Mangroves of Samoa

Status and Conservation

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PREFACE

Mangrove ecosystems have long been an important source of livelihood for coastal communities not only in Samoa but throughout the Pacific. They have provided food, income, as well as protection for people and other sensitive marine habitats.

Despite their invaluable contributions to our daily subsistence, mangrove areas have been destructed to make way for coastal reclamation as well as development. This intensifying destruction of mangrove areas has raised concern as to its potential impacts on the marine environment and resources which are important for coastal community survival.

Nowadays, there is a need to raise awareness and education among the Samoan people regarding the un-noticed importance of mangrove areas, and to address the problems of mangrove ecosystem destruction. The Ministry of Natural Resources Environment and Meteorology and other non-governmental organisations have undertaken various initiatives on mangrove conservation, including community mangrove conservation areas and hosting of community workshops which enhances their knowledge on the fragile mangrove ecosystems.

This booklet is specifically on the Mangroves of Samoa, their current vulnerable status and how they can be conserved. It highlights important issues not only for today but also for tomorrow, such as the need for a specific legislation on mangrove conservation.

Mangroves of Samoa is an important resource for students of all levels and its publication would not have been possible if it were not for the financial support of the Secretariat of the Pacific Regional Environment Programme (SPREP) and the United Nations Environment Programme (UNEP) – Regional Seas Programme.

I sincerely hope that the information provided in this booklet will not only raise awareness but also public appreciation of the full values of mangrove ecosystems and habitats, thus erasing negative public opinions on this important resource.

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"MANGROVES OF SAMOA"

STATUS AND CONSERVATION

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CONTENTS

1. INTRODUCTION

1.1 MARINE ECOSYSTEMS & RESOURCES

The marine environment and its resources have always been an important part in the way of life for small Pacific Island countries such as Samoa. A vast majority of Samoa's population inhabit the coastal fringes of the islands, thus depending largely on coastal marine resources and ecosystems for daily sustenance. Coastal waters support some of the most productive ecosystems such as mangrove forests, coral reefs and seagrass beds, which are all interrelated features crucial to marine wildlife and their habitats. In addition to playing extremely important ecological roles, marine ecosystems provide coastline protection, and sustain resources that contribute significantly to the country's economy.

1.2 MANGROVE ECOSYSTEM

Mangroves are unique ecosystems and amazing trees that live halfway between the land and the sea. They form a very productive ecosystem and is a source of renewable resources in terms of the wide range of vital roles they provide on a continuous basis. The economic importance of mangroves around the world stems from three main sources; forest products, estuarine, and near shore fisheries and ecotourism [FAO, 1994]. Environmentally, mangroves play a pivotal role in coastal protection and maintenance of habitats for a large range of common, threatened and endangered species.

Mangrove ecosystems in Samoa are commonly found on sheltered coastlines where sediments deposit, such as river estuaries. They are scientifically recognised as biodiverse wetlands in the country, yet these unique coastal environments are among the most disregarded and fast depleting habitats.

Pressures from growing populations and urbanisation have led to changes in land use and over utilisation of mangrove ecosystems and resources, contributing to the rapid loss and destruction of these special habitats around the Apia area and other smaller stands around the country. The fast depletion of mangroves worldwide is the cause of serious concern, not only to large nations but also to small Pacific Islands such as Samoa. Therefore the

need for public awareness and education, on the ecological and protective functions or roles of tropical mangrove ecosystems, and the consequences of their deterioration is very much needed.

1.3 FOCUS & AIM OF THE BOOKLET

This booklet focuses mainly on awareness, regarding the status of mangrove forests and shrubs around Samoa. It gives information on the types of mangrove species present and the main areas of mangrove stands around the country. It also looks into the biology of such ecosystems and its associated fauna and flora. Most importantly, the booklet gives information on the values of mangroves to Samoans and the consequences that are associated with their depletion and degradation.

It is the main objective of this booklet to educate and, create awareness and appreciation of the full values of mangrove ecosystems and habitats, which hopefully will result in actions and ways to help minimise the problems of mangrove degradation; and in turn resulting in the effective protection and conservation of this valuable ecosystem.

2. BIOLOGY OF MANGROVES

Mangroves are amazing trees in terms of their various adaptations and characteristics that enable them to live within two changing environments, of the sea and fresh water flow. In this changing environment, mangroves have to overcome problems such as water and oxygen deficiency, substrate instability, erosion, salinity changes, salt accumulation, wave effects, and changing tides. Amazingly, evolutionary adjustments to varying coastal marine environmental conditions have helped produce some astounding biological characteristics, which have enabled mangroves to survive in such a harsh environment.

2.1 WATER-LOSS

Water deficiency in mangrove plants is a result of osmotic loss. Growing in a partially saline environment, water concentration is higher in the plant

tissues and thus tends to diffuse out into the surrounding water. In addition, natural plant processes such as evaporation and transpiration usually lead to water loss from leaves. Mangrove leaves however are well adapted to combat this problem. Mangrove leaves prevent excessive water loss through several special leaf morphologies. Firstly, they have a thick-walled epidermis, which is covered by a waxy cuticle. This acts like a thick waterproof skin, preventing any excessive water loss. In addition to this, tiny and variously shaped hairs line the leaf surfaces. This maintains a moist layer of air around the leaf, reducing evaporation. Furthermore mangrove leaves have a fleshy structure, which contain layers of large water storing cells called spongy cells.

2.2 SALT REGULATION

Together with water loss, mangrove plants also have to face problems associated with osmoregulation and salt level balancing. In its saline environment mangroves have to regulate salt levels so that poisonous levels are not reached. Salt regulation can be carried out using 3 mechanisms of exclusion, extrusion, and accumulation, depending on the mangrove species.

[1] Exclusion: This is carried out by species which are salt excluders, such as the two common mangrove species found in Samoa; *Rhizophora* sp. and *Bruguiera* sp. Roots of these species, are able to take up only water from the surroundings, but exclude the bulk of the salt.

[2] Extrusion: In some species, excess salt, which is taken in during normal plant functions, are excreted through special glands on their leaves. Excreted salt deposit on the leaf and gets washed away when it rains.

[3] Accumulation: This is done by accumulating or depositing all the excess salts in older leaves and other plant parts such as the bark. In this way, when the old leaves and bark fall off from the tree, the salt is also lost from its system.

2.3 PROCESS OF AERATION BY ROOTS

Another problem associated with mangrove habitats is the lack of oxygen in the muddy substrate. Due to continuous flooding by the changing tide, the mud and sediments are often waterlogged and thus highly anaerobic, yielding no oxygen supply for the mangrove plants. However mangroves have adapted well to this type of habitat through the possession of specialised roots called pneumatophores (breathing roots) that act as aerating organs. These specialised roots have pores identical to stomatal pores on plant leaves, which allow air exchange when roots are exposed above the water and mud. Roots are usually exposed during low tide, and in some species roots extend vertically above the mud [Figure, 1].

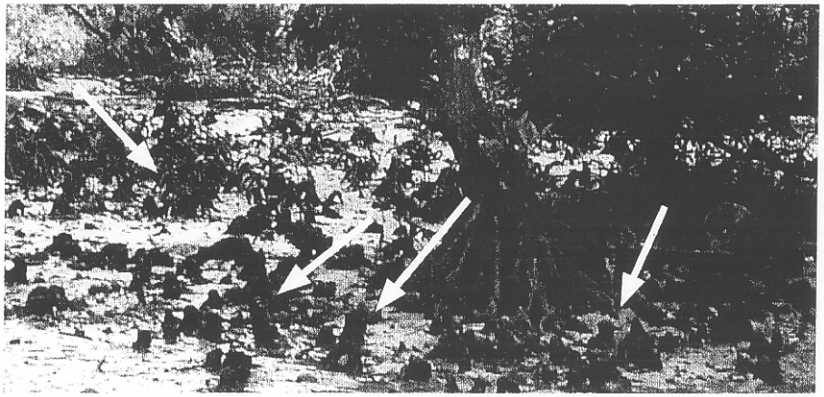

Figure 1: Knee roots of *Bruguiera gymnorrhiza* protrude above the mud and are exposed during low tide, enabling air exchange. These roots are sometimes referred to as breathing roots (pneumatophores).

