The mangroves of the Eastern African region

Adelaida K. Semesi
Kim Howell

ISBN 92-807-1348-5

Published by
United Nations Environment Programme
P.O. Box 30552, Nairobi, Kenya

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The Eastern African Region

The Eastern African Region considered here, is the marine and coastal areas of the Indian Ocean within the jurisdiction of Comoros, Kenya, Mauritius, Madagascar, Mozambique, Seychelles, Somalia, United Republic of Tanzania and France (Reunion). The Region and its major rivers flowing into the Indian Ocean are shown in the Figure 1.

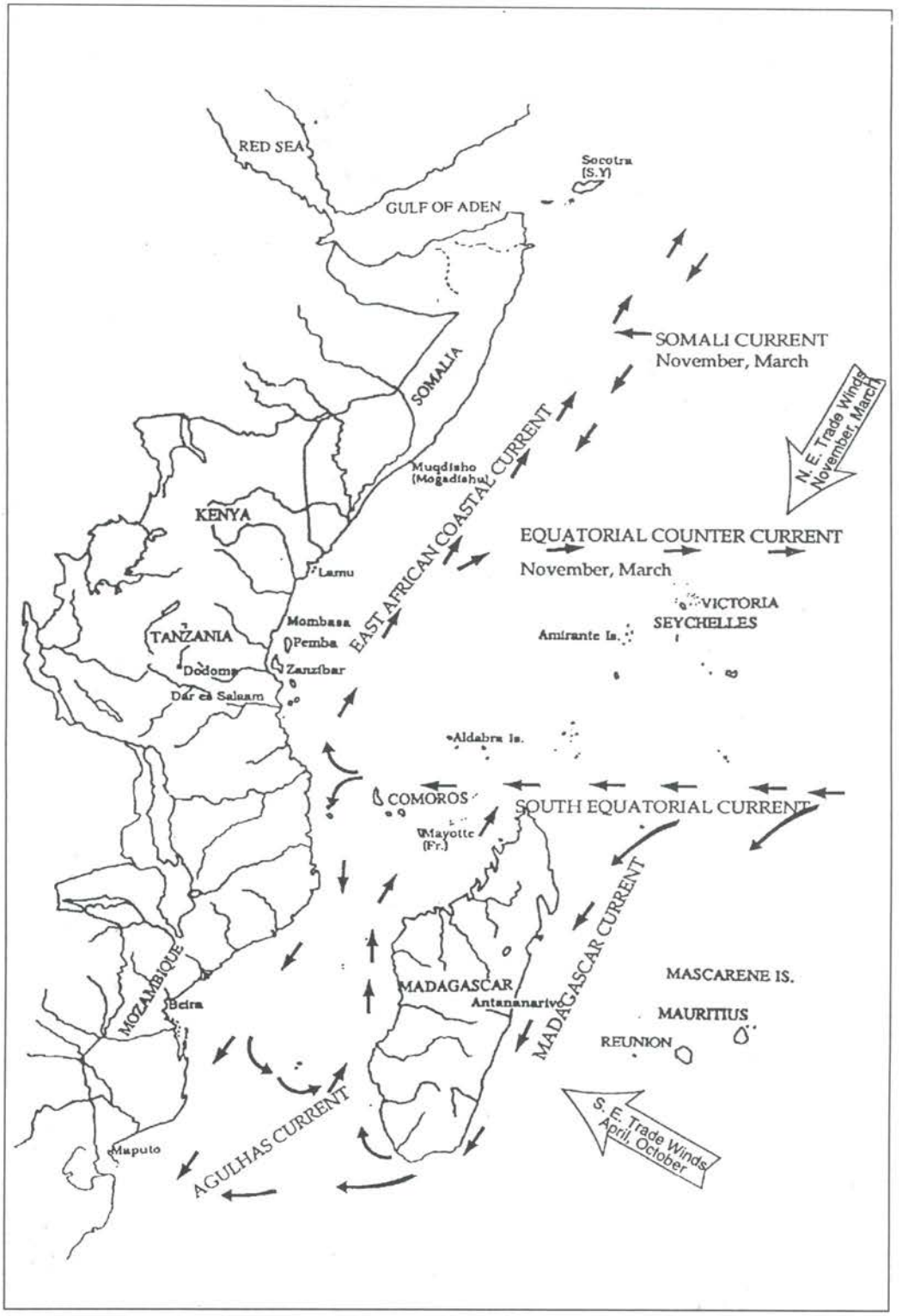
The coastal plains of the Region are generally narrow bands of land varying in width from 15 to 20 km. However, coastal plains are virtually absent on the granitic islands of the Seychelles, the islands of volcanic origin of Comoros and the Mascarene Islands, and almost the entire eastern coast of Madagascar. With few exceptions the coast is not highly indented. This may be due to a general absence of large rivers and to coastal currents which flow parallel to the coast.

Except in some parts of Tanzania, Kenya and southern Somalia, the coastal plain is only marginally suitable for small scale agriculture due to sandy soils, high temperatures and seasonality of rainfall. Its economy is based largely on small-scale agriculture, artisanal fisheries and maritime-related commerce. The coastal zone is also used for a variety of other purposes, including urban development, industries, ports and tourist development.

The population of the Region was about 62.24 million in 1981, with an average annual growth rate of some 3.0%. About 10-15% of the people of most states live in this narrow coastal plain, but in Mozambique and Madagascar, 75% are concentrated along the coast. The small islands in their entirety can be considered as coastal zone, because all man's activities on the islands are likely to affect the coastal marine environment.

Table 1 shows the general features of the Eastern African Region. The continental shelf is very narrow, only some 15 to 25 km in width. However, along the mainland it may extend to 145 km in some places. The shelves and banks are areas of intensive biological activity and high productivity. Thus, the narrower the shelf, the less productive the sea area. Generally, the fisheries of the Western Indian Ocean are relatively poor compared to those elsewhere.

The islands are endowed with a unique scenic beauty as well as marine life and are of diverse ecological characteristics. The Comoros are small, rugged volcanic islands whose deep waters are perhaps most famous as the home of the coelacanth, a "living fossil" fish which appears to be the only living member of its group. Mauritius is also volcanic in origin, and in addition to coastal and marine commerce and natural resources, its economy is based on the large-scale cultivation of sugar-cane. Portions of the Seychelles are granitic in composition and are believed to be a fragment of a previously existing continental mass. The largest of the island states, Madagascar, is famous for its unique terrestrial fauna and flora with numerous endemic species.



The East African region showing ocean currents and winds.

The Region has large variations in climates which range from arid and semi-arid types to humid tropical climates. Rainfall is one of the most variable climatic factors when considered over space and time. Large differences in rainfall between areas in the Region are due in part to varying topographic features as well as differences in wind patterns induced by temperature differences. For example, some coastal areas receive rainfall throughout the year as a result of the land/sea breeze effects whilst other areas receive little or no rain.

Specifically, semi-desert to desert areas occupy much of Somalia, north and north-eastern Kenya, central Tanzania and south-western Madagascar. In the southernmost portion of the Region, Madagascar has a Mediterranean type of climate and southern Mozambique experiences temperatures as low as 2°C during the southern hemisphere winter.

Table 1: General profile of countries in the Eastern African Region (from UNEP 1982)

Countries	Land area (km^2)	Estimated shelf area-depth range 0-200 (km^2)	Length of coastline (km)	Mangrove area (ha)
Comoros	2,236	900	350	v. small (no data)
Kenya	582,650	6,500	500	62,027
Madagascar	595,790	135,000	4,000	320,700
Mauritius	1,865	1,600	200	v. small (no data)
Mozambique	738,030	120,000	2,500	84,800
Seychelles	443	48,000	600	v. small (no data)
Somalia	637,657	32,500	3,000	no data
Tanzania	939,703	30,000	800	133,500

Status of knowledge

Although information on the Region has increased substantially in the last three decades, lack of data and fragmented information are still the main limitations. Comprehensive baseline studies of marine ecosystems upon which to base assessments or evaluate impacts do not yet exist. The paucity of information is further exacerbated by the poor documentation and dissemination of research in the Region. The use of different national languages also hinders communication among researchers and most of the research reports collected by visiting scientists are not available in local libraries or archives.

