Eastern Africa
Atlas of Coastal Resources

A project of the United Nations Environment Programme
with the support of the Government of Belgium

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1 : KENYA

UNITED NATIONS ENVIRONMENT PROGRAMME

UNEP

BELGIAN ADMINISTRATION FOR DEVELOPMENT COOPERATION

The Government of Belgium, through its Administration for Development Cooperation, is pleased to be associated with this worthwhile project under the auspices of the Water Branch of the United Nations Environment Programme. We have always had a special interest in the Eastern African Action Plan activities and we see this project as providing a sound information management basis for the sustainable management of the coastal and marine resources of this region.

Dr. R. Moreels

Minister of State for Development Cooperation

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FOREWORD

Kenya has over 600 kilometres of coastline and this is one of the most important components of our nation's rich heritage. The highly productive ecosystems found in our coastal areas play a crucial role in the economic and social development of our country.

As in many other coastal nations, the earliest permanent settlements in Kenya sprang up along the coastal fringe. Maritime trade and ease of communication were among the most important driving forces in the establishment of coastal settlements which flourished around the natural ports and sheltered waters of the Kenya coast.

Until recently, the Kenya coast retained its predominantly trade-oriented focus. But in the last three decades there has been a distinct shift to service-oriented activities focused on the tourism and visitor industry. This transformation has in turn led to economic growth, a rapid increase in population and the establishment of other industrial enterprises. Unfortunately, population pressures and industrial and tourism developments place heavy demands on coastal habitats and ecological resources, and often result in natural resource depletion, environmental degradation and conflicts over the use of these valuable but vulnerable resources. This has direct consequences for those who live in the coastal region as well as for the nation as a whole and cannot be left to resolve itself. The process of development must be managed and environmental information is an essential ingredient for sound decision-making and sustainable resource use.

Kenyan decision-makers, administrators, planners, resource managers and their scientific advisers, need access to comprehensive environmental information in order to help bridge the gap between scientific understanding of Kenya's coastal processes and sound management of the environment. Lack of accessible data can seriously impair the capacity to make informed decisions affecting the management of the environment and the course of national development.

An Atlas such as this, designed specifically to our needs, was long overdue. We are indebted to the Water Branch and GRID-Nairobi of the United Nations Environment Programme (UNEP) and to the Belgian Government for making such a project possible and to the various Kenyan institutions that provided the raw material to make it happen. I am particularly pleased to note the key role that local institutions have played in this project.

I believe that all Kenyans will find the Atlas valuable. Our need for readily available information will grow as we move from simple exploitation of coastal resources to an approach embodying a pre-emptive and predictive planning process, comprehensive and sound management strategies and the critical integration and coordination of planning with implementation as endorsed by Agenda 21 of the UNCED Conference in Rio de Janeiro in June 1992. I therefore welcome this atlas as a major contribution to the sustainable development of coastal resources in Kenya and Eastern Africa.

Minister for Environment and Natural Resources

Nairobi, October 1997

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Overall responsibility for EAF/14 project management and administration was based within UNEP Water Branch in Nairobi. The overall Project Coordinator was Dr. Dirk Van Speybroeck who also provided information on coastal botany and who was assisted by Mr. Mwangi Theuri in management of the bibliographic database. In July 1997 the Flemish Association for Development Cooperation and Technical Assistance (VVOB) seconded to the project Mr. Lieven Bydekerke as a GIS expert. The last phase of the project was coordinated by Mr. Dixon Waruinge.

Dr. Philip Tortell acted as Principal Consultant and overall Editor.

The development of the coastal resources database and the Geographic system (GIS) framework, were undertaken by the UNEP Global Resources Information Database (GRID) in Nairobi under Mr. M Hernandez, GRID Nairobi Facility Manager and Mr. J Akiwumi. Mr. F Stolle and Ms. L Foley were responsible for satellite imagery interpretation and land cover classification. Data entry and map digitizing were done by Mr. M Mwangi and Ms. R Semakula.

The data was located, accessed and collated by the Kenya Working Group chaired by Dr. E Okemwa, Director of the Kenya Marine and Fisheries Research Institute, who acted as the In-Country Coordinator.

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Mr. S Weru, Marine Ecologist, data and maps on coastal national parks and reserves.

Coast Development Authority

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Ms. W Mokobi and Mrs. P Ochieng, of the Kenya Marine and Fisheries Research Institute, entered the raw data on the database and computer files; while Mr. F Oguta, also of KMFRI, made sketch drawings of the coastal archaeological sites and monuments.

The EAF/14 project acknowledges information from the Kenya mangrove mapping and inventory project funded by the Embassy of the Kingdom of the Netherlands in Nairobi, and finalized by the Kenya Wildlife Service with the assistance of UNEP EAF/14 Project.

The text was compiled from contributions by members of the Working Group and a number of other sources, and edited by Dr. Philip Tortell of Environmental Management Limited, Wellington, New Zealand.

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National Museums of Kenya - information on archaeological sites and monuments.

Kenya Ports Authority - information on port statistics.

Coast Development Authority - information on coastal legislation.

Offices of the Provincial Commissioner and District Commissioners, Coast Province - provided access to information on various economic and social issues relevant to the project.

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Survey of Kenya - topographical map sheets for Kenya, the Kenya coastal zone (1:250,000 in UTM zone 37) series SA-37-8 Kolbio, SA-37 pts 11&12 Lamu, SA-37-11 Garsen, SA-37-15 Kilifi, SB-37-3 Mombasa, SA-37-14 Voi, and SB-37-2 Lushoto.

Mr. J M Ngethi, Secretary and Mr. G M Mwashigadi, Administrator, National Oil Spills Response Committee - provided information on contingency plans at hand in cases of oil spill in the marine environment of Kenya.

Dr. E Vandenberghe, Database Coordinator, Centre for Biodiversity, National Museums of Kenya - for information on database development.

Mr. J Oyugi and Mr. O Nasirwa, Ornithology Department, National Museums of Kenya - data on coastal ornithology, provided training on coastal survey techniques.

Dr. G Abungu, Department of Coast Archaeology, National Museums of Kenya - for pictures and information on archaeological sites and monuments along the Kenya coast.

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Dr. R Salm, Project Coordinator, Marine and Coastal Conservation Programme, IUCN - information on endangered coastal and marine species.

Mr. J Seys, Resident Manager, Kenya-Belgian Project in Marine Sciences - information on birds in the coastal environment, provided training in coastal survey techniques.

Photographs were taken by Mr. Fabby Nielsen, professional photographer and except for those on pages 46-49, 54, 56 and 93 which were taken by Philip Tortell and a few others on pages 74, 76, 91 and 94 which are stock photos from a royalty free photo-CD. Line drawings and other illustrations were provided by the National Museums of Kenya and elicited from a number of other sources, or they were produced specifically for this publication by Philip Tortell and Chris Warring.

Cartographic symbols and icons were designed by Chris Edkins.

The maps were designed and produced by the National Geographic Institute, Brussels, Belgium based on ARC/Info coverages developed by UNEP-GRID, Nairobi.

Cover design by Chris Warring based on a photograph of old Mombasa fishing port by Fabby Nielsen.

Overall design of the publication was by Chris Warring of Wellington, New Zealand, who was also responsible for layout and typesetting as well editing of graphics. Fransisco Vasquez from Reproduction and Distribution Section, United Nations Office at Nairobi was responsible for Pre-press and printing.

Figure 1 : The Eastern African Region

INTRODUCTION

THE EASTERN AFRICAN ACTION PLAN

Governments of the Eastern African Region (Somalia, Kenya, Tanzania, Mozambique, Comoros, Madagascar, Mauritius, Seychelles and France (Reunion)) have recognized the importance of their marine and coastal areas and at the same time, the environmental threats that they face. In their endeavour to address the problem, the Governments came together under the framework of UNEP's Regional Seas Programme. After a detailed preparatory process, the Conference of Plenipotentiaries on the Protection, Management and Development of the Marine and Coastal Environment of the Eastern African Region took place in Nairobi, in June 1985, and adopted the following instruments -

- **Action Plan** for the Protection, Management and Development of the Marine and Coastal Environment of the Eastern African Region;
- **Convention** for the Protection, Management and Development of the Marine and Coastal Environment of the Eastern African Region;
- **Protocol** concerning Protected Areas and Wild Fauna and Flora in the Eastern African Region;
- **Protocols** concerning Cooperation in Combating Marine Pollution in Cases of Emergency; and,
- Four Conference **Resolutions** dealing with programme implementation and with institutional and financial arrangements.

The agencies involved in the implementation of the Action Plan include UN, UNDP, ECA, FAO, UNESCO, IOC, WHO, WMO, IMO, UNIDO, IAEA, IUCN, EU, and UNEP.

The above decisions form the basis for a programme of activities comprising:

- Protection and management of marine and coastal areas (EAF/5)
- Assessment and control of pollution in the coastal and marine environment (EAF/6)
- Contingency planning for marine pollution emergencies (EAF/7)
- Addressing problems of coastal erosion and siltation (EAF/10)
- Environmental impact assessment (EAF/11)
- Eastern African Coastal and Marine Environment Resources Database and Atlas (EAF/14)

In its role as Secretariat, UNEP has spearheaded numerous activities within the general framework of the Action Plan and comprising initiatives under all the above Projects. From 1997, this role was transferred to the newly established Eastern African Regional Coordinating Unit (EAF/RCU) of UNEP's Regional Seas Programme located in the Seychelles.

More than 25% of the population of the Eastern African Region today lives along its coastal areas or not far inland. Most seek employment around the coast as well as the right of unrestricted access to and from the foreshore, the freedom of navigation on any waters, the right to anchor and seek shelter, the right to fish and gather shellfish and other living resources for their livelihood or sustenance and the right to seek their leisure and recreation. In addition, coastal areas provide the landfall or take off point for imports and exports respectively, they are often the focus for industrial development and, increasingly, they are promoted as venues for tourism developments which have become the chief foreign currency earner in many of these countries. These multiple demands on coastal resources require the best management strategies and tools to ensure sustainability. The *Eastern Africa Atlas of Coastal Resources* is such a management tool.

THE EASTERN AFRICAN COASTAL AND MARINE ENVIRONMENT RESOURCES DATABASE AND ATLAS PROJECT (EAF/14)

The dilemma that faces Eastern African nations today is that while they are depending more and more on the coastal zone for their livelihood and wellbeing, the natural habitats and ecosystems which sustain these resources are being destroyed or stressed through pollution, various developments and other impacts.

It is the task of administrators and managers to seek a wise balance between the many conflicting demands being made on the coastal environment, ensuring that its limits of tolerance and its capacity for sustainability are not exceeded. In order to do this successfully they need a comprehensive information base giving them a holistic view of the resources, the demands, and the various direct and indirect physical interrelationships.

One instrument that can help collate, analyse, synthesise and apply large amounts of information in a simple, visual representation, is the electronic database organized on a geographic spatial basis. It is its possibility to juxtapose resource data, demands, potential impacts and the various factors influencing them, on to a single, graphic representation, that makes an electronic database such a versatile and sound tool for decisions on resource use.

The day will come when the majority of institutions in Eastern Africa will have access to both the hardware and the software, as well as the expertise needed to make full interactive use of the potential offered by an electronic database. The EAF/14 project prepares the way for this eventuality by establishing a regional Geographic Information System database (GIS). The Kenyan Coastal Resources Database, located at the Kenya Marine and Fisheries Research Institute, Mombasa, is updated regularly and it is possible to interrogate it whenever necessary to provide the most up-to-date basis for decisions, especially in emergencies (e.g. spillages).

While this capability is likely to meet the current needs of a number of administrative institutions and some academic and research agencies in the region, its electronic format will keep it beyond the reach of a large number of potential users. Therefore, the first, major substantive output of the database is a series of maps accompanied by appropriate text and produced firstly in country sets for use as working documents. *Kenya* is the first volume in a series of such publications that will eventually make up the *Eastern Africa Atlas of Coastal Resources.* This publication is expected to become a major reference work for scholars and administrators alike.

Administrators, decision-makers and managers are identified as the prime users of the database, the maps, and the Atlas. However, the production of the maps and the Atlas in particular recognizes the needs of those numerous other potential users, and the Atlas has been designed accordingly. In addition to being an excellent tool for professional managers of coastal resources, the Atlas works in other ways to enhance the protection and wise use of coastal resources. It is expected to expose weaknesses in the available information base thus helping to focus the research effort by experts; to inform and educate members of the public, making them more sensitive to the multiple issues that need to be resolved, rarely without some cost; and, to provide an excellent record, and a subsequent measure, for policies, objectives and goals adopted for coastal zone management.

The beneficiaries of the GIS database, the individual country atlases and the comprehensive *Eastern Africa Atlas of Coastal Resources* are the people of Eastern Africa who in the face of development must make hard decisions affecting the coastal environment and resources. For planning purposes, the resource maps developed under the EAF/14 project cover a corridor of about 100km of the coastal and marine environment. It is envisaged that these coastal resource maps will meet the demands of the local policy makers, administrators, planners, developers, environmental resource managers, marine ecologists and the general public for synthesized and harmonized information on the coastal and marine environment. Better planning and more soundly-based decisions are made possible by these comprehensive coastal resource maps and related GIS database. UNEP is confident that the increased accessibility to information is an important step towards the wise use and sustainable development of the coastal environment.

Eventually, the *Eastern Africa Atlas of Coastal Resources* will serve as the information base for the Eastern African Action Plan and the *Kenya* volume is the first step in this direction.

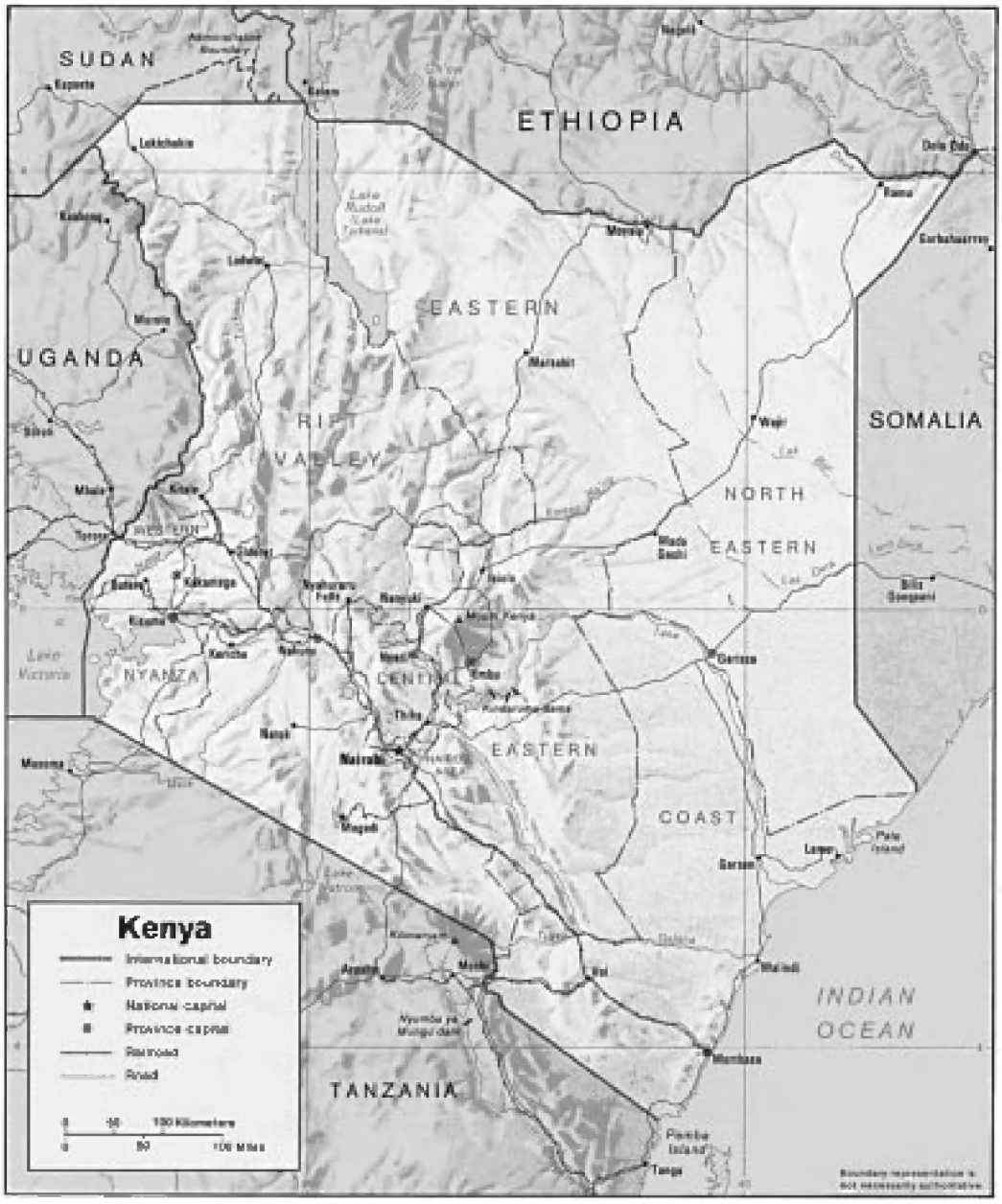


Figure 2 : Kenya

THE KENYA COAST - AN INTRODUCTION

Kenya, with a land area of approximately 580,000km^2, lies astride the equator and exhibits considerable climatic and physical variation as a result of altitude and the strong continental influence inland and marine influence at the coast. Climatic regions range from the cool highlands to the arid savannah in the interior to the low lying and humid coastal plains.

The Kenya coastline is about 600 kilometres in length and forms part of the western border of the Indian Ocean. Its most distinctive feature is the almost continuous fringing coral reef usually running parallel to the coast. Other features include the Lamu Archipelago with its extensive mangrove forests; the Tana River, Kenya's longest, which discharges through a complex wetland system into Ungwana Bay; the Sabaki River which incorporates the Athi and Galana rivers and discharges just north of Malindi; Mombasa Island at the entrance to the most extensive embayment on the coast, with Mombasa Harbour on one side and Kilindini Harbour on the other, the former leading to Port Tudor and the latter to Port Reitz; and, the southern complex of Gazi Bay, Chale Island, Funzi Bay and Funzi Island, Wasini Island and a number of smaller coral islands.

Close to one million people inhabit the Kenya coastal areas at an overall density of 100-200 persons/km^2. Of these, about 400,000 live in Mombasa which is Kenya's major seaport and second largest urban area. The coast provides these people with food, shelter and employment.

