

MARINE RESOURCES

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ABSTRACT

Coral reefs, lagoons, estuaries and beaches form the natural environment of the coastline with rich botanical resources and marine life. Mangroves, seaweeds, sea-grasses are primary food producers for the coastal ecosystems and offer shelter to many forms of marine life. Mangroves have always had manifold uses for the local communities. The coastal waters of this part of the East African Coast are relatively poor in fisheries because of the narrow width of the continental shelf. Nearly all fish landings come from artisanal fishermen with about 10,000 tons/year. Artisanal fishing, including crustacean catch, is considered above or at sustainable levels. Off-shore and demersal fish catches have not reached such levels, yet. Other marine resources include minerals and tourism. Nearly all parts of the coastal ecosystem face serious threats. Coral reefs suffer from sedimentation and pollution which hampers the growth of the micro-organisms, but also suffers from over-fishing and rapacious collection in many parts. Mangrove forests experience massive felling. Sand and salt-mining are other threatening activities. The marine protected areas along the coast are of vital importance to preserve the maritime heritage in conjunction with much needed integrated coastal management.

INTRODUCTION

Marine resources in any given tropical coast are many and varied. The diverse marine life is primarily due to the presence of the variety of marine habitats which include the sea shore, lagoons and estuaries, mangrove swamps, seaweed beds, coral reefs, open waters and the sea bottom. These resources have become important especially today when pressure on the existing land resources is growing; hence the special attention to sea harvesting to supplement the depleting land resources (UNEP 1984). Man has reached an advanced technological stage which has enabled him to exploit those resources that were hitherto inaccessible. The oceans are the source of hundreds of products derived from living and non-living resources. These resources are from the coastal continental shelf as well as the deep sea.

The coast of Kenya includes a diverse environment which consists of estuaries, sandy shorelines, creeks, caves, mangrove swamps, sand dunes and coral reef areas. The marine resources along the Kenya coast therefore include mangroves, coral reefs, seaweed beds, seagrass beds, marine fish and crustaceans, and minerals (and in a sense the natural harbours along the coast as well). The resources and their environment form the basis of the life of many of the coastal inhabitants (Ruwa 1984).

Most of the Kenyan coast to the north of Lamu is little indented. This may be partially ascribed to the absence of rivers and the sea currents which flow parallel to the coast (Koyo 1994). The situation of the rest of the northern coast is the same with large stretches of unindented coastline south of Lamu. The coast is influenced by the Tana and Sabaki rivers which drain into the sea (Figure 1). The Tana River forms oxbow lakes such as Lakes Pongi, Bilisa, Giritu, Shakabo, Moa and Harakisha. There is abundant bird life and a variety of fish species. During the dry season these lakes are utilised as grazing areas for livestock by the Orma but when rains come small-scale fishing activities are carried out by the Pokomo people. The Sabaki River forms an important flood plain along the coast at its lower course near Malindi (Mavuti 1981). In the last 80 km, the river falls 100 m and forms a broad flood plain in which permanent and temporary lakes are common (Whitehead 1960). There is subsistence fishing on the lower reaches by the Orma and Giriama people. The most common fish species are the lungfish and the catfish, while cichlids and freshwater prawns also make a valuable contribution to the fishery on which the local people depend. To the south is the Ramisi River which drains into the sea, south of Msambweni. In general, the continental shelf is narrow, averaging 15 km. The sea bed drops rather sharply after the continental shelf plunging to depths of 200 meters.

BOTANICAL RESOURCES

Botanical resources form the colourful canopy of the coastal waters. They include the mangroves which are confined to the creeks and estuaries and algae and seaweeds which are very conspicuous in the intertidal zones, especially on a spring low tide.

Mangroves

Along the Kenya coast, mangroves cover an area of 530 km² at Lamu, Ngomeni, Mida, Mombasa, Gazi and Vanga. Mangrove ecosystems are open, flow-through systems; they receive nitrogen compounds from outside through river input, rain drainage and seepage and also through domestic sewage disposals. Through endogenic processes such as primary production, grazing and decomposition of organic matter, nutrients are released into the surrounding water (KMFRI 1987). Ecologically, mangroves are important since they are breeding grounds for many marine organisms such as fish and prawns. Leaf litter from mangroves are a source of food to the invertebrates which are the food for fish. Mangroves are also of importance as sediment stabilisers, hence they play a crucial role in controlling beach erosion. They efficiently trap runoff sediments, thus preventing siltation of adjacent seagrass beds and coral reefs, and possibly promoting land accretion.