2.4 REPRODUCTION

Species of mangroves propagate successfully in the marine environment because of a special reproductive adaptation called viviparity. Viviparity prepares the seedling for long distance dispersal, survival, and growth in the harsh saline environment by enabling the embryo to start germinating into a seedling while still attached to the parent tree. Afterwards the developed seedling either drops and takes root in the soil/mud below, or floats vertically in the water until it takes root on a favourable muddy shore [Figure, 2].

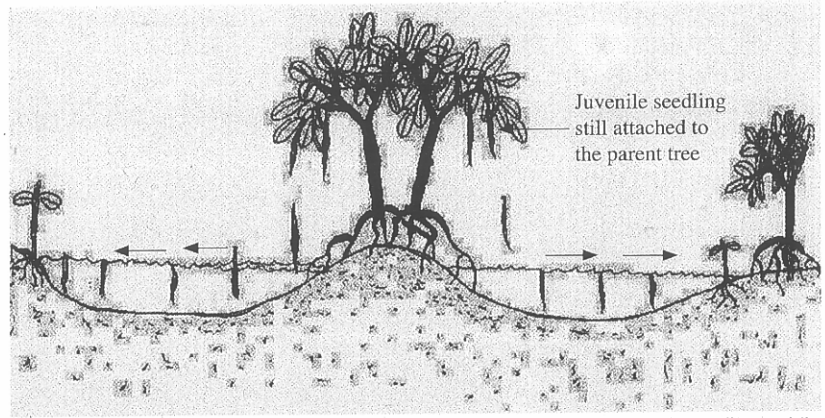

Figure 2: Reproductive adaptations of mangroves. Seeds develop into juvenile seedlings while still attached to parent tree. Afterwards they drop and float to favourable shores where they start growing.

2.5 EROSION

Areas where mangroves grow are subjected to erosion at all times. Daily tidal changes and waves, together with rivers flowing into the mangrove habitats wash the muddy substrate away, making it an unstable site for growth. However mangroves have adapted to this problem with specialised root systems.

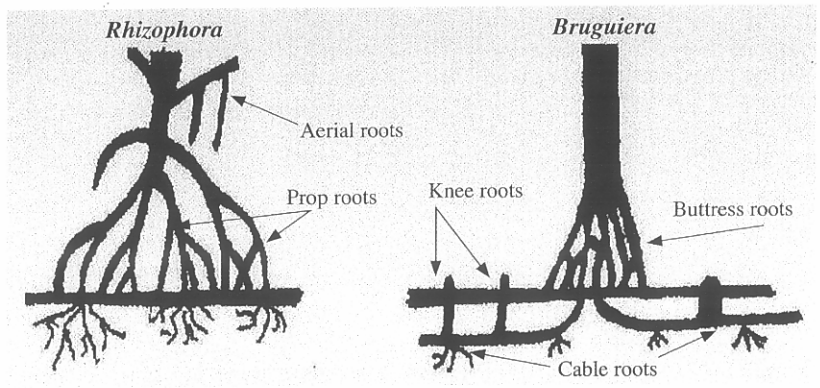

Figure 3: Prop roots of *Rhizophora* and the buttress and cable roots of *Bruguiera* stabilising the trees into the unstable mud substrate.

Rhizophora species have strong intertwining masses of anchoring prop roots which arch from the main stem of the tree, and aerial roots which grow vertically from the branches, securing the tree to the ground. Other species such as *Bruguiera* have strong buttress roots as well as cable roots that grow deep into the ground like tap roots, firmly stabilising the tree [Figure, 3].

3. VALUES OF MANGROVES

Mangroves of Samoa are of high scientific and environmental values. They play an important ecological role as nursery grounds and as a physical habitat for a wide variety of vertebrates and invertebrates. Mangrove leaves, wood, roots, and detritus materials provide essential food chain resources for its associated fauna, and play a special ecological function for a lot of species including species of conservation concern, such as the mullet. They also serve as storm buffers, and their roots stabilize shorelines and trap fine substrates, enhancing water clarity.

3.1 ECOLOGICAL VALUES

- Shelter/Nursery grounds

Many marine species utilize mangrove areas as permanent homes or just for a period of their life cycles. Permanent residents include oysters, crabs and bivalves, while species such as mullets and shrimps use these areas as nursing grounds. Here the juveniles are nurtured and protected from predators by the dense mangrove root network, and move into the deeper waters as they mature.

- Birdlife/Nesting

Mangrove forests and associated scrubs provide good nesting and roosting grounds for many bird species that prefer or need a coastal habitat.

- Food Web

Mangroves are one of the starting points in the great food chain of marine and seashore life. Each year mangroves shed millions of leaves that rot to form nutrient rich compost, which sustain a mass of algae. This becomes a very valuable and constant food source for many species of small fish, eels,

crabs, prawns and other smaller invertebrates. Larger fish and birds eat these smaller organisms, and so the food web extends. Much of this organic matter is also washed into the inshore seagrass beds and corals providing food for the species that live there.

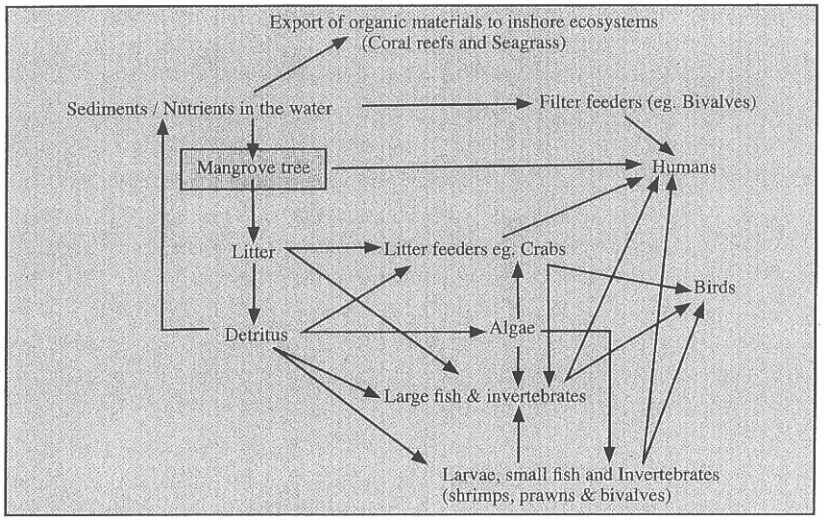

Figure 4: General mangrove food web.

3.2 PROTECTIVE VALUES

- Shoreline Protection

Mangroves form an underground network of roots that hold the substrate together and prevent it from being washed away. Above the ground the roots act like a comb, trapping mud and sediments. This way mangroves help prevent coastal erosion, while at the same time build up and extend shorelines.

- Filtration of water flowing into the reef/lagoon

Mangrove root systems act as filtering mechanisms, trapping materials and sediments that flow from rivers and flooding, hence preventing them from entering and affecting the delicate reef and lagoon ecosystems. Therefore mangroves protect and ensure the livelihood of other marine ecosystems such as seagrass beds and corals reefs from sedimentation and rubbish.

- Storm Protection

Just like coral reefs, mangroves act as a line of defense against storms and cyclones. The closely formed root systems and densely formed tree line help break strong wave and wind action against our coasts, thus preventing extensive destruction to our coastlines.