On land, the coastal corridor is important for its agricultural crops such as cassava, maize, cowpeas, rice, mango, banana, pineapple, cashew and coconut as well as sisal and cotton. In the intertidal and sub-tidal areas, the coast provides finfish, shellfish, marine algae and timber (from mangroves). The coast is also the gateway for the greater part of Kenyan imports and exports, a magnet for tourists and, potentially, the key to further prosperity if petroleum deposits are discovered offshore as expected.

Underlying these resources and uses which are of direct human interest, are the inherent ecological values which rank any stretch of Kenya coast among the most productive and valuable of natural ecosystems. The rich biological diversity reflects the varied habitats which, starting from the oceanic side, include deep waters comparatively close inshore, coral reefs, seagrass meadows, sandy beaches, rocky shores, mangrove swamps, estuarine mudflats, lowland coastal forests, and coastal hill forests which eventually give way to the savannah plains further inland.

The coastal and marine environments of Kenya are very rich in resources. Yet they are the least studied of the Kenyan natural environments and there are a number of significant gaps in the data and information base. However, and in spite of these gaps, the body of knowledge is still substantial and the *Eastern African Coastal Resources Database and Atlas Project* is a first attempt at compiling a comprehensive overview of existing knowledge about the Kenyan coastal environment and its uses. Having developed the electronic framework for data management, the first substantive product is this *Atlas* which, together with the GIS, will provide the basic tools for the complex task of managing Kenyan coastal resources and environments.

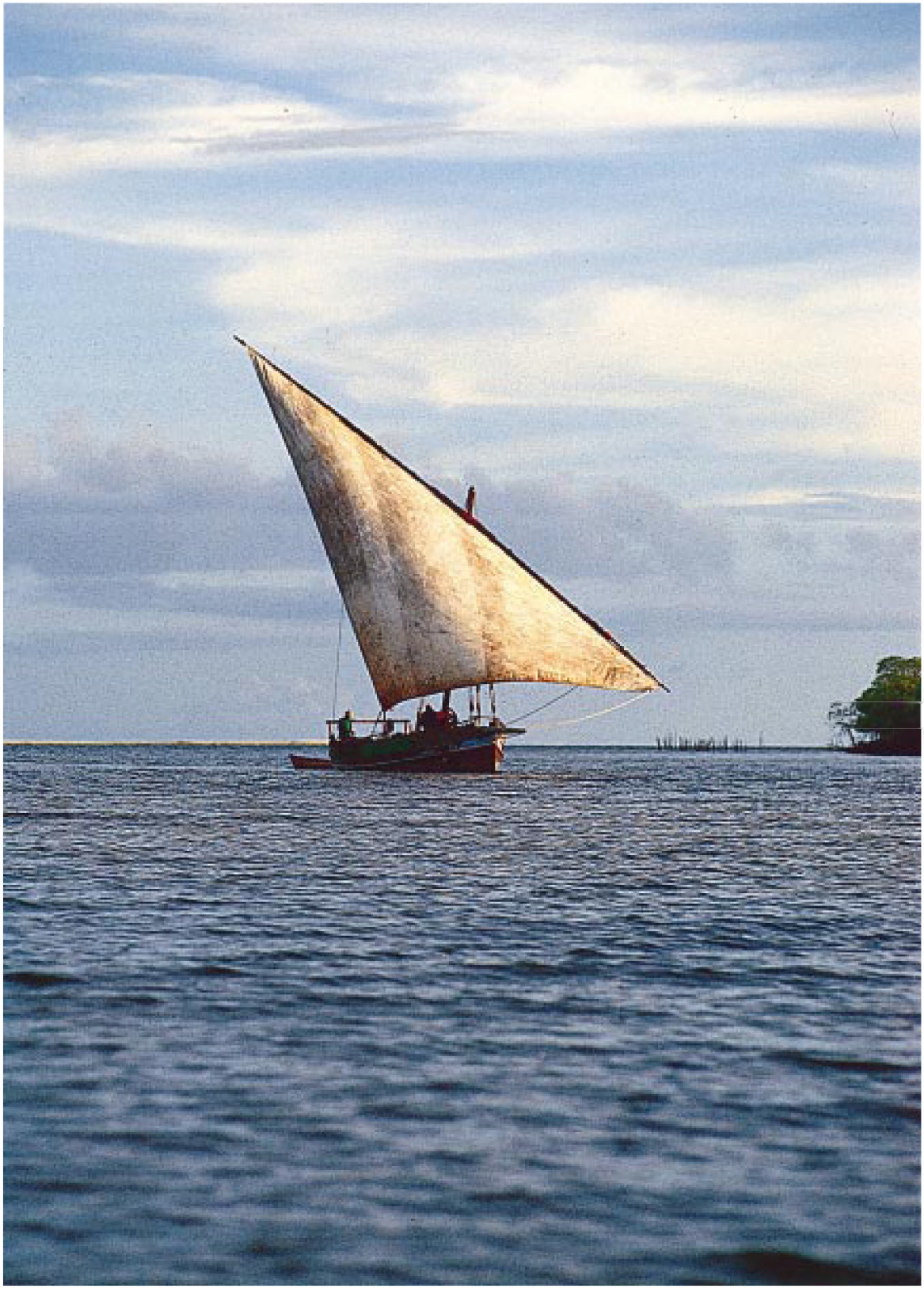


Figure 3 : Ngalawa under sail

Vuma cliffs looking north

THE COASTAL ENVIRONMENT

PHYSICAL CHARACTERISTICS

CLIMATE

The Kenyan coast runs in a southwesterly direction from the Somalian border in the north, at 1° 41'S to 4° 40'S at the border with Tanzania. It lies in the hot tropical region where the weather is influenced by the great monsoon winds of the Indian Ocean. Climate and weather systems on the Kenyan coast are dominated by the large scale pressure systems of the western Indian Ocean and the two distinct monsoon periods.

From November/December to early March, the Kenyan weather, particularly at the Coast, is dominated by the Northeast Monsoon which is comparatively dry. During March and April the wind blows in an east-to-southeasterly direction with strong incursions of maritime air from the Indian Ocean bringing heavy rains. During the months of May, June, July and August, the Southeasterly Monsoon influence gradually sets in and the weather becomes more stable with dull and comparatively cooler temperatures. Between September and November, the Northeast Monsoon gradually re-establishes itself and by December the northern influence is dominant once again.

Rainfall

A relatively wet belt extends along the entire Indian Ocean coast of Africa and annual rainfall on the Kenyan coast follows the strong seasonal pattern outlined above. The main rains come between late March and early June with the rainfall decreasing from August. Some rain occurs between October and November but from December, rainfall decreases rapidly once again to a minimum during January and February.

Mean annual total rainfall ranges from 508mm in the drier, northern hinterland to over 1,016mm in the wetter areas south of Malindi. Relative humidity is comparatively high all the year round, reaching its peak during the wet months of April to July. However, there is a marked diurnal change particularly in Mombasa where it is around 60-70% during the afternoon, rising to 92-94% during the night and in the early morning.

Records kept for Mombasa and Malindi indicate that both are generally sunny throughout the year. The average number of daily sunshine hours at Mombasa are 8.4 in July and 8.9 in February, October and November. The corresponding values for Malindi are 7.3 in July and 9.3 in December.

Evaporation at Mombasa increases from a low of 138mm in July to 221mm in March. Whereas in Malindi the low in July is around 128mm, rising to 193mm in March.

Wind

The windiest time of the year at the Kenya Coast is during the Southeast Monsoon from May to September, while the calmest months are March and November when the winds are also more variable in direction.

Wind records from Lamu, Malindi and Mombasa show a consistent daily pattern whereby wind strength (in knots) drops during the night and is always less at 0600 than at 1200. This pattern is less pronounced in Lamu which also tends to be the windiest place on the Coast at 0600. Overall, it would seem that Mombasa is the windiest, but the strongest winds are likely to be experienced in August in Malindi.

Table 1 : Seasonal wind speeds on Kenya coast

wind speed (knots)		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
at 0600	LAMU	5.6	5.3	3	6	8.3	9.6	9	10	8.6	6.6	4.3	5
	MALINDI	4.3	3.6	1.6	6.3	6.6	8	7	7.3	7.6	6	3	3.3
	MOMBASA	5.5	5.2	1.2	8	8.5	8.7	8	7.7	7.7	5.7	2	4.5
at 1200	LAMU	9.3	10.6	8	9	10	10.3	10	10	9.6	10	7.6	9.3
	MALINDI	10.6	11.3	9.3	10.6	10.3	10.6	11	12.3	10.6	10.3	8.3	9.6
	MOMBASA	11.7	11.7	10	10.7	10.5	11.7	11.2	11.2	11	11	9.7	10
overall average for coast		**7.8**	**7.9**	**5.5**	**8.4**	**9**	**9.8**	**9.3**	**9.7**	**9.3**	**8.2**	**5.8**	**6.9**

Figure 4 : *Temperature, humidity and rainfall averages for Mombasa*

Figure 5 : *Average monthly wind strength and direction recorded at the fishing grounds along the Kenya coast between 1979 - 1981 on board "R.V. Ujuzi".*

GEOLOGY AND GEOMORPHOLOGY

The Kenyan coastal environments are set in a passive continental margin, the evolution of which was initiated by the break-up of the mega continent Gondwanaland in the Lower Mesozoic. The initial opening of the Indian Ocean was preceded by doming, extensive faulting and downwarping similar to that observed in the modern Great Rift Valley of East Africa. These tectonic movements formed a North-South trending depositional basin. During the Mesozoic, this basin was exposed to numerous marine incursions and by the Jurassic, purely marine conditions are thought to have existed. The coastal range running parallel to the coastal zone appears to have been uplifted through faulting during this time.

Throughout the Tertiary, the coastal areas experienced further faulting and extensive continental erosion. The older Cretaceous deposits were totally removed in many areas. The present coastal configuration, however, evolved during the Pleistocene to Recent times, a period marked by numerous fluctuations in sea level.

Three physiographic zones are observed on the Kenya coastal zone. The Nyika lies at 600m above the present sea level and represents the higher ground covered by the Duruma sandstone series and older rocks to the west. The Foot Plateau occurs at an elevation between 140m and 600m above the present sea level. This coincides well with the relatively younger Jurassic rocks. The Coastal Plain, the lowest step, rises from sea level to 140m. On average, this belt increases from a few kilometres wide in the southern sector, to over 40km in the north. The geomorphology of the Coastal Plain is dominated by a series of raised old sea level terraces. Most of the coastal environment and the modern shore configuration, follow the 0-5m and the 5-15m sea level terrace complexes.

Due to its evolutionary history, the principal rocks observed along the Kenyan coastal margin, are of sedimentary origin and range in age from Triassic to Recent. The Duruma Sandstone series, the oldest formation, is represented by the Mariakani and the Mazeras sandstones which were deposited under sub-aqueous, deltaic, lacustrine or possibly neritic conditions that prevailed before the opening of the Indian Ocean. The Upper Mesozoic is represented by marine limestones and shales with occasional horizons of sandstones and early limestones. Cenozoic to Recent rocks comprise mostly of marls and limestones, and are represented by the sandstones, clays, conglomerates and gravels such as the Marafa beds. Quaternary representatives include windblown Magarini Sands, limestones, cemented sands and coral sands. Recent unconsolidated windblown sands, beach sands and clays overlie the older units.

Kenya has a coastline of over 600km, but the exact figure depends on the extent to which small islands are included in the measurements. The Kenyan coastal region is generally low-lying and characterised by the extensive fossil reef which lies a few metres above present sea level. The coastal plain is backed in the interior by a line of hills that rarely exceed 300m except in southern parts where the Shimba Hills reach an altitude of around 1,000m above sea level. Further inland the Taita Hills rise to an elevation of 1,500m above sea level.

Soils of the coastal region show considerable variety. The porous parent rocks of sedimentary origin, generally give rise to soils of low fertility. However, patches of highly productive soils have been observed in areas of alluvial deposits. The principal soil types in the region include a narrow strip of coastal sands towards

the north where it is permeated by narrow bands of grumosolis brown clay soils. The soil south of Lamu is composed of bi-alternate bands of loams beyond which the grumosolis are permeated by thick bands of ash and pumice soils.

The shoreline in most of the region apart from the Malindi area, is receding as a result of coastal erosion. Sand supplies from rivers and coral reefs are not sufficient to keep up with the rise in sea level and the problem is further exacerbated by coastal development.

Shipwrights, Mombasa

Classification of the Kenya Coastline

Many attempts have been made worldwide to classify coastlines. Usually, these classifications are meant to reflect the coast's vulnerability to oil pollution damage and are based on the geomorphology and degree of exposure of a particular stretch of coast. While providing some assistance to those dealing with an oil spill emergency, such classifications do not convey any information on the ecological value or sensitivity of the coast.

The classification adopted for this Atlas is also based on coastal geomorphology and degree of exposure but, in addition, it also takes into account the ecological value and biodiversity of the particular stretch of coastline. This classification is comprised of ten categories or types, each of which is described in Table 2 in terms

of its ecological value, vulnerability and sensitivity. However, in determining the classification of a particular stretch of coast, it must be remembered that there is no definitive and precise measure of qualities such as value and importance. Neither is there an accurate measure of vulnerability. The classification is therefore a comparative one and one which is derived from the collective opinion, experience and technical judgement of experts from the region.

Living coral reefs occur all along the length of the Kenyan coast. A fringing reef colonizes the shallow parts of the continental shelf along most of the Kenyan coastline to a depth of around 45m and at a distance of between 500m and 2.0km offshore, except where river systems create conditions of low salinity and high turbidity which limit coral growth. Estuaries and deltas are characterized by extensive mangrove forests.

The width of the continental shelf off the Eastern African coast varies markedly throughout the region, but it is generally quite narrow. Kenya, with a coastline of about 600km, has an estimated continental shelf area of about 19,120km^2. Of this, some 10,994km^2 is considered trawlable. South of Malindi the continental shelf extends only 5km offshore, whereas north of Malindi, in the North Kenya Banks, the edge of the shelf is about 60km offshore.

Table 2 : Coastline classification

Type	Description	Notes
10	sheltered mangrove swamps, creeks, estuaries, marshes	*Protected from wind and wave action, highly productive environments; easily damaged physically and through pollutants; mainly intertidal - regularly exposed and submerged.*
9	sheltered tidal flats, seagrass meadows	*Mainly submerged but exposed at extreme low tides; usually subjected to medium wave energy; biological activity high.*
8	coral reefs	*Mainly submerged and subjected to significant wave action; high productivity; very susceptible to water pollution.*
7	sheltered rias, sheltered rock coasts	*Reduced wave action, mixture of subtidal, intertidal and littoral; often with extensive seaweed forests subtidally.*
6	exposed tidal flats exposed mud flats	*Exposed to wave action; relatively high biodiversity.*
5	sheltered, fine-grained sand beaches	*Generally sheltered beaches inside lagoons or behind the protection of a coral reef, subjected more to wind than wave action; productivity medium to high.*
4	exposed nearshore rocky platforms	*Subjected to increasing wind and wave action; mainly subtidal; high productivity particularly of some algal species.*
3	exposed gravel, pebble, cobbles and boulder beaches	*Exposed to wave action, usually with prominent storm ridges and steep profiles; productivity low.*
2	exposed compacted sand beaches, wind-blown sand dunes	*Generally flat and very long stretches of beach without the protection of a reef; or accumulated sand dunes which are rarely behind the protection of a reef and usually open to wind and wave action; medium to low productivity.*
1	exposed cliffs, steep rocky coasts, man-made structures	*Usually steeply dipping, near vertical walls; rocky headlands; exposed to wind and wave action; medium to high productivity.*

HYDROLOGY

Rivers and Catchments

The hydrology of the coastal region of Kenya can best be viewed by examining the drainage patterns of both perennial and seasonal rivers draining into the western Indian Ocean basin. There are two main perennial rivers namely the Tana River and the Sabaki River which also incorporates the Athi and Galana Rivers. Each of these perennial rivers has catchments extending far from the coastal hinterland into the high country of the Mount Kenya region and the Aberdare (Nyandarua) Ranges in central Kenya.

The Tana River is the longest in Kenya being approximately 850 km in length and it has a catchment area of 95,000 km^2. The Tana is regularly replenished by a number of tributaries which have their headwaters on Mount Kenya. Several hydroelectric power schemes have been constructed on its upper reaches, including those at Masinga, Kamburu, Gitaru, Kindaruma and Kiambere. In terms of annual freshwater and sediment discharges, the Tana River has the greatest volume of freshwater and the highest amount of sediment. An average of 4,000 million m^3 of freshwater are discharged annually with peak flows occurring between April and June and a shorter high flow period during November/December. The Tana River also discharges some 3 million tonnes of sediment per year. It enters the ocean about halfway between Malindi and Lamu, near Kipini, into Ungwana (Formosa) Bay. However, before it does, and about 30km upstream, it gives off a branch which leads to the complex of tidal creeks, flood plains, coastal lakes and mangrove swamps known as the Tana Delta. The Delta covers some 1,300 km^2 behind a 50m high sand dune system which protects it from the open ocean in Ungwana Bay.

Figure 6: Sand dunes at the Tana River mouth

The Sabaki River (also known as the Athi and Galana in its upland stretches) is the second longest with a length of 650km and a catchment area of 70,000 km^2 extending into the southeastern slopes of the Nyandarua Range in central Kenya. Its floodplain is less extensive than that of the Tana River and its catchment comprises important agricultural regions of central Kenya. The combined Sabaki River discharges 2,000 million m^3 of freshwater and 2 million tonnes of sediment annually into southern Ungwana Bay through the Sabaki estuary north of Malindi.

The high sediment loads carried by the Tana and Sabaki rivers are partly attributable to poor land use practices in their upper catchments which are important agricultural lands. Such a high rate of sediment discharge is threatening the sustainability of marine and coastal ecological biotopes such as mangroves, seagrass meadows and coral reefs. In addition, the high concentrations of silt in river water makes it unattractive for recreational purposes and limits the extent to which river water can be used for other purposes.

There are also a number of semi-perennial and seasonal rivers such as the Mwache, Kombeni, Tsalu, Nzovuni, Umba, Ramisi, Mwachema and Voi, all of which drain into the coastal region from arid and semi-arid catchments.

The Ramisi River, which arises in the Shimba Hills forested area, discharges 6.3 million m^3 of freshwater and 1,500 tonnes of sediments annually into Funzi - Shirazi Bay in the southern part of the Kenya coast. The Umba discharges 16 million m^3 of freshwater into Funzi - Shirazi Bay while the Mwachema and Mwache rivers discharge 9.6 million m^3 and 215 million m^3 of freshwater annually, respectively. Other small streams such as Mto Mkuu, Tsalu, Sinawe, Kombeni, etc, have not been gauged.