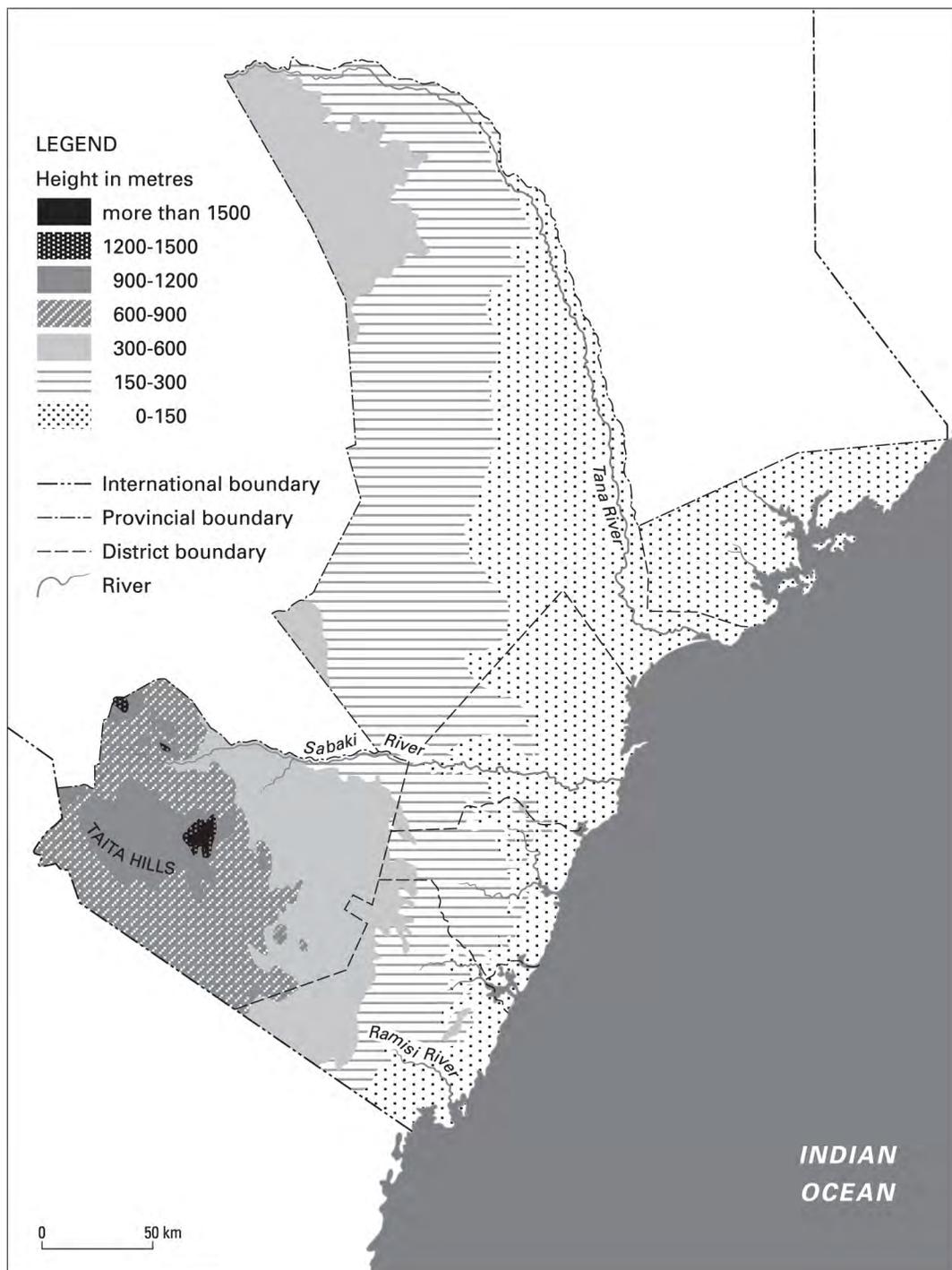


Figure 1 Physical characteristics
 (Source: Survey of Kenya: Route Map 1978)

The tangles of their roots break away wave action, thus preventing erosion of the shoreline. Mangroves act as a buffer for water pollution by trapping pollutants from runoff water. There is high species diversity in mangrove swamps which results into increased biodiversity due to complex habitat characteristics resulting from mangrove trees. They are often described as an environmental pillar and economic treasure of the coast (Ondieki 1994). The mangrove ecosystem hosts animals from marine and fresh waters around. The most common animals are molluscs, crabs, oysters, the mudskipper and many terrestrial animals such as spiders (Aloo 1990).

Mangrove trees have manifold uses for the local communities. Their poles are used for posts, fencing and furniture material. Due to its strength and durability, the main use of mangrove timber is in house construction for the coastal people. A recent and extensive use of mangrove poles has been in the construction of tourist hotels and restaurants (Martens 1992). Mangrove poles from one particular species (*Bruguiera gymnorhiza*) were exported by *dhow* from Lamu to Saudi Arabia and other Middle East countries. Another species (*Avicenia marina*) produces high quality charcoal which is a source of income to the local people. This, together with their use as firewood, is the main cause of mangrove depletion near villages for domestic use. The Kenya Calcium Products Factory in Kwale District uses mangroves as firewood for the production of lime; taken from the mangrove forests of Gazi and Funzi Bay. Trunks from *Sonneratia alba* are used for boat construction and the large pneumatophores are used as floats for fishing nets. The bark of three mangrove species are used for tannin production. Tannin extracted from mangrove trees used for treating leather has formed a good trade for the Kenyan economy. Finally, medicinal properties of mangroves have been cited. Among the Mijikenda, various species of mangroves are used for medicinal purposes, e.g. the sap of young *Avicenia* shoots are used to cure gangrene, *Lumnitzera* leaves are said to treat mouth infections while infusions from the wood of *Rhizophora* are used to treat diarrhoea (Kokwaro 1985).

The enormous amount of litter entering the detrital food web supports high biomasses of commercially valuable species. Fishing provides a protein source for the local community (Hood 1991) while shrimps, crabs and oysters are collected and sold to hotels and restaurants. Oysters, prawns and crabs whose culture is associated with mangrove trees are also exported to oriental countries. Ngomeni prawn culture at Malindi depends on the mangrove environment for the supply of young prawns to stock ponds. The experimental oyster culture at Gazi was established based on nutrient transfer from mangrove swamps to the surrounding environments. However, the decline in specimen size and total weight of catches indicates over-exploitation (UNEP 1985).

Mangroves in Kenya are managed by the Forest Department as forest reserves. However, no management practice or silviculture programme is carried out (van Speybroeck 1990). The existing mangrove resource is under pressure not only from unregulated felling but also from upstream effects of mismanaged watersheds and pollution. Significant felling of trees, with or without licences, has resulted in depletion of the mangrove forests in easily accessible areas such as Kwale, Mombasa and Kilifi Districts.

At Ngomeni (north coast) vast areas of mangrove swamps have been converted into ponds for shrimp farming and solar salt production (Rasowo 1990; personal observation).

Mangroves have been cleared near villages for agricultural purposes. In urban and industrial areas, mangroves are used as dumping sites of domestic and industrial solid wastes. For example, the municipal, domestic and industrial wastes of Mombasa are dumped near Makupa and Tudor Creeks and toxic chemicals seep into the creeks. An oil spill in Makupa Creek behind the port area killed all mangroves and associated mangal (Hood 1991).

Major problems in mangrove management in Kenya include lack of scientific management plans, inadequacy in management of resources and insufficient knowledge of mangrove silviculture. Little effort has been devoted to either enriching the mangrove composition or re-planting the clear cut areas. The Kenya Marine and Fisheries Research Institute initiated the Mangrove Reforestation project in October 1991 (KMFRI 1991) in an attempt to involve the community in the rehabilitation of degraded mangrove areas of Kenya and to monitor the mitigation path of forested areas. By July 1994, a total of 150,000 new mangrove trees had been planted.

