STRATEGIES FOR CONSERVATION AND SUSTAINABLE MANAGEMENT OF MANGROVE FOREST IN SIERRA LEONE

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INTRODUCTION

Mangroves are intertidal vegetation, found in tropical and sub-tropical regions along estuaries and swamplands intimately connected with the sea.

They depend on terrestrial and tidal waters for their nourishment, and silt deposits from upland erosion as substrate for support. The tides nourish the forest, and mineral rich river- borne sediments enrich the swamp. This implies that mangroves derive their form and nurture from both marine and terrestrial influences.

The environmental role of mangrove as coastal barriers in storm protection, flood and erosion control and as habitat for fish, shrimp and other marine fauna, is of great importance, hence the need for its conservation and sustainable management.

In Sierra Leone, mangrove forest in the more accessible and populated areas are over-exploited for fuelwood, charcoal and other wood products. Large tracts are also converted to rice fields and salt industry. A report submitted to Government (Chong, 1987) on the assessment of the mangrove resource and their development potential in Sierra Leone shows that mangrove woodlands occupy 47% of the Sierra Leone coastline, covering a total area of 171,600 ha and its rational management and integrated utilization can contribute significantly to the fuelwood and energy requirements in Sierra Leone and especially the coastal areas.

To safeguard the environmental and economic benefits, and given the multiple use potential of mangrove ecosystems and their linkages to terrestrial land use, an integrated approach is needed for long term sustainability.

However, before sustainable forest management practices can be applied throughout the coastal areas, the legal status of the lands must first be classified. The security of tenure of at least one rotation is required, given the relatively long-term nature of forest plantations and the investments that are required to rehabilitate and improve the quantitative and qualitative value of the largely overexploited and unmanaged forests.

The purpose of this work is to give an overview of the conservation status of the mangrove of Sierra Leone and identify the strategies and interventions for a better management of this ecosystem.
The activities involved are:

- Analysis of the biophysical framework of mangrove formations of the country.
- Analysis of the institutional and regulatory framework of the ecosystems management of the mangrove areas in Sierra Leone.
- Analysis of the socio-economic framework of the mangrove areas of the country.
- Collect strategic proposals and recommendations from the different stakeholders.

1. BIOPHYSICAL FRAMEWORK OF MANGROVE AREAS

1.1. ENVIRONMENT

Mangroves are influenced by factors such as inflow of continental waters, rainfall, ground level, rhythm of tides and exposure to sunlight. The soil is usually waterlogged with the top soil having a layer of silt or sandy clay (Ward and Bunyard 1992). Tidal inundation occurs daily at high tide, but the frequency and depth decreases towards the swamp interior.

The Republic of Sierra Leone lies between latitudes 7° and 10'N and longitudes 10° and 14°W on the West Coast of Africa, covering an area of 73 326 km^2 with a coastal zone extending for a distance of about 560km. The country is bordered in the Northeast by the Republic of Guinea, in the South and Southeast by the Republic of Liberia and in the West by the Atlantic Ocean.

It is divided into three provinces (Southern, Eastern, Northern) and the Western Area, the Peninsula on which the capital, Freetown, is situated.

The coastline of Sierra Leone is in most places covered by mangrove swamp forest. Mangroves are halophytic, woody seed-bearing plants. They have unique adaptation features such as viviparous propagules, prop roots, pneumatophores and lentils, which contribute in one way or another to their survival in their relatively stressful environment.

Presently there are no legally constituted mangrove reserves and the forest is a freely exploitable resource for the nearby communities. Several surveys have been carried out as indicated in Table 1 below, to determine the extent of mangroves in Sierra Leone (FAO.2003). With an up-to-date medium–scale aerial photography (1:10,000 – 1: 25,000) and ground survey, it will be possible to

determine precisely the extent, distribution and optimum production and potential of mangroves in Sierra Leone.

A graphical representation of the trends in mangrove area extent over time is shown in Figure 1. Better information on both the extent and the condition of mangroves is needed as an aid to policy and decision making aimed at the conservation, management and sustainable use of the remaining mangrove areas.

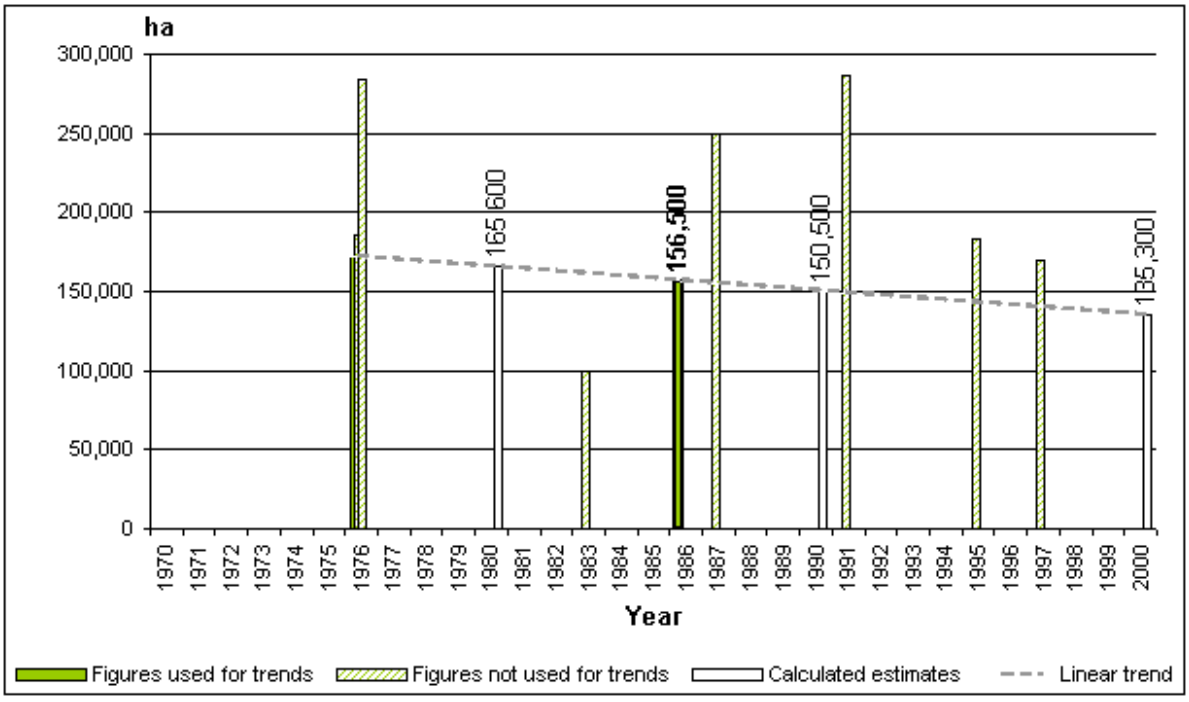
Table 1. National Level Mangrove Area Estimates.

Year	Area (ha)	Source	Trend	Methodology/Comments
1976	185 400	**FAO.** 1996. *Review of Existing Sources of information for Forest Resource Assessment in Sierra Leone.* By Laumans P. A. Field document. DP/SIL/92/006, Rome, 36 pp.		Remote sensing. Probably based on analysis of aerial photographs 1975-1976.
1976	171 600	**FAO.** 1979. *Land in Sierra Leone: A reconnaissance survey and evaluation for agriculture.* Based on the work of Birchall, C.J., Birchall, C.J., Bleeker, P., Cusani-Visconti, C. FAO/LRSP Technical Report No. 1. SIL/73/002	X	Aerial photographs 1975-1976. Scale 1:70 000
1976	283 761	**FAO.** 1979. *Land resources survey, Sierra Leone.* AG:DP/SIL/73/002 Field Document 1. Sierra Leone Freetown.		Cited in: **Johnson, R. and R. Johnson.** 1993. Mangroves of Sierra Leone. *In:* Diop, E.S. 1993. *Conservation and sustainable utilization of mangrove forests in Latin America and Africa regions, Part II - Africa.* pp: 7-9. . Mangrove Ecosystems Technical Reports vol.3

				ITTO/ISME Project PD114/90. Okinawa, Japan, ISME. 262 pp. The figure might include also freshwater swamps.
1983	100 000	**Saenger, P., Hegerl E.J. and J.D.S., Davie.** 1983. *Global status of mangrove ecosystems.* Commission on Ecology Papers No.3. IUCN. Gland, Switzerland. 88 pp.		Secondary reference, no primary source provided. The "Year" is the publication year.
1986	156 500	**FAO.** 1996. *Review of Existing Sources of information for Forest Resource Assessment in Sierra Leone.* By Laumans Paul A. Field document. DP/SIL/92/006, Rome, 36 pp.	X	Remote sensing. No information on the scale.
1987	250 000	**Altenburg, W.** 1987. *Waterfowl in West African Coastland Wetlands: a summary of current knowledge of the occurrence of waterfowl in wetlands from Guinea-Bissau to Cameroon and a bibliography of information sources.* Zeist, The Netherlands: Stichting WIWO (Werkgroep International Wad-en Watervogelonderzoek).		Cited in: **Fisher, P and Spalding, M.D.** 1993. *Protected areas with mangrove habitat.* Draft Report World Conservation Centre, Cambridge, UK. 60pp.
1991	286 000	**FAO.** 1991. *Alleviation of the Fuelwood Supply Shortage in the Western Area - Sierra Leone.* FO:DP/SIL/84/003 FO:DP/SIL/88/008 Terminal Report		The figure represents the extent of coastal woodland-mangrove and swamps. It may include freshwater swamps.
1995	183 800	**Saenger, P. and Bellan, M.F.** 1995. *The Mangrove vegetation of the Atlantic coast of Africa.* Universitè de Toulouse Press, Toulouse 96 pp		Secondary reference, no primary source provided. "Year" is the publication year.
1997	169 500	**Spalding, M.D., Blasco, F. and Field, C.D.,** eds. 1997. *World*		Map analysis. The map was undated.