The Eastern African Action Plan, its goals and objectives

Marine problems neither start nor end at national boundaries. Neighbouring countries which share a common sea often face the same marine problems and it makes sense for them to pool their financial and manpower resources to approach and tackle these on a regional basis.

This is the basis of UNEP's work with the oceans and coastal areas. Setting out to address marine problems in a regional manner, UNEP initiated the Regional Seas Programme in 1974 and has since established programmes in 12 different areas which concentrate particularly on developing parts of the world.

A plan for the Eastern African Region was developed during the early 1980's and in 1985, the Action Plan for the Protection, Management and Development of the Marine and Coastal Environment of the Eastern African Region was adopted by the representatives of Comoros, France, Kenya, Madagascar, Mauritius, Mozambique, Seychelles, Somalia and Tanzania.

Goals and objectives

The general goals and objectives of the Action Plan are:[1]

(a) To promote the sustainable development and sound management of regional marine and coastal resources by:
- enhancing consultations and technical co-operation among the states of the Region;
- emphasizing the economic and social importance of the resources of the marine and coastal environment; and
- establishing a regional network of co-operation on concrete subjects/projects of mutual interest for the whole region;

(b) To establish general policies and objectives and to promote appropriate legislation for the protection and development of the marine and coastal environment on a national and regional level;

(c) To prevent pollution of the marine and coastal environment within the Region originating from activities within the states of the Region or from operations primarily subject of the jurisdiction of extra-regional states;

(d) To provide for the protection and rational development of the living resources of the Region, which are a natural heritage with important

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1. The goals and objectives contain quotes from the Action Plan adopted by the Governments of the Eastern African Region in 1985. For more details about the Action Plan contact: The Oceans and Coastal Areas Programme Activity Centre, UNEP, P.O. Box 30552, Nairobi, Kenya.

economic and social values and potential, through the preservation of habitats, the protection of species, and the careful planning and management of human activities that affect them;

(e) To strengthen and encourage, through increased regional collaboration, the activities of institutions within the Region involved in the study of marine and coastal resources and systems;

(f) To improve training and assistance at all levels and in all fields relating to the protection and development of the marine and coastal environment and;

(g) To stimulate the growth of public awareness, at all levels of society, of the value, interest and vulnerability of the Region's marine and coastal environment.

The activities of the Action Plan are expected to result in:

(a) Assessment and evaluation of the causes, magnitude and consequences of the environmental problems, in particular assessment and control of marine pollution and study of coastal and marine activities and social and economic factors that may influence, or be influenced by environmental degradation;

(b) Promotion of methods and practices for the management of socio-economic development and activities that safeguard environmental quality and utilize resources wisely and on a sustainable basis and;

(c) Establishment of institutional machinery and adoption of financial arrangements required for the successful implementation of the Action Plan.

By working together within the framework of this Plan, it is hoped that the countries of the Region will reach a better understanding of their common problems and make progress in the management of their marine resources.

The ecosystems and habitats of the region

The Region is vast, and includes a variety of habitats, comprising of open ocean and near shore waters, and sandy and rocky islands ranging in size from a few square metres to that of Madagascar. Along the coast are to be found lagoons, sandy and rocky beaches, sand dunes, cays, mud and sand flats, rocky cliffs, seagrass beds, coral reefs, and mangroves.

Aerial view of the coastal strip showing mangroves in sheltered areas, bare saline flats, and sandy beaches

In addition to marine habitats, the Region contains freshwater and terrestrial elements. Rivers and streams discharge freshwater as well as nutrients and sediment into deltas and estuaries, and may also carry pesticides, fertilizers and other pollutants to the coast. Important terrestrial habitats include salt flats, coastal scrubs, thickets and forests.

The marine waters are home to rich fish fauna as well as resident and migratory marine mammals, most notably whales. Seabirds such as gannets and tropic birds fly over the water in search of food; some nest on small uninhabited islands. Sea turtles feed over the coral reefs and on the seagrass beds, but females must come out of the water to lay eggs on the beaches. The rare dugongs are mammals which do not leave the water, but need calm, quiet lagoons in which to give birth and seagrasses on which to feed.

The coral and seagrass habitats support unique associations of fish and invertebrates such as sea urchins, sea cucumbers, and molluscs. The mangroves too have their own unique association of fish and invertebrates such as prawns and crabs, and are also visited by diverse birds and mammals.

The freshwater rivers and streams emptying into the sea contain a mixture of different types of fish which can tolerate variations in salinity.

In coastal thickets, scrubs and forests, a wide variety of wildlife is found, including an array of frogs, lizards, snakes, birds and mammals. Some of these species are unique to coastal forests generally.

Others are endemic to only particular forests, such as the Zanzibar red colobus monkey which is found only on Zanzibar island, and different species of fruit bats or "flying foxes" found in the forests of the Seychelles, Mafia and Pemba islands. At least on parts of the eastern African mainland, it is still possible to see large terrestrial mammals, such as elephants and lions who come to the very edge of the sea, and hippopotamus are common inhabitants of large river deltas and estuaries.

What are mangroves?

Many people living far inland do not know about mangroves because these are salt-tolerant evergreen forests found in the area between dry land and the sea in relatively sheltered areas along estuaries and coastal lagoons with low energy waves. However, the trees are only one part of this complex mangrove ecosystem which includes associated bodies of water and soils as well as a variety of other plants, animals and micro-organisms.

A dense mangrove forest along a channel in the Rufiji delta, Tanzania

Mangroves grow in tropical climates and some even extend into warm temperate regions. The best development of mangrove ecosystems occurs where the upper tidal areas are exposed to a continuous supply of freshwater such as is found in areas with high rainfall, freshwater seepage and river deltas. Conversely, in the subtropical dry zone, such as northern Somalia, thickets of low, scattered mangroves prevail.

An open stand of the mangrove tree *Sonneratia alba* in an area with little regeneration

A mangrove stand degraded by overcutting

Mangrove habitats are diverse and the distribution and ecology of mangroves are determined by many interrelated environmental and biological factors. Environmental factors affecting mangrove distribution include climate, water temperature, sedimentation, tides, relief, shelter from wave attack, salinity and geological history.

Although the hardier species can grow on rocky areas, generally soft, fine-grained soils are necessary for proper mangrove development. Too much sedimentation, however, may bury the aerial roots and thus kill the mangroves. The soil on which mangroves grow is usually firm to soft mud into which one's feet easily sink. Disturbance such as walking in this mud produces a strong smell of rotten eggs. This is due to hydrogen sulfide gas, and indicates the completely anaerobic condition of the water-logged soil. Because it is often difficult or impossible to walk in the mangroves, travel over any lengthy distance is normally by dug-out canoes and boats.

Mangroves grow between mid-tide and high tide levels and species zonation is related to the duration of tidal flooding. The species respond differently to varying salt levels. Excessive salt is toxic to the trees and oxygen is necessary for root respiration. The plants show adaptive characteristics for survival in their difficult environment. Some trees cope with high salinity by excreting excess salts while others exclude the entry of some salt ions. Bare areas of soil found behind or within mangrove forests are those in which the salinity is so high that no plant growth is able to occur.

Mangrove trees have shallow, laterally spreading roots and/or aerial vertically ascending or descending roots, such as in *Rhizophora* and *Avicennia* which allow the plant to cope with anaerobic conditions and to anchor in the usually soft soils. Some mangroves such as *Lumnitzera racemosa* and *Xylocarpus granatum* do not possess above-ground roots but have instead a cable root system which lies near the surface. If the air-breathing parts of mangroves are covered by silt or oil for long periods of time, the trees may die.

The majority of mangrove trees have thick leaves with a heavy waxy cuticle on the epidermis. Some have hairs on the underside and the stomata of the majority are sunken and situated on the underside of the leaves, all of which tends to reduce the loss of water.

An adequate supply of nutrients is necessary to maintain the growth of mangrove ecosystems and these originate from both land and sea. The limiting nutrients, nitrates and phosphates, are derived in greatest quantity from the land and are carried to the mangroves by freshwater streams, rivers and runoff.

Within the mangroves, different species often occupy different areas in relation to the sea. The existence of such zones, often dominated by one tree species, is common. The differences in tolerance and requirements of the several species bring about zonation. Where mangroves occur along river banks, there may be insufficient space for zonation to develop. In some situations the pattern of the vegetation has been changed due to human disturbance. Species which are heavily utilized will be depleted and those with seedlings able to withstand high levels of sunlight or with faster growth rates will out-compete others.