These rivers draining the coastal low plateau and the coastal ranges tend to have relatively low concentrations of silt. Since their water quality is also moderately high, these waters are normally usable for a variety of purposes with minor conventional treatment.

Coastal Lakes

There are a number of lakes in the Kenya coastal region with the greater number being found in the Tana Delta. Most of these lakes are quite small and shallow and are typical oxbow lakes, remnants of the various meanders of the Tana river. Two good examples of such lakes are Bilisa and Shakabobo. Some of the lakes, especially the smaller ones, show swamp characteristics. Examples of such lakes are Ziwa la Chakamba, Ziwa la Taa, Ziwa la Maskiti and Ziwa la Ndovu. These lakes are either recharged through ground water seepage or by the periodic flooding of the Tana River.

Apart from these oxbow lakes in the Tana Delta area, there are two larger lakes in the Mount Kilimanjaro region. These are Lake Jipe which has a maximum length of 12 km and an area of 28 km^2, and Lake Chala which is smaller than Lake Jipe and has an area of 5.0 km^2 and a maximum length of 2.2km. These lakes receive ground-water contributions from the Mount Kilimanjaro region in addition to being recharged by surface runoff.

The coastal lakes of Kenya are very important economically. They are a source of water for domestic and livestock purposes and are also important sources of fish protein. More recently, they are also becoming important for recreational activities. In general, water quality in these lakes is good since they are located some distance away from the main pollution sources.

Figure 7: Water lilies make a fine display in a small coastal lake.

Ground-water resources

The coastal region of Kenya has enormous potential in terms of ground-water resources. This is as a result of its geological structure which promotes rapid infiltration and percolation of surface runoff to recharge. Hot water springs with temperatures ranging between 65°C and 75°C are found near Mkongani and Mwananyamala in Kwale District which is also the site of other potable freshwater springs.

The rate of ground water yield varies from place to place depending on physiographic and hydraulic factors in addition to geological influences. Highest ground-water yields are experienced in areas covered with Kibiongoni beds, and Magarini and Kilindini sands on the coastal belt (for example at Tiwi). Areas covered with Jurassic shales and Pleistocene limestone of the low plateau and coastal belt tend to yield relatively poor quality water and yields are normally lower in volume when compared with areas covered with Kilindini and Magarini sands. Areas with Triassic sandstone geology also have relatively high ground-water yields.

Chemical analysis of ground-water from boreholes, wells and springs throughout the coastal area has been undertaken by the Government Chemist's Department, Mombasa Laboratory. A ground-water quality map of Kenya covering the coastal area is available.

Four main types of ground-water have been identified according to their anionic content - carbonate, bicarbonate, chloride, and sulphate.

Mixed types of ground-water composed of carbonate, bicarbonate, chloride and sulphate types, have also been reported in certain locations in the coastal belt.

The main factors that control the quality of ground-water are the permeability of the rock, the rock type and the degree of recharge from surface runoff and rainfall. Water of the poorest quality, with high total dissolved solids (TDS), is associated with the poorly drained Jurassic shales; intermediate quality water is associated with Triassic sandstones and Pleistocene coral limestone; while the best quality is associated with unconsolidated sands (Magarini and Kilindini) that receive efficient recharge due to their high infiltration capacities.

Ground-water quality also varies depending on the depth of the borehole or well, nearness to the ocean and proximity to human settlements. Boreholes and wells located near the coast have problems with seawater intrusion and this problem is exacerbated by overextraction. Boreholes and wells located in urban areas such as Mombasa and Lamu have the added threat of pollution originating from pit-latrines and septic tank-soak pit systems which are often the source of contamination of the otherwise potable water, rendering it unsafe for drinking without disinfection.

The exploitation of ground-water resources in the coastal areas of Kenya has been haphazard with no strict government control on borehole drilling and development. With the current problems of water supply deficit and increased urban and rural populations, people of the coastal region (and especially in urban areas such as Mombasa) are increasingly relying on ground-water resources to supplement reticulated water supplies. The south coast areas of Mombasa and Kwale District depend predominantly on ground-water which comes from the Tiwi and Ukunda areas. Many of the middle and higher class tourist hotels are also drilling their own boreholes to augment the reticulated water supply system.

OCEANOGRAPHY

Coastal currents

There are four oceanic currents affecting the Kenyan coast. These are the South Equatorial Current, the East African Coastal Current, the Equatorial Counter Current and the Somali Current. The westward moving South Equatorial Current divides into two branches once it reaches the African coast at Cape Delgado. It gives off the Mozambique Current which flows southwards, and the East African Coastal Current which flows northeastwards, parallel to the coast.

The East African Coastal Current flows northwards all the year round at least as far as Malindi. During the Southeast Monsoon it continues beyond Malindi northwards, joins with the Somali Current and continues right to the Horn of

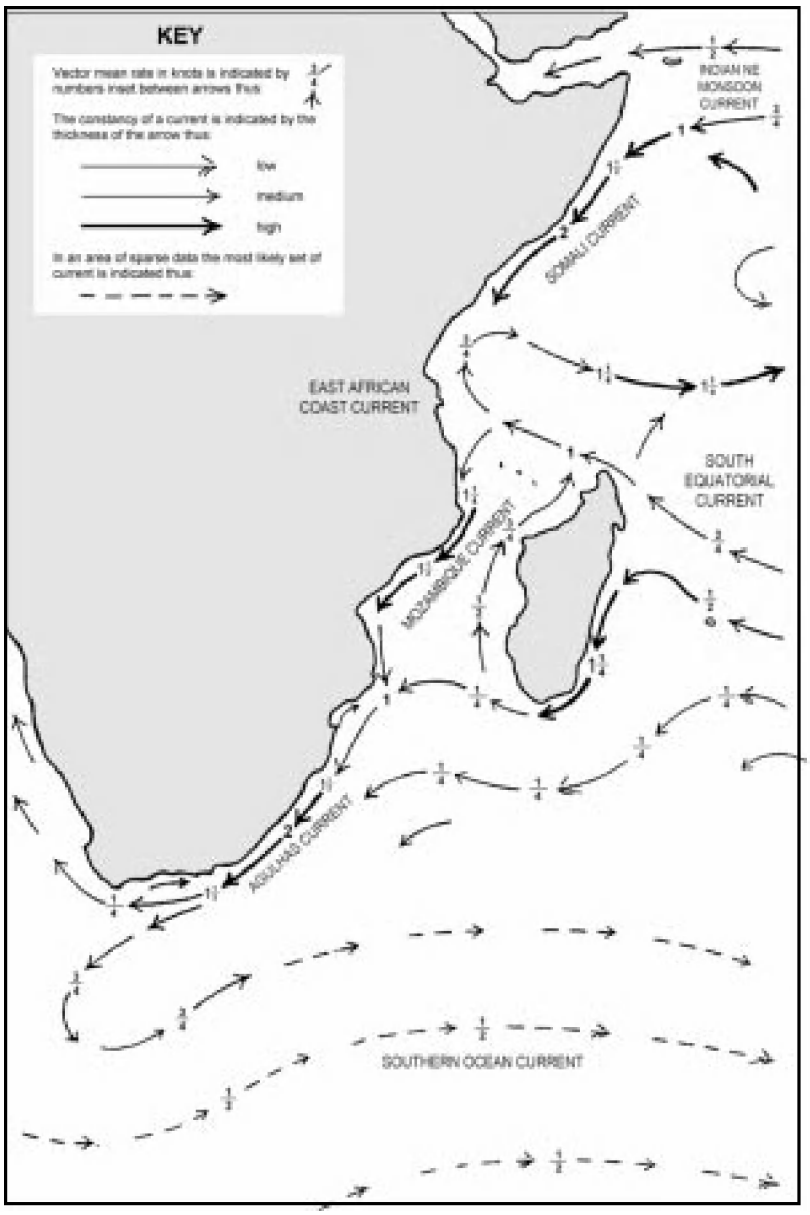


Figure 8a : Vector-mean currents for January

Africa. During the Northeast Monsoon (November to March), however, the northward extent of the East African Coastal Current is more restricted. At this time it meets and joins the southward flowing Somali Current (which changes direction under the influence of the monsoon) with this convergence taking place anywhere between Malindi and north of Lamu, depending on the strength of the monsoon in any particular year. The two streams then turn eastward and flow offshore as the Equatorial Counter Current.

The Somali Current is the only one that reverses its direction of flow under the influence of the monsoon. It flows in a southwesterly direction at about 1.5-2.0 knots with the Northeast Monsoon (November to March). While during the Southeast Monsoon (April to October), the Somali Current reverses its flow and increases its velocity to around 2.0-2.5 knots. It now appears as the northwards extension of the East African Coastal Current which still arises from the onshore

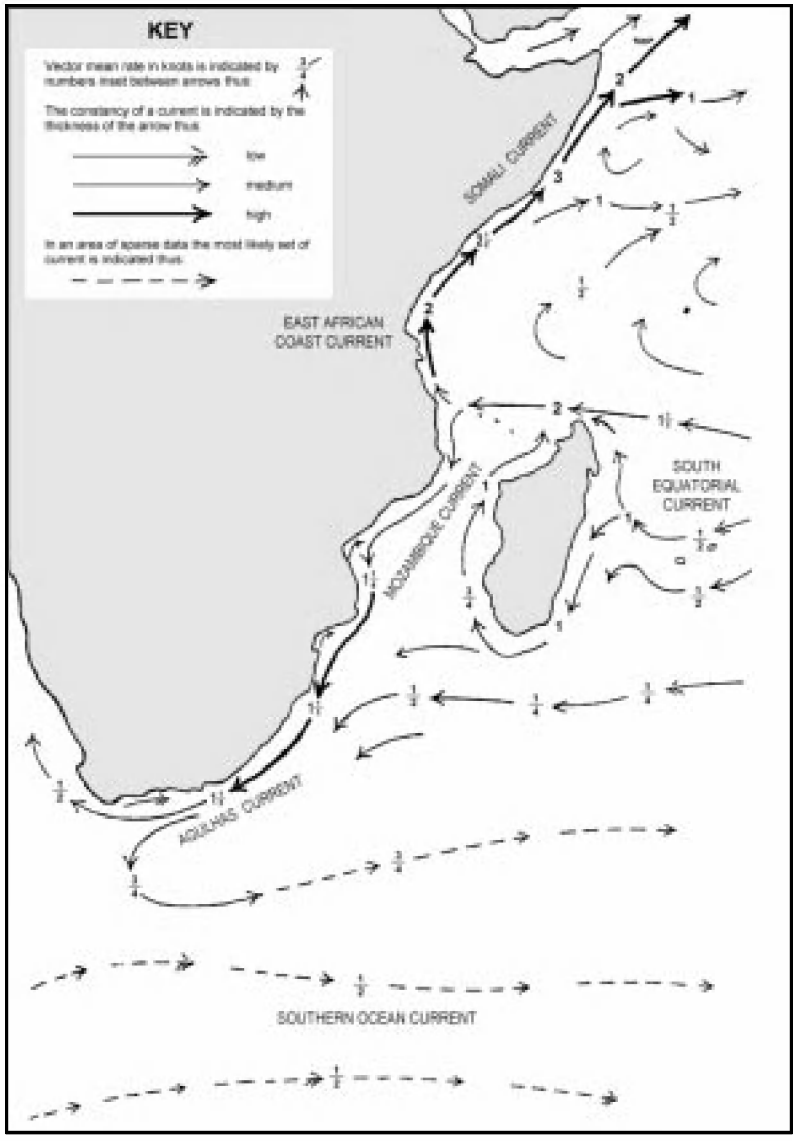


Figure 8b : Vector-mean currents for July

South Equatorial Current. At this time of the year, the Equatorial Counter Current is not so distinctive from the general Southwest Monsoon Drift at the lower northern latitudes of the Indian Ocean.

The net onshore currents result in the sinking of surface waters along most of the Kenyan coast. The exception is near Kiunga where some mild upwelling is thought to occur during the Northeast Monsoon.

Tides

Kenyan coastal waters are characterized by semi-diurnal tides - approximately two tidal cycles for every 24 hour period. Except for limited periods in the year, however, the levels of high and low water of each successive tide differ appreciably from the corresponding tide before and the tide following. The tides can therefore be designated as mixed semi-diurnal tides.

The reference port for tidal observations in Kenya is Kilindini (Port Mombasa) where the maximum tidal range does not usually exceed 3.8m but may occasionally go beyond this. Tidal range for Malindi is 2.0m for neap tide and 2.9m for spring tide. There is a lag in the tidal state which increases with distance north along the Kenyan coast. Malindi is normally 5 minutes after Kilindini while Lamu is about 40 minutes behind.

Deviations from the predictions in tide tables are influenced by barometric pressure, onshore winds and oceanic swell. However, the lowest tides occur persistently during the Northeast Monsoon since they combine with the prevailing winds to drive water offshore.

Figure 9 : Southermost mouth of the Tana River

Sea temperature and salinity

Sea surface temperature and salinity also vary with the monsoon season. The highest temperatures of 28-29°C occur following the Northeast Monsoon in the months of March and April. On the other hand, the lowest sea surface temperature occurs in August and September with a minimum of 24°C.

During the Southeast Monsoon the shifting of ocean currents brings Pacific Ocean water of high salinity into the South Equatorial Current while during the Northeast Monsoon the South Equatorial Current draws water of low salinity from the Malay Archipelago. These changes in turn result in higher and lower salinities of the East African Coastal Current waters. A further influence on salinity is the incidence of rainfall, especially the heavy rains of March to May when the discharges from all major river systems as well as all the more minor seasonal ones are at the maximum. As can be expected, offshore waters are influenced mainly by the oceanic currents and surface water salinities in Kenyan coastal waters vary from a minimum of 34.5‰ to a maximum of 35.4‰. The influence of the river outflow is contained mostly in inshore areas by the prevailing wind conditions and much wider variations in salinity do occur at the local level.

Concentration of Chlorophyll-a

A measurement of the concentration of Chlorophyll-a is used as an indicator of ecological productivity.

As can be seen from Table 3 below, the concentration of Chlorophyll-a in Kenyan surface waters is highest during the Southeast Monsoon and at this time of the year, the concentration decreases with depth. However, during the Northeast Monsoon the gradation in concentration is exactly reversed with the highest levels found at 50 metres and decreasing towards the surface. If the average for the whole water column is considered, concentration is highest during November to April. On the other hand, there is a tendency for Chlorophyll-a concentration to increase northwards along the coast during May to October. This is thought to be the result of the Somali upwelling.

Table 3 : Concentration of Chlorophyll-a in Kenyan coastal waters (mg/m^3)

Depth	May to October (South East Monsoon)	November to April (North East Monsoon)
Surface	0.30 to 0.50	0.10 to 0.20
At 25 metres	0.20 to 0.30	0.30 to 0.50
At 50 metres	0.10 to 0.20	0.30 to 0.50

COASTAL ECOSYSTEMS

Figure 10 : Reforestation at Jilori

COASTAL FOREST AND BUSHLAND

The coastal forest communities of Kenya exist mainly as isolated blocks which show high levels of species endemism and comprise a total of about 83,800ha in a narrow belt which extends inland for about 30km. The forests are characterized by dense or moderately dense stands of tall trees, species of the genera *Sterculia, Chlorophora* and *Memecylon*. The drier woodlands include stands of *Cynometra, Manilkara* and *Afzelia*. Centuries of human occupation have reduced the forest element which was originally more extensive. Mangrove swamps occur in tidal estuaries and lagoons while coconut palms are common above high tide. A complex of many bush types occur in the high bush area. Scattered baobab trees present a striking appearance while the prevalence of mango trees underlines long human occupation of the more productive areas.

There are an estimated 257,200ha of coastal evergreen bushland. Characteristic woody plants found in this area include *Crossopterix febrifuga, Piliostigma thonningii, Annona chrysophylla, Heeria mucronata, Lantana camara, Rhus natalensis, Securinega virosa*, etc. These areas are not noted for abundance of wildlife except for monkeys, baboons, birds and rodents.

The coastal high bush merges into the hinterland foreland region through a transitional vegetation where Acacia species and *Euphorbia candelabrum* are more prominent. Other chief constituents including *Diospyros, Terminalia* and *Combretum* species may also be found in the transition zone.

Coastal palm stands, which total about 55,500ha, are characterized by *Hyphaene* and *Borassus* palms on open grasslands. Such areas are important for birds and monkeys.

COASTAL GRASSLANDS

Many open areas at the coast are dominated by rank growth of grass about 2-3m high. In the Tana River Delta alone, approximately 67,000ha are covered by floodplain grasslands. A variety of grassland associations occur, including a widespread tall grass found in heavy black clays and areas with open water which is dominated by *Echinochloa haploclada* with *Bothriochloa glabra, Setaria splendida* and other less common species. Sedges (*Cyperus* spp.) are common in the wetter areas and they may be dominant in permanent swamps. In areas with more sandy soils and less risk of flooding, usually the levees associated with the old and present Tana River courses, a variety of grass species occurs. The two main grasses are *Digitaria alscendens* and *Sporobolus confunis*. A third grassland type is dominated by tall stands of *Panicum maximum* growing to a height of over 2m in places. On the inland side of the coastal sand dunes and mangroves, a salt tolerant grassland occurs which is dominated by the tough, spiky *Sporobolus spicatus* in association with the salt bush *Suaeda monoica*.

MARINE BEACHES AND DUNES

Marine beaches and dunes occur along the coastal areas and are usually characterized by bare sand dunes. Often they are only lightly vegetated by highly specialized colonizing plants, but at times the woody vegetation cover can be relatively heavy at 70%. Common plants include *Balanites* sp., *Dombeya* sp., and *Grewia* sp., which can form a thick shrub layer while common tree species include *Hyphaene coriacea, H. compressa, Garcinia livingstonei, Euphorbia candelabrum* and *Afzelia quanzensis. Ipomea pes-caprae*, a creeping vine, forms a dense mat seaward above the high water mark. There are an estimated 27,000ha of beach and dunelands in Kenya.

ESTUARIES AND OTHER WETLANDS

The Kenya coast has a number of estuaries which came about as a result of sea-level rise (or land subsidence) during recent geological time. These include Mombasa, Shimo la Tewa, Kilifi, Turtle Bay and the area around Lamu. These estuaries are the flooded lower courses of rivers that about 18,000 years ago flowed to a shoreline that may have stood about 160m lower than it does today, and thus several kilometres offshore.