3.3 RENEWABLE RESOURCES

- Mangrove forest products

Similar to normal inland forests, mangroves can provide wood materials that can be used for cooking, and construction of houses and boats [Atherton, 1994]. Bark, leaves and fruits are used to derive many products such as dyes (coloring materials), traditional medicines and drugs, house thatching and handicrafts. In other countries they are used to make traditional costumes, produce paper products, and textiles such as leather. Mangrove leaves are also useful as fodder and green manure in agriculture.

3.4 FOOD AND INCOME

Despite their limited distribution in the country, mangrove areas still play a vital role in the economies and everyday life of coastal communities.

- Food source

Marine resources such as oysters, and other bivalves, prawns, especially the mud crabs and the various species of fish associated with mangrove areas are usually caught or collected for everyday subsistence. In some countries mangrove propagules are also consumed.

Figure 5: Ladies collecting venus shells, an important food source associated with mangroves. Photo taken at Fusi, in the Safata Marine Protected Area.

- Income

Marine resources – In addition to being utilized as food, marine resources associated with mangroves also have commercial value. They are usually collected and then sold either at the local fish market or along side the roads. Edible bivalves such as the venus shells are collected from the swamp and sold in plastic bags or baskets [Refer to Figure, 17]. Crabs are caught using traditional traps called mataupa'a and sold in a group (taupa'a) or as individuals [Figure, 6]. Fish are also caught from mangrove areas and sold.

Figure 6: Mangrove crabs being sold at the local fish market.

Tourism – Tourism offers great potential for foreign exchange, employment creation and overall earnings in developing countries every year [GoS, 2002]. A new industry developing in this area is Ecotourism, where tourists visit natural and pristine environments such as lakes, rainforests, and also mangrove areas. This can generate income for local communities, empowering them to control and manage their own resources. An example of this is the Saanapu-Sataoa Mangrove Conservation Area, where recreational activities like nature walks, botanical studies, nature photography, bird watching and kayaking attract tourists, and generate income for the local communities. [Figure, 7].

Figure 7: Board walk at the Saanapu-Sataoa Mangroves. (Ecotourism)

Other larger mangrove species found in overseas countries produce wood that have quite high commercial values, unlike the species here in Samoa.

Timber – Large mangrove species have tall and large trunks, ideal for the forestry industry in the production of timber. Large mangrove stands in other countries such as Matang, Malaysia and Ma-swar, Sierra Leone have been logged extensively and sold to either local or overseas construction companies [FAO, 1994].

Charcoal – Some mangrove species have very little moisture content in their wood thus making them ideal as firewood. These species are used extensively in the charcoal industry where they are logged and then burned in dome-shaped furnaces/ovens. In other countries, mangrove trunks are piled up in a mound and then burned to get mass amounts of charcoal which are then processed and sold locally or internationally.

4. MANGROVES OF SAMOA

Plants identified as mangroves represent over 80 species [Saenger *et al.*, 1983] of which 3 are found in Samoa. These are *Rhizophora samoensis* (Red mangrove) originally believed to be *R.mangle*, *Bruguiera gymnorrhiza* (Oriental mangrove) and the rarest of the three, *Xylocarpus moluccensis*. This rare species is only present in a single small stand of less than 1 hectare, on white sand substrate at a stream mouth near Salailua on Savaii Island [Schuster, 1993]. All mangrove species are known collectively as Togo in Samoan. Whistler [2000] recorded the red mangroves as Togo tane (male mangrove) and the oriental mangroves as Togo fafine (female mangrove).

4.1 GROWTH FORMS

The two common mangrove species in Samoa have different growth forms.

- The small Red Mangrove has stilt roots, which grow like arches from high in the tree. These roots enable survival in changing mud and sand levels.

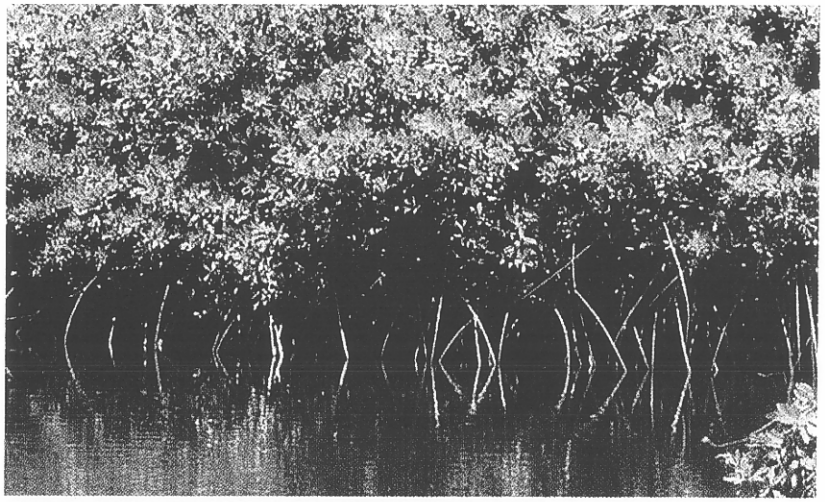

Figure 8: Arching roots of *Rhizophora* visible during low tide.

- The taller Oriental Mangrove has thick vertical buttress roots growing around the trunk, and knee-like (hooped) roots that grow up above the mud surface.

Figure 9: *Bruguiera* trees possess buttress roots which secure them firmly to the mud.

4.2 TYPICAL MANGROVE ZONATION IN SAMOA

Mangrove forests show clear zonation patterns as you walk inland from the water edge. Zonation occurs because different species require different environmental conditions to grow. The mangrove forests of Samoa show four distinctive zones of vegetation [Sasaki, 1992]. Red mangroves dominate the zone at the water edge, followed by a zone of oriental mangroves on the mudflats. A zone of ferns occur immediately behind the mangrove communities, and finally a zone of sea hibiscus before entering the swamp forest areas [Figure, 10].

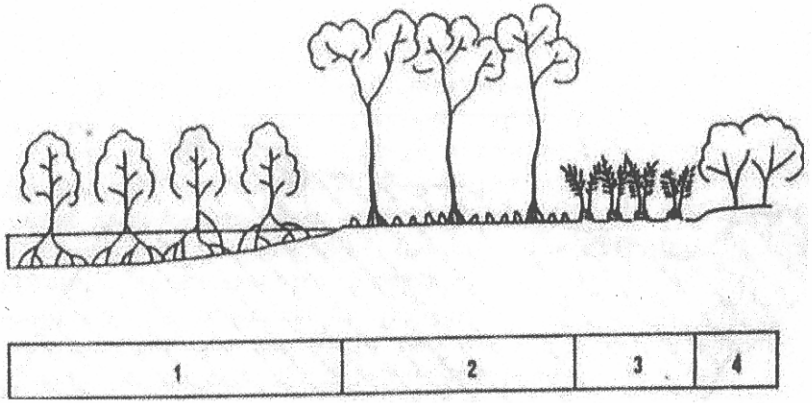

Figure 10: The four major vegetation communities of mangrove forests in Samoa recorded and described by Sasaki [1992]. 1: *Rhizophora samoensis* community. 2: *Bruguiera gymnorrhiza* community. 3: *Acrostichum aureum* community (Mangrove associated fern). 4: *Hibiscus tiliaceus* community (Beach hibiscus)

4.3 MAIN MANGROVE STANDS

Mangroves of Samoa are not very common and confined to the two large islands of Upolu and Savaii [Figure, 11]. It is estimated that the total area of coastal swampy areas and mangrove forests come to less than 10km^2 [Bell, 1985]. Despite the small area covered by mangroves, the Vaiusu Bay mangal near Apia is considered to be the largest mangrove area in Eastern Polynesia. The Vaiusu Bay and Saanapu-Sataoa mangrove stands are the two main mangrove stands in Samoa. Other areas show significant levels of degradation and in need of immediate conservation.