A mangrove stand showing many aerial peg roots

Progagules of the mangrove tree *Bruguiera gymnorrhiza* which fall to the ground and germinate immediately

Propagules from this tree have fallen and established the numerous seedlings below the tree

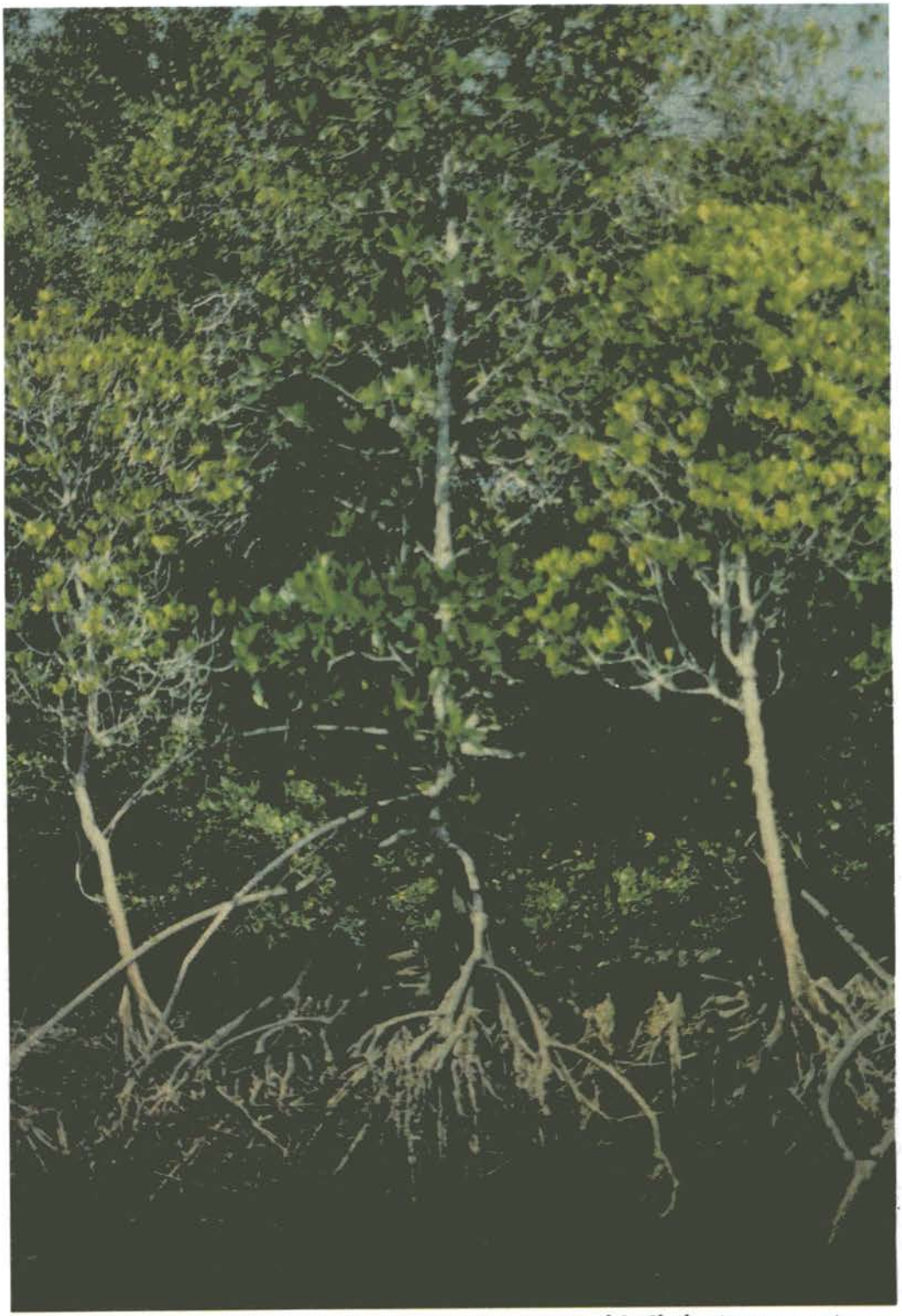
The mangrove trees of the region

In the Eastern Africa Region 10 different mangrove tree species are recorded (Table 2) and these normally occupy specific portions or zones in the forest depending on both the species and the particular ecological conditions present. Such zones may be composed of only a single species, others contain a mix of several species. For example *Sonneratia alba* occurs in areas where tidal water reaches daily, and where the salinity is almost constant and close to that of sea water. *Rhizophora mucronata* forests are dominant on muddy soils and often form extensive pure stands. On sandy soils, however, the species fails to compete with others. *Bruguiera gymnorrhiza* is often found between *Rhizophora mucronata* and *Ceriops tagal* zones, or mixed with them.

Heritiera littoralis, a riverine mangrove species, grows only in habitats with low salinity and is restricted to areas in the vicinity of river mouths.

Avicennia marina can tolerate high ranges of salinity, varied flooding regimes, compacted substrate, sand flats and newly deposited sediments. As a result, it is the most widely distributed species in the region. It is found on the landward margin, on the seaward side and in the mid-portions of the forest.

Stunted *Avicennia* trees at the edge of a forest



Rhiozophora is one of the common mangrove trees with distinct prop roots

Ceriops tagal is one of the mangrove trees which can survive in even marginal habitats near bare saline areas

The shallow, ribbon-like roots of *Xylocarpus* are distinctive

Xylocarpus granatum **showing the characteristic large, round fruits used in traditional medicine**

A regenerating stand of *Sonneratia alba* which is flooded at high tides

Mature *Sonneratia* trees with numerous peg roots which help stabilize sediments but make walking in the forest extremely difficult

Xylocarpus granatum is most often found mixed with *Avicennia marina*, and grows on raised portions where flooding takes place only for a few days a month and where there is fresh water influence. As is the case for *Heritiera littoralis*, *Xylocarpus granatum* is an important element of the riverine mangroves but does not form pure stands.

The mangrove trees vary from a few metres tall to up to 25 m. The height depends on the growth conditions. The tallest trees are to be found in the Rufiji delta, Tanzania.

Why are mangroves important?

The mangrove ecosystem provides socio-economic, ecological, environmental, cultural, scientific and educational value to the people in varying degrees and therefore should be conserved. Direct and indirect products from the mangroves form the basis of mangrove-dependent economic activities vital to the lives of the coastal villagers. The mangrove ecosystem is important because it:

- provides habitats for fish and other animals
- traps, concentrates and recycles nutrients
- protects the coast from erosion
- supports bird life
- supports recreational activities
- is a source of food
- provides fuel
- provides building materials
- provides for scientific research
- supports educational programmes
- is a source of traditional medicines

Thus the mangrove ecosystem is valued for the extractable resources it supports and for the non-consumptive services it provides as well as its ecological values.

Indirect uses of mangroves

Mangrove ecosystems provide a variety of non-consumptive services from recreational and aesthetic benefits derived from their unusual fauna and flora to protection from soil erosion, flood mitigation, filtering of nutrients, and protection of the hinterlands from saline intrusion.

The ecological functions provided by the mangrove resource are felt within and beyond its boundaries but are not always appreciated because a majority of the people are not aware of the ecological role played by the mangroves. It is only the products

Numerous molluscs which are important sources of protein for villagers find a home on mangrove trees

obtained directly from the mangrove systems (Table 2) which are considered when policy and management decisions are made concerning mangroves.

From the ecological standpoint, mangroves are of paramount importance (1) in nearshore nutrient enrichment (2) as breeding, feeding and nursery grounds of economically important finfish, crustaceans and shellfish (3) as breeding, feeding, shelter and roosting sites for a wide variety of wildlife and (4) in shoreline stabilization and protection.

(a) Providing habitats for fish and other animals

Mangroves are spawning and nursery grounds for many economically important species of finfish as well as for prawns. Although the adults may be caught far from the mangroves, the mangrove ecosystem is critically important for larvae and young animals and thus the well-being of the mangroves is important for the continuation of the artisanal and commercial fishing industry. For example, all the main prawn fishing sites in Madagascar, Tanzania and Mozambique are in close proximity to the main mangrove areas.