These estuaries are generally sheltered from high energy waves and receive fine-grained sediments from inflowing streams. Their shores have been colonized by mangrove trees and associated plants. Several human-induced changes have also taken place in these estuaries. The clearing of mangrove forest for example, exposes the soft shores and leads to erosion. On the other hand, increasing amounts of sediment brought down by rivers such as the Tana and the Athi-Galana-Sabaki complex, are fed into the inshore environment, leading to accretion.

The Sabaki forms a very important floodplain at its lower course near Malindi. In the last 80km, the river drops 100m and forms a broad floodplain in which permanent and temporary lakes are common. There are subsistence fisheries on the lower reaches of the Sabaki River operated by the Orma and Giriama people. Lungfish (*Protopterus* spp.) and catfish (*Clarias* spp.) are the largest fish of the Sabaki with the latter reaching up to 10kg in weight. Two cichlid species (*Sarotherodon mossambicus* and *S. spirulus nigra*) also occur in the lower Sabaki and reach up to 2kg in weight.

Freshwater prawns are also abundant and make a valuable contribution to the local fishery. The main species are *Macrobrachium lepidactylus* (which reaches 40g in weight), *M. rude* and *M. scabrinsculum.*

The Tana River delta is Kenya's only major ocean delta. It is a low-lying area composed largely of sediments brought down by the river. It is subject to frequent flooding and changes in the network of channels and canals. The input of water is almost exclusively from the river itself because of the net outward flow of water, except in situations where invasions of saltwater occur such as under certain meteorological conditions. The delta maintains high levels of productivity in a dynamic balance which revolves around the frequency, extent and duration of flooding. Water circulation transports nutrients, influences a wide variety of habitat types, flushes away wastes, controls salinity and disperses and nurtures larval stages of a number of coastal organisms.

The basins of oxbow lakes and the deeper parts of dammed lakes where water remains for most of the year include Lakes Bilisa, Shakababo, Kongolola, Kitumbuini, Dida Warede, Harakisa, Moa and Kenyatta. In these lakes, profuse growths of true aquatic plants occur. The Nile cabbage or water lettuce (*Pistia stratiotes*) carpets the water surface and interspersed with it are the water lily (*Nymphaea lotus*) and the floating aquatic fern (*Azolla nilotica*). Lake Bilisa is an expansive wetland dominated by grasses, sedges, floating macrophytes and submerged macrophytes. The dominant plant species include aquatic grasses (*Bothriochloa bladhii, Echinochloa haploclada*), sedges (*Cyperus frerei, C. heterophylla, C. tuberosus*), floating macrophytes (*Pistia stratiotes, Azolla nilotica, Lemna spp.*) and submerged macrophytes (*Ceratophyllum demersum*). The lake has abundant bird life and fishing is a major activity with 145 tonnes of fish captured in 1990. The Orma people harvest aquatic grasses as fodder for their livestock. They also use sedges for thatching.

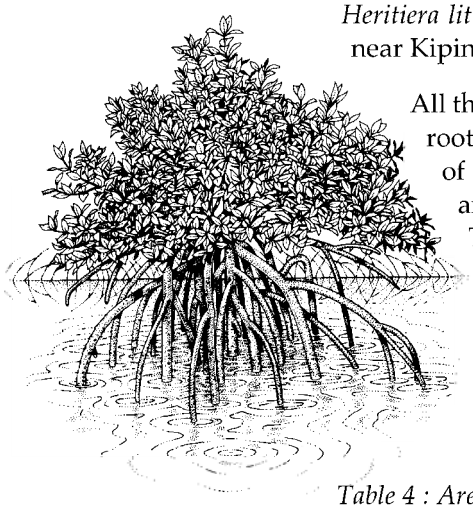
Lakes Shakababo and Kongolola have relatively clear waters and among the fish species that made up the 82 tonnes caught in 1991, were 'Barabara' (*Oreochromis mossambicus*), 'Chokole' (*Synodontis zambesiensis*), 'Pawa' (*Mormyrus sp.*), 'Pumi' (*Clarias mossambicus*), 'Borode' (*Labeo gregorii*), 'Kamongo' (*Protopterus amphibius*) and 'Mkunga' (*Anguilla mossambicus*).

Traditional land-use practices of small-scale agriculture, pastoralism and fishing have, in the main, maintained the ecological balance of the Tana River Delta for thousands of years. However, more recent human influence has been very strong in the Tana Delta. Most notably, the draining of land for agriculture and the control of water flow for irrigation and hydro-power production have left their mark.

MANGROVES

There are 8 species of mangrove trees and shrubs found along the Kenya coast - *Rhizophora mucronata, Ceriops tagal, Bruguiera gymnorrhiza, Sonneratia alba, Xylocarpus granatum, Avicennia marina, Lumnitzera racemosa and Heritiera littoralis.* The mangrove swamps along the Kenyan coast cover approximately 53,000 hectares (see Table 4) with the largest stands occurring in the Lamu area and the Vanga-Funzi coastal system near the Kenyan-Tanzanian border. The mangrove forests around Lamu are the second largest on the Eastern African coast and amount to 460km^2.

None of the mangrove species is endemic to Kenya. The commonest Kenya mangrove species are *Rhizophora mucronata* (the red mangrove) and *Avicennia marina* and both are found all along the entire Kenyan coast. On the other hand, *Heritiera littoralis* is found only in a small pure stand at the Tana River estuary near Kipini.



All the Kenyan mangroves except *Sonneratia* are viviparous, most have stilt roots and pneumatophores. *Avicennia* and *Sonneratia* are the first colonizers of the swamps. Once established, mud accumulates around their roots and produces favourable conditions for *Ceriops* and *Rhizophora* species. The latter is the commonest and most important constituent of the Kenyan mangrove swamps. It usually occupies the most favourable sites between *Sonneratia* and *Avicennia* on the creek edges, with *Ceriops* on the landward side. *Bruguiera* is normally found scattered within stands of *Rhizophora*.

Table 4 : Areas of mangrove on the Kenyan coast

locality	district	area (ha)
Kiunga	Lamu	3,025
Lamu	Lamu	30,475
Kipini (Witu)	Tana River	1,595
Mto Tana (Witu)	Tana River	250
Mto Kilifi (Witu)	Kilifi and Tana River	2,335
Mto Fundisa (Ungwana Bay)	Kilifi	330
Ngomeni	Kilifi	1,815
Mida Creek	Kilifi	1,600
Takaunga	Kilifi	30
Kilifi Creek	Kilifi	360
Mtwapa Creek	Kilifi and Mombasa	525
Tudor Creek	Mombasa	1,465
Port Reitz	Mombasa and Kwale	1,575
Maftaha Bay (Gazi)	Kwale	615
Ras Mwachema	Kwale	5
Funzi Bay	Kwale	2,715
Vanga	Kwale	4,265
total		**52,980**

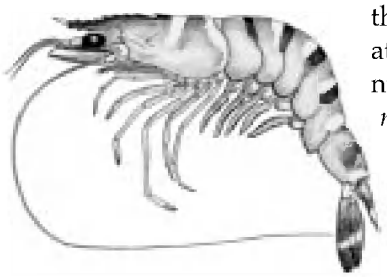
Coastal geomorphology and other abiotic factors influence the zonation of mangroves. In the Western Indian Ocean, *Sonneratia alba* and *Rhizophora mucronata* are usually at the outermost edge on the seaward side, followed by a *Ceriops tagal* zone in the intermediate levels, then by an *Avicennia marina* zone at the higher shore levels, and lastly, *Lumnitzera racemosa*, which usually occurs as a narrow fringe behind the *Avicennia marina* zone at the highest landward zone. Mangroves on the Kenyan coast exhibit this typical zonation pattern. Of the other species, *Bruguiera gymnorrhiza* occurs frequently just above the *Rhizophora* zone, while *Xylocarpus granatum* is most often found well above the *Avicennia* levels. This pattern of zonation exhibited by mature, adult trees, is reflected in the survival pattern of specific seedlings whose dispersal appears to follow both the 'self-planting' and the 'stranding' theories.

Figure 11 : Zonation in a mangrove swamp at Mtwapa Creek

Kenyans have traditionally exploited the rich natural products of the mangrove swamps as well as various parts of the trees themselves (see Table 5). Mangrove vegetation has also been cleared in many places for solar saltworks and, more recently, prawn farms. Loss of mangrove since pre-agricultural times is thought to amount to 70%. However, estimates of the area of mangroves in Kenya have remained constant over the past 20 years, despite extensive subsistence and small market use.

Mangrove forests are an important, if not critical, habitat for a variety of terrestrial and aquatic plants and animals many of which may in turn play an important part in coastal economics. The terrestrial fauna includes many species of birds, reptiles including crocodiles, mammals (pigs and monkeys) and insects; while the terrestrial flora mainly comprises fungi, lichens and mistletoes. At the Tana River near Kipini as well as at the Ramisi River, the animal life is abundant when compared to other mangrove areas in Kenya. Very large crocodiles are very evident here as

are herds of hippopotamus. Frequent marks of buffalo and other large mammals are also commonly found in these mangroves. Other smaller mammals that are known to inhabit mangroves are baboons, duikers, rodents and fruit bats. Bird life is rich and varied in most mangrove forests but especially so at Mida Creek. Many birds depend on the mangrove ecosystem for their existence, but even larger numbers roost on the mangroves and feed on the rich fish resources offshore. Other birds use the mangrove forests as resting and feeding stations as they migrate from and to the rest of Africa.



Penaeus monodon

The aquatic flora and fauna are much more diverse. Many (possibly up to 90%) of the species found in the mangrove forests are known to spend their entire life, or at least a major part of their life cycle in these areas. These species include a number of prawns (*Penaeus indicus, P. monodon, P. semisulcatus, Metapenaeus monoceros*); crabs (*Scylla serrata, Uca* spp., *Sesarma* spp. and *Birgus latro*); molluscs (oysters such as *Brachydontes* spp., and *Crassostrea cucullata*; and cockles, *Donax* spp.).

Mangroves are also of critical importance for a number of coastal fish species. Although they inhabit deeper waters when adults, many species of fish use mangrove areas to feed and as a nursery for their young. The fry of these species stay in the mangrove throughout their juvenile stages benefiting from the shelter, protection and abundant food. Although the role of mangroves in the life cycles of coastal fish in Kenya is not yet fully understood, it is known to be a very important one. Artisanal, commercial and subsistence fisheries, all rely on mangroves for a large part of the catch.

Table 5 : Economic use of mangroves in Kenya

SPECIES	Poles	Tannin & Dyes	Boat-building	Fuel	Medicinal & Food	Various
Avicennia marina		6% tannin, dyes	dhow ribs, canoes	wood used for lime burning	aphrodisiac, contraceptive	drums, carts, beds
Bruguiera gymnorrhiza	boriti, nguzo, telephone poles	53% tannin, dyes		firewood	fish smoking	fishing stakes
Ceriops tagal	fito, mapau, nguzo	24-42% tannin		high quality firewood & charcoal		fishing stakes, fence posts
Heritiera littoralis		14-15% tannin	dhow masts	good firewood & charcoal		
Lumnitzera racemosa	building poles			good firewood & charcoal		
Rhizophora mucronata	majority of building poles	12-50% tannin, dyes		good charcoal		fence posts, fish traps, fishing stakes
Sonneratia alba		15% tannin	boat ribs		camel fodder, condiments, medicaments, fruit edible	carpentry, native huts, fishnet floats
Xylocarpus granatum	poor quality building poles	33% tannin	dhow masts	firewood	fruit infusion, aphrodisiac, medicinals	handcarts, buildings

Sonneratia alba

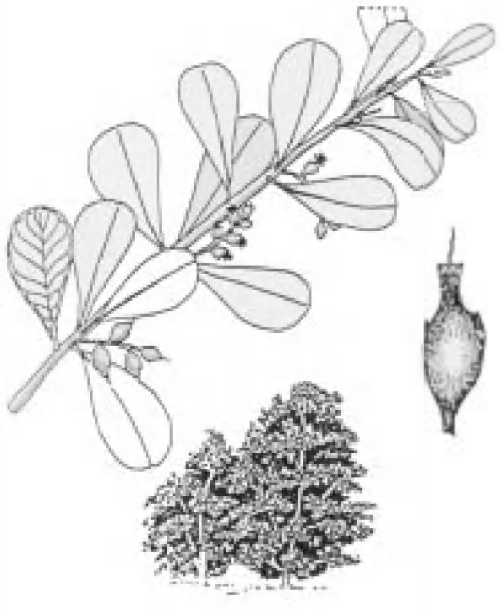
Avicennia marina

Ceriops tagal

Rhizophora mucronata

Figure 12 : Species of mangroves on the Kenya coast

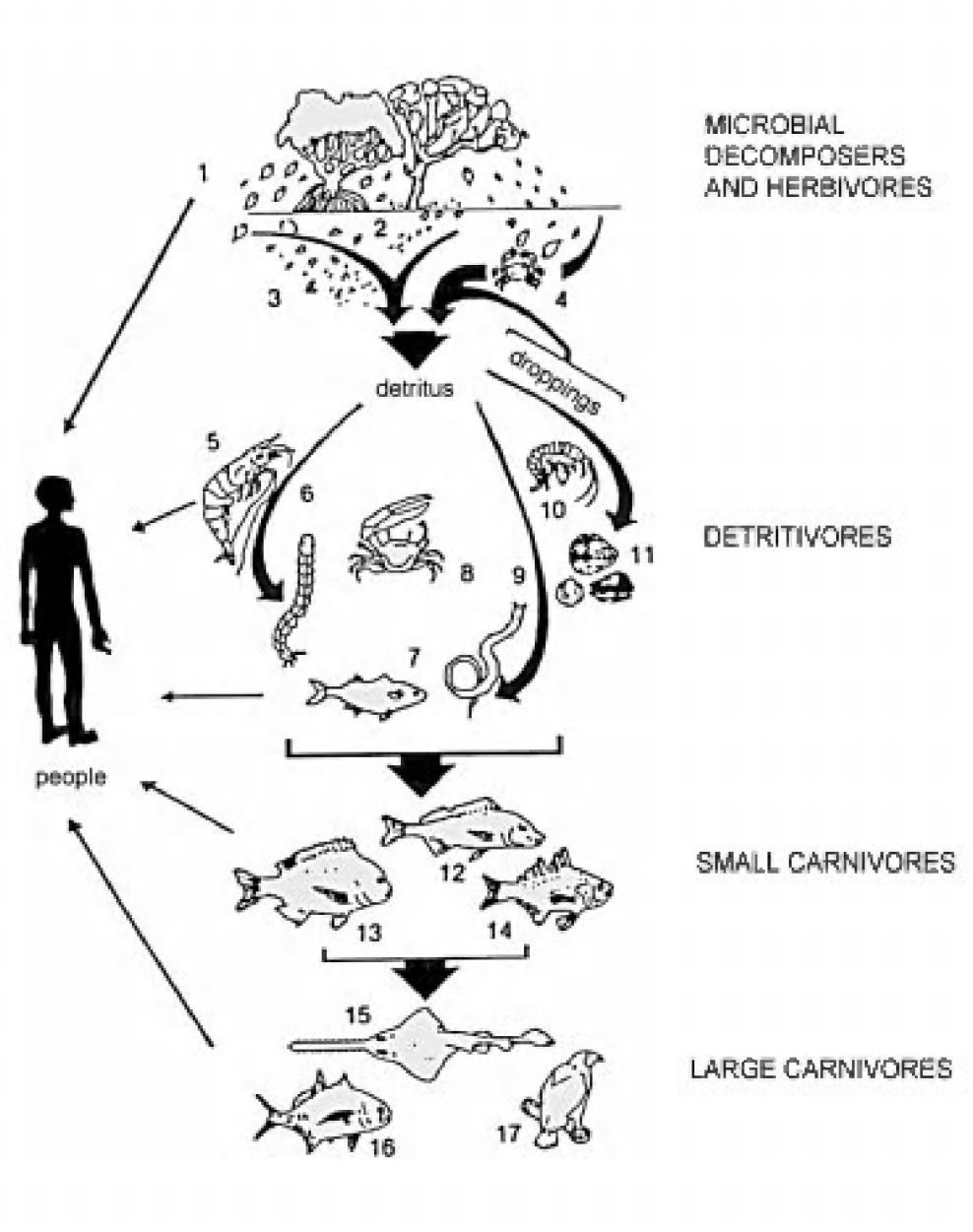
Xylocarpus granatum



Lumnitzera racemosa

Figure 12 : continued

Figure 13 : Mangrove poles ready for the market

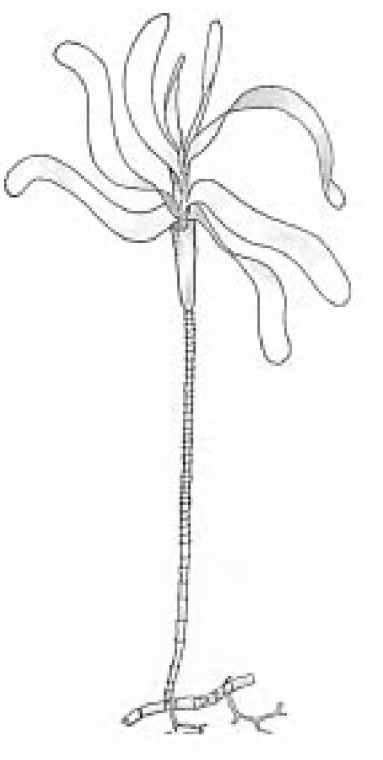


1	leaves	10	amphipods
2	algae	11	bivalve molluscs
3	fungi,protozoa, bacteria	12	grunters
4	sesamid and grapsid crabs	13	emperors
5	shrimps	14	pony fish
6	insect lava	15	sawfish
7	mullet	16	trevallies
8	fiddler crabs	17	sea eagle
9	worms		

Figure 14 : Ecological relationships within the mangrove environment

SEAGRASS MEADOWS AND SEAWEEDS

Seagrasses

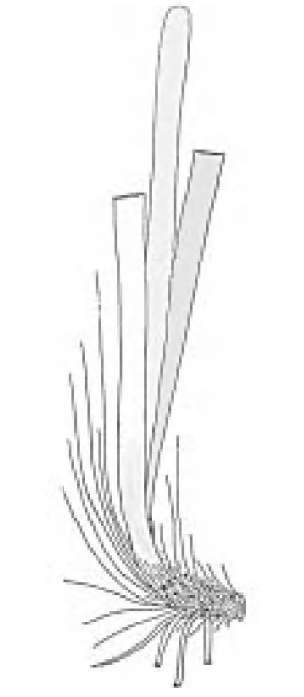


Cymodocea ciliata

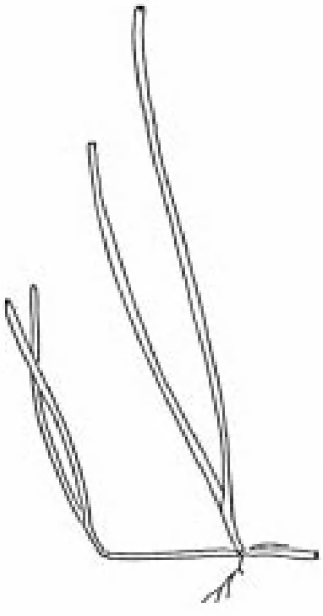
Seagrasses are not really grasses, but marine flowering plants. They are found predominantly in sandy and muddy areas where their roots can penetrate and provide easy anchorage. Seagrass meadows provide a habitat for a variety of commercially important fish species. Also found are the more mature specimens of those fish whose early life stages are found near the estuaries and mudflats. Seagrass beds are trawlable using larger mesh sizes and in this way various species of rays, octopus, holothurians, etc, can be fished. These areas are also the feeding grounds for endangered species such as the green turtle (*Chelonia mydas*), the hawksbill turtle (*Eretmochelys imbricata*) and the dugong (*Dugong dugon*).