Seaweeds and seagrasses

Seaweeds (marine algae) differ from other plants in that they do not possess true roots, stems and leaves. The three main groups of seaweeds which are of commercial importance are green algae (Chlorophyta), red algae (Rhodophyta) and brown algae (Phaeophyta). Kenya has about 367 species of seaweeds occurring in varying degrees of abundance in shallow bays, lagoons and coastal areas which offer suitable substrate for their growth.

Some of the oldest products from the sea were derived from seaweeds. Weeds were used by ancient men for food, fodder, medicine, fertiliser and even as mattresses. Seaweeds are of direct importance to man as a dietary supplement, food additive, source of industrial feedstock and as a base for the synthesis of a wide range of chemical products (e.g. shoe stains, shaving creams and cosmetics). Indirectly they are contributors to natural food chains and habitats, supporting commercially important marine fish and shell fish.

Along the Kenyan coast, seaweeds can be cultivated for commercial purposes (Wamukoya). Some of the suitable farming areas include the shallow bays of Gazi, Mida and Mtwapa. They are currently the basis of an industry that uses their chemical extractives, such as agar from red algae for exportation mainly to the oriental countries. The weeds themselves are exported to these countries where they are an important foodstuff. Besides exportation, seaweeds are used as a source of algin acid, seaweed meals which are famous with visitors from the orient. According to Ruwa (1984), the demand for seaweeds along the coast has continued to exceed the supply, hence there is search along the coast for suitable seaweed cultivation areas. Studies have revealed that the Kenyan coast has a great potential of seaweed production.¹

¹ Exploitable seaweeds, types and products are: Green algae (Chlorophyta); types: *Enteromorpha*, *Ulva*, *Caulerpa*, *Codium*; use: food, fodder, manure. Brown algae (Phaeophyta); types *Sargassum* and *Turbinaria*; use: algin. Red algae (Rhodophyta); types: *Gracilaria*, *Hypnea* and *Eucheuma*; use: agar (Wakibiya & Oyieke 1992).

Cultivation of seagrass (marine angiosperms) is a modern type of farming along the Kenyan coast with *Cymodocea ciliata* being the dominant species. It is a naturally rich pasture. The grass is abundantly found along most parts of the coast and it is not grazed by most species of fish. Another botanical resource is the marine angiosperm *Enhalus acoroides* which occur mostly around Lamu. It has long tough leaves which are used for weaving mats for sale and its rhizome is eaten in the Lamu area (Ruwa 1984).

Seagrass meadows are highly productive, rich in fauna and ecologically important habitats and protection for large populations of invertebrates and fishes (Zieman 1982). Many marine species within the mangroves and coral reefs use seagrass beds as their nursery, breeding and feeding grounds. The rhizome-root system also helps to trap sediments and stabilise the near-shore bottom, providing a suitable habitat for numerous benthic macroalgae while seagrass leaves are important substrata for epiphytic algae. Seagrasses are also grazed upon by turtles and crabs.

Overall, the ecological importance of marine botanical resources are fourfold. First, they are the primary producers for food which is the key maintenance of the ecosystem. Secondly, they offer shelter to many animals such as echinoderms, crustaceans, molluscs, epiphytes and the many species of fish fingerlings; hence preserving the much valued biodiversity. Thirdly, they are sediment binders and builders, for example the sand-binder *Rhizoclonium* sp. on the roots of various angiosperms. Mangrove roots help the accumulation of sediments which accommodate various nutrients to the surrounding environment. Finally, marine aquacultures like oyster farming and prawn culture are highly correlated to the mangrove swamps which also offer shelter to myriads of organisms which breed in the swamp.

MARINE LIFE AND FISHERIES

Although the Kenyan coastal waters are not particularly rich in fishery resources, there is potential for increasing fish production. The major causes of the limited resources is the narrow width of the continental shelf, which does not exceed 50 miles at the widest part (Odero 1984). One area that could prove significant in improving the fisheries resources would be the use of the so called 'bye-catch' or 'trash fish'. Most of it is usually thrown back into the ocean but with proper management this could be used for the processing of fish meal and included into livestock feeds.

Artisanal fishery

Artisanal fishermen land about 10,000 tons of marine fish per year (McClanahan 1996). Earlier estimates mentioned 12,000 fishermen operating about 1,800 small boats (Odero 1984) with gillnets, hooks and lines, shark nets, beach seines and traps within the in-shore areas. More recent estimates arrive at 2,500 boats (Wamukoya *et al.* 1996) with probably 8-10,000 fishermen. The major fishing districts are (i) Lamu District, which includes the North Kenya Banks and the Lamu Islands from the Somali border to north of Ungwana Bay; (ii) Malindi, including Ungwana Bay, the Mambri-Sabaki estuary and the Malindi Banks from Ngomeni to Kanamai; (iii) Mombasa, including the coastline from Bamburi

to Likoni and the waters of Tudor and Kilindini creeks; and (iv) Kwale, which includes grounds from Tiwi to Vanga on the southernmost point. In the creeks, the artisanal fishermen use local boats of sizes not more than 10 m long (i.e. dug-out canoes, sail *dhow*s and engine *dhow*s). Fishing gears used include hand lines, traps, lobster pots, gillnets, castnets and beach seines (Table 1).² They use most of their catch as a source of food, fish being a rich source of protein. Besides this, artisanal fishing also offers ready employment to the local population (Oteko 1987).