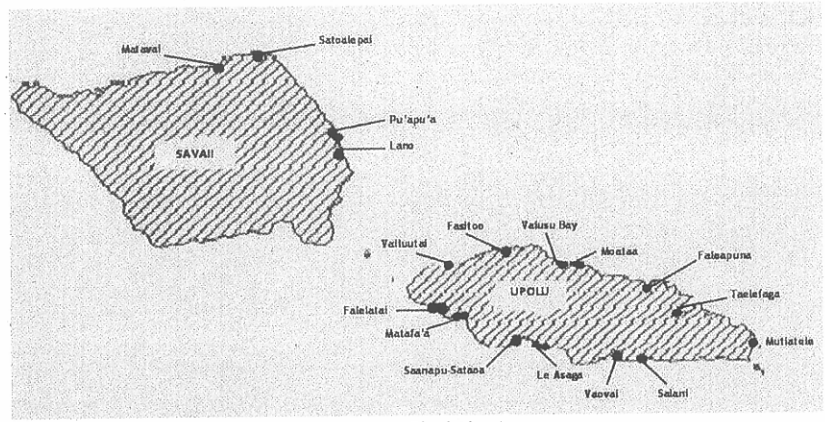

Figure 11: Major mangrove stands of Samoa (Black dots).

Vaiusu Bay mangal area

This is a narrow strip of mangrove scrub lining the shoreline of the Vaiusu bay, along the north coast of Upolu. It is the largest area of mangroves in Samoa starting from the Mulinuu Peninsula through to Sogi, Fugalei, Lepea, Vailoa, Vaigaga, Vaitele and Vaiusu. This important mangrove stand is largely degraded because of its location in the main urban area. Part of this stand was utilised as the main public rubbish dump in the past, before the dump was shifted to an inland landfill recently. The stand is still of importance, but faces rapid reclamation, especially at the Fugalei and Mulinuu points.

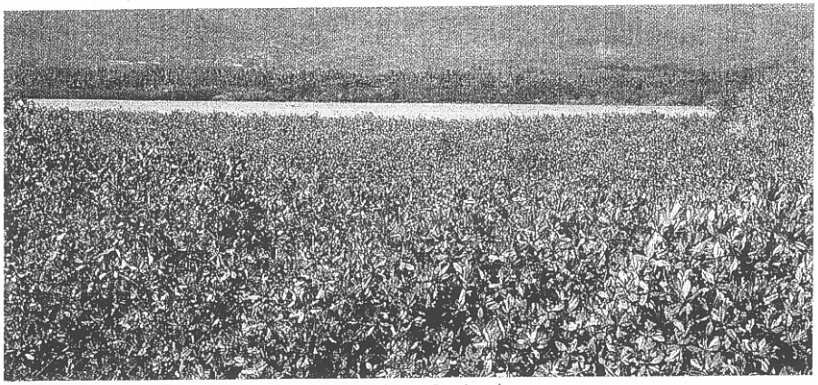

Figure 12: Vaiusu Bay mangal area from Mulinuu Peninsula.

Moataa mangrove area

The Moataa mangrove is a small mangrove patch just east of Apia harbour. It is now largely degraded by reclamation for settlement and sports park development, as well as rubbish disposal by some individuals.

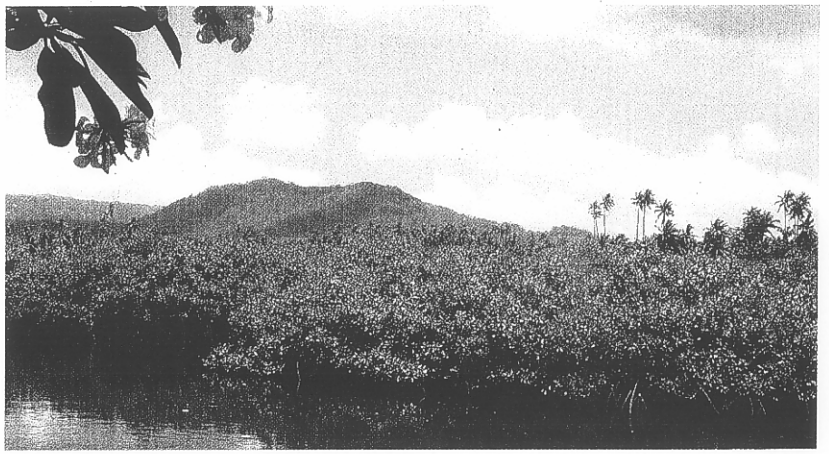

Figure 13: Moataa mangrove area, east of Apia.

Saanapu and Sataoa mangrove forest

This is a large mangrove forest on the west side of Safata Bay on the south coast of Upolu. It is the least disturbed mangrove area in Samoa and is an extremely important fish and mangrove crab (pa'alimago) breeding and nursery site. Various recreational activities including canoeing and nature walks are available at the reserve for the many tourists that visit the site every year.

Le Asaga mangroves

This is another main mangrove scrub land, lining a creek on the east side of the Safata Bay on the south coast of Upolu. The area is sheltered from the sea by the Le Muta peninsula and stretches across 5 villages (Nuusuatia, Vaiee, Fusi, Fausaga and Tafitoala). It is threatened by increasing encroachment by nearby villages on the main land, but remains in a fairly healthy state on the peninsula. This large mangrove area is protected under the Marine Protected Area (MPA) of Safata.

Figure 14: Passage through a part of Le Asaga mangrove area at Safata Bay.

Other mangrove stands

Mangrove areas in Vaovai and Pata (both situated in the Falelatai District) were once identified as priority sites for conservation by Pearsall and Whistler [1991].

The Lotopu'e mangrove forest in Aleipata consists mainly of *Bruguiera*. This mangrove area was largely reclaimed for settlement by nearby villages, but now protected under the Aleipata Marine Protected Area (MPA) program.

Figure 15: Mangrove forest at Lotopu'e, Aleipata.

Other mangrove stands have all been degraded by human settlement and activities. These include the Fasitootai, Faleapuna, and Saoluafata mangrove stands in Upolu, as well as the Lano and Lalomalava mangrove areas in Savaii [Schuster, 1993].

4.4 MANGROVE ASSOCIATED FAUNA & FLORA

A diverse array of plants and animals are present and depend on mangroves for various benefits, such as habitats and food sources. In Samoa, some of the important species of crabs and fish are associated with mangrove areas.

[i] Associated Fauna

- BIRDS

Birds associated and recorded at Samoan mangroves include the Pacific Reef Heron (*Egretta sacra* – Matu'u), Pacific Black/Grey Duck (*Anas superciliosa* - Toloa), Lesser Golden Plover (*Pluvialis dominica* – Tuli), Purple-capped Fruit Dove (*Ptilinopus porphyraceus* – Manutagi/Manufili), Polynesian Triller (*Lalage sharpie* – Miti-tai), Samoan broadbill (*Myiagra albiventris* - Tolai) and the Cardinal Honeyeater (*Myzomela cardinalis* – Segasegamau'u).

- INVERTEBRATES

Crabs of the genus *Scylla* are strongly associated with mangrove areas throughout the Pacific, forming the basis of substantial inshore fishery and aquaculture [Keenan and Blackshaw, 1999]. The species *Scylla serrata* is the only mangrove crab species recognised in Samoa. They are generally abundant in well established mangroves areas, residing in burrows, especially during the breeding season [Bell and Mulipola, 1995]. Fiddler crabs (*Uca* sp), land crabs (*Cardisoma carnifex* – tupa) and red claw mangrove crabs (*Sesarma erythrodactyla* – u'a), are also common around mangroves. Land crabs and red claw crabs are also utilised as food, and as baits for catching mangrove crabs.