The trees themselves serve as substrate for many different marine organisms, such as sponges, molluscs and algae. Although not all of the invertebrates dependent on the mangroves are of commercial importance, village women assisted by their children are specialists in harvesting these "non-commercial" species, which are important sources of protein in the diet of local people.

(b) Traping, concentrating and recycling nutrients

The massive root systems of mangroves serve to trap sediments and nutrients so that these are not lost. Mangroves absorb nutrients through their root systems and with their green leaves photosynthesize food. When the leaves drop into the surrounding mud and water, they are broken down by various animals and micro-organisms, and eventually decompose to provide a rich source of food for other animals and plants. Some of these small particles of vegetation called detritus are exported out of the mangrove ecosystem and form the food base of nearshore marine organisms. Mangroves support valuable estuarine and nearshore fisheries for finfish, crustaceans such as prawns and crabs, and molluscs.

Fish traps made from young mangroves are placed adjacent to mangroves in seagrass beds as these areas are rich in fish and prawns

(c) Protecting the coast from erosion

Mangroves perform a flood reduction function and help prevent erosion of the river banks which in turn protect adjacent property. Mangrove swamps maintain deep water channels in tidal creeks draining the swamps. This flood reduction function may be lost if the mangroves are felled and the area converted into other uses.

Mangroves reduce coastal erosion. They serve to dampen the force of storm surges and, to a minor extent, high winds, both associated with tropical storms.

Mangroves build land through the accumulation of silt and detritus, and while the mangrove coastal barrier may be battered and damaged in severe storms, it will grow back naturally without cost to man. In contrast, no man-made coastal protection barrier is capable of self-repair.

(d) Reducing siltation on coral reefs

By trapping sediment washed down from upland waters, mangroves prevent the covering of coral reefs in nearshore waters. If living corals are covered with sediment, they cannot survive and eventually die. The coral reef is then unable to grow and expand, and many other organisms which depend on it will also not survive.

(e) Supporting birds and other wildlife

Mangroves support a variety of birdlife as well as provide food and cover for other vertebrates. While in the Eastern African Region there are no species of vertebrates found exclusively in the mangroves, a species of duck is strongly associated with mangroves on Madagascar, and many species from nearby habitats, utilize the mangroves as a bridge between the land and the coastal waters. In addition to resident species of birds found throughout the year, mangroves serve as "resting and feeding stations" for migratory birds from within and outside Africa. Many of these migrate along the coastline, and seek food and shelter in mangrove trees. Many species of smaller mammals, such as bush pigs, monkeys, baboons, duikers, rodents and fruit bats are found in mangroves.

Migrant crab plovers depend on mangroves

Sandpipers rest and feed in the mangroves

(f) Supporting recreational activities

In Eastern Africa, there has been little development of ecotourism related directly to the mangroves, but elsewhere, boardwalks have been built, and mangrove tours are

Visitors enjoy exploring mangroves and adjacent habitats

popular with many visitors. Few visitors from other countries will have had the opportunity to see mangroves, and to walk and take boat tours through the mangrove forests. Tourist fishing dependent on the mangrove and reef ecosystems is becoming more popular, and the importance of mangroves to the survival of the coral reef ecosystem so attractive to tourists has been mentioned above.

(g) Scientific research

The mangroves are a marvelous natural laboratory in which to make observations and carry out scientific experiments. In addition to the pure research aspects of the mangroves their important economic role demands that major investments be made into studies which will tell us how to best manage this resource.

(h) Educational programmes

Once research projects are established in the mangroves, and in conjunction with boardwalks and boat tourism, educational programmes for school children, university students, and various professionals and civil servants may also be initiated. Very few people other than members of fishing communities have had any experience in the mangroves, and with training, some of these indigenous "local experts" would make ideal guides to assist in explaining the complexities of the ecosystem to students and other visitors.

(i) Biodiversity

Biodiversity refers to the number of species within a particular habitat or ecosystem. Diversity in an ecosystem has been related to its stability; the greater the diversity, the more stable the system. Mangroves support diverse communities of micro and macro terrestrial and aquatic flora and fauna. They are closely linked with other complex, species-rich ecosystems such as seagrass beds and coral reefs. It is important to ensure that this biodiversity is maintained so that the ecosystems themselves remain productive and stable.

(j) As indicator species

A major interest of biologists concerned with pollution studies is finding species of plants and animals which act as indicators of pollution. Mangroves and associated molluscs such as oysters and cockles are known to absorb heavy metals and other pollutants from water and to retain these. They may be suitable as indicator species, and by learning more about how they process pollutants, we may be able to use mangroves as temporary storage sites for heavy metals which otherwise would be released directly into the estuarine environment.

Direct uses of mangroves

Mangroves have been used by man for centuries. Coastal communities use mangroves on a small scale to supply local needs for fuelwood, fences, house construction, boat building, for fish traps and medicine. The direct uses of different mangrove species are summarized in Table 2.

At a commercial level, mangroves are an important item of trade and a source of employment and income for the coastal communities. Mangrove poles are cut for both the export and local market. The earliest historical records available indicate that as early as 200 BC, mangrove poles were an important item of commerce between Eastern Africa, the Gulf states and Asia. No data are available as to when people first began living in association with the mangroves, but it must have been well before this time.

(a) Providing sources of food at a commercial and subsistence level

Mangroves serve as nurseries and hatcheries for fish and prawns, and thus their well-being is important for the continuation of the commercial fishing industry as well as artisanal fishing.

Similarly, women collect a herbaceous fleshy plant, *Sesuvium portulacastrum*, (known as "mboga pwani" in Kiswahili), for use as a green vegetable. This herb grows

Fleshy herbaceous plants found in the mangroves and used as a green vegetable

on sandy portions in the mangroves. Since this species is salt tolerant and is found throughout the year in many mangrove areas, it is an important food source in an environment otherwise hostile to the growth of plants, such as spinach and cabbage.

(b) As a source of fuel

Mangroves are used widely as a source of fuel for different purposes and under different circumstances. On a local subsistence level, mangrove wood may be the only fuelwood available for cooking, especially if other types of wood (such as those found in terrestrial woodland), have already been depleted.

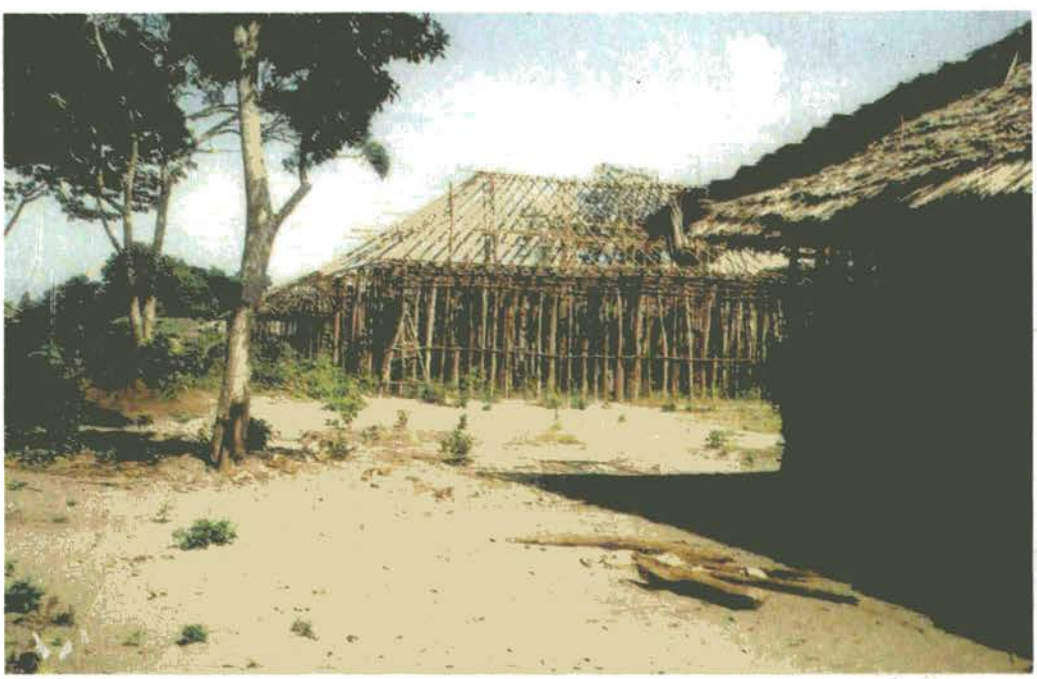
Collecting firewood from a heavily used mangrove area

In places where salt is obtained by boiling of brine, the mangroves come under very heavy use as a source of fuel. Usually the trees are not cut on a sustainable yield basis, and they have little chance for recovery. The smoking of fish and coconut oil products may also lead to the depletion of mangroves if done on a large scale. Producing lime from coral by heating such as is done in Comoros and Tanzania, for example, also may destroy large numbers of mangroves.