Table 1 Number of boats by district and gear type, 1984

	Lamu	Malindi	Mombasa	Kwale	Total
Castnets	51	34	94	49	228
Gillnets	164	120	42	78	404
Beach seines	33	16	5	20	74
Hand lines	111	127	121	155	514
Traps	37	58	139	235	469
Lobster pots	112	6	0	21	139
Total	508	361	401	558	1,828

Source: Odero 1984

Fish species composition in landings by artisanal fishermen also vary greatly by gear. In the year 1992 a total of 6,276 metric tonnes of fish were landed and the revenue was about US\$ 1.9 million. The most common species landed include sardines, shark and rays, kingfish, rabbitfish, parrotfish and scavenger snapper (Table 2). Demersal fish species dominate over pelagic species in the catches. Demersal fish are mainly caught along the northern Kenya coast. Also of economic importance are the sharks which are caught either for zoos or for extraction of shark oil, paints and sprays. Their skin is used for making belts and handbags. In terms of total catch, Kwale is the most important fishing district followed by Lamu, Malindi and finally Mombasa. Odero (1984) estimated that the inshore waters of Kenya could yield as much as 20,000 tonnes of fish per year while the deep waters within the exclusive economic zone of 200 miles could produce as much as 50,000 tonnes of fish per year. A more recent estimate by McClanahan (1996) is much lower with a total of 37,000 tons. This author is of the opinion that artisanal fishing is already above sustainable levels, the catch of crustaceans has probably reached maximum sustainable level, and the off-shore and demersal fish catches are still below. Fish catches over the past 25 years have steadily increased, certainly in the last decade.³

2 In addition to the types of boats, gears and monsoon weather patterns, social and economic factors also affect fish landings. Examples are religious fasting, holidays, festivities and diversion of fishing boats into the more lucrative business of tourist transportation and mangrove pole transports.

3 In 1993, there was a sudden and steep drop in fish landings which is, so far, unexplained but figures show recovery in the next years (Kenya 1996). The same phenomenon occurred in 1972 (McClanahan 1996).

Table 2 Marine fish landings by species, 1992

	weight*	value**		weight*	value**
= <i>Demersal</i>			= <i>Pelagic</i>		
Rabbitfish	495	7,929	Cavalla Jacks	142	2,833
Scavenger	477	6,760	Mulletts	117	1,885
Snapper	155	2,225	Little mackerel	75	1,462
Parrotfish	177	2,679	Barracuda	53	901
Surgeonfish	37	421	Milk fish	19	246
Unicornfish	35	320	King fish	72	3,610
Grunter	61	884	Queen fish	39	623
Pouter	95	1,249	Sail fish	73	1,627
Blackskin	63	1,078	Bonito	70	1,451
Goatfish	37	585	Dolphin	21	663
Steaker	22	403	Mixed pelagic	102	1,821
Rockcod	78	1,280	Not accounted for	117	2,567
Catfish	33	343	Sub-total	900	19,689
Mixed demersal	416	5,874			
Not accounted for	327	4,808	= <i>Other species</i>		
Sub-total	2,508	36,838	Sharks and rays	173	2,404
			Sardines	358	3,748
			Mixed fish	1,962	47,535
			Not accounted for	375	8,035
			Sub-total	2,868	61,722
			Grand total	6,276	118,249

* metric tons ** Ksh '000
 Source: KMFRI 1993

Crustacean fishery

Crustaceans are an important food resource found in varying quantities along the Kenyan coast. Although they rank lower than fish in terms of tonnage, they sell for much more money per unit weight (Mutagyera 1984). Table 3 shows crustacean landings during 1985-1994. Five different species of lobsters are commonly fished along the Kenya coast. All of them are very common in the Ungwana Bay where they are caught using nets, spearing, live capture and bait traps (Nzioka 1984).

Prawn fishing is also carried out by artisanal fishermen using stake traps, cast nets, beach seines and 'juya' trawls. The species commonly fished are *Pineas monodon*, *P. indicus*, *P. semisulcatus* and *P. japonicus* which are highly demanded by tourist hotels along the coast shores and in Mombasa town. Portunid crab species *Scylla serrata*, *S. sangunotontes*, *Sesarma* sp. and *Poxtumus pelagicus* are also important crustaceans which are fished for local consumption. This fishery is under-exploited due to low demand but has a potential to become important for export. The crabs are associated with mangroves and are caught at Lamu and Vanga. Oysters are also collected and sold to tourist hotels and restaurants.

Table 3 Crustacean landings, 1985-1994 (metric tonnes)

	Prawns	Lobsters	Crabs	Not acc. for	Total
1985	99	65	64	46	274
1986	145	68	55	34	302
1987	67	117	523	105	812
1988	535	186	51	115	887
1989	468	74	80	93	715
1990	474	74	90	95	733
1991	523	66	71	100	760
1992	388	52	58	75	573
1993	208	47	69	48	372
1994	379	44	59	72	554

Source: KMFRI, Annual Reports 1985-1994

Commercial large-scale fishery

Commercial fishery along the Kenyan coast is concentrated at Diani and Malindi Bays due to favourable fishing conditions. The commercially important fishes are: (i) the scombroid fish species, mainly *Scomberomorous commerson*, and the dolphin *Corypheana hippurus*; (ii) tuna shoals of *Thunnus albacares*, which are caught by long lines up to 4.5 km offshore; surface shoals of these fishes are present throughout the year but the catch increases during the south-east monsoon winds; (iii) billfish, caught within 40 km from the shore around Malindi and very important in the pelagic fishery along the coast; and (iv) Indian mackerel, *Rastrelliger kanagurta*, which form the major part of commercial fishing and is most abundant during the north-east monsoon winds.

Marine turtles

The Kenyan coast reportedly harbours five of the world's eight species of marine turtles: the green turtle (*Chelonia mydas*), the hawksbill turtle (*Eremochelys imbricata*), the loggerhead (*Caretta caretta*), the leather back (*Dermochelys coriacea*) and the olive ridley (*Lepidochelys Olivacea*) (Frazier 1975). However, recent surveys show that only green turtles and hawksbill turtles do nest on the East African coasts (Wamukoya *et al.* 1996). These species have been confirmed to be nesting in Kenya along several beaches from Lamu to Chale and at Wasini on the south coast. Turtles are protected by Kenyan law which prohibits their hunting and fishing. However, these animals, like other wildlife are threatened since they are caught and killed as they come to nest.