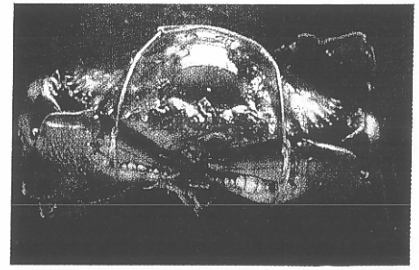

Figure 16: *Scylla serrata*, an important resource associated with mangroves.

Another important group of invertebrates associated with mangrove areas are bivalves. Bivalves include oysters (tio), venus shells (tugane), ark shells (pae), coconut scraper cockles (matatuai/asi), and sand cockles. These bivalves inhabit the soft muddy substrate, or cling onto rocks, or roots of mangroves. Also associated with the mangroves are prawns and shrimps.

Figure 17: Bags of Venus shells (tugane) being sold along the Vaiusu roadside.

Another interesting species associated with mangrove estuary is the edible peanut worm (ipo), *Siphonosoma australe*. People usually dig and collect this worm for food.

- FISH

About 35 species of fish, distributed among 22 families have been recorded in Samoan mangroves [Table, 1]. Puffer fish, mullets and the crescent perch are usual dominating species. Other important fish species include the goatfishes, trevallies, and surgeonfishes. Another interesting fish species which inhabits the mangrove areas is the mudskipper, *Periophthalmus cantonensis*. It is an amazing fish species as they can remain out of the water for several days by breathing air trapped in highly vascularized cavities in their mouth and gill chambers, and move/skip around on the mud using their fins as feet.

Table 1: Checklist of fish species that have been recorded in Samoan mangroves. [Table from Thollot, 1993].

Family	Scientific Name	Samoan Name
Muraenidae (Moray eels)	*Uropterygius concolor*	Pusi
Ophichthidae (Snake eels)	*Cirrhimuraena tapeinopterus*	Gatauli
	Muraenichthys macrostomus	
	Yirrkala lumbricoides	
Chanidae (Milkfish)	*Chanos chanos*	Ava, Avali'i
Hemiramphidae (Halfbeaks)	*Zenarchopterus dispar*	Ise
Kuhliidae(Mountain basses)	*Kuhlia marginata*	Lalele
	Kuhlia rupestris	Inato
Terapontidae (Cresent perch)	*Terapon jarbua*	Ava'ava
Apogonidae (Cardinalfishes)	*Apogon lateralis*	Fo
Carangidae (Trevallies)	*Caranx melampygus*	Malauli apamoana
	Caranx papuensis	Malauli sinasama
Leiognathidae (Ponyfishes)	*Leiognathus equulus*	Mumu
Lutjanidae(Snappers)	*Lutjanus fulvus*	Tamala
Lethrinidae (Emperors)	*Lethrinus harak*	Filoa-vai
Gerreidae (Mojarras)	*Gerres macrosoma*	Matu
	Gerres oblongus	Matu-loa
Mullidae (Goatfishes)	*Mulloidichthys flavolineatus*	Vete/ Afulu
	Parupeneus indicus	Tauleia
	Upeneus vittatus	Ula'oa
Monodactylidae (Monos)	*Monodactylus argenteus*	Vavale/Valevale
Poeciliidae (Livebearers)	*Poecilia mexicana*	Fo-vai
Pomacentridae(Damselfishes)	*Abudefduf septemfasciatus*	Mutu
	Chrysiptera biocellata	Tu'u'u
Mugilidae (Mullets)	*Liza melinoptera*	Poi(5-8cm), Aua(8-12cm), Anae(>20cm)
	Valamugil engeli	
	Valamugil seheli	
Eleotridae (Sleepers)	*Ophiocara porocephala*	
Gobiidae (Gobies)	*Glossogobius biocellatus*	
	Oxyurichthys tentacularis	
	Periophthalmus cantonensis	Mano'o
	Taenioides jacksoni	
Tetraodontidae(Pufferfishes)	*Arothron manilensis*	Sue
Acanthuridae(Surgeonfishes)	*Acanthurus xanthopterus*	Palagi

[ii] Associated Flora.

Numerous plant species are associated with the mangrove forests and scrubs of Samoa. Typical plants recognised in Samoa mangroves are *Acrostichum aureum* (mangrove fern) and *Hibicus tiliaceus* (beach hibiscus). Orchids and a high density of epiphytes made up of mosses and algae are also dominant in mangrove sites. Recent survey of mangrove-associated algae resulted in the discovery of new algae species associated with Samoa mangroves [Skelton and South, 2002]. A summary of several botanical surveys of Samoa mangroves is given in Tables 2 and 3.

Table 2: Vegetation associated with mangroves of Samoa. Data from botanical surveys by Nakamura [1992], Sasaki [1992] and Thollot [1993].

Scientific Name	Common Name	Samoan Name
Barringtonia asiatica	Fish/ Sea poison tree	Futu
Clerodendrum inerme		Aloalo tai
Asplenium nidus	Bird's nest fern	Laugapapa
Phymatosorus grossus	Wart fern	Lauauta
Pyrrosia lanceolata	One leaf fern	Lau tasi
Vigna marina	Beach pea	Fue sina
Cyathea spp	Tree fern	Olioli
Davallia solida	Giant hare's foot fern	Laugasese
Hibiscus tiliaceus	Beach hibiscus	Fau
Hoya australis	Wax plant	Lau mafiafia
Pandanus tectorius	Screw pine	Lau fala
Paspalum conjugatum	T-grass	Vao lima
Morinda citrifolia	Indian mulberry	Nonu
Calophyllum inophyllum	Alexandrian laurel	Fetau
Dysoxylum sp.		Maota mamala
Bulbophyllum sp.		Lili vao
Erianthus maximus		Fiso
Cananga odorata		Mosooi
Histiopteris incisa	Batwing fern	Fiso vao
Humata heterophylla		Vao sosolo
Bulbophyllum nigroscapum		Vao sosolo i le laau
Hymenophyllum imbricatum	Filmy fern	Vao sosolo i le papa
Inocarpus fagifer	Polynesian chestnut	Ifi
Lycopodium phlegmaria		Laau fai pale
Ophioglossum pendulum	Ribbon fern	Laugapapa
Psilotum complanatum	Flat fork fern	
Taeniophyllum fasciola	Leafless orchid	
Davallia fejeensis	Rabbit foot fern	
Drynaria rigidula	Oak leaf fern	
Earina sp.	Easter orchid	
Asplenium polyodon	Sickle spleenwort	
Acrostichum aureum	Swamp fern	Saato
Thespesia populnea	Hibiscus	Milo

Table 3: Algae species associated with mangrove areas of Samoa. [Skelton & South, 2002].

CHLOROPHYTA (Green algae)	RHODOPHYTA (Red algae)	CYANOPHYTA (Blue-Green Algae)
Enteromorpha clathrata	*Caulacanthus ustulatus*	*Calothrix confervicola*
Chaetomorpha brachygona	*Gelidium pusillum*	*Calothrix crustacean*
Chaetomorpha mimima	*Gelidiella pannosa*	*Lyngbya sp.*
Cladophora liebetruthii	*Ceramium flaccidum*	*Caloglossa adhaerens*
Cladophora sp.	*Ceramium upolense*	
Rhizoclonium africanum	*Caloglossa leprieurii*	
Boodlea composita	*Bostrychia tenella*	
Cladophoropsis carolinensis	*Murrayella periclados*	
Boodleopsis carolinensis	*Polysiphonia howe*	

5. CAUSES OF MANGROVE DESTRUCTION

Mangrove areas in Samoa all show signs of degradation and destruction from human activities. They are usually foul smelling and regarded by most people as good mosquito-breeding places, hence leading to the false assumptions that such areas are unhealthy and therefore only useful for rubbish dumps or filled in for development. The situation of mangrove degradation in other countries is more severe, because of more advanced developments and economic ventures. In most Asian countries such as Malaysia and Thailand [FAO, 1994] large mangrove areas have been removed and most rivers have been diverted or altered to make way for man-made ponds, used for shrimp and crab farming/aquaculture. In addition mangrove forests have been extensively logged in Malaysia, Thailand, Vietnam and Sierra Leone for utilisation in the timber and charcoal industries.