		Mangrove Atlas. The International Society for Mangrove Ecosystems, Okinawa, Japan. 178 pp.		

Figure 1. Trends In Mangrove Area Extent Over Time



FAO. 1979. *Vegetation and land use in Sierra Leone: A reconnaissance survey.* Technical Report No. 2SIL/73/002. Freetown.

Mangroves are distributed in the four main estuaries that fringe the coastline of Sierra Leone as shown in Figure 2 and Table 2. Satellite Imagery and Topographic Map of the different mangrove sites (1-4) are shown below.

Scarcies River - commercial stands of mangroves occur mainly along the riverine fringes of Mahela, Kipimp, and Sasiyek Creek. Some stands also occur in the following Islands:- Yeliboya, Kortimaw, Yeligbungbo and Bankapia.

Sierra Leone River - the estuary has extensive fringes of shrubby mangroves. Some mangroves also fringe the Bunce River which is a tributary of the Sierra Leone River

Yawri Bay - the mangroves cover the coastal belt in varying widths stretching from Tombo to Shenge. Denser stands also cover the estuarine plains of the three main rivers – Ribbi, Bumpe and Kagboroko creek

Sherbro River - the bulk of the mangroves covers the coastal belt north of Sherbro Island and the various rivers and creeks, and Turners Peninsula.

Table 2. Distribution of Mangrove

Location	Area (ha)	Percent (%)
Scarcies River	13,007	7.6
Sierra Leone River	34,234	19.9
(Western Area)	(7,139)	(4.2)
Yawri Bay	24,505	14.3
Sherbro River	99,854	58.2
TOTAL	**171,600 ha**	**100.0 %**

Source: Chong, 1987

The drainage system consists of a series of rivers from North to South including the following: Great Scarcies, Little Scarcies, Rokel, Jong, Sewa, Moa and Mano. Other streams include Ribbi, Kukuli, Gbangbaia and Wanje rivers. There are in addition to the four main estuaries (Scarcies, Rokel, Yawri and Sherbro) numerous small estuaries and lagoons.

The continental shelf is about 125 km wide in the North around Yeliboya and tapers to only 13-km at Sulima in the South. The coastline is about 560 km long and the shelf covers an area (up to 200 m depth) of 50,000 $km^{2.}$ The Exclusive Economic Zone (EEZ) is 155,700 km^2. The shoreline consists of a Western and Eastern part. The Western part has four large estuarine systems separated by rocky and sandy coastlines and the Eastern part consisting of about 280 km of almost unbroken steep sandy coast backed with swamp communities.

1.2. CLIMATE

The climate is tropical and there are two well-defined seasons of wet and dry weather. The wet season generally lasts from May – November with two periods of squally weather in March – April and May and again in September – October. During the rainy season, clouds of vertical development of 8-10% generally prevail everyday. The heaviest rains occur in July and August and the mean monthly amount of rainfall reaches its maximum in July and August, when the average number of rainy days is 27 (Johnson and Johnson 1991).

The dry season (December – April) is dominated by north-east trades winds from the northeast whereas during the rainy season (May - November); the south-west monsoon dominates. Both seasons may have some variations in their commencement and duration. The mean long-term air temperature regime shows an average monthly temperature of 26 - 28^0 C from June to October, with a maximum temperature of 32^0C. Temperature of up to 36^0C has also been recorded especially during the month of March. A minimum temperature of 20^0C has also been recorded.

The mean sunshine hours during the dry season is 7 hours and is longer than that of the wet season which is 3 hours. Evapotranspiration in the area is estimated at 1300 – 1600 mm annually, with daily rates varying between 3.5 – 4.5 mm. The mean monthly solar radiation is about 380cal. cm – 2 day – 1 with a maximum of 440 cal. cm – 2 day – 1 in March and 250cal. cm – 2 day – 1 to 280 cal. cm – 2 day – 1 – in august. Air humidity according to monthly means can be as high as 80 – 90% during dry season and decreased to 70 – 80% during the rest of the year (ESCG, 1988).

Farmers must take account of the seasonality of the rainfall. The monsoon period when crops are grown, usually start with light rains which rapidly build up to a peak rain period and then decline. Farmers must judge when to commence planting, knowing that rainfall at the beginning of the rainy season is often unreliable (Mansaray, 1990). Planting with the first rains, when successful, however, brings advantages as plants will have reached a reasonable height and good prospects of surviving any hazards occurring later. Storms can cause considerable damage particularly along the coastal belt. Violent thunderstorms occur at the beginning and end of the rainy season.

1.3. GEOLOGY

The geology of the mangrove areas comprises of a coastal strip of nearly horizontal marine and estuarine sediments which constitute the bullom series of recent (tertiary) alluvial deposits and the gabbro masif of the Western Area Peninsula which is cut by basaltic dykes. The bullom series comprises an alternation of gravel, sand and clay some 45km wide, and these tertiary sediments rests conformably on the Kasila series and unconformably in the gabbro masif of the Western Area Peninsula. The sequence consists of Eocene lignite – bearing clays with fauna of fish and molluscs overlain disconformably by quarternary gravels, sand and clays.

Concretions and nodules of clay ironstone and marcasite are common with the clay beds. The bullom series varies in thickness and there is the possibility that late cretaceous sediments are present beneath the Eocene sediments where the sequence is thick as is the case in the coastal strip of eastern Ivory Coast where similar sediments occur (ESCG, 1988).

1.4. GEOMORPHOLOGY

Two types of geographic terrain recognised in the mangrove areas are: the gabbro masif of the Western Area Peninsula Mountains and the coastal lowlands which is mainly bullom rock series of recent alluvial origin. The hills and mountains of the western Area Peninsula mainly constitute basic and ultra- basic rocks. Within the coastal plains are coastal terraces derived from the deposition of relatively unconsolidated sediments. They have intricate pattern of dissected plains, especially along the seaward margin. They lie at elevations of 2 – 40m asl. At the foot of the coastal terraces lie estuarine swamps, resulting from the deposition of silt and clay along major rives channels (ESCG, 1988).

1.5. HYDRO SEDIMENTOLOGY

The mangrove areas can be divided into the following hydrological areas; the Scarcies River, Sierra Leone River, Sherbro River and the Yawri Bay.

The Scarcies River Hydrological Area

The river is tidal and during the rainy season rises about 2.7m. The wide estuary mouth has mud banks and sand bars forming Yeliboya, Kortimaw, Yeligbungbo and Bankapia Islands. Further inland, it splits into the Great and Little Scarcies rivers which are relatively narrow.

Sierra Leone River Hydrological Area

The main rivers entering this hydrological are the Rokel, Port Loko creek and Kumrabe creek.

Sherbro River Hydrological Area

Three major river systems, the Taia, Sewa and Wange rivers enter the Sherbro River estuary through a complex system of brackish water channels draining an extensive area behind the ancient beach ridges in the South east region. The water divides around Sherbro Island and flows west into Yawri Bay and south along Turner's Peninsula.

Yawri Bay

Three small rivers, Ribbi, Kukuli and Kagboroko rise inland and reach the bay. Several small creeks are also connected to the sea and river systems.

The mangrove areas are subjected to tidal movements and changes in volume of inflow between the wet and dry season. The tidal influence reaches about 10km inland from the sea at the time of high flow in the rainy season. The volume of inflow to the swamps from their catchments and rivers are high during the rainy season resulting in high run-off from the catchments. Precipitation is common in the wet season and evaporation is common in the dry season. During the wet season, the excess of precipitation which cannot be stored as soil (ground) water represent the amount of rainfall input that become available as run-off. The water balance deduced from rainfall minus evapotranspiration shows that there is a 'water surplus' 2000 – 2200 mm, which is higher than 'water deficit' during the dry season. During the dry season, much of the water in the swamps within the interior plains dry up while the coastal swamps still maintain an appreciable amount of water albeit saline (ESCG, 1988).

The soil associations have been developed on recent and Pleistocene alluvial salts and clays. The most dominant solid are characterized by strongly weathered, yellowish –brown loams to sandy clay loam. The soils are strongly acidic (pH = approx. 4.5) with a cation exchange capacity (CEC) of 5 – 10 meq%. Iron toxicity is common in the poorly drained inland swamps particularly in the middle and upper reaches. Good quality peat occurs in several locations around the Ribbi area (Birkenhager, 1988).

The western tip of Sherbro Island delimits two contrasting coastal waters. The narrow southern shelf has limited fish resources and is influenced by the east ward flowing Guinea current. The Northern Sierra Leonean coast on the other hand constitutes the productive shelf of Sierra Leone. Therefore most of the artisanal fishing activities in Sierra Leone occur in the North. Here, there are three major estuaries: the Scarcies River, the Sierra Leone River and the Sherbro River; as well as the Yawri Bay. The continental shelf has good yield potential for demersal and pelagic fish as well as shrimps.