(c) Providing building materials

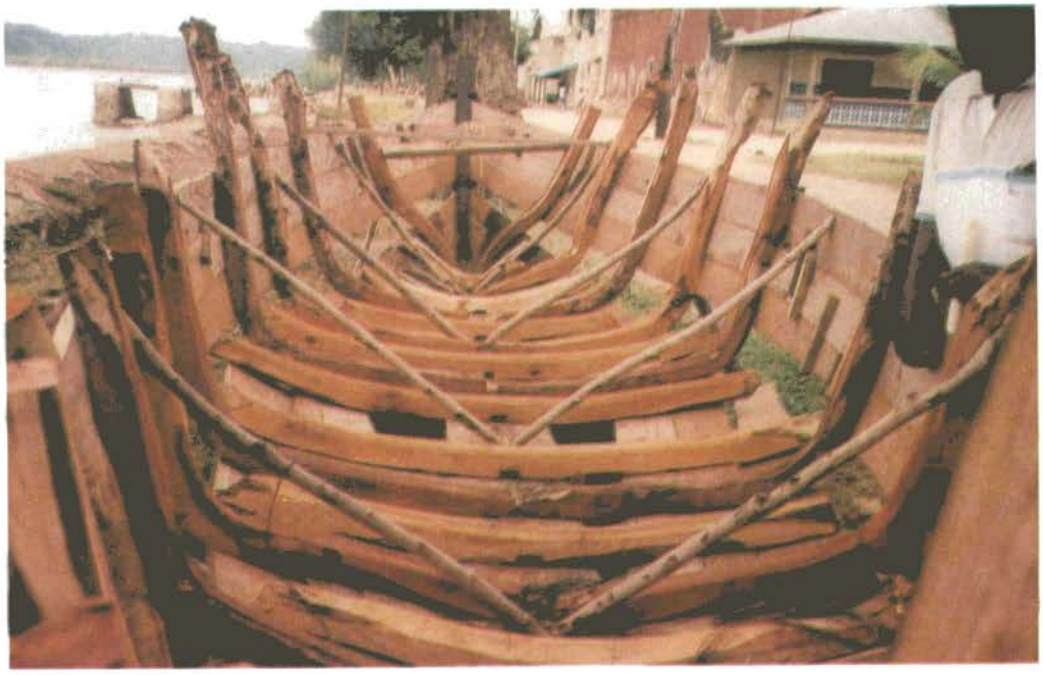
The best-known use of mangroves is for poles used in the construction of traditional houses. Because the poles last for many years, and are relatively resistant to rot and termites, they are preferred over wood from other trees. As the population on the coast

Mangrove timber is used to make window and door frames as well as furniture



The framework of a traditional house made of mangrove poles

Mangrove poles used for building traditional coastal houses



The ribs and keel of this large boat are made from mangrove timber

The trunks of large *Avicennia marina* are used to make dug-out canoes, used for transport and fishing along the coast

increases, and with it, the demand for more housing, a large local commerce in mangrove poles developed in addition to that for the export market.

Because of their resistance to the effects of long immersion in water, mangroves also are traditionally used in the manufacture of dug-out canoes and are used to make the ribs of larger craft such as dhows.

Other uses of mangrove wood include furniture, fence posts, fishing traps and net supports, and the aerial roots may be used as floats for fishing nets.

(d) Used as medicinal plants, cattle fodder, and honey production

There are other uses of mangroves which are not strictly commercial but which are important to local inhabitants.

Some species are used as traditional medicines to cure various complaints (Table 2). The leaves of some species are used as fodder for goats, camels and cows.

Bee-keeping in the mangroves is not as developed as it is elsewhere, for example, in India, and relatively few people in the Eastern African Region hang out hives in the mangrove forests.

In the past, the bark of mangrove trees was important as a source of tannin used in the process of tanning leather, but the introduction of other trees with bark rich in tannin, such as wattle, has largely replaced mangrove bark in the commercial market.

Mangrove wood bed for smoking fish

Table 2: Mangrove tree species in the Eastern African Region and their uses. (Kiswahili names are shown in brackets.)

Species	Uses
Avicennia marina (mchu)	Inferior firewood, but used for boiling of brine, fish smoking and production of lime, building dug-out canoes, dhow ribs, drums, carts, beds, and beehives; leaves used as goat and cattle fodder; branches support beehives, used for medicine (aphrodisiacs, contraceptive)
Avicennia officionalis	Inferior firewood (only reported from Madagascar)
Bruguiera gymnorrhiza (msinzi or mshinzi)	Good firewood; used for fish smoking; fishing stakes; building poles and telephone poles.
Ceriops tagal (mkandaa)	Good firewood; charcoal, poles; fishing stakes; fence posts.
Heritiera littoralis msikundazi or mkungu)	Good firewood; timber for boat-building; furniture; dhow masts, charcoal.
Lumnitzera racemosa (mkandaa dume)	Good firewood, building poles.
Rhizophora mucronata (mkoko or mkaka)	Good firewood; poles; fence posts; fish traps; fishing stakes.
Sonneratia alba (mlilana or mpira)	Inferior firewood; commonly used in boat-building; pneumatophores used as fish net floats, used as medicine, camel fodder, carpentry.
Xylocarpus granatum (mkomafi)	Good firewood; used for fish smoking; boat-building; carts, dhow mast, making furniture. The seeds are used to treat stomach problems and the fruit pulp to cure rashes.
Xylocarpus moluccensis	Good firewood, dhow masts, joinery sandals (mkomafi)

Mangrove wood stacked up ready for burning to make charcoal

Interactions of mangroves with seagrass beds and coral reefs

Mangroves, coral reefs and seagrass beds are among the most productive of coastal habitats, and provide the majority of the fish caught by many local people. There is a close inter-relationship between mangroves, coral reefs and sea-grass beds in terms of fauna, nutrients, and environmental protection.

Coral reefs

Coral reefs grow where the marine waters are clear, warm, and free from suspended sediments, excessive freshwater runoff and pollutants. They grow best in waters between 25°C - 29°C and cannot grow at water temperatures below 16°C.

Coral reefs form a more or less unbroken quasi-barrier reef from central Mozambique to Somalia. In general the coral reefs of Eastern Africa are typically shallow mainland fringing reefs, often enclosing a lagoon or moat. In certain areas there are offshore islands and/or patchy reefs. The island groups of the Region display a wider variety of reef formation with some outstanding example of atoll formations