5.1 MAIN CAUSES OF MANGROVE DEGRADATION IN SAMOA

[i] Human Induced Causes

- Rubbish Disposal

Mangrove areas around the country have been used largely by coastal communities and the government as rubbish disposal areas in the past. The Vaitoloa Point of the Vaiusu Bay mangal used to be the main rubbish dump for the Apia municipal area,

until recently. Despite public awareness on the effects of rubbish on mangrove ecosystems, and the efforts of the government to rehabilitate these areas, some individuals are still using mangrove areas as dumping grounds.

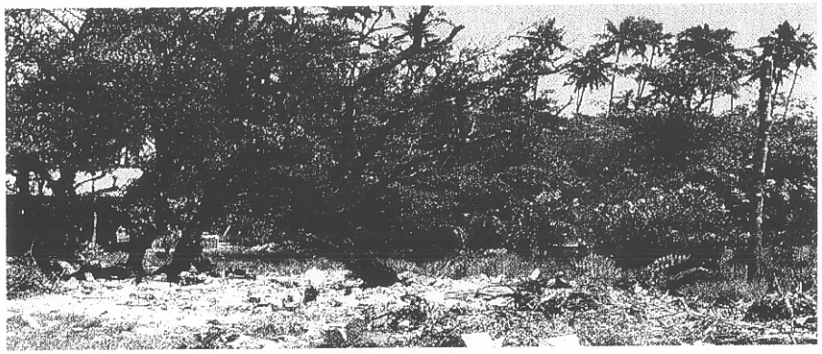

Figure 18: Rubbish disposed at the Vaitoloa mangroves.

- Land Reclamation

With increasing populations and development comes the need for more land. Reclamation results in large areas of mangrove swamps being filled in with soil to make land. This poses a threat to mangrove areas, especially around the town area. Large portions of the Moataa mangrove area was reclaimed for extensive settlements and government projects such as the development of the Apia Park sports fields. Reclamation is also evident along the edges of the Vaiusu Bay mangal, especially at the Mulinuu, Vaitoloa and Fugalei Points. Another cause of mangrove reclamation is to make way for infrastructure developments such as bridges, roads and water drainage systems.

Figure 19: The Fugalei point of the Vaiusu Bay mangrove area has been reclaimed rapidly in the past decade, to make way for various industries.

- Pollution

Oil spills from large tankers that enter into ports can pollute coastal mangrove stands, upsetting the entire ecosystem. Mangrove roots are easily damaged when subjected to crude oil pollution, as oil can cover the pneumatophores preventing any gas exchange.

In addition to this, heavily industrialised areas near mangrove stands or along rivers can cause pollution through chemicals and waste runoffs or spillages, which flow or get dumped directly into mangrove areas.

- Uncontrolled cutting and clearing

Mangrove areas in Samoa have been affected largely, through cutting and felling of trees for its various uses. Harvesting of mangroves for firewood and construction materials have become uncontrolled in some areas and have led to the loss of large mangrove areas throughout the country.

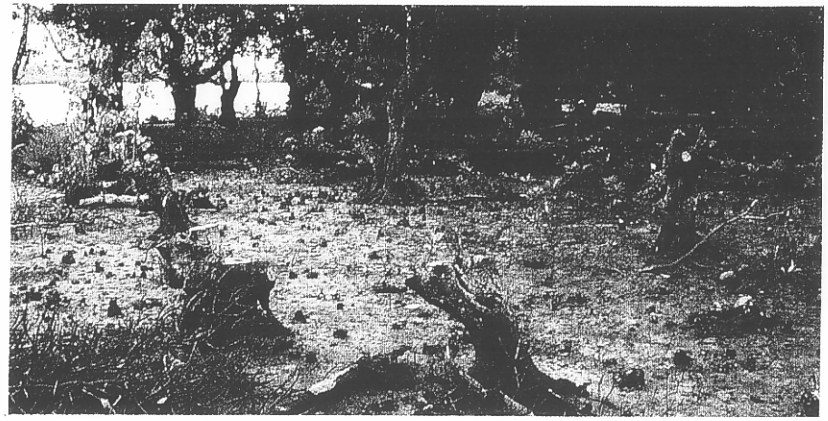

Figure 20: Deforestation at Le Asaga mangroves, Fusi, Safata.

[ii] Natural Causes

- Tropical cyclones and storm winds

Naturally, mangrove forests can be destroyed by strong winds and waves, during cyclones. Strong winds can cause trees to topple and create salty mists and sprays that can "burn" mangrove leaves, making them wilt and dry [Bell, 2002]. In addition to this, strong wave actions can cause erosion on the exposed coastal edges of mangrove areas, causing edge trees to be washed

away. This was evident after the two cyclones of the early nineties, Ofa in 1991 and Valeria in 1992.

5.2 CONTRIBUTING FACTORS

- Change in land use

Land use has changed remarkably in the past decades and has contributed to threats posed on mangrove areas. Agricultural developments near rivers can lead to chemicals and wastes to seep into rivers causing pollution. Also, the changing of river flow for other purposes such as hydroelectric centres and aquaculture can alter the freshwater influx and hence the salinity levels within the mangrove environment increases.

- Urbanisation

The problem of urbanisation also contributes to the destruction of mangrove areas. As more people move into the urban areas for employment and education, the need for land together with pollution increases. Thus mangrove areas are either filled in to make room for settlement, or used as rubbish disposal sites.

- Siltation

Sand dredging in the inshore areas close to mangroves can disturb ground sediments that can block pneumatophores used for air exchange in mangrove species. Sand dredging is evident at the tip of the Mulinuu Peninsula, with old machines and equipment used for dredging operations in the past rusting in the vicinity of the Vaiusu Bay.

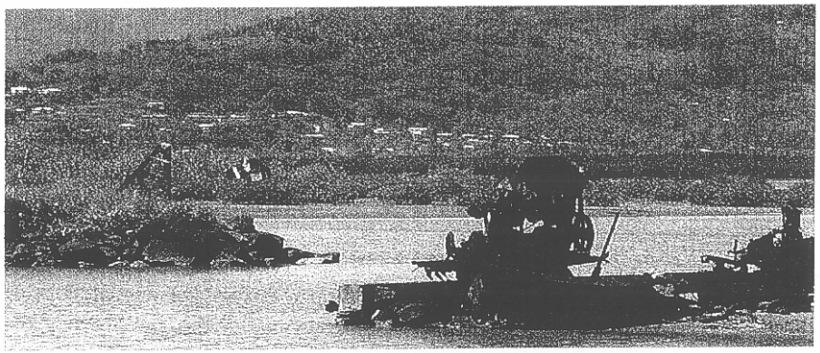

Figure 21: Rusting machinery used for sand dredging at Mulinuu Peninsula.

- General attitude and lack of public awareness

Another contributing factor to the degradation of mangrove areas is the lack of public awareness on the vital roles and values they provide for everyday well being and sustenance. In addition to this, general public attitude towards mangrove areas is that they are unhealthy wastelands, and only good for reclamation and rubbish disposal.

- Lack of Legislations and Regulations

The lack of specific legislations to regulate detrimental activities affecting mangrove areas, and the absence of law enforcement also contribute to mangrove degradation.

- Damaging fishing methods

The ecosystems within mangrove areas are very fragile and the use of any damaging fishing method such as dynamiting and poisoning, not only poisons the fish but also the entire ecosystem as a whole, through the food web.