Long shore drift current is the main mechanism by which sediments are transported along the Sierra Leone coast. The sediment transport takes place mainly within the 1 – 10m water depth. Three main long shore drift current directions can be recognized along the Sierra Leone coastline. These currents flow in a northeastern direction causing erosion of the northern coastline around Yeliboya Island and Konakridee. Similar south easterly flowing currents in the south carry sediments from the Freetown Peninsula beaches and along the entire southern coastline of Sierra Leone. Tidal currents also influence the sediment transport dynamics particularly those of very fine sand and mud mainly at the entrances of bays and estuaries (Johnson and Johnson 1991).

1.6. MANGROVE SWAMP SOILS

The coastal swamps where the mangroves are found, consists of alternating banks of silt, sand, gravel and clay. Silt is predominant in the Northwest. In the South, large areas of coarse sand are alternatively waterlogged or very dry. The soils in the Sherbro estuary area are characterized by partly compacted, cohesive silts and clays. The clays have a good salt-fixing capacity and therefore provide an ideal base for the development of potentially acid sulphate soils (sulfaquents) and also because of the marine influence. Generally, acid sulphate palarcosols tend to occur in the contact zone between the tidal flats and pre-holocene non-estuarine deposits usually colonized by fresh water grasses and herbs.

Mangrove swamps have fertile soils but are difficult to cultivate because of the salinity and acidity problems. During the raining season, there is enough fresh water to flush the salt from the topsoil, which then allows salt tolerant varieties to be transplanted as soon as the salinity level drops. Deep soft alluvial muds are observed to be associated with the most productive forest along the creek and river banks with a gradual transition to compacted soil towards the swamp interior. Rice is the only crop grown in most swamps but during the dry season, the area is left to fallow.

1.7. VEGETATION

In Sierra Leone, mangrove forests are found in the coastal area, usually on tidal flats at the mouths of rivers. Stilted shrubs or trees are frequent. Along creeks, the trees are larger and the forest is dense, resulting in a "gallery forest" effect.

Extensive areas of large trees (*Rhizophora racemosa*) up to 40 m are found e.g. in the Sherbro River complex. The mud flats between creeks have a low mangrove cover, usually less dense. The main tree species are *Rhizophora racemosa, Rhizophora mangle* and *Rhizophora harrisonii*. The first is a pioneer species at the edge of the water. The other two are dominant upstream at the tidal limits, where *Avicennia africana* (syn *A. nitida*), *Conocarpus erectus* and *Laguncularia racemosa* can also be found. On the fringe of the mangroves, grasses occur together with ferns and halophytes.

Botanical Name		**English Name**
Rhizophora racemosa	-	Red mangrove
Rhizophora mangle	-	"
Rhizophora harrisonii	-	"
Avicennia Africana	-	Black mangrove
Laguncularia racemosa	-	White mangrove
Conocarpus erectus	-	Button mangrove

The mangrove cover is mainly made up of low regrowth with few trees of any size. This is characteristic in the area around Freetown that has apparently been cleared for poles are fuelwood in the past. Paddy rice cultivation is present in some areas.

There is a natural succession of mangrove species within the mangrove ecosystem as land levels rise and the soil becomes more compacted towards the swamp interior.

Newly formed mudflats are initially colonized by the species *Avicennia africana* and *Laguncularia racemosa*. As land levels rise through sedimentation, and the

soils become more stable, *Rhizophora racemosa* will gain a foothold. *Rhizophora racemosa* thrives along river and creek banks, where the soils are firm and tidal inundation is frequent, and develop into luxuriant stands of 20 – 40m in height.

As land levels rise further and tidal inundation becomes less frequent towards the swamp interior, *Rhizophora racemosa* rapidly looses its vigour to form a shrub - like crop of poor form and low productivity, often in mixture with *Rhizophora mangle* and *Rhizophora harrisonii*.

Avicennia is less exacting in site requirements and can be found throughout the mangrove ecosystem growing to 15 – 20 m in height, commonly in mixture with *Rhizophora* species. Where *Rhizophora racemosa* thrives along river and creek banks, *Avicennia* tends to be shaded out but it increases in dominance towards the drier swamp interior as *Rhizophora* looses vigour.

Rhizophora harrisonii and *Rhizophora mangle* form tall shrubs of poor form towards the interior and gradually give way to inland species.

In addition to the mangrove species, two non woody plants are found pioneering cleared sites. *Sesuvium portulacastrum*, a herb like species with fleshy leaves and *Paspalum vaginatum*, a grass like sedge.

1.8. NATURAL REGENERATION AND PHENOLOGY

Rhizophora species are characterized by the stilt roots whereas *Avicennia africana*, which can dominate minor areas is characterized by aerial roots (pneumatophores) rising through the mud.

The fruit of the *Rhizophora sp.* develop a long primodial root, a radicle, while still hanging on the tree. The occurrence of a ring scar on the radicle protruding from the fruit is an indication of ripeness

Seed production and dispersal of *Rhizophora* and *Avicennia* species differ, but under conditions of continuous exploitation, increases the likelihood of *Avicennia* becoming the climax species. *Rhizophora* produces seeds most heavily along the river banks and seed dispersal is most efficient directly below the mother tree where falling propagules penetrate the soft solids. The successful establishment of propagules which fall into water is limited particularly where land levels are high and tidal inundation is infrequent. However, where the two species are mixed, a ground flora of *Avicennia* pneumatophores limits the potential for direct seeding beneath the mother tree.

Avicennia produces abundant seed on the higher ground away from the waterways which are easily dispersed by light tidal inundation and is more of a pioneer native enabling efficient colonization of newly formed and drier denuded sites. *Avicennia* is able to coppice and can survive harvesting of main stems maintaining a seed source on exploited sites. Also land formation is faster under *Avicennia* due to the abundance of pneumatophores which serve as an effective trap for silt and litter deposition.

The propagules of *Rhizophora racemosa* starts to ripen in April while those of *Rhizophora mangle* and *Rhizophora harrisonii* follow one month later. Seedlings of *Avicennia Africana* and *Laguncularia racemosa* appear underneath the mother trees in July.

1.9. ARTIFICIAL REGENERATION

Rhizophora racemosa is the selected species for artificial regeneration in the felling strips. *Rhizophora* propagules are the regeneration materials used for planting. They can be found all year round, with the peak period running from April to September. The propagules are ripe when the tip of the root is reddish and a ring appears just below the fruit. The fruit cap is easily removed during collection which is best done when the propagules are still on the tree. Only propagules of 30cm and above should be selected in order to ensure that *Rhizophora racemosa* is collected rather than *Rhizophora mangle* or *Rhizophora harrisonii*. The propagules should be stored in a cool dry place in the shade when picked, until planting but no longer than 2 – 3 weeks. When stored in mud or water, the limit is one week because the roots will start to develop and this will make planting difficult.

Planting is done by pushing the swollen end of the propagule 10 – 12cm into the mud. Chong 1987 recommends a close plant spacing of 1.5m x 1.5m to promote early canopy closure for soil protection and to optimize biomass production.
Planting of propagules can be done all year round but is better restricted to the months of highest propagule production for ease of collection.

Restoration programmes for mangrove degraded areas have been done by various institutions in Sierra Leone since the 1980s. A Rehabilitation programme planted a total of 35,000 propagules in the Project Area called Allen Town about 9 miles from Freetown on the Freetown-Waterloo Rural. School children of the Faith in Christ Primary School, Lower Allen Town also planted 1,500 mangrove trees in connection with the National Tree Planting Day observance in the country in 1987. Communities in the area also integrated oyster collection in the Project in cooperation with the Fisheries Department (Loyche, 1987).

Other institutions include the West North West Artisanal Fisheries and Community Development Programme (WNW AFCOD) funded by the government of Sierra Leone and the European Economic Community (EEC) and the FAO/UNDP Fuelwood Project FO:DP/SIL/84/003. Recently, the Forestry Division in partnership with the Artisanal Fisheries Development Project (AFDEP) has also undertaken mangrove rehabilitation programmes in the Western Area, where about 100 acres were planted by different fishing communities in 2003, with the involvement of the local inhabitants but this had not been very successful as there are reports that fish feed on the young seedlings or foliage. It was suggested that the time of replanting of the seedlings should be reviewed and adjusted to evade the fish.

1.10. GROWTH RATES

In Sierra Leone, a vegetation survey of 200 hectare tract of the Scarcies River Mangrove Forest was undertaken by the Mangrove Resource Management Section of the West North West Artisanal Fisheries and Community Development Programme (WNW AFCOD Programme) between November 1992 and April 1993, to produce the following data:

(i) an up to date vegetation map of the area including species, structure and extent of each vegetation type.

(ii) Standing volume of each vegetation type.

The survey method used was based on the recommendations of Chong, 1987 and the practical experience gained from the Ma-Swar / Ribbi River mangrove area of Sierra Leone in 1987/1988 under the FAO Fuelwood Project. The method involves systematic line sampling, with circular sample plots of 5m radius

land cut at 20m intervals, giving a sampling intensity of 4%. All trees of 7 cm d.b.h. and above were measured for diameter at 1.3m above ground levels or above the stilt roots in the case of *Rhizophora* species. Structure and regeneration potentials were also recorded.