Twelve species of seagrass have been recorded from Kenyan waters namely, *Cymodocea ciliata, C. rotundata, C. serrulata, Halodule uninervis, H. wrightii, Halophila balfourii, H. minor, H. ovalis, Syringodium isoetifolium, Zostera capensis, Enhalus acoroides and Thalassia hemprichii.* Most studies of seagrasses have concentrated on their ecology and taxonomy and very little work has been done on their distribution, densities and productivity. None of the species is endemic and while most have a wide distribution in the Indian, Pacific and Atlantic oceans, all but *Zostera* are confined to the tropics.

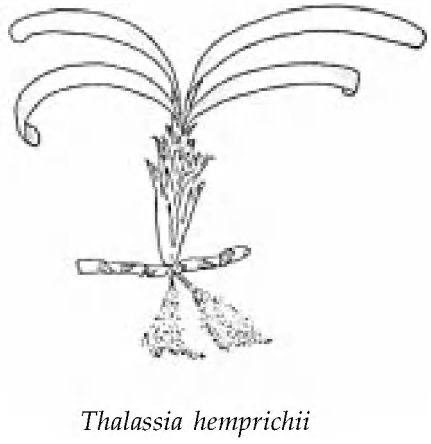
The most abundant species in Kenyan waters are *Cymodocea ciliata* and *Thalassia hemprichii* which are found in most places where the substrate is rock or old coral covered to a greater or lesser degree by sand. They root firmly in the substrate and can withstand rough wave action. *C. ciliata* does not do well in sheltered creeks away from the open sea. In locations where it is never exposed by low tides it



Enhalus acoroides



Zostera capensis



Thalassia hemprichii

Figure 15 : Various seagrasses of the Kenya coast

reaches its maximum development. *T. hemprichii* does sometimes occur in sheltered places where it assumes luxuriant growth and may root to considerable depth. However, it too suffers stunting in areas where it is uncovered by low tides.

All but two of the other species are also quite common although they are less conspicuous because of their smaller size. The first exception is *Enhalus acoroides* which is restricted to the Lamu area and Mida Creek where it grows in deep water away from the open sea. The rhizome of this species is edible and is eaten by the people of Lamu who call it Mtimbi. The second rare species is *Zostera capensis*, but this is not surprising since it is normally more at home in cold or cool temperate regions.

The major threat to seagrass meadows comes from excessive sedimentation of shallow coastal waters resulting from the erosion of agricultural lands. Turbidity also tends to cut down the light penetration and seagrasses cannot flourish under such conditions.

Seaweeds

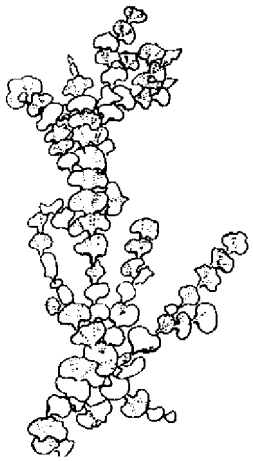
The seaweed species occurring along the Kenyan coast can be assigned to one of four groups, conveniently distinguished by their colour - blue-greens, greens, browns and reds.

One blue-green seaweed species which is ubiquitous on the Kenya coast is *Lyngbya majuscula*. It is very variable in size and is found on the rock surface at varying levels. It also occurs as an epiphyte on the leaves and stumps of seagrass plants in dense clumps streamed out into the water like tresses of grey-black hair, 15cm or more in length. Also widespread and with similar habits is the tufted *Symploca hydnoides*.

The green seaweeds are found in shallow water where they are able to make the best use of sunlight and grow better than those of other species. They include the bright green sea lettuce, with *Ulva pertusa* growing in continuous sheets while others like *Ulva reticulata*, are delicately perforated and net-like. They are much sought after by grazing fish and molluscs and are often found at the water's edge at low tide. Another green seaweed in shallow waters is *Enteromorpha* spp. Its bright green sheets often form hollow tubes and may appear filamentous, but others are more like deflated balloons (e.g. *Enteromorpha flexuosa*). The seaweed *Chaetomorpha crassa* is common in rock pools where it resembles tangled masses of thick, bright green nylon fishing line. Each of these three green seaweed groups are highly resistant to changes in salinity and temperature and can cope with the wide range of conditions encountered in the intertidal zone.

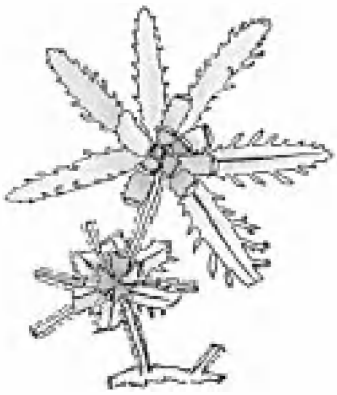
The green seaweed that has exerted the greatest effect on the Kenyan coast is *Halimeda*, which is represented by several species, all with rather oval, fleshy "leaves" impregnated with calcium carbonate. *Halimeda opuntia* forms thick, greyish-green mats, ten or more centimetres deep in the lagoons, which crunch as you walk over them. The calcium carbonate of any that are eaten by herbivores, is not digested and passes out as a fine white sand. This accumulates together with the thick layer of bleached skeletons of dead *Halimeda* to form what are often erroneously referred to as 'white coral sands'.

The brown seaweeds are often more robust and tend to be larger than the greens. Their colour is designed for intermediate depths below the low tide mark, as well as in the deeper lagoon pools and channels. The largest type on the Kenyan coast is *Sargassum* which can form impressive 'algal forests' similar to those of the

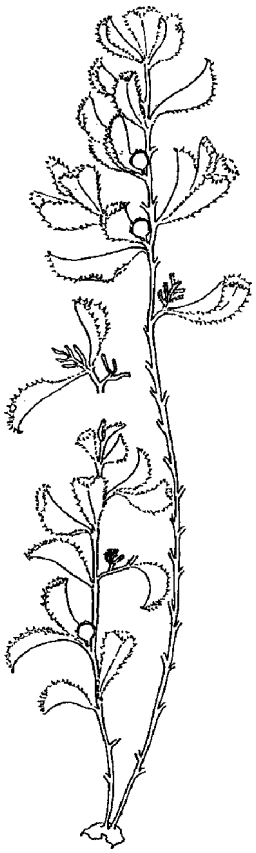


Halimeda opuntia

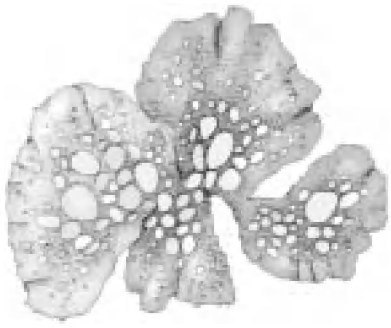
Turbinaria



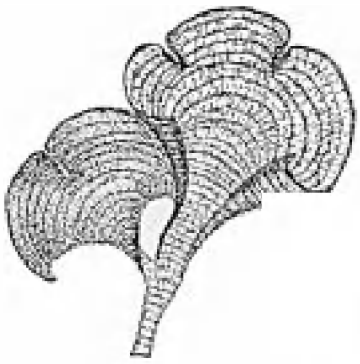
Amansia glomerata



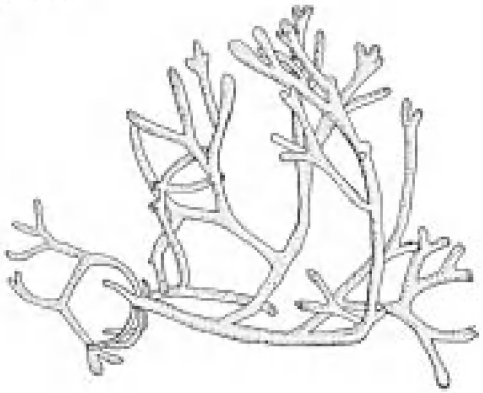
Sargassum duplicatum



Ulva pulchra



Padina boryana



Gracilaria crassa

Figure 16 : Various algae of the Kenya coast

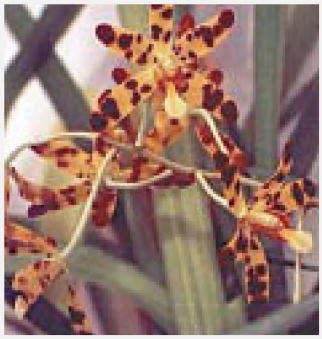
temperate kelps to which it is related. Many brown seaweeds, including some *Sargassum*, have air bladders in their fronds to hold them vertically above their holdfast, enabling them to make the best use of the penetrating sunlight. Another brown seaweed, common on the Kenyan coast is *Turbinaria*. This alga has tetrahedral lobes which are often hollow. It is found in areas where strong currents occur and its heavy structure allows it to hold on and resist all but the strongest buffeting.

A brown seaweed that stands out on the edge of rock pools is *Padina boryana*, which is very beautiful with its concentric tracery of creams and browns and a slight iridescence. Other species of this genus are more gross, but all have light bands made by crystals of calcium carbonate on their rounded lobes. Also among the brown algae are *Ectocarpus* spp. and *Giffordia* spp. which are common and important components of the filamentous algal turf which normally covers every available space in lagoons and on reefs.

The red seaweeds are adapted to living at depths where their red pigment is very effective in absorbing the light wavelengths that are able to penetrate through the water. However, this ability does not confine red seaweeds to deep waters. A profusion of red seaweeds can be found in shallow rock pools and channels, where they are able to grow under overhangs and in dimly lit caves where other seaweeds cannot survive.

There are probably more species of red seaweeds than browns and greens put together in the Kenyan shallows alone. They range from the gelatinous *Laurencia* to the fragile and brittle articulated corallines such as *Amphiroa fragilissima*. None are very large and many live as microscopic epiphytes on the larger brown seaweeds. Some are calcified and rocklike, such as *Porolithon onkodes*, others are leafy like *Amansia glomerata* and yet others are finely filamentous like *Ceramium*.

Seaweeds have a number of commercial applications in addition to their use as a food in their natural state. Thickening and gelling agents such as the alginates



COASTAL ORCHIDS THREATENED WITH EXTINCTION

Ansellia africana, commonly known as the leopard orchid because of its yellow flowers heavily blotched with dark maroon, belongs to the family Orchidaceae and is listed as endangered under the Convention on Trade in Endangered Species (CITES). Like other members of the orchid family, this species is highly valued for its beauty. As a result they have been collected excessively from the wild from Shimba Hills, Kwale, Msambweni, Port Reitz, Tiwi and Gazi by local people who sell them to hotels, tourists and the general public.

Many of those who sell and buy the orchids have no idea how to care for them. The host tree is cut down and clumps of orchids are jammed into tins and left in the hot sun, or they are separated by cutting, destroying the roots in the process. As a result of poor handling, only a small percentage of the orchids collected survive, only to be cut and hung in dark lounges, or placed on unsuitable hosts in too much shade where they struggle.

The species and its hosts are now considered in danger of extinction unless urgent action is taken to curb the indiscriminate collection from the wild.

used in soft cheeses and ice-cream, are extracted from seaweeds. Agar, also a seaweed product, is used in the preparation of microbiological media for use in the laboratory culture of bacteria, fungi, etc. Iodine and bromine, which are concentrated by seaweeds from the surrounding seawater, can be easily extracted. House plant food preparations are extracted from seaweeds, and they are often spread on to fields as a mulch. A broad survey of Kenyan coastal waters has shown that there are no sites with significant stands of commercially important seaweeds and therefore none could be considered available for harvest from the wild. Any exploitation of existing natural stands of commercially important seaweeds will lead to irreparable damage to primary productivity in the coastal zone and drastically change the biotope where they occur.

Of the seaweeds that are exploited internationally on a commercial basis, only those in the two genera *Gracilaria* and *Eucheuma*, are found in Kenyan waters. Of these, *Gracilaria* sp is widely distributed within the intertidal waters of the Kenya coast and studies on their distribution pattern show some species to be of a wider occurrence than others. Some are even found as epiphytes on seagrasses, but most grow on rocky shores and only a small number of species are found growing in sandy habitats. Studies of this genus to date have concentrated on its ecology, taxonomy and biochemistry and no attempts have been made to quantify *Gracilaria* stands in Kenyan waters.

Eucheuma is extremely sparse and present only as isolated specimens along the whole of the Kenyan coast with the exception of the extreme southern parts around Shimoni where all the species recorded in Kenyan waters occur in rocky coral reef areas in appreciable amounts. This concentration of *Eucheuma* species around Shimoni could indicate that this is the northernmost limit of its natural geographical distribution along the African coast and that while climatological and other factors at Shimoni are favourable, conditions further north along the Kenya coast allow only sporadic and isolated occurrences.

CORAL

Coral reefs exist along most of the Kenya coast. They occur as coral flats, lagoons, reef platforms and as fringing reefs. The total area of coral reef in Kenyan waters is estimated at 50,000ha and the coral types include the families Portidae (*Porites* and *Goniopora* spp.) and Faviidae (*Meandrina* and *Favia* species).

The best known reefs are in the Malindi-Watamu area, most of which are included within the boundaries of the two Marine National Reserves and the two Marine National Parks. The entire area was designated as a Biosphere Reserve in May 1979. The Parks are a complex of fringing reef, channels, islands, offshore reefs, sand, clays, seagrass meadows and isolated coral heads. Most of the reef flat which dries at low tide is dominated by *Goniastrea retiformis* interspersed with *Acropora* colonies. *G. retiformis* is also the dominant species on adjacent reef slopes although the back reef slopes are dominated by *Galaxea*. On the landward side coral cover is less than 50%, with much of the substrate being occupied by *Halimeda* and rubble.

The marine fauna includes *Tridacna squamosa, Pinctada margaritifera* and many other molluscs. The green turtle (*Chelonia midas*) and the hawksbill (*Eretmochelys imbricata*) occur in the park. Whale Island is a nesting site for the roseate tern (*Sterna dougallii*) and the bridled tern (*S. anaethetus*). Some fish such as the parrot fish (*Leptoscarus vaigiensis*), and the crown-of-thorns starfish (*Acanthaster planci*) are specialized to feed on coral polyps. Other fish groups usually associated with

coral include moray eels (Muraenidae), damselfishes (*Abudefduf annulatus, A. xanthozonus*), acanthurida (*A. triostegus*), cardinal fish, wrasses, angelfish, scorpion fish, etc. Other fauna include the long-spined sea urchin (*Diadema setosa*), a variety of molluscs often anchored in the coral, the giant sea anemone, lobsters and turtles.

In addition to their undisputed value in attracting tourists, Kenya's coral reefs are also important for fisheries, with the tourism industry as one of the main markets for fish products. The most important fishery areas are in the north of Ungwana Bay, offshore near Lamu, and in areas some 20km and 80km north of Lamu respectively. Malindi and Lamu are important fishing ports with industry based on and around the coral reefs. The maximum sustainable yields along this part of the coast have been estimated by FAO at 5 tonnes/km^2. Unfortunately, tourism also creates demands on the inedible reef resources. Large quantities of shells and corals are known to have been collected in the Shimoni, Lamu and Kiunga areas and even within some marine parks. Many species are probably being overexploited and careless collection methods have led to serious habitat damage. Despite controls, large quantities of coral and shells are still exported from Kenya.

These pressures, coupled with silt deposition from rivers draining agricultural land and pollution from the cement industry, chemical and textile plants near Mombasa, domestic effluent, mining and oil discharges from tanker traffic, have diminished both the productivity and the species richness and diversity of the entire coast. Virtually all reef outside of the marine parks is degraded to some extent. In the extreme south, some coral has been destroyed by dynamite fishing even though this is minimal when compared to Kenya's neighbouring countries.

Recovery of degraded reefs is very slow and it could take up to 50 years for a reef damaged by dynamite fishing to repair itself.

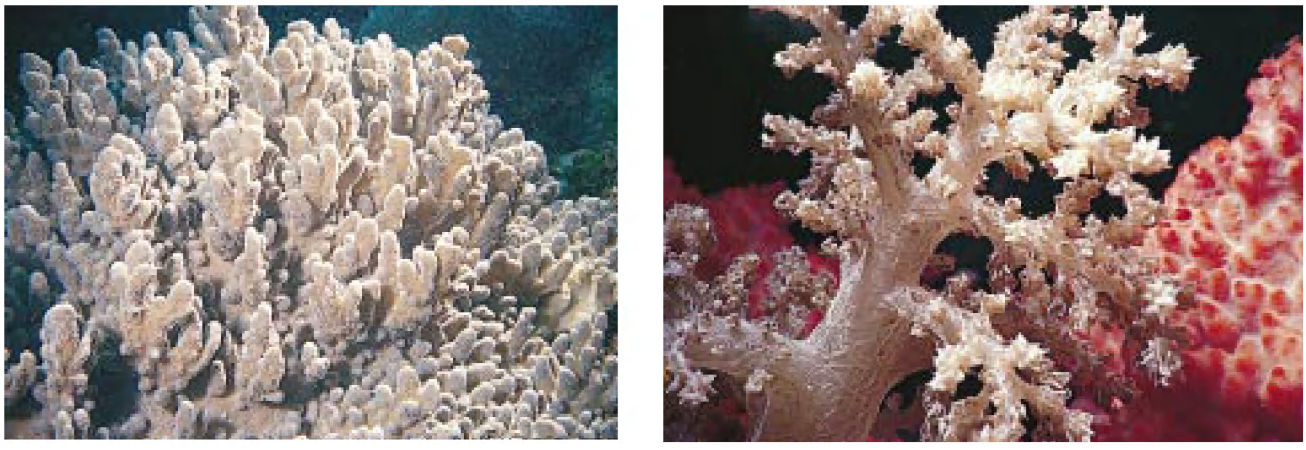


Figure 17 : Hard and soft corals abound along the Kenya coast

SPECIES AT RISK

The coastal and marine species which inhabit Kenyan waters have been little studied and the majority are not well known. However, the small and inconspicuous terrestrial species of the coastal zone such as the butterflies, other insects, small mammals, reptiles, etc, are probably even less known. All these poorly known or as yet unknown species are at risk as a result of their anonymity. Listed below are coastal and marine species which are known, some better than others, and which are considered at risk. These include the species that are endemic to Kenya; those which are listed in the IUCN Red Data Books as threatened; those that are migratory and which have their critical habitats spread over two or more countries; and, those commercial species that are threatened by over-exploitation or habitat degradation.