- Introduced species

Animals introduced into the country such as pigs and exotic fish species have all contributed to the pollution and destruction of the natural mangrove ecosystems. Feral animals such as pigs can destroy newly established seedlings by digging them up or trampling on the propagules, thus destroying regeneration. In addition to this, these animals are a major source of sewage pollution. Their droppings and wastes, account for a high amount of ammonia, which is generally detrimental to the survival of fish and other marine species within the mangrove ecosystem. The introduction of exotic fish species can also upset the ecosystem, because introduced fish species can compete with native species for food and space, and some might even predate on native organisms and juveniles.

6. IMPACTS OF DAMAGED MANGROVES

"If there are no mangrove forests, then the sea will have no meaning. It is like having a tree with no roots, for mangroves are the roots of the sea" [FAO, 1994].

The continuing destruction and damage of mangrove areas is of great concern because of the various vital roles they play ecologically, physically and economically. Not only do these areas support a significant array of animals and plant species important to community well being and sustenance, but they also build up land and filter or clean the water entering the lagoons and reef areas. Therefore the degradation of these ecosystems will not only have major consequence on coastal communities but also the marine environment and species.

6.1 ECOLOGICAL IMPACTS

- Loss of important habitat areas

If mangrove areas are reclaimed and destroyed, all the important breeding, roosting and nursing grounds for important species will also be destroyed.

- Alteration in the food web

When mangrove areas are destroyed, the mass of plankton and algae, which support the small organisms within mangrove areas and inshore regions will be lost. Thus there will be a collapse in the food chain, and food sources for larger animals become unavailable. In addition, rubbish disposed into mangrove areas can poison the small invertebrates and fish as well as all the other larger organisms and even humans, through the food chain.

6.2 IMPACTS ON THE ENVIRONMENT

- No Shoreline and Inshore Reef Protection

Damaged or degraded mangrove forests have very weak root networks and therefore can't hold the earth together and prevent it from being washed away. This leads to a lot of erosion and much of the land and shoreline areas become exposed to strong waves. This also means that the filtration process, which helps build land and filter sediments that flow into the lagoon, will not exist. This results in materials, sediments and mud entering the lagoon, smothering the coral reef and seagrass ecosystems.

- Reduction in mangrove ability to recuperate naturally

Mangrove trees are known for their ability to grow in a harsh environment and recover easily after disasters such as cyclones and flooding. They are very resilient trees and if undisturbed can naturally grow back after a hazard.

However, pollution and degradation can hinder the recovery processes of mangrove trees and prevent them, from naturally bouncing back into their healthy states.

6.3 SOCIAL AND ECONOMIC IMPACTS

- Limited renewable resources.

As the over-exploitation of mangrove resources and the degradation of such areas increase, the availability of forest products derived from mangrove trees becomes limited, and if degradation is not stopped, then these products will eventually become unavailable in the future.

- Limited or loss in food and income

Mangrove areas provide coastal communities with food and income on a daily basis. Fish, bivalves, prawns, and crabs are some of the important food resources, which provide sustenance, subsistence and income for these communities. The destruction of mangrove areas can lead to the decrease or loss of these food sources and income. In addition to this, ecotourism would not succeed if mangrove areas are degraded. Thus the degraded mangroves can't be utilized as a tourist attraction, which can provide income for the village.

7. MINIMISING PROBLEMS

Conservation efforts are continuing in main mangrove areas in the effort to minimize the problem of mangrove stand/forest degradation. Conservation is defined as, "the management of human use of the bio-sphere (all living things) so that it may yield the greatest sustainable benefit to present generations while maintaining its potential to meet the needs and aspirations of future generations" [FAO, 1994]. Following are a few ways in which mangrove stands can be protected, ensuring that its resources are not over exploited and its benefits are not lost.

7.1 SUSTAINABLE MANAGEMENT STRAGTEGIES

- Conservation - Mangrove reserves/protected areas

Mangrove areas are unique and fragile ecosystems and require extensive

protection. Establishment of mangrove protected areas or reserves not only ensure the protection of all flora and fauna associated with mangroves, but also allow easy governance of the resources and enforcement of laws. Existing mangrove reserves and protected areas include:

[a] *The Saanapu-Sataoa Mangrove Conservation Area*
This conservation area is co-managed by the villages of Saanapu and Sataoa. Both villages look after the reserve and ensure the effective management and protection of the area by executing tough laws regarding the use of the resources within the conservation area.

[b] *The Safata and Aleipata Marine Protected Areas*
All mangrove forests within the established Safata and Aleipata MPAs have been proposed to be protected. Both districts have compiled management plans for their MPAs and have stated the protection of mangrove forests, as a priority. Actions formulated under these management plans includes:

- the ban on the clearance and reclamation of mangrove areas anywhere within the districts without proper assessment and village approval.
- the control of pigs and other feral animals within the mangrove areas of the districts.
- the ban on rubbish dumping into the mangroves, and the marine environment of both districts.

[c] *Mangrove Reserves under the Fisheries Division Extension Program*
Several villages have established marine protected areas and mangrove reserves under the Fisheries Extension Program. These villages together with the Fisheries Division have developed Village-based Management Plans and Fisheries by-laws to actively manage activities that can adversely affect mangrove areas and the marine environment. The village council of Fusi, Safata, for an example, declared the mangrove area in their village as a reserve.

[d] *The Lano Mangrove Reserve*
The Lano village on the north coast of Savaii has proposed its mangrove area to be established as a mangrove reserve through the Climate Change Project. The management plan for this reserve has already being drafted and awaiting final submission before implementation.

- Reforestation or Replanting

This has been practiced successfully in other Pacific nations such as Fiji. This involves planting juveniles or seedlings in the effort to rehabilitate mangrove areas. Outer edges of degraded mangrove areas can be replanted and through time will naturally adjoin with the older growth. The Ministry of Natural Resources and Environment [MNRE] during the Arbor Day in 2004 recognized the significance of mangroves in costal ecosystems through a replanting scheme at the Mulinuu edge of the Vaiusu Bay Mangroves.

7.2 LEGISLATIONS

Specific legislations and laws regarding the utilization of mangrove areas and their resources should be formulated and implemented. These laws should include regulation of land use around mangrove areas and river systems, disallowing any development with no supporting Environmental Impact Assessment [EIA] report.

- Current legislations

Although the Land, Survey and Environment Act 1989 do not cover mangroves specifically, their protection can be incorporated into other parts, such as the protection of the coastal and foreshore zones. The proposed MNRE Bill currently under review lists the protection of wetlands and mangrove areas specifically as one of the Ministry's general responsibilities.

"*Lands, Survey and Environment Act 1989: Division 5 – Coastal Zones*"

Sections 119 & 120 provides for the protection of the foreshore and coastal waters.

Prior consent in writing of the Minister is required:

[a] To remove any material from the foreshore, and that such removal will result in the restoration or preservation of the natural configuration and features of the foreshore or the natural flow of water.

[b] To carry out any activity within the foreshore which may result in the alteration of the natural configuration of the foreshore.

Penalties include a fine not exceeding $5000 for repairs or restoration of any damage done by an offender as a consequence of the offence and if the Department has undertaken any repair work to the damage.

"*The Ministry of Natural Resources and Environment Bill*"

Division 3, Section 16 of the proposed MNRE Bill states that the Environment and Conservation functions of the Ministry includes the management of public areas and the protection of wetlands and mangrove areas.

- Fisheries By-laws

Most government laws are hard to enforce and monitor, however if individual villages decide to set-up and enforce their own by-laws, the villagers will be more inclined to conserve their coastal environment. The Fisheries Act 1988 allows for the formulation of Fisheries by-laws. Fisheries by-laws are recognized by the Government and are formulated by the village fono in consultation with the Fisheries Division. Thus these by-laws have the matai council support meaning strict enforcement. Several villages have included mangrove area protection and conservation under their by-laws, eg. the village councils of Fusi, Fausaga, Tafitoala in the Safata district have by-laws prohibiting the cutting of mangrove trees or undertaking of any activities that will render damage or change to the mangrove area ecosystem.