Results indicate that some 57% of the study area supported a High Forest crop of mean standing volume 120 – 138 cubic metres per hectare (m^3/ha) located predominantly along the river and creek banks. The remaining 43% supported a High Bush/Poor Forest crop of 10 – 52 m^3 mean standing volume, decreasing in productivity towards the swamp interior.
Total standing volume of the 200 hectare management area was 17,586m^3, comprising of 10,780m^3 of *Rhizophora* species (61%) and 6,806m^3 of *Avicennia*. species (39%). Signs of exploitation were seen in all productive areas that were studied.

According to field observations, *Avicennia* harvested mainly for fuelwood for salt processing had undergone limited exploitation while *Rhizophora* had been heavily harvested for fuelwood for fish smoking.

The volume estimations for the Scarcies River with results of a similar survey conducted in the Ribbi area were compared. The Ribbi area has a higher mean standing volume for *Rhizophora* High Forest (231.10 m^3/ha) than that for the Scarcies (120.71 m^3/ha). However, diameter class distributions for *Rhizophora* High Forest in the Scarcies showed a predominance of 7-15 cm poles with few trees of 15 cm and above indicating that the Scarcies have been exploited.

In collaboration with the FAO/UNDP Fuelwood Project in the 1980s a study was conducted by the Forestry Division, then of the Ministry of Agriculture, Natural

Resources and Forestry (MANR&F). The objective was to formulate an Integrated Utilization and Management Plan in order to secure maximum fuelwood production on a sustained yield basis without causing adverse effects to the environment.

Species were tried for site conditions, survival and growth. Selection of species was based on widespread natural occurrence, availability of planting material and its value for firewood and charcoal production. *Rhizophora* species and *Avicenna africana* were given priority for the trials. In planting the *Rhizophora* species, the radicle was gently pushed 7-10 cm (3-4m) down into the soft mud. Within 4-5 weeks the first two leaves unfolded. Height growth of the propagules attained a height of 120 cm (4 ft) after 8 months. In general, survival rate was good averaging about 90% although assessments discontinued for various variables or parameters. Casualties were due mainly to wrong handling of the planting material and consumption of the planted propagules by crabs.
Laguncularia racemosa and *Conocarpus erectus* prefer dried sites and are not very valuable as fuelwood species.

1.11. FISHERIES AND WILDLIFE

The role of mangroves as a fish breeding area and as a nutrient input to coastal fisheries is one of the most important but indirect economic values of mangrove.
The rich fish stocks in Sierra Leone waters is largely attributed to the numerous rivers and estuaries vegetated by mangroves (Chong, 1987). Commercially important shrimps such as *Panaeus notialis* and *Panaeus kerathus* are dependant on the mangrove habitat for at least part of their life cycle.

No surveys on mammals have so far been carried out but crocodiles, monkeys, forest genet have been observed and there is evidence of the presence of the threatened African Manatee (Schwarz, 1992). Three species of game mammals

inhabit the coastal forest including Maxwell Duiker *Cephalopus maxwelli* (Near Threatened - NT). There are numerous species of birds including various herons and egrets, pelicans, kingfishers, bee-eaters, eagles and the occasional flamingo. Crabs, mudskippers and oysters are abundant.

Different studies conducted for Yawri Bay include the following:
Forty six species of Palaeartic migrant birds are known to occur in the bay. The near threatened Damara tern *Sterna balaenarum* (NT) was first recorded for Sierra Leone at this site, and is also the westernmost record of the species in Africa.
Recent water bird surveys recorded four new species for Sierra Leone including the Greater Flamingo *Phoenicopterus rubber* (NT) and Great White Pelican *Pelicanus onurotalus,* Northern shoveler *Anas clypeata* and Terek sandpiper *Tringer cinereus* (Okoni–Williams et al.,2005). Tye and Tye (1987) and Thompson and Wood (1992) estimated that the bay holds over 20,000 waders. Also five species of marine turtles that occur in Sierra Leone, exist in Yawri bay.

1.12. ENVIRONMENTAL SIGNIFICANCE

The mangrove forest form a protective barrier to wave by reducing coastal erosion and the consequent siltation of rivers and stabilizing estuarine flood plains, provide detritus and nutrients which form the food base of many marine and fresh water organisms; these in turn support estuaries and near shore fisheries. The mangrove swamp being consolidated by the plant roots are known to retail land based pollutant heading for coastal water.

1.13. MANGROVE RESOURCE UTILIZATION

The mangrove forest in Sierra Leone are being cleared for fuelwood production, agriculture, salt making, boat making, tanning leather, poles for transmission of electric energy, fish and oyster traps etc. A list of some mangrove based products is found in Appendix 1.

Rhizophora species yield a fuelwood with a calorific value substantially higher than most fuelwood species. It is easy to split, burns well and produces excellent charcoal. It also has a high content of volatile oils which account for its fuelwood properties. Freshly cut *Rhizophora* does not float.
Avicennia can also be used as a fuelwood but requires seasoning. Its straight growth habit and reasonably resistant timber make it a useful building material. However, the high salt content is sufficient to corrode wire nails if the timber is not dry.

Rhizophora racemosa is the preferred species for fish smoking as it burns when fresh and gives the smoked fish the desired colour and taste.
Avicennia is rarely used for fish smoking but may be used in domestic cooking and salt making.

Large poles of *Avicennia* with a diameter of 15cm and 2.3m long are used as uprights containing large proportion of durable heat wood. *Avicennia* poles of 10cm are used to make banda poles and roofing sticks and anything smaller can be split for wattling. It is also used for making paddles, mortars, pestles and stakes
Rhizophora poles are used for construction of ridge poles and boat keels. Small *Rhizophora* poles are always in demand for smoke oven construction as they are regularly replaced.

Due to the technical difficulties of extraction and pit sawing in the mangroves, the expansion of timber board production will be difficult. However, poles will continue to be in demand for house construction.
In most parts of the country, the development of mangrove swamp rice has been going on for several centuries and plays an important role in the rice economy of the country

In Sierra Leone, the extraction of salt from the mangrove swamps as well as other anthropogenic activities is leading to the decimation of the mangrove ecosystem. Only mangrove area of low fuelwood productivity (*Rhizophora* shrub of poor form) is used for salt making and takes place during the months of March and April.

Crassostrea tulipa (mangrove oysters) are collected from the roots of *Rhizophora* for local consumption. Trees bordering the river and creek banks are sometimes damaged considerably when the roots holding the oysters are cut with cutlasses instead of breaking the oysters with hammer.

1.14. LEVEL AND CAUSES OF DEGRADATION

There is high intensity of wood cutting in these mangrove areas, especially around fishing villages, where most of the wood is used for smoking fish. Logging is done mainly for the construction of housing, dug-out canoes and small boats.

Because of the long period of rice cultivation in these areas, the naturally fragile soil structure is now very vulnerable to erosion during heavy rains, thus a potential for siltation to occur.

Fishing is the main occupation of most of the inhabitants around the mangrove areas; therefore there is extremely high fishing intensity. The fishing intensity has been exacerbated by the development of small artisanal fishing projects in many communities, especially around the Yawri Bay, funded by various agencies, especially UNDP and AFRICARE. There is legislation against large fishing trawlers and on the size of net mesh used by artisanal fishermen, in order to prevent depletion of the fish resources, but enforcement is weak. Large fishing trawlers are not given access into the waters of the mangrove, because of the international marine regulation of a 20 – mile exclusion zone. The smallest sizes of fishing nets are used by artisanal fishermen and offtakes include fingerlings of a variety of fish species and even the eggs. Fishing within exclusion zones by large vessels is reported to be having serious effects on the artisanal industry.

Recently, the frontage of the Aberdeen Creek (part of the Sierra Leone River Estuary) along the Lumley Beach road has been leased to investors for Hotel Construction and Development. Also the Thompson – Bay end of Aberdeen Creek (that is within Murray Town Community) has been leased for urban expansion.

No mining is currently going on in the mangrove areas but a concession was given to a South African company, de Beers, for an offshore mining operation in Yawri Bay; which is yet to materialise. Heavy metal poisoning from large-scale mining operations upstream by Sierromco and Sierra Rutile Mining Companies was suggested to have caused fish kills within the Yawri Bay (Ndomahina, pers comm.) This needs to be investigated to ascertain the effect of the long-term mining activities on fish stocks, migratory bird numbers and the general ecology of the mangroves.

Mangroves have no national legal protection status; most of the threats to its conservation are regulated either by traditional bye-laws or international legislations affecting all countries along the coast.
Thus fishing and wood cutting, which constitute the most important economic activities in the area, are controlled by traditional bye-laws imposed by chiefdom authorities, but this has not been very effective.

1.15. EXISTING CONSERVATION INITIATIVES

The conservation initiatives existing now are the traditional bye-laws and implementation of a 20 - mile exclusion zone. However, the Conservation Society of Sierra Leone (CSSL) submitted a proposal to the Government Forestry Division for a Ramsar designation of the Yawri Bay.

CSSL is also conducting a regular annual water bird census as a means of monitoring population status and trends of migrant water birds that visit the Bay. A small area at the northern end of the Bay around Bumpe Creek has been proposed as a Game Reserve (Phillipson, 1978). Kagboro Creek has also been proposed as a protected area.

1.16. MANAGEMENT

Food Security is given the highest priority is Sierra Leone, therefore, sustainable management of mangrove forest and aquatic resources and an improved environment will contribute towards this national goal.