As can be expected the number of endemic species within any continental country is comparatively lower than the number of similar species from island nations. This is because many species roam throughout a range of habitats over and beyond national boundaries. However, Kenya would seem to have more known coastal and marine endemics than the other mainland countries of Eastern Africa, though this higher number may just be a reflection of the extent of research rather than the comparative richness of endemic species.

The 12 coastal and marine species which are endemic to Kenya are listed in Table 6 below. To these can be added the 6 species which Kenya shares with Tanzania (i.e. Ader's Duiker, *Cephalophus adersi*; Amani Sunbird, *Anthreptes pallidigaster*; Sokoke Pipit, *Anthus sokokensis*; East Coast Akalat, *Sheppardia gunningi sokokensis*; Spotted Ground Thrush, *Turdus fischeri fischeri*; Caecillian, *Schistometopum gregorii*) and a further 2 species which are endemic to Kenya, Tanzania and Mozambique (the Plain-backed Sunbird, *Anthreptes reichenowi*; and the East Africa Dragonet, *Callionymus marmoratus*).

The Coast appears to be the habitat for the majority of Kenya's internationally threatened species. Of 159 species of trees and shrubs that are considered threatened, 38% of them come from the Coast; of the 71 species of threatened birds, 27% inhabit the Coast; while out of 9 threatened mammal species, 55% are in the Coast environment. These percentages are the highest for each of the three groups and only the afromontane

Table 6 : Marine and coastal species endemic to Kenya

	common English name	scientific name
MAMMALS	Striped bush squirrel	*Paraxerus flavivittis*
	Coastal red-legged sun squirrel	*Heliosciurus rufobrachium undulatus*
	Giant Cane rat	*Thyronomys swinderianus*
	Thomas silvery mole rat	*Heliophobius spalax*
	Golden-rump elephant shrew	*Rhynchocyon cirnei chrysopygus*
	Coastal suni	*Neotragus moschatus kirchenpaueri*
BIRDS	Tana River cisticola	*Cisticola restrica*
	Malindi pipit	*Anthus melindae*
	Sokoke scops owl	*Otus ireneae*
	Clarke's weaver	*Ploceus golandi*
FISHES	Mombasa butterfly cod	*Pteropterus mombasae*
PLANTS	Euphorbia	*Euphorbia warkefieldii*

environment shows any similar concentrations of threatened species, even though in the latter, the number of species is half that inhabiting the Coast.

The following Table 7 comprises those Kenyan species that are thought to be threatened in some way or another. Species considered Endangered are in danger of extinction and their survival is unlikely if the causal factors continue operating unchanged. They include taxa whose numbers have been reduced to a critical level or whose habitats have been drastically reduced or altered. Vulnerable species are those believed likely to move to the Endangered category in the near future if the causal factors continue operating. Their populations are currently showing declining trends either because of over-exploitation or as a result of extensive destruction of their habitat or some other serious disturbance. Species with small world populations which are neither Endangered nor Vulnerable but are still considered at risk are classified as Rare. These are usually taxa confined to small geographical areas or thinly scattered over a more extensive range. Indeterminate/Status Unknown species are thought to be either Endangered, Vulnerable or Rare, but the information available is not sufficient to determine precisely which category they should be assigned to. Species that are commercially threatened may not be threatened with extinction at present, but their rate of exploitation is such that their long-term commercial sustainability is at risk. These would include species that have been overexploited to the point of local extinction.

The two marine species that are considered Endangered in Kenya are the Green Turtle and the Hawksbill Turtle. They are both discussed in the section further below. Another turtle, the Loggerhead as well as the Dugong are classified as Vulnerable. Three bird species and a mollusc are considered as Rare and two molluscs and the Spiny Lobster have been classified as Commercially Threatened. The rest of the list requires further research before the remaining four species could be placed in any one category with certainty.

Table 7 : Threatened marine and coastal species in Kenya

	common name	scientific name	status
MAMMALS	Dugong	*Dugong dugon*	vulnerable
BIRDS	Sokoke Pipit	*Anthus sokokensis*	status unknown
	Amani Sunbird	*Anthreptes pallidigaster*	rare
	East Coast Akalat	*Sheppardia gunningi sokokensis*	rare
	Clarke's Weaver	*Ploceus golandi*	status unknown
	Spotted Ground-Thrush	*Turdus fischeri fischeri*	rare
REPTILES	Green Turtle	*Chelonia mydas*	endangered
	Hawksbill Turtle	*Eretmochelys imbricata*	endangered
	Loggerhead Turtle	*Caretta caretta*	vulnerable
MOLLUSCS	Triton's Trumpet	*Charonia tritonis*	rare
	Green Snail	*Turbo marmoratus*	commercially threatened
	Fluted Giant Clam	*Tridacna squamosa*	indeterminate
	Small Giant Clam	*Tridacna maxima*	insufficiently known
	Pearl Oyster	*Pinctada spp.*	commercially threatened
CRUSTACEANS	Spiny Lobster	*Panulirus spp.*	commercially threatened

MARINE TURTLES

Out of the world's eight species of marine turtles, five have been recorded on the East African coast. Out of these, the two that are found commonly nesting on the Kenyan shores are the green turtle (*Chelonia mydas*) and the hawksbill turtle (*Eretmochelys imbricata*).

There are 22 known nesting beaches stretching from Funzi Island on the south coast to north of Manda Island in the Lamu archipelago. The nesting season follows the northeast and the southeast monsoons with the peak of nesting for the green turtle between March and June and for the hawksbill turtle between December and January. The Olive Ridley turtle (*Lepidochelys olivacea*) was recorded nesting at Ras Tenewi Island 20 years ago.

Traditionally, marine turtles have always been utilised, but over-exploitation of their meat, oil, shell, leather and eggs now threatens their survival. Incidental capture of the green turtles in fishing nets, including trawls, drift nets and gillnets, in the open sea results in many turtles being killed, often as they are trying to reach nesting beaches. Development along the Kenyan coast has also resulted in the widespread loss of turtle nesting sites. Security lights at night, walls and other structures, solid wastes especially plastic debris, oil and similar toxic liquid wastes and domestic sewage discharges all have an impact on the turtles. Some of these impacts are direct such as the deterring lights or the physical barriers hindering access to the beach. Others are more subtle such as the impact of toxic discharges and eutrophication on the seagrass meadows which are a prime source of food for the turtles.

A Sea Turtle Conservation Project has been established to enhance breeding populations through the protection of breeding sites, animals, eggs and hatchlings. Information on the occurrence, feeding, nesting grounds and threats, is obtained from local people; nests are identified from the telltale flipper marks on the sand; feeding areas established by noting the preferred seagrass species; and, the seasonality of nesting behaviour for both the hawksbill and the green turtle has been determined by correlating behaviour with phases of the moon, tide and monsoon seasons. Local people are given monetary rewards for the location and protection of nests *in situ* and the money goes towards a modest improvement in their subsistence living while reducing the threat to the turtles.

Safe nests are left and protected *in situ*, while eggs from endangered nests are carefully dug out, marked and transferred to hatcheries for incubation. After about 60 days, the newly hatched turtles are weighed and measured before being released. The release often involves local people as well as visitors from local

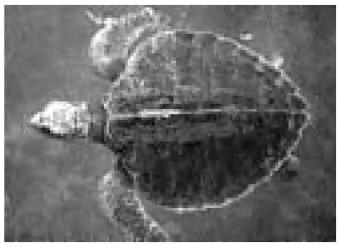


Figure 18 : Hawksbill turtle (Eretmochelys imbricata)

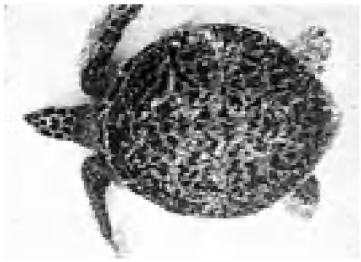


Figure 19: Olive Ridley turtle (Lepidochelys olivacea)

hotels, thus involving more of the wide community. A tagging programme is also planned so that more is learned about the turtle's behaviour and therefore their potential threats.

Ultimately, the only way to protect the turtles from extinction is to identify the most critical nesting beaches and either prevent development or ensure that existing development is in harmony with the survival of the turtles. Areas which have already been identified include, on the north coast - Nyali, Serena, Jumba ruins, Kikambala, Takaungu, Bofa, Watamu, Malindi, Mambrui, Robinson Island, Kipini, Ras Tenewi Island, Kipungani, Manda and Kiunga; and on the south coast - Shelly, Tiwi, Diani, Msambweni, Chale Island and Funzi Island.

Figure 20 : Green turtle (Chelonia midas)

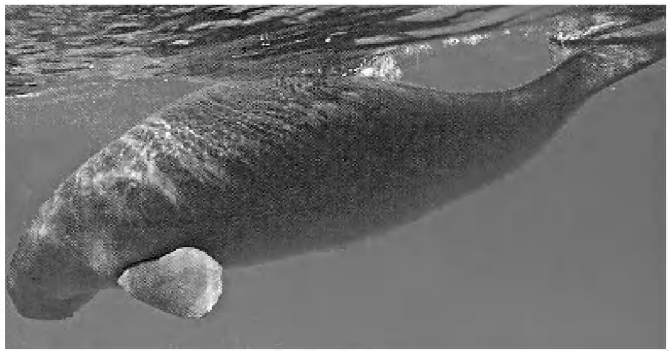


Figure 21 : Dugong dugon

MARINE MAMMALS

Popularly known as seacows or manatees, the herbivorous *Dugong dugon* is severely depleted throughout the shallow coastal waters of Somalia, Kenya, Tanzania and island waters. The dugong is heavily exploited by the local people for its meat, oil, skin and medicinal/aphrodisiac products. It is also killed by accidental drowning when caught in fishing nets, when hit by power boats and as a result of seismic exploration activity. Although it has legislative protection in much of the region, enforcement is inadequate.

The Kenyan coast, in common with the rest of the Indian Ocean, is an important habitat for a variety of Cetaceans which are severely depleted worldwide. In fact, the Indian Ocean is a sanctuary for great whales. Dolphins, however, are not protected and thousands are lost each year through incidental kills from fishing activities.

MIGRATORY AND OTHER COASTAL BIRDS

The Kenyan coast provides a number of habitats for migrating and local birds. In addition to the intertidal areas, especially mudflats, other habitats include creeks, narrow recesses in the coastline subject to tidal movement, estuaries, and salt pans which are small natural depressions flooded only occasionally and filled with salt deposits. Tidal creeks are often lined with mangroves which may form dense swamps and these are excellent habitats for a variety of bird species. Of the 1,100 bird species recorded in Kenya, more than 450 species (41%) are found in the coastal strip.

BIODIVERSITY IN ARABUKO-SOKOKE

The Arabuko-Sokoke forest has been identified as the most important area of land for biodiversity conservation in Kenya. Rare mammals, birds and plants abound in the forest. One bird species, Clark's Weaver, is found nowhere else in the world; another, the Sokoke Scops Owl, is known only from Arabuko-Sokoke and one small forest in Tanzania. The forest has been ranked by Birdlife International as the second most important forest for bird conservation in the whole of continental Africa.

Arabuko-Sokoke is also of enormous importance for the local people - more than 80,000 people around the forest depend on it for fuel, foods and medicines. Eco-tourism is being developed, and the East Africa Natural History Society now oversees an innovative project to train people living next to the forest to raise forest butterflies for export.

Figure 22 : Various terns and common noddy

Among the many species found in these localities, is the Great White Egret, almost 90 cm long, with striking white plumage, entirely black legs and a noticeably long black or yellow bill. It is a member of the heron family and closely related to the Yellow-billed Egret and the Little Egret.

Locally seen at coastal salt pans, estuaries and creeks is another similar sized bird, also with all-white plumage, but with bare red legs and face. This is the African Spoonbill with its distinctively shaped bill. In lagoons and estuaries it is often possible to come across the Sacred Ibis with its white feathers, bare black head and neck, and its down-curved elongated bill. A strange-looking bird, about 35cm long, with a large head and big yellow eyes, is the Water Thicknee which is widespread along the creeks and islands. The large eyes are an adaptation for its mainly nocturnal habit. In some respects the Thicknee resembles bustards. They can also be said to resemble plovers, however, they are a family in their own right.

Figure 23 : Verraux's Giant Eagle Owl

In the calm waters of creeks and estuaries it is common to find Fish Eagles which are widespread around Kenya. The Pied Kingfisher, with its distinctive black-and-white plumage, can be seen characteristically hovering over water in creeks and estuaries. Immediately its prey is spotted, the bird plunges headlong into the water with eyes closed and comes up almost immediately, with or without fish. Its chances of a successful catch are only about one in ten.

A great deal of shoreline is thickly wooded and when the indigenous trees in these forests are in fruit, it is usual to hear the loud raucous braying of the Silvery-cheeked Hornbill. This is about 70 cm in size and belongs to a distinctive group of

birds with a big down-curved bill, frequently surmounted by a large, often grotesque, growth on the upper mandible.

With distance inland from the sea, the bushy grassland is home for a slim bird with a long slightly down-curved bill and bright plumage with its very elongated central tail feather. This is the Carmine Bee-eater with its mostly carmine-red body, and greenish and cobalt-blue head, neck and rump. Between November and the end of March they are seen in their thousands roosting in the mangroves north of Mombasa. The Little Bee-eater offers a sharp contrast to its relative, being smaller in size and mostly green with a yellow throat and lacking the elongated tail feather. Along the course of coastal rivers and streams, in trees, bushes and reeds, can be seen and heard a noisy breeding colony of an entirely yellow bird with a bright orange head and black eyes. This is the Golden Palm Weaver frequently associated with its look-alike, the Golden Weaver which, however, has a chestnut head and pale red eye.

Further inland is the Arabuko-Sokoke Protected Forest which is home to some endemic and threatened birds. This forest is discussed elsewhere in this book.

Among the critical bird habitats on the Kenya coast, the islets off Kiunga at Ras Tenewi deserve special mention because they are the breeding and feeding grounds for a number of important marine bird species. These species include the Bridled Tern (*Sterna anaethetus*), the Roseate Tern (*Sterna dougallii*), the White-cheeked Tern (*Sterna repressa*), the Common Noddy (*Anous stolidus*) and the Sooty Gull (*Larus hemprichii*).

Eastern Africa as a whole receives 159 species of migrating birds and about 29 of these are waders or shorebirds. While the Greenshank is a common migrant to all the wetlands in Kenya, the largest numbers are recorded from the Coast. Another visitor, the Little Stint, is only 12.5cm in size and the smallest of the wintering shorebirds arriving by the beginning of August. A small dumpy bird, seemingly running at breakneck speed as it feeds along the tidal margins, is the Sanderling.

COASTAL GIANT MILLIPEDES

The Giant Millipedes of the Kenya Coast are not uncommon but they are certainly not well known. The largest of these is *Archispirostreptus gigas* which can grow to length of over 10cm. Like many other giant millipedes, *A.gigas* can cause serious localized seasonal damage to crops and small forestry seedlings. In dry conditions, millipedes turn to living plants as a source of food and they burrow down and seek shelter in crevices. On the other hand, under wet conditions their populations appear to increase explosively but they seem to confine their diet to leaf litter and other dead plant matter.

Epibolus pulchripes is more common on the Coast than its larger cousin. It is also more conspicuous with its bright orange-red legs. This species very seldom damages living plants, but instead is a very valuable agent in humus formation.

Predators of millipedes include the Civet, which is not found in large number on the Coast, the Banded Mongoose, and a number of birds for whom millipedes do not seem a main dietary item. Among those that are know to prey on millipedes are the Fiscal Shrike, the Red-Billed Hornbill and the Cuckoo.

THE HUMAN DIMENSION

POPULATION

The estimated population of Kenya in 1992 was 25.3 million and this is expected to rise to 32.8 million by the year 2000. This is an annual growth rate of 4.2% which is among the highest in the world. The population density for the country as a whole is 44 persons/km^2. In Mombasa, the density is 280 persons/km^2. However, in other parts of the Coast such as Lamu it is less than 10 persons/km^2.

Figure 24 : Giriama elder, Lamu

The population in coastal urban agglomerations has been growing just as fast, if not faster than, the rest of the country. In 1980, the coastal population was below 0.5 million (489,000). By 1992 it had reached 1.64 million and by the turn of the century the Coast is expected to have a population exceeding 2 million.

In very broad terms, the people of the Coast can be said to belong to three tribal groupings - the Mijikenda peoples settled mainly in the hilltop areas; the Pokomo speakers along the lower Tana River; and the Swahili, dispersed in coastal towns and villages. The people of Kenya's Coastal Province have been mixing, trading and intermarrying both among themselves and with overseas immigrants for hundreds of years. The first traders on the East African Coast appear to have been Arabs from the Persian Gulf who sailed south along the coast during the northeast monsoon, sailing home again with the southwest monsoon. At this time the Swahili people were already a major economic force in the Indian Ocean trade and its relations with the African continent. Not only were they the caravan leaders to the interior of Africa, but they also acted as cultural and commercial

go betweens and suppliers to the outside world of items from the interior. These products were usually related to wild animals such as the tusks of elephants or the feathers of ostriches.

By the 12th Century, some substantial settlements had developed mainly on islands such as Lamu, Manda, Pemba and Zanzibar. By the end of the 15th Century, Mombasa, Malindi and Pate (in the Lamu Archipelago) were all substantial towns with mainly Arab inhabitants but also with significant numbers of African labourers. At this time, Mombasa was already an important settlement for the Shirazis from Persia.

The first Europeans, the Portuguese, arrived in 1498 and by 1506 they had gained control of the entire coast. They fortified the towns and built defences such as Fort Jesus in Mombasa. However, there were many local uprisings during the 17th Century and the Portuguese were finally defeated in 1698 and Fort Jesus taken with the help of the Sultans of Oman.