Sea turtles are rapidly becoming a tourist attraction and, over the years, they have been of great value to the coastal peoples, particularly the Bajuni, for nutritional, economic and cultural purposes (Frazier 1980). Their shells can be curved into ornaments which are then sold to tourists (Oteko 1987). Other products from green turtles, for example, include meat as a source of protein and turtle soup, oil for medicines, cosmetics and protection against spirits, eggs for food and as an aphrodisiac, blood which is drunk as a health tonic, shells for its scales which are used to make lampshades, and the skin for leather shoes and handbags (Olendo 1993). Reports indicate that nesting females are preferred by fishermen and this has reduced their reproductive potential. Nests are often dug up in search of eggs by man and other predators. There is urgent need to protect already

identified nesting beaches from human encroachment, which is the most critical problem of turtles in Kenya (Olendo 1994). A recent aerial survey in 1994 of the entire coastline counted 442 sea turtles. The animals were widely distributed along the Kenya Coast. Green turtles were the predominant species. On the ground, however, only 19 nests and 11 tracks were found and it appears that the observed population uses the Kenyan waters mostly as a foraging ground. Many of the former nesting beaches have been destroyed or are inaccessible (Wamukoya *et al.* 1996). The Kenya Sea Turtle Commission promotes research and conservation measures to halt the decline in turtle numbers. Turtles, like birds or fishes, are known to migrate over long distances between feeding and nesting grounds, notably the leatherback. Where feeding and nesting grounds are far apart, the turtles cross national boundaries. This necessitates inter-regional cooperation in management and conservation of this animal species.

Marine mammals

Three groups of marine mammals are present along the Kenya Coast: dugongs, whales and dolphins. Records show that there has been a decline in the population of dugongs (*dugong dugong*) from 67 animals in 1973 to as few as 10 animals in 1997 (Watson 1973; Wamukoya, Otichilo & Salm 1997). The latter authors attribute the decline to intensive hunting (for meat and oil but also as a source of aphrodisiac and medicinal tokens). Accidental drowning because of entanglement in fishing nets is a significant cause of mortality but it is very difficult to obtain precise figures (Kendall 1986). Other factors are habitat degradation and pollution.

There are large numbers of dolphins in Kenyan waters (estimated at 1,300 in 1997) which are a potential tourist attraction. The animals are not hunted for any product but they are subject to incidental capture because of the increases in the number of setnets by artisanal fishermen. Whales are known to migrate through the Kenyan waters. The oil and the meat of stranded or captured animals was previously used for lamp fuel and for human consumption (Wamukoya *et al.* 1996).

CORAL REEFS

"Coral reefs are a naturalist's paradise. The vast quantities of limestone produced by them, their warm clear waters, the spectacular colours, their high productivity, the richness of their species with complex biological relationships put corals at the centre of attention of numerous scientists" (Castro & Huber 1992:370). Coral reefs have tremendous potential in that they are productive and offer habitats for many species of organisms including the beautiful coral fishes. These fishes are exploited for food, but the great variety of life within the reefs is of economic importance to the country as a tourist attraction. Coral reef habitats exhibit some of the richest biological diversity.

The Kenyan coast is lined by a nearly continuous fringe of coral reefs, from Shimoni to Malindi, a distance of about 200km, only interrupted by the mouths of various inlets and rivers. Extensive reefs also exist north of the Tana River and in the Lamu-Kiunga area. They run parallel to the coast at a distance of 500-2000 m from the shoreline. The

reefs are an important habitat for many marine fishes which are fed on by the commercially important deep-shelf demersal species. Many tropical marine fish species including those found at a considerable distance from the reef itself are in various ways dependent on the reef (Brakel 1984).

Ecologically, coral reefs have been identified as one of the essential life supporting systems necessary for human sustainable development in tropical coastal areas (Wells 1988). In addition they protect the coastline against wave and storm action, prevent erosion and contribute to the formation of sandy beaches. The coastal community of Kenya benefit from the reefs directly by obtaining construction materials, jewellery, ornamental objects and medicinal products. Above all they provide an important source of food. At least 50% of the fish caught at the Kenyan coast is reef associated fish caught by artisanal fishermen (Dubois, Berry & Ford 1985).

Over the last decade, many of the reefs show signs of serious degradation due to over-fishing and use of destructive techniques such as dynamites, unmanaged tourism, construction and pollution from rivers that carry silt from eroded land and human waste from coastal settlements (Brown, Flavin & Starke 1994). Reports of coral bleaching along the coast have increased greatly in the last decade. Bleaching is caused when corals lose photo-synthesising algae and associated pigments which live symbiotically within the coral's body tissue. Many researchers believe that bleaching may be the result of global changes in the earth's temperature (which has risen 0.5 degrees centigrade in the last century) and increased ultra-violet light because of loss of ozone protection. Coral bleaching along the Kenyan coast is most evident on the second spring tides of March when its equatorial position receives the maximum sunlight (McClanahan 1994). Other threats to the coral habitat include the damages caused by tourists walking on the reef crests and shallow reef patches and by turning over the coral boulders and rocks without replacing them. The collection of shells and corals, starfishes and sea turtles cause disturbances in the reef environment and reduce its diversity. This, for example, encourages the proliferation of certain species of sea urchins – natural reef grazers. The catches of reef fish are near or above the maximum sustainable yields (McClanahan & Obura 1995; 1996).

OTHER MARINE RESOURCES

Lagoons and estuaries

Shallow lagoons are a common feature along the Kenyan coast and are very productive environments with a high biodiversity. Many economic activities of the coastal people are based on the lagoon ecosystem. Most of the traditional fisheries and rapidly expanding aquaculture are carried out in the lagoons. They also play a central role in the mangrove harvesting, salt extraction and coastal transportation. In many places along the coast, lagoons like other resources are being overused and their resources degrading. The need for information on the environment of lagoons and their sensitivity to various human activities is urgent in order to preserve them (UNEP 1984). Lagoons along the Kenya coast have been identified as suitable areas for seaweed farming (Wakibiya & Oyieke 1992).

Estuaries are rivermouths where a river enters into the sea. They consist predominantly of freshwater but with the ebb and flow of the tide provide a brackish environment of fluctuating salinity. This fluctuating salinity is believed by biologists to provide an important evolutionary bridge between marine and freshwater organisms. Along the Kenyan coast are two main estuaries, notably the mouths of the Sabaki and Tana Rivers. There are also a number of minor ones, some of which are seasonal and others only noticeable by the mangrove swamps they support. Ecologically, estuaries are environments inhabited by relatively few species but they are among the most productive environments on earth. Salt-marsh grasses or mangroves thrive along the shore while seaweeds live further out (Castro & Huber 1992).