Mangroves in the more accessible and populated areas are depleted or over exploited, however, there are productive forests north of the Great Scarcies

River, in the Yawri Bay and the Sherbro River Estuary. It is therefore imperative that a proper management system be put in place to regulate its exploitations, including proper land use, conservation and protection of its biodiversity and conduct various studies in mangrove ecology.

P.W. Chong, mangrove consultant for the FAO fuelwood project in 1987, made recommendations for the management of Sierra Leone mangroves in his report - Proposed Management and Integrated Utilization of the Mangrove Resource in Sierra Leone - FO:DP/SIL/84/003 and this forms the basis of Forestry Division policy in respect of the mangrove resource.

The management goals to be considered are outlined as follows:-

A. Production Forestry Goals

1. **Generally** to manage, develop and protect the mangrove resources in order to achieve sustainable production of wood and non-wood benefits in order to fulfill local and coastal demands for energy, construction materials and other wood products.

2. **Specifically** to produce a sustained yield of the following products for local consumption at affordable and stable prices; fuelwood, fishing stakes, poles, posts and structural materials for local communities.

B. Social Forestry Goals

1. **Generally** to improve the standard of living and quality of life of the mangrove dependent population, including fishermen and oyster-collectors.

2. **Specifically** through extension, demonstration and training activities increase their awareness and acceptance of forestry programmes.

C. Environmental Forestry Goals

1. **Generally** to maintain the integrity of mangrove vegetation along the coasts and rivers to serve as storm barriers, flood and erosion control; and to provide environmental support and protection to coastal agriculture and villages.

2. **Specifically** to protect, rehabilitate and manage mangrove ecosystems that are required as breeding ground or source of nutrition or shelter for oysters, fish and other high protein sea-foods;

   - preserve natural mangrove ecosystems as reservoirs of species diversity and for conservation of plant and animal genetic resources;

   - set aside sufficient areas required for research, education and training purposes

- manage recreation and tourism areas

- promote social acceptance for forestry programmes

- maintain navigational value of main waterways

Various partners have been involved in management processes in the areas of surveys, research and restoration – Forestry Division, Fisheries Division and Projects sponsored by FAO/UNDP, European Union and African Development Bank.

Based on the resource survey data (Kellett, 1993), the management area can be divided into four management zones: Protected Forest, High Forest, High Bush and Poor Forest. For each zone, management prescription will vary as indicated in Table 3 below:

Table 3. Summary of Management

ZONE	**MANAGEMENT**
Protected Forest	Protected Area
High Forest	Fuelwood Production
High Bush	Pole Production
Poor Forest	Rice and Salt Production.

	Artificial Regeneration Research

Protected Forest

To help maintain the habitats of wildlife and fisheries resources and to limit erosion, a 30 m wide belt along the creek should be left intact. Also, the felling of trees bordering the main internal creeks is prohibited.

High Forest

This zone will be managed for fuelwood production, to supply the fish smoking centres and can also be suitable for charcoal production. The vegetation of this zone is found classes 1 – 3 (Appendix 2).

High Bush

It will be managed primarily for pole production to meet the local demand for building poles. Vegetation of classes 4 and 5 can be found in this zone.

Poor Forest

This zone will be primarily set aside for activities like rice cultivation, salt making and for artificial regeneration trails. It consists of *Rhizophora* shrub of poor form and low productivity, with occasional dominant *Avicennia*.

1.17. SILVICULTURAL SYSTEMS AND YIELD CONTROL

A. Silvicultural Systems

High Forest Zone

This zone is managed by using a clear fell with standards system, on a sixteen year rotation, which is proposed for the production of fuelwood. All trees of 7 cm and above should be removed, including branches and stilt roots of harvestable size.

According to Chong 1987, at an average diameter increment of 0.8cm, this rotation will produce an average pole size of 12.8cm dbh. Natural regeneration is encouraged by retaining fifteen healthy, seed bearing mother trees per hectare and also by felling in strips. Strips not more than 50m wide should be felled alternatively with eight years apart.

In areas where natural regeneration stocking is inadequate two years after felling, that is having less than 2,500 seedlings per hectare, artificial regeneration should be done.

High Bush Zone

The silvicultural system involves selecting poles (for construction) of the required size and species at random. *Avicennia* species normally dominates this zone and because it coppices vigorously, it will replace the selected poles and maintain an adequate stocking.

Natural regeneration is also encouraged by retaining fifteen healthy, seed bearing mother trees. Harvesting of fuelwood for commercial purpose – fish

smoking – is prohibited, but collection of fuelwood for domestic cooking is allowed.

B. Yield Control

High Forest Zone

Yield in the High Forest Zone should be controlled by area. The zone is divided into compartments, which are of almost equal size and standing volume. The compartment is divided into 50m wide strips and should be felled annually with eight years between the felling of adjoining strips.

High Bush Zone

Poles should be extracted as required, to meet market demand. Standing volumes should be monitored bi-annually, by random sampling, to determine whether stocking levels are maintained.

However, mangrove rehabilitation programmes have been undertaken in different fishing communities, with the involvement of the local inhabitants but this had not been very successful as there are reports that fish feed on the young seedlings or foliage. It was suggested that the time of replanting of the seedlings should be reviewed and adjusted to evade the fish.

2. INSTITUTIONAL AND REGULATORY FRAMEWORK OF THE MANAGEMENT OF MANGROVE AREAS

Mangrove management is multi – sectoral in nature and therefore requires an integrated approach. No legal protection status and specific government land use policy for the mangrove exists. However, various pieces of policy and legislation relating to coastal environment are either parts of a broader legislative framework or are incorporated into various legislative machineries in line ministries. The prominent ones are:

The Forestry Act 1988 and corresponding Regulations of 1990, provides for the management and development of all forest resources including mangroves. The Act classified three types of forest reserves; National Production Forests for production of forest resources, National Protection Forests for the protection of soil, water, flora and fauna and Community Forest, for the supply of forest products and or protection of forest ecosystems and resources at community level.

The Wildlife Conservation Act 1992 sets a legal framework for the protection of wildlife and creation of protected areas in the country, providing definitions and management objectives for Strict Nature Reserves, National Parks, Game Reserves and Sanctuaries, Controlled Hunting Areas and Non-Hunting Forest Reserves.

Fisheries Management and Development Act 1988, provides the framework for the regulation of fishing activities.

The Environmental Protection Act 2000 makes reference to the coastal environment. The National Environmental Policy (NEP) that was approved by cabinet in 1990 has specific areas that relate to mangrove management like:
Land Tenure, Land Use and Soil Conservation, Coastal and Marine Resources, Public Participation, Institutional and Governmental Arrangements, Legal Arrangement, etc.
An Environment Impact Assessment (EIA) is mandatory for any project whose activities could constitute major environmental threats like substantial change in farming and fisheries practices.

The Mines and Mineral Act 1994 controls all mining activities including coastal.

Agricultural Ordinance, Cap. 185, Produce Inspection Rules (Public Notice No. 66 of 1974) – Plant Phytosanitary Import Rules (Public Notice No. 66 of 1974), govern the control and preservation of agricultural produce in Sierra Leone.

The Government Institutions bearing the greatest responsibilities for mangrove management are:

Ministry of Agriculture, Forestry and Food Security
Ministry of Marine Resources
Ministry of Lands, Country Planning and the Environment
Ministry of Mineral Resources
Ministry of Tourism and Cultural Affairs

Conservation Society of Sierra Leone, a local NGO has been involved in mangrove area protection with the Forestry Division in the following ways:

- Promotion of public awareness and action on environmental degradation in the mangrove areas.
- Promotion of public interest in conservation and the protection of biodiversity in the mangrove areas.

The Institute of Marine Biology and Oceanography (IMBO) is the recognized institution for Coastal and Marine Research. They are responsible for the collection and analysis of data on coastal resources, environmental degradation, pollution, oceanographic parameters and sea level rise. IMBO is however constrained due to the lack of a research vessel, modern equipment and inadequate operational funds.