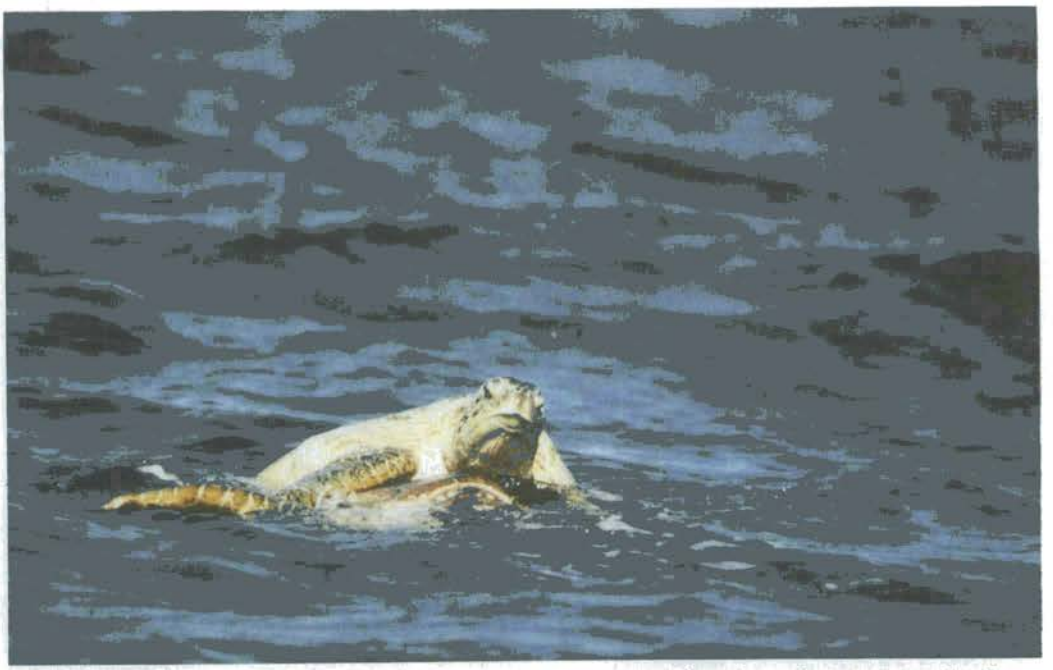
such as Aldabra (Seychelles), or the barrier reefs such as Mayotte (France). Rodriguez and Mauritius have well developed fringing reefs, often located far offshore, while Reunion has fringing reefs only on its south west coast.

This coral reef is protected from siltation by mangroves

The east coast of Madagascar has an extensive fringing reef and coral sand barrier beaches. In Kenya coral reefs fringe the coast 1/2-2 km off shore except where the influence of river mouths is felt. In Tanzania, fringing reefs are also the main type of reef formation.

Coral reefs have a considerable economic value because they support the inshore fisheries and protect the coast from erosion. Moreover tourism related to coral reefs and beaches has become a major source of foreign currency, especially in Kenya, Tanzania, Mozambique, Mauritius and Seychelles. Corals are a big attraction for tourists and collections of species with semi-precious jewel value are made. The marine parks of Kenya are visited by approximately 124,000 tourists per year, generating considerable income for the local communities.

The Eastern African coral reefs are in places overexploited and damaged by overfishing, unsuitable fishing practices such as poisoning, use of stone anchors, trampling of reefs by net fishermen, and explosive fishing using dynamite. The latter is especially destructive, and appears to be increasing in some areas, especially in Tanzania. Local people know the ill effects resulting from explosive fishing but there seems to be little effort to combat this problem.



Sea turtles are endangered species, and depend on coral reefs, seagrass beds, and sandy beaches for their continued survival

An egret finds food on mangrove mud flats

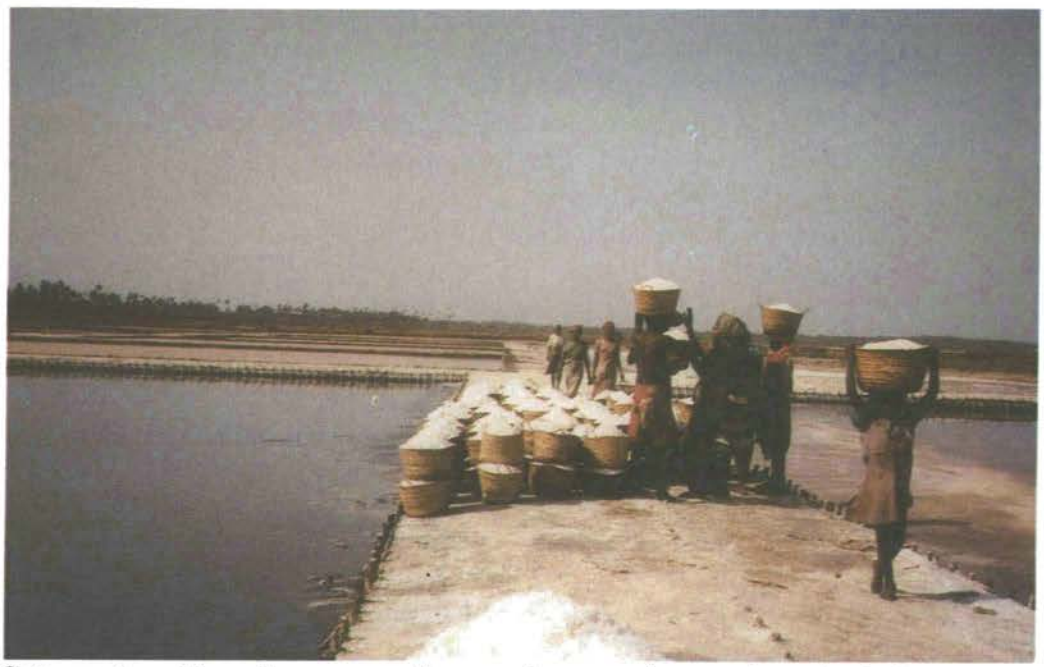
Mining of living corals for lime production and as building construction materials takes place in Mauritius, Comoros and Tanzania. The trade in corals, mollusc shells and decorative fish also damages the coral reef ecosystem.

Some protection of coral reefs is being done through the establishment of marine parks and reserves. Kenya, Seychelles and Mozambique have marine parks and nature reserves. Aldabra atoll in Seychelles is a strict nature reserve and a world heritage site. Other states have begun to recognize the need for increasing the protected status of coral reefs. Although in some cases (e.g. Tanzania) marine reserve legislation has existed for many years but has not been implemented, there is now growing pressure to improve the level of protection of coastal areas in general, and coral reefs in particular.

Seagrass beds

Unlike the coral reefs which have an intrinsic aesthetic value, seagrass beds are not usually regarded as needing protection and may even be considered as a nuisance to swimmers and boat users. The seagrass ecosystem in the region has so far received little attention from biologists, and information concerning seagrasses is extremely limited.

Seagrass beds like mangroves are highly productive ecosystems which provide substantial support grounds for marine fauna and are heavily utilized by artisanal fishermen. They also are sediment traps, preventing organic matter and nutrients from being washed out into the deep ocean by tidal and wave generated currents. Seagrass



Salt produced by solar evaporation; each person is carrying a basket weighting 25 kg

habitats are important feeding grounds for dugongs (*Dugong dugon*) and sea turtles - all species considered threatened or endangered in the Eastern African Region.

Seagrasses are also used directly by the indigenous people. The leaves of the seagrass *Enhalus acoroides* are used for weaving mats and its rhizomes as food in Kenya. Algae associated with seagrasses are locally used as fish bait.

Currently seagrass beds are not under major threat except in areas where high sedimentation or pollution occurs.

The sediment trapped by seagrasses and mangroves ensures the survival of coral reefs which cannot withstand turbid waters and high levels of sediments. The coral reefs in turn reduce the severity of wave action and hence protect the mangroves from being uprooted. The animals of reefs, seagrass beds and mangroves may use one or more of these at one time or stage of their lives, either for resting, feeding or reproduction. The detritus produced by mangroves and seagrasses supports a wide variety of animals.

History of mangroves in the Eastern African Region

Although the Gulf states are now famous for wealth derived from petroleum, it should be recalled that many of the cities there were built on a framework of mangroves from the Eastern African Region! Such places as Oman, Siraf, Basra and other localities of relatively treeless south-eastern Arabia and the Persian Gulf needed a source of building poles, and this was found in the mangrove forests of Eastern Africa. The history of commercial exploitation of mangroves is intertwined with that of the development of the Indian Ocean trading network in the 9th century AD, with its focus towards the Persian Gulf and Baghdad. Luxury items from Africa such as gold, ivory, ambergris, and leopard skins made their way to markets in China and the Far East.

During the colonial period at the turn of the century, mangrove poles were the major forest products exported from the Region. Recognizing the importance of the mangrove resource, the German administration in Eastern Africa attempted to control the cutting of mangroves. The very first forest management plan by the Germans for Tanzania, for example, involved limiting the cutting of mangroves for poles and firewood. In order to improve the quality and quantity of the mangrove forests, the replanting of cleared areas and the replacement of lower quality trees with those of a higher commercial value began. Successive governments in the region, both Colonial and post-independence, have also been concerned with the management of the mangrove resource.

