of the old forest.

Regular monitoring of both nursery and planted sites is essential for at least the first two years of the management plan, to ensure that species selection is correct, and to alter the design if the plan if problems are encountered. This should take the form of detailed seedling and planting records, and physical measurements of growth and survival rates.

If one species continually fails in one location, there must be contingency plans to replace it with an alternate.

Figure 11: Mangrove habitats in Fiji

Red Mangrove on - Muddy riverbank



- Rocky shore



- Sandy shore



Black Mangrove on sandy beach



White Mangroves on sandy beach



Rotting mangrove roots after foreshore cutting



Natural Wildling on foreshore



G) References

Batibasaga A., Korovulavula J. “**Fisheries Impact Assessment, Vulani Island Resort Mangrove Reclamation**”, Fisheries Research Report (No.3) February 1997

Gray A. “**A Directory of Wetlands in Oceania**”, Fiji Section. Wetlands International www.wetlands.org

Kitamura K., Anwar C., Chaniago a., Baba S. “**Handbook of Mangroves in Indonesia**” Ministry of Forestry INDONESIA, Japan International Cooperation Agency (JICA) and the International Society for Mangrove Ecosystem (ISME) ISBN 4-906584-04-7 1997

Kula Eco Park – **Use of Mangroves in Aquarium Filtration in Fiji** – personal communications with Philip Felstead 2007

Melana D. M., Atchue III, J., Yao C.E., Edwards R., Melana E.E., Gonzales H.I., “**Mangrove Management Handbook**”, Department of Environment and Natural Resources, Manila, Philippines, through the Coastal Resource Management Project, Cebu City, Philippines, 96 p.
CRMP Document No 15-CRM/2000 ISBN 971-91925-6-9 2000

OISCA International – **Mangrove replanting in the Fiji Islands** - personal communications with Sairusi Masi Valebuli 2007

Sprung J., “**A Guide to the Ecology and Care of Mangroves**”.
Two Little Fishes Item #170 www.twolittlefishies.com 1999

Sykes H.R. “**Assessment of Marine Resources for Proposed Development at ‘Vulani Islands’ Nadi, Viti Levu, Fiji.**” Marine Ecology Consulting, October 2006

Watling D. “**A Mangrove Management Plan for Fiji – Stage 1**” Fiji Government and the South Pacific Commission 1985

Watling D. “**A Mangrove Management Plan for Fiji – Stage 2**” Fiji Government and the South Pacific Commission 1986

Whistler W.A., “**Flowers of the Pacific Islands Seashore**”, Isle Botanica, ISBN 0-8248-1528-9 1992