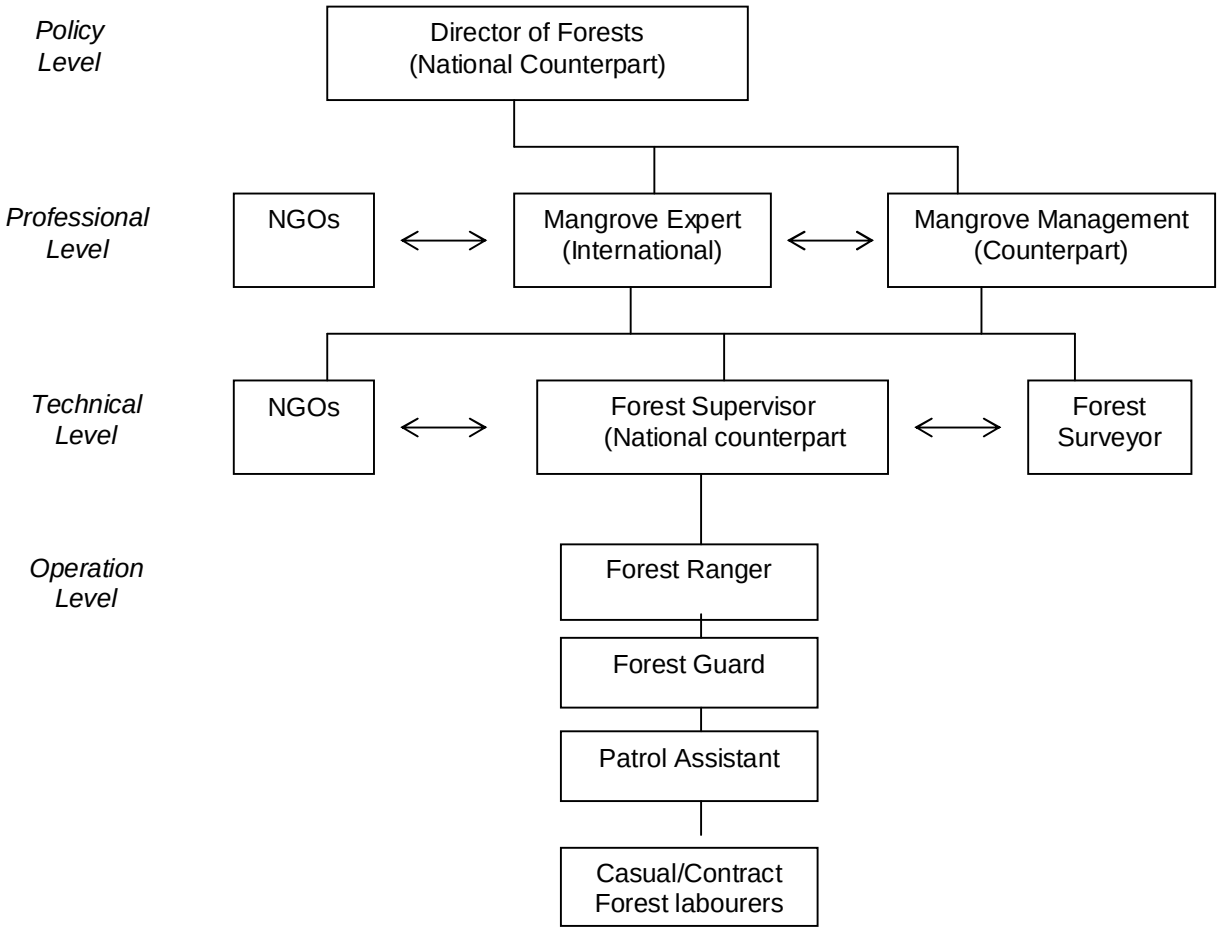
The Department of Geography and Biological Sciences, Fourah Bay College, University of Sierra Leone and Njala University College are also involved in research activities concerning other aspects of the coastal zone.

Given the environmental importance of the mangroves as a habitat and shelter for important commercial fishery, coastal protection, sedimentary stability and fuelwood energy, the long term development objective may be described as the integrated conservation and management of mangrove resources for the maintenance of ecological stability and sustainable production of wood and aquatic benefits, as well as, the creation of rural industries and employment opportunities within a rural development context in the coastal areas.

This implies that the mangrove management section in the Forestry Division should be strengthened considerably in terms of staff and equipments.

The organization is summarized in Figure 3, which shows the activities planned for the mangrove management section.

Figure 3. Organization - Mangrove Management Section



ACTIVITIES – Professional

Extension Forestry	Felling Plans	Training Modules	Inventory & Analysis	Management Planning	Energy Planning
Community Forests	Socio-Economics	Marketing Surveys	Aquatic Resources	Wildlife Conservation Environmental Protection	

ACTIVITIES – Professional level

Planning Stock & nurseries	Plantation Establishment	Trial Plots Measurement	Supervision & Patrols	Planning Stock & nurseries
Mapping & Cartography	Forest Surveys	Harvesting Operations	Maintenance of Boats & Vehicles - supplies	

ACTIVITIES – Professional

Practical aspects of forest management, enforcement, revenue assessment, surveys wildlife protection, conservation

3. SOCIO-ECONOMIC ACTIVITIES IN MANGROVE AREAS

3.1. SOCIAL ORGANIZATION

For the purpose of local government and administration, Sierra Leone is territorially organized into provinces, districts, chiefdoms and the Western Area which is the seat of government and has the capital city Freetown. In general, districts are not indigenous groups, but were created for administrative convenience. Although they are groups of chiefdoms, their boundaries do not coincide with tribal limits. All districts are administered through the Ministry of Internal Affairs.

Traditionally, the basic unit of local government is a small settlement or town originated from a single founder and surrounded by satellite settlements, each with a headman chosen by the local ruling family. Towns are grouped administratively into sections under section chiefs and sections into territorial units called chiefdoms.

The executive head of chiefdom is the paramount chief elected by the chiefdom council. By tradition, the paramount chief presides over all land issues and all land development Programmes need the blessing of the chief or the headman in the case of Western Area since it is his decisions that are most likely to be respected by his subjects.

Within the above setup there are homogenous groupings with specific responsibilities directed toward the welfare of the community as for example youth groups, women's organizations, religious congregations etc. Thus, it is not uncommon to see these groups converge to make decisions related to the development of the community.

3.2. DECENTRALIZATION

The decentralization policy is now well rooted in Sierra Leone by the Local Government Act of 2004. The Act provides local authorities substantial autonomy in financial and human resources management, and communities with platform to actively participate in decision-making at the local level.

3.3. LAND TENURE

While land tenure within Western Area is freehold, outside Western Area it is communal. Ownership is vested in the local authorities, notably the paramount chief who holds such lands for and on behalf of the rural community concerned. In contrast with Western Area, there is hardly formal tenure in the provinces. Mangroves in the Western Area are state property under the custodian of the forestry division. However over the years, communities living close to these resources have taken de facto ownership arising from long years of usage. The laws and customs recognize usufruct right.

Family ownership is by far the commonest form of land tenure. A family may be interpreted as anything from a quite extensive group to simply a man, his wife, immediate descendants and near relatives. A family member, however long he has been away, has a right to demand a portion of the family land if he wishes to cultivate it. In some cases family members do come together to cultivate a family land but at the same time individual members may each develop the land separately. The general control and administration of the land is carried by the senior member of the family, a responsibility passed down patrilineally.

There is marked tendency for family lands to be fragmented and, while the position of the head of the family still descends patrilineally, a man may inherit a

portion of land indirectly through his mother. Where a land holder has more than one wife, it is customary for him to cultivate a separate portion for each. Upon his death, the children of each wife can lay claim to the portion of land cultivated for their mother. The original land holding is thus sub-divided into as many portions as the late holder had wives. If the wife marries another man, she cannot transfer the right to her new husband's family, even if she is childless, although the husband himself may be allowed to farm it.

A stranger may obtain land by request from his landlord on payment of a small fee. If he remains a long time and helps his landlord with his land use activities, he will eventually be absorbed into the family thus acquiring rights of usufruct.

Although the whole trend of land tenure is moving towards individual ownership, this only exists in parts of the country where land has acquired great value, for example, cleared mangrove areas and land in the immediate vicinity of large towns.

Land can be pledged. There are instances where land has been pledged for an indefinite period of time with no intention of redeeming. The pledgee's descendants may, of course, redeem it for themselves, but the pledgee acquires complete right of usufruct until the pledge has been redeemed. This may not happen for a very long time and complicated disputes arise in local courts especially if the pledgee has himself pledged the land to another party. Plantations are the property of the individual who plant them, though he may have no right over the land on which they are planted. Where this is the case, the land holder will expect a small portion of the crop to be given to him in recognition of his rights. Plantations, but not the land on which they are planted, can be sold.

3.4. LAND USE RIGHTS AND RESOURCE SHARING

Mangroves are not classified forests and as such are not placed under formal management regimes although FAO in 1989 provided technical support for the assessment of mangrove resources in Sierra Leone with a view of bringing them under management. In the main, exploitation of mangroves is governed by traditional use rights which are determined by the customary law of the respective ethnic group. In effect, members of a community who are recognized as having claim to a particular area, whether forested or not, also posses the right of land use. These rights mainly concern fishing, collection of fuel wood, hunting and agricultural use.

At local level, the spread of individual holdings could make it difficult to preserve an essential minimum of land for community use and need. However, land can be set aside for common purposes under the chiefdom Councils Act (Cap 61 amended by Acts nos. 13 (1964), 13 (1974) and 18 (1975) which empowers councils to issue orders restricting the destruction of trees and to make by-laws for purposes of including the setting aside of land for development of the town and other facilities for inhabitants of that town/ village.

All lease rents or royalties are paid in cash or kind and the principal beneficiaries are the paramount chiefs, the headman in the case of western area, the original land owners and the chiefdom administration.

The Forestry Regulations of 1989 provides under section 10 (4) that the distribution of royalties shall be fifty per centum to the land owners, forty per centum to the chiefdom administration and ten per centum to the paramount chief. The emergence of District Councils requires that the review of the mechanism for benefit sharing be urgently undertaken.

3.5. HOUSEHOLD STRUCTURE AND INCOME

Household compositions generally range between 8-10. Most households are headed by a male it is however common to see households headed by females when husbands desert them.

The income of households vary considerably depending on the income earning activity carried out, the output and market conditions. The main economic activities carried out in coastal areas are paddy rice cultivation, firewood collection from mangroves, salt production, fishery and fish trade. Outputs are generally low due to poor infrastructure and transportation facilities. The lack of value addition also contributes to low incomes. Given these varying conditions, it is often difficult to quote income levels of households.