This large area of mangroves has been cleared for the construction of solar salt pans

One activity which threatens mangroves is salt making by boiling; note the huge pile of firewood used in this process

However, as other forest products, especially tropical hardwood timbers, came to dominate markets, less attention was paid to the mangroves and their management. Thus, the quality and quantity of this valuable resource has deteriorated in all countries in the Region.

Despite a long history encompassing hundreds of years of utilization and commerce, relatively little is known about the biology and populations of mangroves in the Region. It is only now that governments are beginning to realize the importance of maintaining and even increasing the amount of land under mangrove forest cover.

Status of mangroves and their utilization in the region

Mangroves are found in all the states in the Region, Kenya, Tanzania, Madagascar and Mozambique having the largest areas. Mangroves on Madagascar have been estimated to cover some 3,200 km^2; on Mozambique, 850 km^2; on Kenya, 587 km^2. Somalia has a few mangroves in the south. Extensive mangroves near river mouths are present on the Tanzania mainland approximately 115,475 ha in 1989 and the mangroves of Zanzibar in 1959 covered approximately 18,000 ha. Except for Tanzania, which had its mangroves inventoried in 1989, the figures for the other mangrove areas are based on older data.

Having exhausted the mangrove trees, the salt boilers now depend on fuel from terrestrial woodlands. About 7 tonnes of wood are needed to produce a single tonne of salt.

In the past, large mangrove stands existed on the island states, but these have been destroyed for fuel and land reclamation for industrial purposes and human occupation. Now only smaller patches of mangroves are found in the sheltered embayments.

Mangrove habitats in the Region are diverse and are best developed in riverine estuaries where there is sufficient rainfall, such as the Rufiji delta,with 53,250 ha of forest. In other situations growth may be limited by availability of fresh water, such as in northern Somalia, or low temperature and exposed coasts.

In some situations the composition of the mangrove vegetation has been changed due to human disturbance. Heavily utilized species are depleted and those whose seedlings can withstand high light levels or have higher growth rates can then outcompete the others. The mangroves in the Region are extensively cut for poles, firewood and charcoal and therefore have become mainly secondary forests. Like the terrestrial tropical forests, mangroves are being degraded and destroyed through over-exploitation of their renewable products and through conversion to single use options such as rice farms and salt evaporation ponds.

In the Eastern African Region, ecological changes, uncontrolled exploitation by man, uncoordinated and insufficient institutional measures, inadequate policies and an often unclear status of the mangrove resources have all contributed to the present situation in which the survival of the mangrove ecosystem is in danger.

Environmental impacts of socio-economic activities on the mangroves

In the past when human populations were relatively low, activities such as cutting mangrove trees for building poles and firewood were on a sustainable basis with no formal system of control but this is now no longer the case. The increase in the population along the coast, the rapid growth of villages and towns generally, and influx of people from inland to the coast due to adverse conditions (e.g. war and drought) such as in Mozambique, increase the threat to mangroves through over-utilization.

Among the most destructive activities affecting mangrove ecosystems are clear felling of mangroves, for rice cultivation, construction of solar salt pans, aquaculture ponds, charcoal production, or simply for large scale removal of firewood. In contrast, the selective cutting of poles for export and for local house construction is not a major threat if adequately controlled.

Although both domestic and commercial uses of mangrove products have increased dramatically, there is very little control over these destructive practices in countries of the Region other than Kenya.

This mangrove stand has been killed by industrial waste from a factory

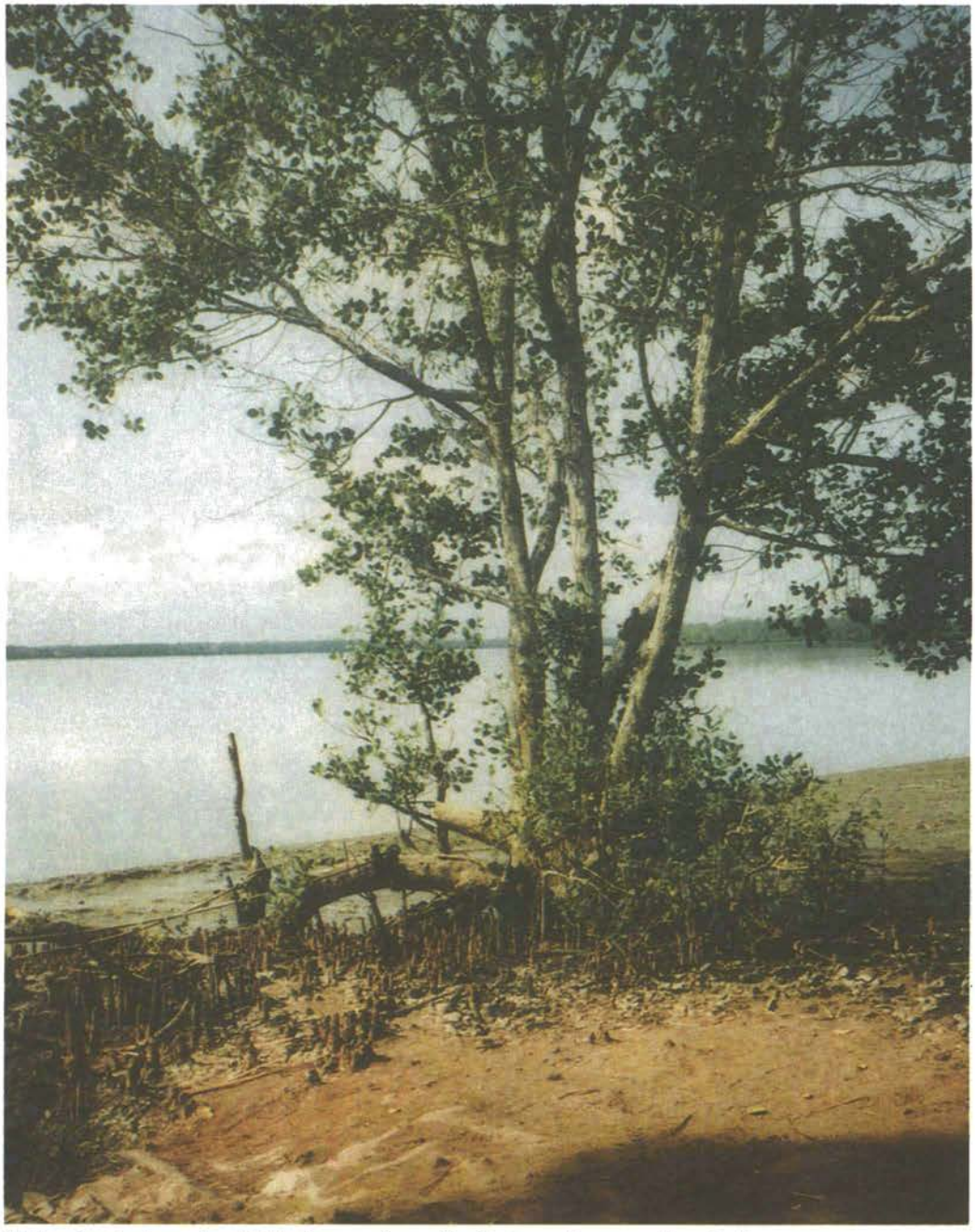
Commercial activities are especially harmful because they are usually done with little or no planning or control by government management bodies, and in many cases, the activities are illegal. Alternatively, permits may have been obtained for cutting and development projects, but there is little coordination between the branches of government which issue the permits. It might be possible for one government office to issue a license to construct a salt pan in the mangroves without even consulting the forest or fisheries department as to the impact of such a project on other resources.

Petroleum prospecting, oil pollution from ships, the dumping of garbage and sewage as well as various types of industrial chemical pollution in the estuarine environment also may have direct negative effects on mangroves.

Other reasons why mangroves are lost

Aside from man's activities in the mangroves which have been shown to directly damage or destroy mangroves, natural phenomena may threaten the survival of mangroves. These include large storms, hurricanes, tidal waves, volcanic activity, pests and diseases, sediment movement and river floods. Storms and hurricanes are especially damaging to mangroves on Mauritius and Madagascar.

The ecological stability of the mangrove ecosystem is dependent on that of both upland terrestrial and the coastal estuarine ecosystems with which it is intimately and inseparably linked.