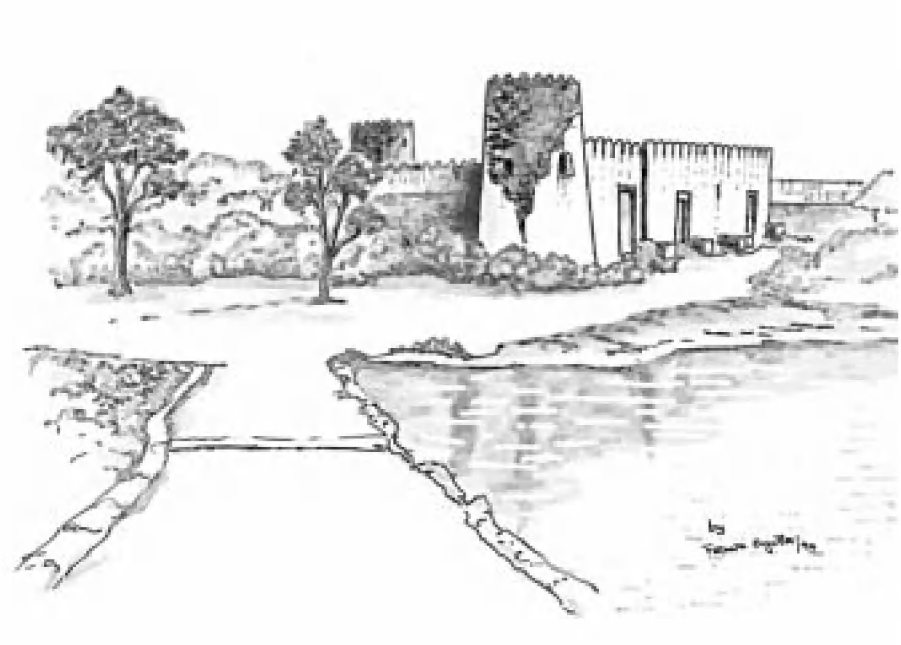


Figure 25 : Siyu Fort, Siyu Town, Pate Island, built by the Omani Sultan of Zanzibar in the 19th century

The Omani dynasties flourished and Mombasa and Pate rose to pre-eminence on the Coast even though both were defeated by Lamu in 1810. During this period of Omani rule the slave trade was at its peak. Economic activity also increased and attracted the first Indian and European traders into the area. Trade agreements were signed with the Americans, the British and the French, and exports to India also flourished with ivory, cloves, hides and coconut oil being the most important. In 1840 the Sultan of Oman transferred his capital from Muscat to Zanzibar and a treaty was signed which banned the export of slaves to the Middle East.

The British East Africa Company took over administration of the interior but left a 10 mile coastal corridor under the administration of the Sultan. This was leased from him in 1887. In 1920 the coastal strip became the British Protectorate, in contrast with the rest of the country which had become a fully fledged British colony. During the protectorate years the British confirmed Mombasa's status as East Africa's most important seaport by constructing the railway from Mombasa

Figure 26 : Market scene, Mombasa

to Uganda. The railway was completed in 1901 and can be considered as one of the historical chain of events which have contributed to Mombasa's pre-eminence as a trading centre, and a population focus for the Coast.

Mombasa especially, but the whole Coast in general, has continued to flourish and grow. This growth has been neither planned nor rational. Only recently, have attempts been made to rationalize the process of urban growth and to improve the municipal infrastructure. Most of the housing in Mombasa is of the local, Swahili type although more space intensive buildings are found in older neighbourhoods on the island. Unplanned housing areas occur all around on the mainland, which is where future growth is expected to be accommodated. Plans are afoot to upgrade and expand the existing public infrastructure such as sewerage, water supply and solid waste management. In the absence of upgraded infrastructure, the potential for coastal water pollution and unsanitary conditions in Mombasa is great.

However, Mombasa is not alone in experiencing the problems associated with rapid growth. The town of Malindi is also going through rapid population growth as a result of the expansion of tourism. Increased demands and popularity have resulted in an upsurge in employment in the tourism sector and associated services such as handicrafts. This growth has severely stretched the ability of local authorities and the private sector to provide adequate housing, municipal infrastructure and public services.

Figure 27 : Old Town, Mombasa

THE COAST ECONOMY

The economic foundations of urban life in Mombasa, Malindi and other population centres on the Coast are maritime commerce, large industrial and energy facilities, small workshops and tourism, not necessarily in that order. As the numbers of permanent residents and visitors continue to increase, retail trade and the service sector can also be expected to make an increasing contribution to the Coast urban economy.

For the rest of Coast Province, outside urban centres of population, economic activity centres around primary production (including agriculture, livestock production, horticulture, fisheries, and forestry), artisanal activities (such as boat building, furniture making and handicrafts) and a significant informal sector with activities ranging from mobile fruit and vegetable vendors to stationery jua kali with tin smiths, shoe shines and repairers, hair saloons, garages and second-hand clothing dealers being the most common.

Figure 28 : Fishing boats, Mombasa

INFRASTRUCTURE AND UTILITIES

Domestic Water Supply and Sewerage Services

Nearly 50% of households at the Coast are connected to a reticulated water supply, whereas the national figure is only just over 40%. The number of connected households is highest on Mombasa Island with nearly 20,000. This is followed by Mombasa mainland where nearly 13,000 are connected and fewer household numbers for the other centres making a total of over 45,000 households connected to a reticulated water supply in Coast Province.

The water demand is estimated at 190,000m^3/day during the low season and 210,000m^3/day during the high tourist season. Despite a number of major sources being fully operational, there is a shortage of water due to the high demands arising from the growth in population and industry. Consequently, private and communal boreholes are quite common supplementary sources of water.

Over 65% of the coast population is served by pit latrines. Around 6% have a water closet and a mere 2% have a flush toilet. Over 25% have no provision for domestic wastewater whatsoever. These data contrast somewhat with national averages where 6% have a flush toilet and only 16% have no provision for sewage whatsoever.

Figure 29 : View of Fort Jesus, Mombasa Island

Roads

Most of the roads in the Mombasa District converge on the city due to its importance as an industrial and commercial centre. The district is relatively well-served by both classified and unclassified roads, although the network is not equally distributed with many of the roads being concentrated on the Mombasa/West Mainland axis. This has left the north/south mainland areas with few vehicular roads and this has been a contributing factor in the relative underdevelopment of these parts.

The Kwale District has probably the densest road network on the Coast outside Mombasa District. However, the district is divided into two unequal parts by the Lunga Lunga - Kihangu Silaloni road with one third lying to the western side and being served by unclassified roads. The remaining two-thirds lying on the eastern side are well served by classified roads being more densely populated and economically more significant.

The road network in Kilifi District is composed mainly of unclassified roads nearly all of which are impassable during the wet season. Tana River, Lamu and Taita Taveta districts have few tarmac surfaced roads the majority of which are usable only in the dry season.

It has been estimated that nearly 75% of all goods imported and exported through the Port of Mombasa are conveyed by road, underlining the critical importance of this means of transport. The main exception to this is the oil products pipeline between Mombasa and Nairobi which handles a range of products from the Mombasa refinery which used to be transported by road.

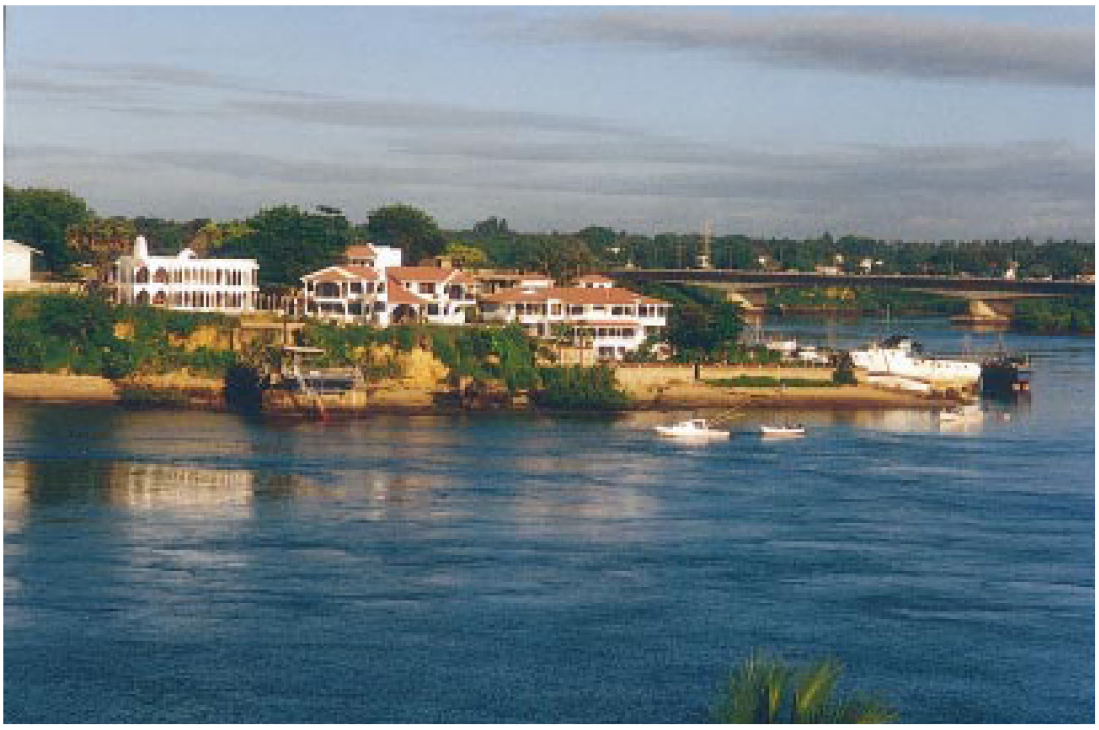


Figure 30 : View of causeway with Mombasa Yacht Club in foreground

Rail Transport

Rail transport between the Coast and the upcountry regions is still very important in the carriage of both passengers and freight. The main railway line between Mombasa and Nairobi branches at Voi to connect with Taveta township. Kenya Railways has large marshalling yards and depots at Mombasa and lines extend from this into the industrial area and the port warehouses.

Airports

Moi International Airport in Mombasa is the main airport for the Coast. It is served by the national airline, Kenya Airways, as well as a number of overseas airlines and can handle all types of passenger airliners currently in use. There are frequent flights every day between Mombasa and Nairobi. There are also less frequent flights between Mombasa and other, smaller, centres such as Malindi and Lamu which have small airstrips and are served mainly by local airlines.

Malindi is the only other airport on the Coast apart from Moi International Airport with tarmac runways and a terminal building and it can take medium sized aircraft. However, there are numerous airstrips of various standards around the Coast capable of taking light aircraft. The main third-level airstrips are at Kilifi and the Mnarani Club in Kilifi District; Kiunga, Mokowe, Manda and Witu in Lamu District; MacKinnon Road, Ramisi, Diani, Shimba Hills National Reserve and Wasini Island in Kwale District; Taveta, Mwatate, Voi, Mtito Andei, Kilanguni and Aruba in Taita-Taveta District; and, Garissa, Galole and Garsen in Tana River District.

Figure 31 : The Likoni Ferry provides a vital link for commuters and commerce to and from Mombasa Island

KONGO MOSQUE, *Diani Beach, South Coast*
maintained by the National Museums of Kenya and still in use today

COASTAL RESOURCES AND THEIR USE

HISTORICAL AND CULTURAL RESOURCES

The Kenya coast is rich in historical and archaeological sites, a testament to its long and full history depicting centuries of Swahili culture. Various remnants of mosques and other buildings reflect different ensembles of Islamic architecture using lime, coral stone and timber. Whatever the site, the historical remains may comprise of mosques, groups of tombs located inside or outside city walls, mounds and house walls representing the old city houses. Following are brief descriptions of the main archaeological sites of significance along the Kenya Coast based on various reports of the National Museums of Kenya.

Lamu, one of the most spectacular areas, was mentioned in the writings of Claudius Ptolemaeus in the second century AD, by Masudi in the 10th Century, Ibin Battuta in the 14th Century and later by Abu Mahasin. Among the historical remains in the area are Fort Lamu, Mkomani and Hidabu, many tombs, ruined houses, as well as good collections in the Lamu Museum. There are also many buildings with old traditional carved wooden doors and a lot of moulded plaster work, some dating back to the 18th Century.

Pate is the largest site on the coast. It has eight ruined mosques, numerous house ruins and tombs. This is one of the earliest sites on the Coast, along with Manda and Shanga and it has a high tourist potential.

Gedi, in Mida area, is a 15th Century Arab town and has been declared a national monument. A great mosque, six minor mosques, numerous large houses, pillar tombs, stone tombs and the town walls are some of the most distinctive attributes of this magnificent site. Further south is Jumba La Mtwana, another national monument with four mosques, numerous houses and some tombs as well as the Home of the Slave-Master.

Another national monument is Takwa. This site has a very high archaeological potential, well above average because of the number of surviving structures. These include a fine Friday Mosque and 148 other coral-built structures, including houses, the town wall with gatehouses, and a pillar tomb with an interesting inscription.

Ungwana in the central sector has eight mosques including an old and new Jamia and a mosque of the Domed Mihrab. There are also numerous houses and tombs and the old town wall. Probably, Ungwana is one of the sites with the greatest potential for development for tourism.

Figure 32 : The Palace, Gede, just south of Malindi, 15th century

The ruins at Malindi include the Jemadari Mosque in the north, the pillar tombs, an old Portuguese chapel, the Da Gama Cross (at the southern end of Malindi Harbour given to the Shirazi Sheikh of Malindi in gratitude for the warm reception received) and the South Mosque.

The Mombasa area has many interesting sites and monuments. These include a large part of Mombasa Old Town, Fort Jesus (built by the Portuguese in the 15th Century), Fort St Joseph, the Mbaraki pillar, the Mazrui Cemetery, the redoubts at the present-day golf course, the ruins at Allidina Visram school and other minor remains of great interest to tourists. There are also numerous other sites of relatively low tourist potential but of significant architectural merit.

At Siyu, the Siyu Fort, the old town including four mosques, many ruined houses and tombs are significant. This town was probably founded much earlier than archaeologists have been able to prove to date.

The Mwana remains include a fine domed mosque, a crumbling Friday Mosque, a small mosque with carved bosses, and at least one other mosque. There are also numerous houses spread over a large area and nearby there is a group of fine tombs.

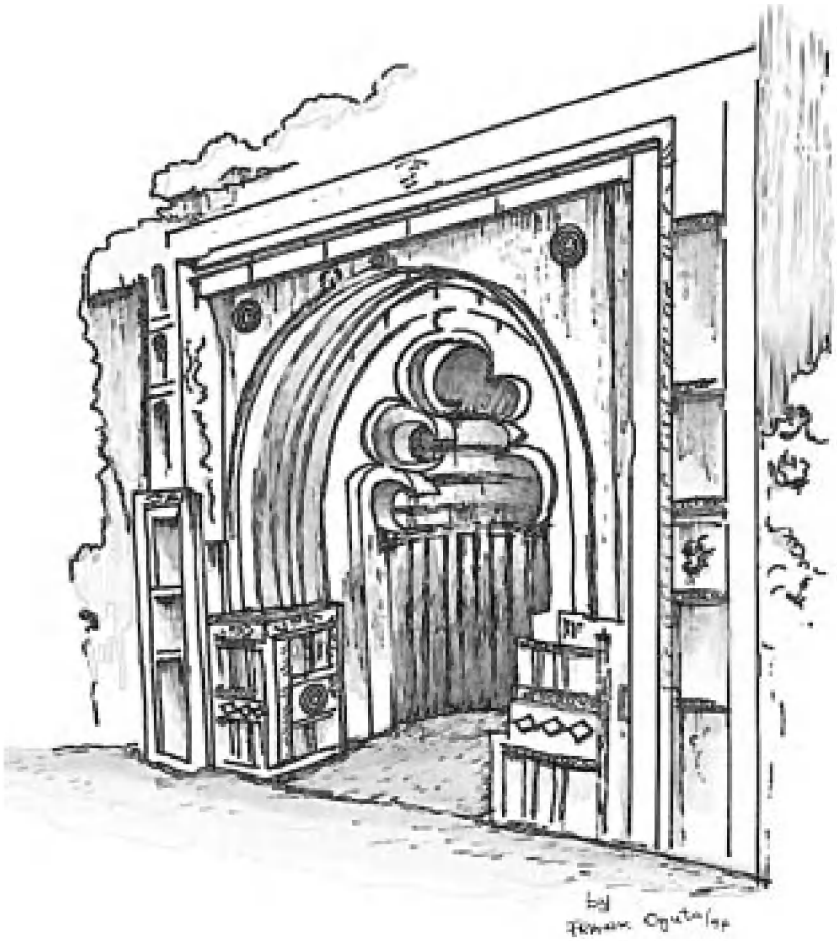


Figure 33 : Mosque of Bwana Bakari, Pate town, Pate Island (Lamu Archipelago), dates to the 17th century

There are many more sites all along the Coast. Some of the most exciting ones include Ishakani with two mosques and various tombs of outstanding architecture at the main site, as well as two outlying tomb groups with some of the finest funerary architecture on the East African coast. Mtwapa has a large Friday Mosque, tombs, and the remains of over sixty houses, often well-preserved with fine architectural details. Mwana Mchama has several houses, one of which has fine doorways and niches of cut coral and a mosque with large abutting tomb. Omwe has two very ruined mosques, and numerous monumental tombs. Shanga, with its three mosques, many ruined houses and many tombs, has great archaeological potential.

Figure 34 : An example of the intricate carving found on entrance doors to some buildings in Mombasa Old Town.

FISHERIES AND AQUACULTURE

MARINE FINFISH AND SHELLFISH

Marine fisheries in Kenya are based on a small number of species, the most important of which are demersal and caught by artisanal fishermen operating between the shoreline and the reef. Of the national total annual fishery production only 7.4% comes from marine waters. Freshwater fish landings in Kenya have always been higher than those from coastal waters. However, while the disparity was not too great until the mid-1970s, the difference has broadened significantly due to the marked increase in freshwater fish production since then. While freshwater fish production increased from around 22,000 tonnes in 1975 to 138,000 tonnes by 1989, marine fish landings have remained consistent between 5,000 and 8,000 tonnes over the same period.

According to fish landing records, Mombasa accounted for 46.6% of the mean fish catch between 1988 and 1992, followed by Tana River, Lamu, Kwale and Kilifi in that order. However, fishermen can land their catch anywhere, regardless of where the fish are caught, and they are probably attracted by the bigger market and more affluent potential buyers of Mombasa and Malindi.