Minerals

The sea as a source of minerals offers some advantage over the land. The distribution of marine minerals is generally widespread and consequently available to most coastal zones without the political economic constraints that operate to localise and nationalise land minerals. Currently, most mining of the sea is limited to the beaches and continental shelf. Common salt is the most important extractive and accounts for 29% of the total salts mined. Desalination is fast reaching the practical levels as a source of fresh water in areas of demand and limited source of supply (Othmer 1969).

In Kenya, more than fifty per cent of the salt is obtained from the ocean. The salt works near Malindi utilise the intertidal region and the influence of tides to fill up ponds. The salt is extracted by concentration through evaporation leaving salt in the ponds. It is then purified and iodised (FAO 1979). Limestone is quarried from raised pleistocene fossil reefs for cement manufacture at the Bamburi Portland Cement Factory near Mombasa, the leading cement producer in Kenya.

Tourism

Socially as well as economically, the coast's recreation potential is one of the most important marine resources. The most popular forms of marine recreation include swimming, boating, sportfishing, water skiing, surfing and skin diving. The Kenyan coast is renowned world-wide as a tourist attraction. Tourism is today the leading foreign exchange earner in Kenya. The coast has a wide variety of marine life which are a big attraction to foreigners. According to Ruwa (1984), the marine parks Watamu, Malindi, Kiunga and Kisite (Figure 2) deserve their international fame and are a testimony to the foresight of the Kenyan Government in developing tourism. Numerous tourist hotels have been built along the Kenyan coast, offering employment as well as a ready market to fishermen for their catch. In 1993, Kenya received about 700,000 tourists. Almost half of these visitors toured the coast with a good percentage visiting the marine parks. Essentially, the economy of Kenya's coastal areas depends invariably on the tourism industry which thrives on the basis of marine resources (Koyo 1994)

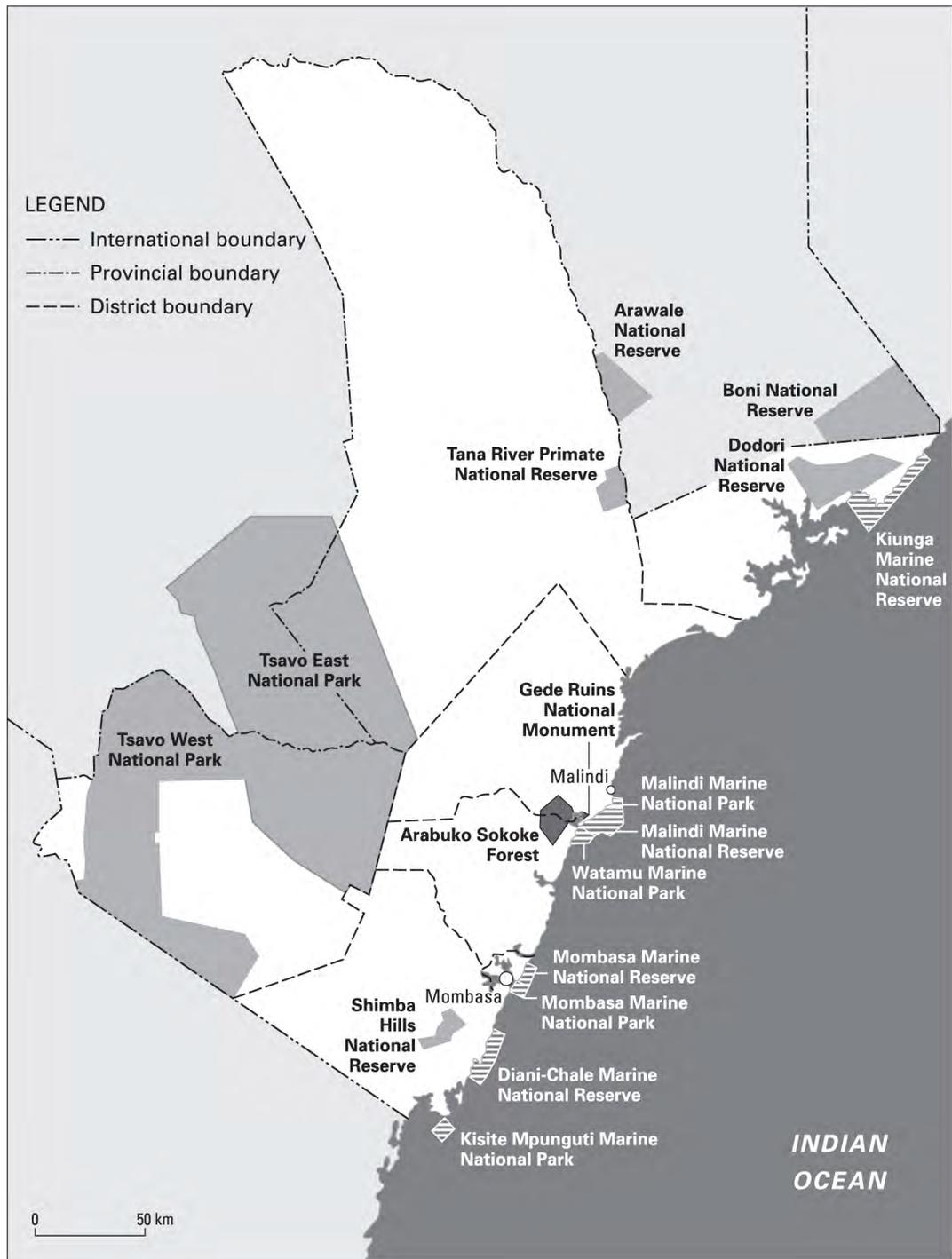


Figure 2 National parks and reserves

COASTAL CONSERVATION

Biodiversity

The seventies was the decade of the environment and the eighties was the decade of the green house effect, ozone layer and global warming. The currently fashionable word of the 1990s is 'biodiversity' which is of great concern to environmentalists, scientists and policy makers. Diverse landscapes contain the greatest variety of plants and animals. Kenya's coastline is one of such, changing abruptly from one scenario to another, offering a fascinating collection of flora and fauna (SAREC 1992). For instance, the coastal forests such as Arabuko Sokoke has a very high biodiversity value with an outstanding variety of plant, bird and butterfly species, several of which are extremely rare as are several species of forest mammals. The mangrove forests, the shallow lagoons, the sandy dunes, seagrass beds and the coral reefs open into the deep vast waters of the ocean.