This single tree is all that remains of a former larger stand of mangroves which was destroyed to make boat landing site

Severe erosion, improper agricultural and forestry practices and pollution from pesticides and herbicides hundreds of kilometres upstream in catchment areas can all affect mangroves and other elements of the coastal ecosystem, such as coral reefs.

Consequences of mangrove destruction

The consequences of mangrove destruction are:

(a) decreased production of firewood poles and timber which leads to less revenue paid to government from royalties;
(b) decrease of fauna and flora associated with and/or dependent upon mangroves with an observed decrease in fish and prawn catches;
(c) increased coastal erosion which may have very negative effects on buildings such as dwellings in villages as well as hotels; and
(d) increase of siltation of coral reefs, with resultant reduction in productivity of fish, and reduced tourism.

All these will affect local people because their income will be reduced. Their economic security and "pension" in the form of wood products as well as other values of mangroves will be lost or greatly reduced.

Women are the most affected when the nearby mangrove resource no longer suffices for the needs of the community. It is they who must cover longer distances in search of firewood and who must spend more time searching for molluscs, crabs and mangrove plants upon which they and their families depend. Less labour and monetary assistance will be available to them from husbands and sons, who themselves will tend to travel further from home in search of fish, building poles, other employment opportunities.

An area of mangrove forest destroyed by overutilization for firewood

Can mangroves areas be revegetated?

Mangroves can be revegetated in suitable areas and this can be done by natural regrowth or transplanting seedlings or nursery grown plants. Mangrove species fruit, and seed abundantly and germinate readily. The majority of species have seeds which start germinating while still attached to the plant and when the seedlings come into contact with soil they grow quickly. All mangrove seeds/seedlings are dispersed by water and have some initial ability to float.

Compared with terrestrial forests, the regeneration of mangroves after selective cutting is a relatively reliable process requiring little or no soil preparation. The planting of mangroves in clearfelled or bare areas, assuming suitable ecological conditions, can be carried out very easily, simply by pushing the propagules or seedlings into the soft mud. Seedlings do not require watering.

The planting operation is simple and can be carried out by untrained labourers with brief instructions. In most cases propagules are available in adequate supply from trees in the area. In some mangrove areas natural regeneration may be deficient due to various causes:

(1) Clear-felling of large areas leads to poor regeneration, possibly due to alteration of soil and microclimate and also due to few seed bearing trees being left to act as seed sources. In other cases weeds may overgrow the area and prevent seedlings establishment.

(2) If the amount of wood left behind after felling an area is too great, it can interfere with the dispersal of seeds; natural regeneration can take place effectively only after most of the stilt roots of the felled trees have decayed.

(3) Animals such as hippos, monkeys and crabs feed on seedlings and if present in large numbers may completely prevent natural regeneration.

(4) Soil conditions also affect regeneration of the exploited mangrove forests; mounds, for example, wherever they exist, are almost immediately invaded by the fern *Acrostichum aureum* which becomes particularly abundant in the exploited areas. This is because soil in the mounds is thick, sticky clay and is nonporous and poorly aerated; regeneration of *Rhizophora* spp. and *Bruguiera* spp. on this type of soil was found to be very scarce except on the soft mud near river and stream banks. The seedlings cannot anchor easily in such soils, and even if they do, most of them fail to develop.

(5) Poor drainage due to deep flooding or poor tidal flushing also prevents mangrove regeneration.

Good natural generation of *Avicennia marina*

Mangroves were cleared for rice cultivation and when the farmers abandoned the site, it was no longer suitable for mangrove tree regeneration

(6) If the site is overwashed by strong tides, seedling establishment is poor. This is a common occurrence in the *Sonneratia* zone on islands.

(7) Insect attacks from borers and caterpillars are known to interfere with regeneration.

Thus, success in transplanting mangroves depends upon the site, species, season, soil and tidal flow.

In Tanzania, mangrove planting was carried out in the Rufiji delta. Enrichment planting in the overcut areas was successful as long as the species was planted in the correct habitat.

Currently, regeneration of heavily cut areas is practised in Pangani District, Tanzania. The growth rate of *Rhizophora mucronata* is about 1 m a year, while for *Bruguiera gymnorrhiza* and *Ceriops tagal* it is about 0.5 m per year.

Existing legislation and administrative practices regulating the protection and utilization of mangrove forests

Legislation relating to mangroves is generally included with that for terrestrial forestry in Kenya, Tanzania, and Mozambique. The emphasis of forest policy has tended to focus mainly on the trees rather than the entire mangrove ecosystem, and has stressed the utilization of wood products, specifically timber and poles, rather than other values of mangrove habitats such as fisheries. In Tanzania, with its long history of mangrove pole use and export, all mangroves were gazetted as Forest Reserves in 1928-1930. In contrast, on Madagascar, mangrove forests are not exploited for timber or poles on a commercial scale and there is no management or control of encroachment by agriculture.

The complexity of the mangrove ecosystem makes attempts to manage it sustainably extremely challenging. It is relatively simple to appreciate the wood product values of the mangroves. But it is much more difficult to include in national legislation and to administer controls on the use of the related mineral, fishing, and other uses. Equally difficult are attempts to control pollution in the coastal ecosystem. Quite apart from the most obvious sources of pollutants and waste from the coastal strip itself, pollutants from hundreds of kilometres away on upstream watersheds can have drastic effects on mangroves and related ecosystems such as coral reefs. It is difficult to explain, and certainly to demonstrate in a court of law that improper agricultural and forestry practices hundreds of kilometres upstream in freshwater can seriously affect the livelihood of coastal people and the resources on which they depend.

Villagers and entrepreneurs are unlikely to agree on uses of the mangroves, as "development" often precludes the use by local people, and may very well destroy other values of the mangroves.

Generally, no overall national authority exists in countries in the Eastern African Region which can effectively resolve conflicting issues related to conservation and development of the mangroves. At present, conflicts arise between those branches of government responsible for forests, fisheries, wildlife, agriculture, ports, surveying of land and issuing of titles, and mineral mining.

In Tanzania for example, traditional government schemes aimed at management solely for wood products. However, conflicts arose between the government forestry department which had simply banned the cutting of all mangroves, and villagers, who needed mangrove products for their local, non-commercial uses, and who deeply resented the "no cutting" directive. Villagers also found it difficult to accept the ban on cutting when they observed large areas of mangroves felled by commercial operators who were granted a licence from the same authority which refused them permission to cut even a single tree! Under such circumstances, it was not surprising that local residents were not cooperative in assisting government efforts to prevent illegal commercial cutting of the mangroves.

After extensive research and planning, Tanzania developed in 1991 a National Mangrove Management Plan which takes into account the needs of local people to continue to harvest mangrove trees and forest products on a local, sustainable basis. The villagers are required to participate fully in managing huge areas of mangroves and obtain direct benefit from the careful management and controlled harvesting of products such as mangrove poles. The many indirect benefits derived from the mangroves are also preserved. This plan emphasizes the need to have close coordination among the various users of the mangrove ecosystem, and although the primary management authority still rests with the director of forestry, government officers directly involved with management will include those also trained in broad aspects of mangrove management and fisheries as well as forestry.

Environmental and management considerations

Many of the major rivers of the region have been dammed for hydro-electric power projects, and more such dams are planned. These affect the flow of freshwater into the estuaries and deltas associated with them, including the suspended organic matter so vital to prawn productivity. The reduced flow of freshwater caused by large dams may considerably alter water conditions. For example, salt water ascends some 80 km up the Zambezi River after the construction of the Cabora Bassa dam.

In much of the Region, local people do not have access to the technology and capital necessary to allow them to spend long hours on waters far from shore fishing. Larger trawlers and other motorized vessels are owned and controlled by foreign investors. Instead, such traditional fishermen and women concentrate their efforts on the habitats closer to shore, where they use a number of traditional and modern methods to harvest fish, shellfish, other invertebrates, and plant products.

Tourism is at present almost non-existent in mangrove areas, but is of potentially great importance. There are possibilities of educational and wildlife tours through the mangroves, either by boat or on boardwalks. These could be combined with a beach holiday involving snorkeling on coral reefs, game viewing in the hinterland, and sport fishing.

As the human population increases and places more and more pressure on the relatively limited area available for exploitation of coastal natural resources, it is evident that if even present levels of harvesting are to continue, greater knowledge of the resources as well as careful control and management are needed.