3.6. LABOUR AVAILABILITY

Labour demands are seasonal. In mangrove zones where Labour-intensive operations such as clearing mangroves, transplanting rice seedlings and water control require large amounts of labour input, Labour costs are high. Heavy dependence is paced on family labour, nevertheless, in most cases labour is hired or contracted. Goswani et al, 1980 estimated that as much as 15% of farm work is done by paid labour. There are various forms of labour hire and exchange schemes. At local level, young men and women organize themselves for work on an exchange and mutual help basis but frequently this will include a meal, drinks, cigarettes and a small amount of money as token. Other work groups hire themselves out to farmers.

Alternative employment opportunities, such as fishing and tourism in coastal areas, create labour shortages in the farming communities.

3.7. ECONOMIC ACTIVITIES

The UN Human Development index has often classed Sierra Leone as one of the poorest country mainly because of the high population of poor people, especially in the rural areas. The poor who survive on less than a dollar a day depend heavily on the productivity of the ecological sites and the associated biological resources; their survival is intrinsically linked with these environments for food, shelter, health and sanitation needs, and their income sources are largely derived from there.

Economic activities in mangrove areas are closely linked to land use and are treated under the following: agriculture, forestry, fishing/fish culture and other activities.

3.8. AGRICULTURE

Generally mangrove soils are marginal for long term agriculture due to the chemical nature of the soil, salinity and shrinkage and subsidence when soil is tilled. During the dry months, shortage of portable water causes hardships and sanitation problems.

Farmers in tidal areas experience a number of problems related to their specific environment and soil conditions. Because the land is flooded during high tide, a system to keep out the saline water must be devised. This takes the form of low bunds, dikes and/or drainage canals. Due to high incidence of potential acid sulphate and acid sulphate conditions in the mangrove mud, an adequate supply of water is not only necessary but water control to maintain the water table above the sulphitic layer is a precondition to the successful reclamation of mangrove land.

3.9. PADDY RICE CULTIVATION

Rice cultivation became a major food crop in mangrove areas in Guinea and Sierra Leone around 1858 (FAO, Forestry Paper 117, 1994) thus for many years, high quality mangrove soil has been used for growing rice in Sierra Leone

(Gledhill, 1963; Jordan, 1964; Ayodele-cole, 1968; Walsh, 1977). Due and Karr (1973) describing the need for additional land for rice cultivation in the country thus recommended clearing and reclaiming mangrove forests to increase production.

The main areas where paddy rice is grown are the mangrove swamps and rivarain grasslands. In the Northern Province these are along the Great Scarcies and the Little Scarcies rivers where an estimated 1300 ha of mangrove exists (Chong, 1987). This comprises most of the land which can be easily farmed in that area. In the South, suitable areas are located in the north of Bagru river estuary with better areas lying between Bagru creek and Sherbro River.

Production involves clear felling the mangroves and all rice grown are transplanted. The bulk of the transplanting is done in July and August, when rainfall is at its peak. The heavy discharge of fresh run-off water prevents the inland movement of brackish sea water, even at high tide, and washes out most of the salt deposited during the dry season. Rice is the sole crop as water conditions limit the range of crops that can be planted.

3.10 FORESTRY

The uses and values of products obtained from mangrove are many and important. The importance of the resource stems from the many products taken directly from the mangroves, including the non-wood products, as well as amenities provided from within and beyond its boundaries. Wood products are firewood and charcoal. Non-wood products include fish and wildlife. In addition, mangrove lands are often converted to salt ponds for aquaculture purposes

3.11. FUELWOOD

Mangroves provide an essential source of wood. Unlike agriculture which is essentially seasonal, forestry activities such as firewood production and charcoal making can offer employment opportunities to counter seasonal unemployment. The supply of these commodities to towns and other areas of concentrated demand is fully commercialized.

The population of Sierra Leone is heavily dependent on fuelwood for domestic energy. 90% of household energy is for cooking of which 97% is in the form of firewood and charcoal (Forestry Sector Review, 1989). Studies separating rural and urban household usage indicate wood provides around 97% of total energy use for rural household while corresponding figures for urban usage range from 58-61% in Freetown and are estimated at 90% in Bo in the south (Hunter, 1989).

In mangrove areas fuelwood plays an important role in the economy especially for women and an additional major use of firewood is in the coastal fishery industry for fish processing.

Rhizophora spp. are in great demand because the wood is dense and ignites easily when partially dry, burns uniformly with little smoke and is easy to split (Chong, 1987). Large quantities of *Rhizophora racemosa* are used for fish smoking because there are no other economic alternatives (Figure 4). The inland coastal woodland savannah is burned regularly and the remaining trees are often stunted and can produce little fuel wood.

In Shenge and Plantain Island (Chong, 1989) about 10,000 m3 of fuel wood are consumed annually for fish smoking. About 50% of the fuel wood is derived from mangroves mainly from Kagboro chiefdom. The fuel wood price delivered to site varies considerably depending on the distance and includes the cost of cutting, boat transportation and unloading on the beach where the unsplit billets are sold and collected by women.

Peat formation has been identified at Ma-Swar village in the Western Area. This is as a result of longtime decomposition of mangrove debris and it may in future lead to the formation of coal.

3.12. FISHING AND FISH CULTURE

From an economic point of view, mangroves are often far more important for the aquatic production they support than for the wood production. In coastal communities (Mansaray, 1990) many species of fish, molluscs and crustaceans find food and shelter in the mangrove ecosystem and many depend on it during critical stages of their life cycle. According to FAO Field Report 117, 1994 Kapetsky (1985) estimated that the average yield of fish and shellfish in mangrove areas is about 90 kg/ha, with maximum yield being up to 225 kg/ha.

The continental shelf of Sierra Leone is rich in fish stock on account especially of the numerous rivers and estuaries vegetated by mangroves. The main fish caught in order of importance are bonga/awefu (*Ethmalosa fimbriata*), herring (*Sardinella spp*), gwangwa (*Pseudotolithus elongates*), lati (*Ilisha Africana*), breadfish (*Pentanemus quinquarius*), skate (*Raja spp*), croms (*Pamadasys jubelini*), ninebone (*Galeoides decadastythus*) and Spanish mackerel (*Polydactythis quadrifilis*) Chong, 1987.

Figure 4. ***Rhizophora*** **firewood bundled with split mangrove stilt-roots. Photo by P. W. Chong**

Figure 5. Oyster Culture along a mangrove creek. Photo by P. W. Chong

In addition to commercial fishing in the form of trawling, there are important small-scale fisheries within the mangrove areas. A large proportion of the fish catch is smoked in kilns using the banda", a timber frame structure for suspending the fish above a strong burning wood fire.

About 80% of the fish processors in Sierra Leone are women. Women fishing activities include marketing, fish smoking, fresh water fishing and even own canoes. Their activities are however constrained by shortage of funds.

3.13. RAFT AND CLUTCH CULTURE

Oysters, exploited at subsistence level, are gathered from the roots of *Rhizophora* (Figure 5). Considerable damage is caused by severing mangrove roots with machetes to remove the oysters. In Lower Allen town close to the capital Freetown, women gather the wild oysters (*Crassostrea tulipa*) during low tide by cutting the mangrove roots. Due to the destructive method used and over cutting for fire wood, the coastal mangroves have been transformed into low shrubs and even destroyed, leading inter alia to a decline in the amount of oysters collected. However, by stringing oyster shells with a nylon string, and hanging these on bamboo racks by the tidal creeks, oyster spat can be collected and mature oysters harvested without destroying the mangrove vegetation after about twelve months. This has been applied with some success (Chong, 1989).

3.14. SHELLFISH

The term shellfish is used here collectively to describe crustaceans (crabs, shrimps) and molluscs (bivalves and gastropods)

Mud crabs (*Scylla spp*) are locally consumed. Three commercial shrimps are found in Sierra Leone waters, *Panaeus notialis* (the pink shrimp) being the dominant species. *P. kerathus* and *Parapanaeus longirostris* are the other.

3.15. OTHER ACTIVITY

3.15.1. Salt Production

Salt production using solar evaporation method is not a favourable option because Sierra Leone has an equatorial and very humid climate which makes it unlikely for salt production throughout the year. However, great quantities of salt are produced in the mangrove areas in dry season with a slightly different technique: The top layer of the mangrove soil is scraped off and loaded into a v-shaped vessel lined with straw and mud and leached with sea water. The resulting brine solution is boiled in big pans until the water evaporates and the salt is left as a residue (Figure 6 and 7). This method if practiced on a big scale can be very destructive as mangrove wood is used for the boiling process. However, in most areas it is undertaken on a small scale in the drier, less productive parts of the mangrove and utilizing Avicenna wood, which regenerates by coppicing.

3.16. PARTNERSHIPS AND COLLABORATION

Mechanisms for building partnerships and collaboration do not exist. In the past the public sector institutions assumed full responsibility for environmental resource management issues. All other actors were alienated, severing partnership and jeopardizing full-scale and active public participation by adopting command and control approaches. The off-reserve areas became a free-for-all

access heritage that was over used and abused. The on-reserved, policing type management style has proven to be counterproductive. The general concept today is shared management responsibility with other partners. There are however, barriers that need to be removed quickly and these are associated with public sector reluctance and mistrust among partners.