Conservation of this diversity has become imperative in recent years due to the non-sustainable utilisation of resources and the environmental degradation being exerted by the fast expanding human population and inappropriate development practices. Mangrove resources along the Kenyan coast have shown a serious decline as a result of massive felling without replanting, selective felling of straight trees of timber, pest attacks, and pollution, among other causes.

Coral reefs face a number of serious threats due to natural as well as man-induced causes. Some of these detrimental activities include deforestation and soil erosion up-country which result in sediment and nutrient run-offs which in turn reduce growth by smothering corals, inhibit the settlement of young corals, and impair water clarity thereby impeding photosynthesis, while nutrient enrichment, whether from sewage or agricultural run-off, leads to rapid overgrowth by seaweeds (McClanahan & Obura 1996).

Coastal activities, including dredging, construction and shipping also cause siltation as do polluting effluents. Other threats include damage from boat anchors and boat grounding, all of which destroy reefs. It is possible that reefs will be among the first ecosystems to be affected by global warming. Corals succumb to high temperatures through a process called bleaching and there is also concern as to how well reef growth will keep pace with predicted rates of sea level rise. Although the effects are uncertain, what is certain is that healthy reefs will be able to withstand climate change better than damaged ones.

Traditionally the main human activity on reefs was subsistence harvesting. This is still important in many areas, but growing human populations in Kenya mean that its impact is now greater than it used to be. Apart from local demand, there is also an increasing international demand for reef fish, spiny lobsters, marine curios such as shells, and recreation (Koyo 1994).

Marine protected areas

The maintenance and development of resources in marine and coastal environments require that some areas be retained in their natural state (UNEP 1984). Safeguarding critical habitats for fish production, preservation of genetic resources, protection of scenic areas, coastal protection and opportunity to enjoy this natural heritage may require rigorous management of these areas. The most appropriate use of these areas is a suitable level of

strict protection. In other areas, limited uses such as fishing and use by tourists may be permitted on a sustainable basis (Bryceson 1981). Marine protected areas include coastal areas which are functionally linked to the sea — e.g. mangroves, salines, estuaries, beaches, cliffs, lagoons and corals — and adjacent land areas which form an integral part of the coastal environment, such as dunes, alluvial banks, spits and barrier islands (Table 4).

Kenya has one of the most extensive systems of marine protected areas in Africa, established through the Kenya Wildlife Conservation and Management Act. Marine national parks are areas for the protection and preservation of biodiversity in which fishing and removal of marine organisms is prohibited. Only tourism is permitted within designated areas. Similar regulations apply for marine national reserves, but in these areas, traditional forms of fishing are permitted. Ecologically, marine protected areas play an important role in biodiversity protection and nature conservation. They provide breeding grounds for myriads of marine organisms which eventually disperse into the outer waters from where they will be exploited by man. Like the terrestrial parks and reserves, these areas do have high scientific, educational, economic, cultural and aesthetic values. There are currently five marine national parks and six marine reserves, in the areas of Kiunga, Malindi/Watamu, Mombasa, Diani/Chale and Kisite/Mpunguti (Figure 2).

Kiunga Marine National Reserve covers a total area of 250,000 hectares and was established in 1979. It is the largest of Kenya's marine protected areas situated from about 16 miles south of the Somali border to a few miles north of Lamu Island. It is an important reserve for coral reefs, islets with large colonies of nesting seabirds, dugongs, turtles

Table 4 Coastal and marine habitats for conservation purposes

Environments	Habitats
Coastal	Sand beach Rocky shores Cliffed shores Bays Estuaries Intertidal mud/sand flats Deltas Dunes Coastal plains Limestone caves
Offshore	Islands Alluvial bar/bank Continental shelves Continental slope Submarine canyons
Coast-associated	Algal beds Seagrass beds Saline marsh Mangrove forests Maritime forests/woodlands Coastal shrubland, grasslands and palm forests
Living reefs	Reef-associated lagoons Fringing and patch reefs

Source: UNEP 1984

and mangroves. The Malindi/Watamu Marine National Park has a total area of 20,000 hectares and was established in 1976. The park is located south of Malindi up to Mida Creek and is important for the conservation of fringing reefs, coral gardens within the lagoons, and seagrass beds, while the estuarine Mida Creek has mangroves and mudflats. It is also known for its shorebird populations, dikdiks, mongoose and monitor lizards. Close to this park are the famous tourist attractions such as the Gedi Ruins and Arabuko Sokoke Forest.

The Mombasa Marine National Park and Reserve has a total area of 200,000 hectares. The area is located in the most important and extensive tourist area of Kenya. The Park lies within the reserve which extends from the shoreline to about 13 km offshore and runs from Nyali to Mtwapa Creek. It was established to protect a representative area of coral reef ecosystem with associated beaches and other natural features. Located 25 km south of Mombasa is the Diani-Chale Marine Reserve. It extends from the mouth of Mwachema River in the north to Chale Island, with its reefs, fishing grounds, mangroves, seabird nesting sites and limestone areas, in the south. This reserve is a prime site for tourism bordering the famous Diani tourist complex. On the south coast off Shimoni and south of Wasini Island are the Kisite and Mpunguti Marine National Reserves with an area of about 1,100 hectares. These are important for coral reefs which surround four small limestone islets with nesting seabirds, fisheries and other marine resources.

The proposed Tana Delta Reserve is a largely undisturbed area which has been nominated as a wetland of international importance. The delta covers an area of 20,000 hectares and lies north-west of Kipini. It has a high biodiversity and is a haven for numerous species of sedentary and migratory birds and turtles. The delta encompasses the traditional forms of small-scale agriculture, pastoralism and fishing which have maintained the ecological balance of the area. Protection would ensure the continuation of such natural functions to benefit both the local community and the whole country.