7.3 REDUCE POLLUTION

- Prevent rubbish and waste disposal into mangrove areas

Rubbish materials and chemical wastes of any kind should not be dumped or thrown into mangrove areas and rivers.

- Practice proper land use near rivers and catchment areas

Proper land management should always be practiced near rivers and mangrove areas. Riverbanks should never be cleared for any purpose including agricultural activities. This is important in reducing sedimentation from erosion, and poisonous runoff from agricultural chemicals.

7.4 PREVENT HABITAT DESTRUCTION

- Stop reclamation and damaging developments

Filling in and reclaiming mangrove areas to make way for development such as fields, housing and roads should be avoided. Road constructions near or through mangrove areas should be assessed carefully for any negative impacts on the environment. Roads or bridges intersecting mangrove areas should have enough large pipes below them to allow fresh water and the sea to mix naturally for proper mangrove growth.

- Stop or reduce deforestation

Deforestation for firewood and other traditional uses should be avoided or done in a sustainable way. Mangrove forest removal to make way for any aquaculture undertakings should also be avoided, because this damages the important habitats.

7.5 RECREATION AND ECOTOURISM

Ecotourism together with their recreational activities can generate money for coastal communities when tourists pay to see well-established mangrove areas. This can empower local communities and give them a sense of pride in their natural resources, encouraging them to undertake conservative measures in keeping these areas natural and protected. The full potential of ecotourism can only be realized if the mangrove resources are well protected [FAO, 1994].

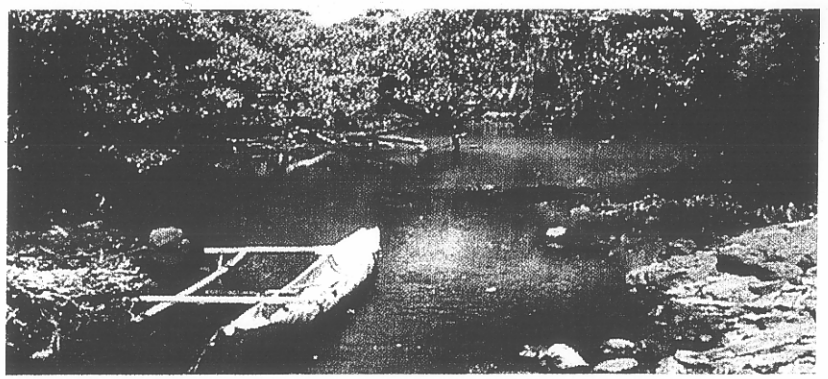

Figure 22: Traditional canoe rides, available at the Saanapu and Sataoa Mangrove Conservation Area.

7.6 PUBLIC AWARENESS AND EDUCATION

Workshops, newspaper publications, booklets, posters and other awareness programs can help promote the values and conservation of mangrove areas around the country. This is important in educating the public and reversing general public attitudes which often look at mangrove areas as unhealthy wastelands, fit only for rubbish disposal and reclamation for land. Helping the communities understand and realize the importance of mangrove habitats and its entire ecosystem, will hopefully make them appreciate such biodiverse areas and in turn lead them to becoming more environmentally friendly in their everyday work, hence minimizing the problems facing mangrove areas nationally.

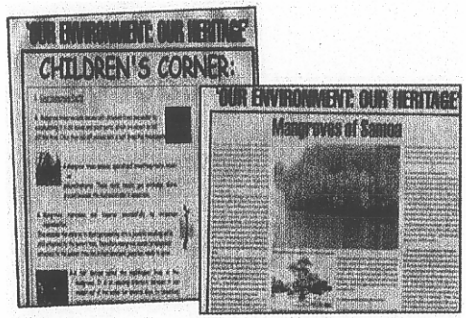

Figure 23: Newspaper articles on Mangroves of Samoa.

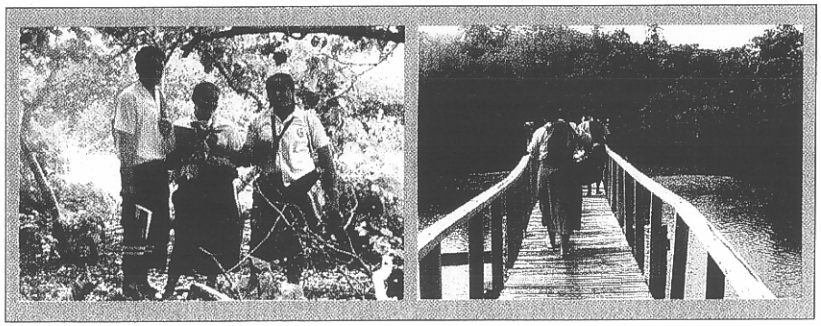

Figure 24: Students conducting fieldtrips at mangrove sites as part of their school curriculum.

8. SUMMARY

The extensive loss and degradation of mangrove areas worldwide have raised concern on implementing immediate conservation measures. Mangroves are recognized as biodiverse habitats that play vital roles, not only to the coastal communities but also to the marine environment.

Approximately 70 percent of Samoa's population are coastal communities and depend mostly on the marine environment and resources as a source of protein and income. Thus the marine environment should be considered with respect. Mangroves is one of the main marine ecosystems that helps keep the marine environment in a clean and healthy state. Destruction of these areas is a concern as mangroves are associated with inshore marine resources and coastline protection.

Main causes of mangrove degradation are directly linked to detrimental human activities and developments that influence the ecosystem. Increasing demand for lands and the lack of public knowledge on the importance of such biodiverse areas also contribute to the problem.

Main sources of degradation have been classified and conservation objectives to minimize their impacts and enhance recovery need implementation. To successfully conserve and manage mangroves, people and governments alike must work together, and be convinced that mangrove areas left in their natural state is more valuable than if converted into another form of land use.

It is also important that communities living adjacent to these areas are involved in formulating and implementing management plans, and be given the chance to benefit from managing not only their mangrove areas but their marine resources as a whole. Important conservation measures are given in this booklet, with the hope to raise awareness and lead to actions that will hold further degradation.

9. GLOSSARY

Aquaculture: the farming of aquatic organisms including fish, mollusks, crustaceans and aquatic plants.

By-laws: rules formulated and implemented by some local authority such as the village council for the management and conservation of their environments e.g. Fisheries By-law.

Conservation: wise use of natural resources to ensure they meet the needs of present and future generations.

Deforestation: the cutting down or removal of forest stands.

Dredging: removal of sediments from the bottom of a water body e.g. Sea.

Ecology: study of the relationships between living organisms and their environment.

Ecosystem: the interacting system between living things (biological community of plant and animals) and their environment (sunlight, air, water, minerals and nutrients).

Ecotourism: tourism venture that fosters environmental and cultural understanding, appreciation and conservation.

Evaporation: conversion of liquid into water vapor.

Introduced species: species occurring in an area outside of its natural range as a result of intentional or accidental dispersal by humans.

Legislations: laws/policies in place to ensure complete resource and environment protection.

Marine Protected Areas (MPAs) and Reserves: a geographically defined coastal or foreshore area protected primarily for nature conservation. A range of laws and penalties can provide long term security to these areas.

Pneumatophores: specialized roots in certain aquatic plants which can perform respiratory functions (gas exchange-breathing roots).

Siltation: is the build-up of fine dirt/silt that is suspended in rivers or other water bodies.

Sustainable utilization: use of resources in a way and at a rate that does not lead to a permanent decline, but instead maintain its potential to meet the needs and aspirations of present and future generations.

Transpiration: is the loss of water vapour (gas) from a plant/ tree through small pores called stomata in leaves.

Urbanization: movement of people into urban areas where they can be closer to schools and work (employment).

Viviparity: an adaptive characteristic where seeds develop into juvenile seedlings while still attached to the parent tree.

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