The main stakeholders in mangrove management in Sierra Leone are the Ministry of Agriculture, Forestry and Food Security, the Ministry of Fisheries and Marine Resources, the Ministry of Transport and Aviation, the Ministry of Local Government, the Universities, the Law Enforcement Agencies, Ministry of Trade and Industry, Ministry of Lands, Country Planning and the Environment, Conservation Society of Sierra Leone and other NGOs and CBOs.

Figure 6. Leaching of mangrove soils with salt water.

Photo by M. P. Milkie

mangrove resources, and providing for establishment of permanent resource base.

Multiple-use management of mangroves should be promoted particularly for fishery, forestry and agriculture as these are the three most significant economic activities carried out in mangrove communities in Sierra Leone. These should be driven by political commitment at the highest level. Single-use management must be avoided as this precludes the many direct and indirect benefits and services that the natural ecosystem can offer.

To give credence to the implementation of such a policy a National coordinating committee representing stakeholders from line ministries, research and academic institutions and NGOs will be established to coordinate and promote environmentally sound development of mangrove resources.

4.2. LEGISLATION

Many sectors such as Fisheries and Marine Resources, Forestry and Agriculture etc with interest in the management of Coastal zones have several overlapping regulations and other laws within their sectors. Legislation on conservation of mangroves should therefore be framed to be in harmony with the general body of legislation in the country and to reflect the agreed forest policy.

4.3. RESOURCE INVENTORY

The Mangrove resources (i.e. Terrestrial and aquatic), regardless of ownership and status, should be inventoried to assess their relative economic and ecological importance and management requirement at National and Local level. Village resource management plan for mangroves to be prepared and prescriptions made for its use.

4.4. CREATION OF MANGROVE RESERVES

Sustainable management and use of mangroves will be far fetched without a permanent resource base. This is a requirement for optimization of mangroves for national development.

To ensure protection and conservation, mangroves regardless of their ownership, should be constituted as mangrove reserves, and sufficient area be set aside for production purposes. There is therefore need to sensitise law makers on the extent, productivity and socio-economic benefits of mangroves in meeting livelihood needs of local communities.

4.5. CLASSIFICATION OF FOREST USE CATEGORIES

The economic potential of mangroves in Sierra Leone stem from two main sources: viz, forest and marine products (production function). In addition, mangroves have protection functions. There are also marginal mangroves in the inter-terrestrial areas that are more suitable for permanent or other non-wood uses (conversion forests).

Mangroves should be classified into three functional categories. A necessary first step at national level is accurate mapping of estuarine and mangrove resources of the country, from aerial photographs, preferably of medium scale ranging from 1: 10,000 – 1: 25,000, the mangrove zones in the country will be delineated into three functional categories:

- Production
- Protection
- Conversion forests

Mangroves can be placed under permanent reservation for protection in the following situations in accordance with normally recommended practices to ensure that a robust and effective system of protective buffers operate

- Where mangrove areas adjoin the mouth of major rivers
- In mangrove areas prone to erosion and storm hazards
- For virgin mangrove forest with dense young under growth
- Mangrove forest stabilizing small islands
- For mangrove areas near traditional fry and fishing ground

4.6. LAND TENURE AND USUFRUCT

The customary and usufruct rights of indigenous people and rural communities over forest produce should be clarified as part of the enabling mechanism devised to promote broad based participatory forestry Programmes.

To augment the resource base, community-based mangroves plantations and private woodlots should be promoted, particularly in wood deficit areas.

4.7. CAPACITY BUILDING OF THE FORESTRY DIVISION

In Sierra Leone, the management, protection and integrated use of mangrove resources have not been institutionalized, assistance in strengthening the technical and managerial capacity and capability of the forestry division is strongly recommended particularly in the following areas:

- International expertise in preparing model management plans for selected pilot areas and to provide on-hand experience
- Provide technical assistance to formulate and implement appropriate research Programmes
- Fellowship and study tours
- Organization of seminars, workshops and training courses in academic, research institutions and NGOs.

4.8. MANAGEMENT PLANNING

The management objective should meet the socio-economic, technical and environmental requirements of the forest. The first vital step is the preparation of a long term management plan, integrating the production of selected wood and non wood resources, needs of the rural population, recreation, conservation of genetic resource and soil/water protection. The management should detail the

harvesting method, silvicultural treatment, growth and yield studies annual allowable cut.

4.9. SOCIO-ECONOMIC AND FINANCIAL ASPECT

There should be equitable distribution of forest management incentives, cost and benefit between the forest authority and land owners, rural communities and private entrepreneurs.

4.10. EXTENSION AND DEMONSTRATION

The social and cultural aspirations of indigenous and local population must be respected. The management objectives must take into account the interest of local population and through extension, secure their support and commitment.

Participation of rural communities in mangrove-based small scale industrial activities should be given priority. It is also most desirable to encourage a degree of 'self-management' amongst the various users of the mangrove environment, such as oyster farmers, farmers, fishermen, firewood cutters so that they may be involved in protecting their own resources.

Sensitization and knowledge of mangroves for rural development are lacking. There is therefore need for planners and decision makers to have access to factual information on the role and potential of mangroves through seminars, talks, workshops, film shows and exhibitions on mangrove products targeting various audiences. These should form the basis of the public awareness strategy.

Providing economic alternatives is vital. Over exploitation occurs because of lack of economic alternatives. To win public acceptance and support for forestry programmes, it will be necessary to demonstrate the economic viability,

sustainability and manageability of planting mangroves and sound management practices.

The forestry staff should broaden their knowledge base on mangrove ecology by attending short courses conducted by universities as this will increase their appreciation of the technical basis needed for successful integrated forest management.

4.11. RESEARCH

Improved effective management is based upon research; research on plant succession, structural development, phenology, effects of treatment and other related aspects are essential, as the findings are highly relevant to the formulation of appropriate silvicultural systems and management prescriptions. Research into other areas such as environmental impact and socio-economic studies are all vital.

APPENDIX 1.

A LIST OF SOME MANGROVE BASED PRODUCTS

A. Mangrove Forest Product

Fuel

Firewood
Charcoal

Construction
Timber, scaffolds
Heavy construction
Railway sleepers
Mining props
Boat building
Dock pilings
Beams and poles
Flooring, paneling
Thatch or matting
Fence posts, chipboards

Fishing
Fishing stakes
Fishing boats
Wood for smoking fish
Tanning for net/lines
Fish attracting shelters

Food, drugs & beverages
Sugar
Alcohol
Cooking oil
Vinegar
Tea substitute
Fermented drinks
Dessert topping
Condiments (bark)
Sweetmeats (propagules)
Vegetables (fruit/leaves)

Household items

Glue
Tool handles
Rice mortar
Toys
Match stick
Incense

Agriculture
Fodder

Paper products
Paper - various

Other product
Hairdressing oil
Packing boxes
wood for smoking
sheet rubber
Fuelwood for salt making
Brick kilns
Tobacco drying
Medicine

Textile, leather
Synthetic fibres (rayon)
Dye for cloth
Tannin for leather
Preservation

B. Other Natural Products

Fish/Crustaceans

Honey
Wax
Birds
Mammals
Reptile/other fauna

Source: FAO. 1994.

APPENDIX 2.

VEGETATION CLASSIFICATION

The mangrove forest can be categorized into six vegetation types:

i.	RHF	-	*Rhizophora* High Forest
ii.	AHF	-	*Avicennia* High Forest
iii.	R/AHF	-	*Rhizophora/Avicennia* High Forest
iv.	RHB	-	*Rhizophora* High Bush
v.	R/AHB	-	*Rhizophora/Avicennia* High Bush
vi.	PF	-	Poor Forest (species)

Categorization carried an inevitable element of subjectivity but followed the following guidelines:

i. The crop is classified as being pure if greater than 80% on one species are present.

ii. High Forest refers to an area which contains or has previously supported trees of 20 – 30m tree height.

iii. High Bush refers to an area which contains or has previously supported trees of 10 – 20m tree height.

iv Poor Forest refers to an area supporting a shrub like crop of poor form and minimal productive potential.

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Figure 7. Boiling of the brine solution in big pans.

Photo by M. P. Milkie Key areas of partnership are:

- Law enforcement and regulations
- Management of resources
- Research
- Sensitization and awareness
- Livelihood support Programmes

Bomah et al, 2006 recommends as a general strategy for enhanced collaboration and partnership, the use of indigenous knowledge and incorporating relevant portions of external knowledge in evolving best practice.

The tool that lends itself to such a strategy is participatory processes. Taking advantage of participatory Rural Appraisal, the process follows a logical path that ensures involvement and relationship building of all key stakeholders. This guarantees collective ownership and sustainability of mangrove management in Sierra Leone. The social and cultural aspirations of communities must be respected and their indigenous capacities to manage built upon. The aspect of policing or using some force is not sustainable. Community co-management systems with adequate rewards and payment are the best options.

3.17. CONFLICTS AND CONFLICT RESOLUTION MECHANISMS

The table below gives a broad concept of possible conflicts and their resolution mechanisms. At local level disputes over land issues are settled by the traditional courts.

Sources of conflicts	Resolution strategies
Local community goals may not be compatible with National aspirations	• Encourage active participation of local communities in mangrove areas in decision making • • Ensure the economic spin-offs from mangrove management benefit local communities (employment, services, revenue sharing etc). • Monitor socio-economic parameters to feed into mangrove management planning.