DEVELOPMENT EFFORTS

Mariculture is the culture of marine plants and animals. In view of the over-exploited species and an increasing demand for food due to the ever increasing population, the potential of controlled farming of marine organisms seems great (UNEP 1984). The development of mariculture in coastal waters will cause a change of attitudes in using parts of the sea as a common property (Hood 1971). The purpose of mariculture is threefold: (i) to exploit a food source, which may for example alleviate local protein deficiency; (ii) to produce a luxury product which is exported for foreign exchange; and (iii) to provide employment to the local population. Mariculture activities along the Kenyan coast include seaweed⁴, crustacean and fish cultures (Nzioka 1984). The latter two will be briefly discussed below.

⁴ Seaweed culture is a new type of farming. Unlike in Zanzibar where it was started several years ago and now employs about 15,000 people, this type of farming is still in its infancy in Kenya (SAREC 1992; Wamukoya). However, studies have shown that algae can be cultured along the coast with much success.

Crustacean culture

Crustacean culture is being practised on a pilot basis at two locations along the coast. There is an experimental oyster culture at Gazi on the south coast which is highly correlated to the surrounding mangrove trees. However, the project has never taken off from the initial stages. On the north coast is the Ngomeni prawn culture which was started by the Kenya Government in 1976 with the help of United Nations Environmental Programme (UNEP) and the Food and Agricultural Organisation (FAO). The farm uses the tides to fill up and drain the ponds. Young prawns for stocking the ponds are collected from the lagoons within the mangrove swamps. The prawns are currently sold to the tourist hotels. However, the project and any eventual followers are controversial in nature because it entails clearance of mangroves.

Fish culture

Although strictly speaking not a 'marine' resource development, the Baobab intensive tilapia culture, located 10 km north of Mombasa, is an outstanding example of a successful fish culture. Fish farming was introduced in 1971 as part of an integrated process of nature reclamation. The site is a worked-out coral limestone quarry of the Bamburi Portland Cement Company. An abundant supply of water to this farm varies in salinity from 1.0-15.0 ppt and is at a near constant year-round temperature of 26 degrees centigrade.

Up to 12 species of tilapia and various strains are maintained at Baobab fish farm. Predominantly *Oreochromis leucostictus* and *O. spirulus* are used. As fingerlings, the fish are stocked in the raceways at 2-5 g for on-growing to 40-50 g. The fish undergo a rigorous grading programme whereby 30-50% of the incoming stock are graded out at below 30 g in size. By this process there is a positive selection for 60-80% male fish. Slow growing stocks, generally female fish, which will never achieve a good market size in an economic time period, are removed at an early stage (Armitage & Haller 1987). They are used as food for the integrated crocodile farm.

Baobab fish farm is a testimony to the benefits of 20 years of hard work (Lockwood 1994). It has several offshoots. Some fish are sold to visitors and the local communities whereas others are used for research. Many tourist hotels in the surroundings depend on fish from this farm. According to Lockwood (1994), by the year 2010, an estimated amount of 245,000 tonnes of fish will be needed to match Kenya's present protein consumption. The total yield from marine and freshwater fisheries is currently 150-200,000 tonnes a year. Therefore, cross-breeding programmes are underway at Baobab to find the most attractive fast growing tilapia. In this regard, Baobab's fish culture research is relevant world-wide to supplement the dwindling wild stocks.

Within the farm is the crocodile farm which forms part of the system. These animals are bred for their meat and the usefulness of their skins to the fashion market. This farm is contributing to Africa's conservation of the Nile crocodile, listed under special criteria

of the Convention on International Trade in Endangered Species (CITES).⁵

CONCLUSION

The coastal areas consist of highly productive ecosystems supporting a wide variety of flora and fauna which are of essential importance not only to the coastal population but also communities inland. Fishing and aquaculture are providing essential proteins as well as employment to the local people. They are also an important source of foreign exchange. Tourism, which is the leading foreign exchange earner in Kenya, is highly dependent on the coastal marine parks and reserves. Each year almost half of the tourists visit the coast with a good number touring the parks and reserves.

However, the socio-economic pressure is increasing steadily and large-scale destruction of some of the region's most valuable resources has caused serious degradation of the environment, thus affecting the economic life of the coastal inhabitants (Hoorweg 1998). Mangroves are being indiscriminately felled, coral reefs are being destroyed, while sea-grasses are not spared either. Poor methods of fishing have led to a decline in the coastal fishery, shell collection has depleted the coast of the beautiful molluscs that were one of the many tourist attractions. To a large extent, this situation is the result of inadequate knowledge among the experts, lack of education of the local people, coupled with ineffective and poor management of the coastal resources (UNEP 1984).

The Kenya Wildlife Service (KWS) is actively involved in the conservation and management of marine resources for sustainable development (Koyo 1994). Surveys and monitoring are conducted regularly along the whole coastline to determine the status of the resources and to identify suitable areas for conservation as marine parks or reserves. Boundary marking is done to show the location of the protected areas. Zonations for various activities in the parks and reserves are done in order to establish effective management. Visitor facilities such as underwater trails, boat-anchors, swimming/ goggling sites, and guided boat tours are provided. Marine education and awareness materials such as posters, postcards and panels, are provided to enhance the visitors' understanding and enjoyment of the resources and the environment. Security of the protected areas as well as of visitors is provided by KWS staff. Unauthorised fishing and collection of shells or corals and other souvenirs are prohibited.

Community participation in marine conservation is encouraged through various programmes. KWS is collaborating with the Fisheries and Forest Department, the Coast Development Authority and the Kenya Marine and Fisheries Research Institute, among others, in order to initiate and integrate planning and management of the beautiful Kenyan coast. Research and monitoring are a necessary basis for planning and management. Recently, different stakeholders were brought together which resulted in an Integrated Coastal Management plan for the Mombasa-North area and urgent priority issues identified (ICAM 1996). The latter include fresh and coastal water degradation; coastal ero-

⁵ Other aspects of wildlife utilization or game farming are also practised by Baobab farm. Small herds of waterbuck and eland graze around the hippo pools. Buffaloes and other animals also form part of this rehabilitated eco-system which is a tourist attraction.

sion; degradation of coastal and marine habitat such as mangroves, coral reefs, beaches and seagrasses; and increasing on-water and land-use conflicts.

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REVIEW DETAILS

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