During the 1988 to 1992 period, the annual mean fish production was about 7660 tonnes. Refer to Table 8 for details.

Table 8 : Annual mean fish production 1988 to 1992

species	tonnes
demersal species	2922.50
pelagic species	1059.25
other finfish	1985.75
crustaceans	733.75
molluscs	172.33
deep sea fish	469.50
marine shells	216.00
big-game fishing	102.00

There are only about 5,000 coastal fishermen compared to well over 27,000 fishermen engaged in inland fisheries. Of the 5,000 fishermen, around 4,000 are considered artisanal fishermen and the rest are classified as marine industrial fishermen. There are also about 2,000 farmers who engage in fish farming as a secondary activity. Assuming a dependency ratio of 7:1, there are approximately 230,000 fisherfolk, fish farmers and dependants for both marine and freshwater. It is estimated that around 20,000 persons (including dependants) are involved in fish distribution and processing nationwide. Hence about 250,000 persons in total are dependent on freshwater and marine fish production and this is about 1.0% of the total population. Of these totals, the marine and coastal portion is about 5%.

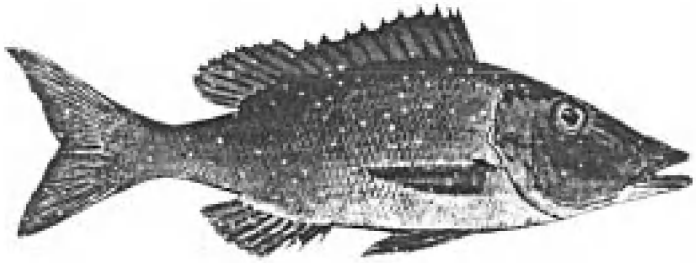
Figure 35 : A basketful of crabs

Figure 36 : Outrigger fishing canoe

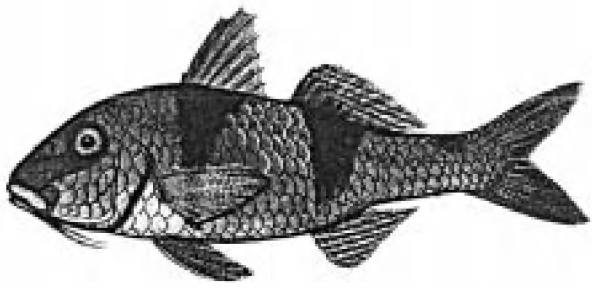
According to the 1984 census, Kwale District had the highest number of fishing canoes (558), followed by Lamu (508), Mombasa (401), and Malindi (361). These figures are probably a better reflection of where the greatest fishing activity takes place along the Kenya Coast and more relevant than the landings statistics which are more usually quoted.

There are a number of physical, climatic and economic factors which combine to constrain the coastal and marine fishery in Kenya. Firstly, the area of the continental shelf, to a depth of 200m, is only 8,500 km^2, less than 10% of the fishable area of Lake Victoria. The 200m depth contour lies within a mere 3-8km offshore except in the North Kenya Bank and Ungwana Bay where it extends out to about 64km. Secondly, the Southeast Monsoon which is prevalent from March to October, is associated with very strong winds and reinforces the East African Coastal Current giving it speeds of up to 5 knots. These conditions which prevail for the greater part of the year, are a hazard to the small canoes which are the main fishing craft for the Kenyan marine fishery. Thirdly, the East African coast does not have a very high productivity. Coastal currents are oceanic in origin and therefore nutrient deficient and there are no known major upwelling areas.

Marine fish species landed in Kenya can be categorized as demersal, pelagic, sharks and rays, crustaceans, molluscs and deep sea/big-game fish. Practically all fishing is artisanal and practised inshore of the reef and demersal fish make up over 38% of the species taken. The commonest demersal fish families are the scavengers (Lethrinidae) and the rabbitfish (Siganidae) each of which contribute some 20% of the demersal catch, while parrotfish (Scaridae) and snapper (Lutjanidae) are the next most common and contribute between 6 and 8%. Sharks and rays make up around 21% of landings and pelagic species account for just under 15%. Prawns account for the greater part of the crustacean catch which is just under 10% of the total; while molluscs, which make up a mere 2.5% of the total catch, also include beche-de-mer.

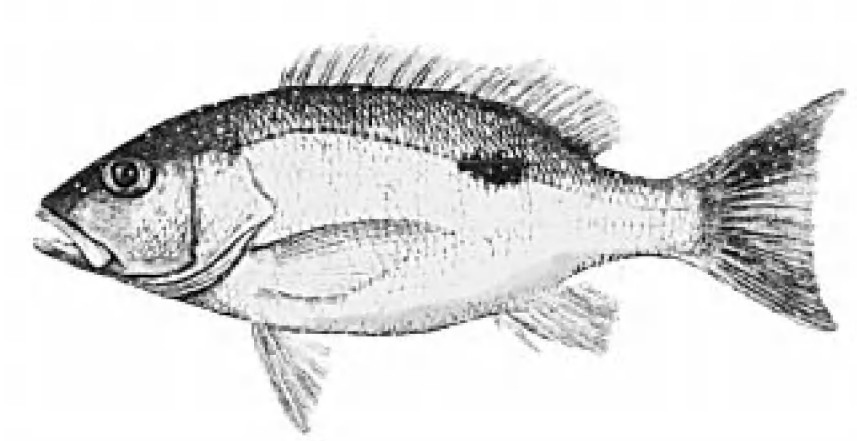


Lethrinus elongatus

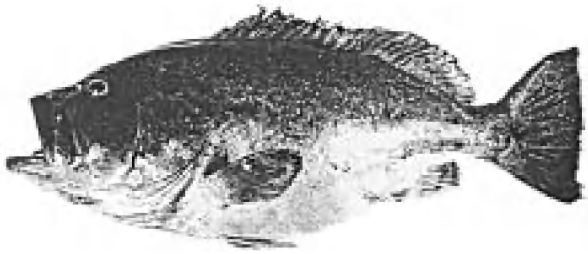


Parupeneus bifasciatus

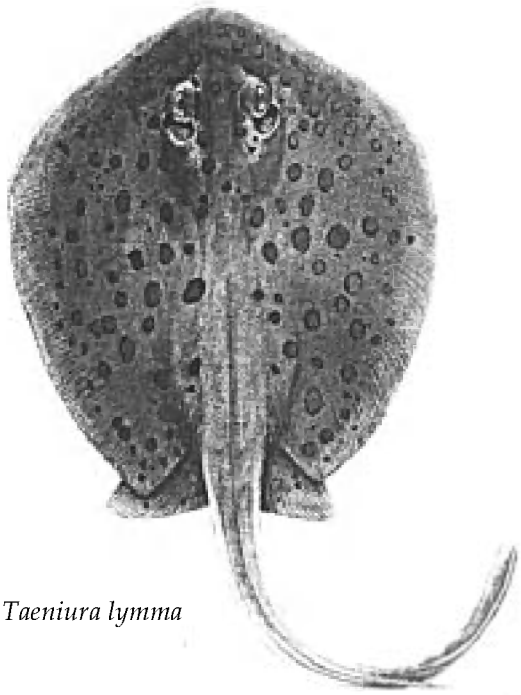
Figure 37 : Common species of fish from the Kenya coast (continued on following pages)



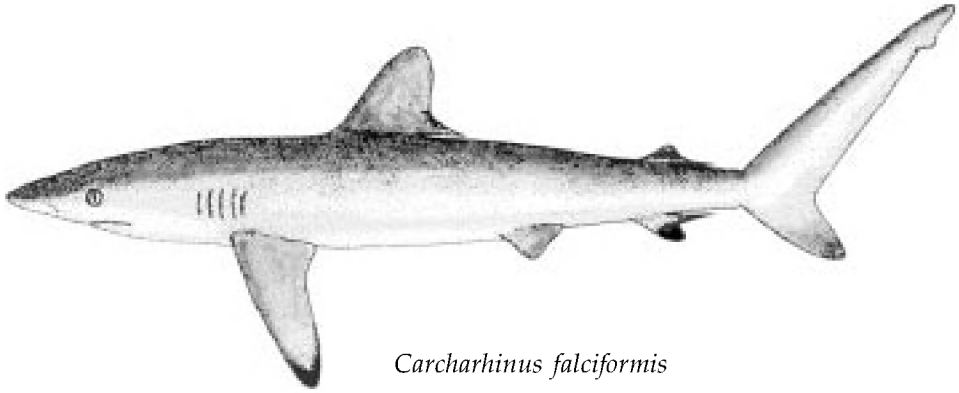
Lutjanus fulviflamma



Epinephelus flavocaeruleus



Taeniura lymma



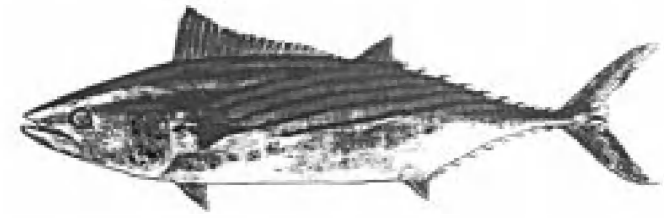
Carcharhinus falciformis

Figure 37 : Common species of fish from the Kenya coast (continued from previous page)

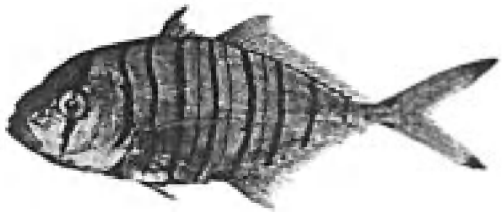
Species lists for Kenyan finfish are known to be incomplete. Only one biotope, the mangrove swamps, has been studied in any detail. Studies in the Gazi mangrove creek identified 109 finfish species belonging to 44 families and similar species diversities have been reported from other mangrove areas. Empirical calculations on the size and age of some mangrove species have established that this environment is indeed used as a nursery area by the species studied. However, with the exception of mangrove species and some of the more important commercial ones, there are no reliable estimates of the relative abundance, species diversity and biomass of Kenyan finfish resources.

A penaeid prawn trawl fishery has operated in waters around 20m deep in Ungwana Bay and the areas around Lamu since the 1980s with catches of around 237 tonnes per year. The best catches occur from July to November and the main species caught are *Penaeus indicus, Metapenaeus monoceros* and *Penaeus monodon*. *Penaeus semisulcatus* and *P. japonicus* are also present but are of lesser importance.

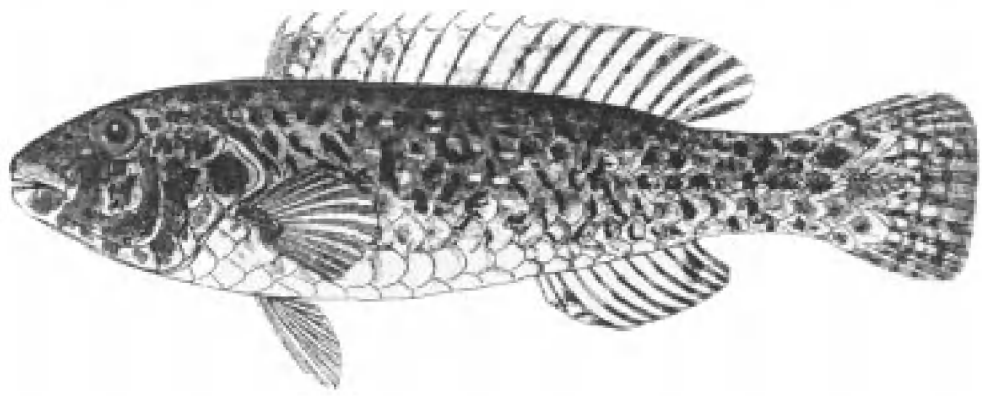
Other crustaceans of commercial potential are the rock lobsters (up to 120 tonnes annually with a return of around US$720,000) and the edible crabs which occur in shallow waters along the entire Kenyan coast. The lobsters include *Panulirus ornatus*, which makes up 90% of the lobster landings and which is fished mainly in the north coast - Lamu District; *P. homarus*, which is also caught mainly from the north coast; *P. longipes* which is mainly caught from the south coast; and, *P.*



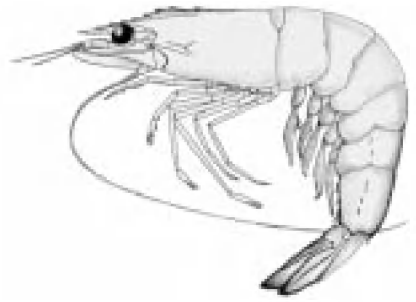
Sarda sarda



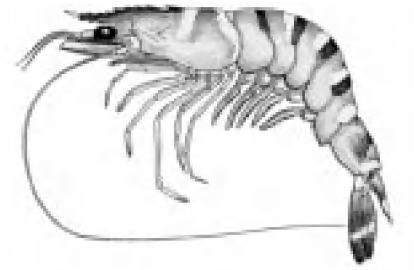
Gnathanodon speciosus



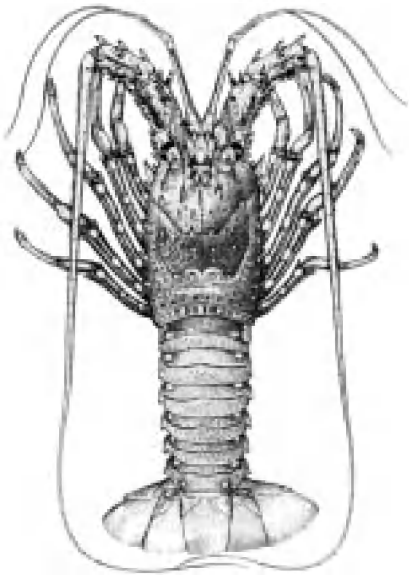
Leptoscarus vaigiensis



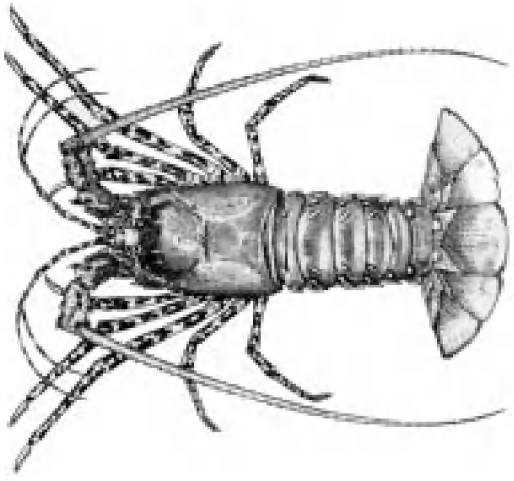
Penaeus indicus



Penaeus monodon



Panulirus longpipes



Panulirus ornatus

versicolor, and *P. penicillatus*. The most common edible crabs are *Scylla serrata* and *Thalamita crenata*. There are also two deep water species of lobster, *Puerulus angulatus* and *Metanephrops andamanicus*, which occur in commercial quantities in waters beyond 180m deep.

Kenyan marine fisheries also include significant landings of echinoderm (sea cucumbers sold under the trade name of Beche-de-mer), as well as the more common molluscs such as squid, octopus and oysters. However, large numbers of other molluscs are gathered for the souvenir/tourist trade. It is reported that over 80 species of gastropods and bivalves find their way into curio shops and fish markets. The commonest of these include *Lambis* spp. (5 species), *Cyprea* spp. (22 species), *Strombus* spp. (3 species), *Conus* spp. (20 species), and 2 species each of *Murex*, *Turbo*, *Drupa*, *Terebra*, *Tridacna*, *Pinctada*, etc. According to statistics, Kenya exported 232 tonnes of marine shells in 1992.

Figure 38 : Examining the catch

Figure 39 : Discharging a catch of bonito

ARTISANAL AND SUBSISTENCE FISHING

Marine fisheries in Kenya are in the main, artisanal and undertaken mostly from small, non-motorized boats such as outriggers, dhows, cataracts and planked pirogues. Only about 10% of fishing craft are motorized. This constraint limits most of the fishing effort to inside the reef and rarely is fishing undertaken beyond territorial waters (20km). The exceptions are the medium-sized trawlers which fish for prawns mainly in the Ungwana Bay area.

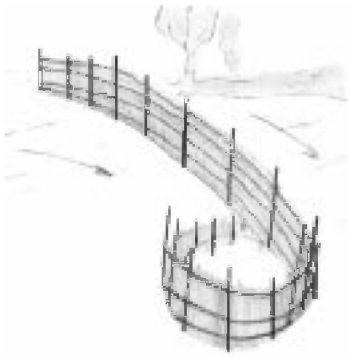


Figure 40 : Artisanal fish trap (uzio)

The most commonly used fishing gear is the artisanal gill net and the seine, particularly in the Lamu archipelago and around Malindi. Other gear includes traps and handlines in Ungwana Bay and the Malindi/Mambrui area, bottom lines and traps from Mombasa south to the Tanzanian border, and lobster pots in Lamu, Malindi and Kwale districts.

While it is comparatively easy to make a distinction between artisanal and more up-to-date technology, it is almost impossible to provide statistics on the degree of subsistence fishing. It is sufficient to note that all artisanal fishermen take away part of their daily catch, after it has been weighed and recorded, to their families, friends and relatives for food. This proportion of the catch which is not sold, is known locally as kitoweo and the Department of Fisheries estimates that it probably accounts for up to 4% of all the artisanal landings each year.

Figure 41 : Prawn fishing, Mwachi River

MARINE FARMING

Marine farming activity in Kenya is in its infancy. Besides some traditional brackishwater ponds and artisanal shrimp and oyster cultivation, coastal aquaculture has been restricted to capital intensive shrimp culture on an experimental scale. Unfortunately, this development at Ngomeni has been undertaken at the expense of mangrove productivity, with 60ha of mangrove forest being cleared. However, in spite of this inauspicious beginning, coastal aquaculture in Kenya has considerable potential as a source of economic return and, if properly planned and managed, it need not have an impact on the productive and valuable mangrove ecosystems.

There are three types of marine farming activity which could be utilized on the Kenyan coastal environment - pond culture in cleared mangroves or on land behind the mangroves, suspension culture (cage and raft) in sheltered waterways that are of sufficient depth, and rack culture in the shallow intertidal areas.

Figure 42 : Seaweed farm, "seeding" the ropes

Figure 43 : Harvest from seaweed farm

In view of their accepted value, further mangrove destruction is not favoured. Instead, better use could be made of the mangrove areas which have already been cleared but which are not being utilized efficiently. At the Ngomeni shrimp farm site there are around 45ha which could still be used. The abandoned saltworks nearby comprise a further 50ha which were once mangroves and which could also be used for aquaculture. Furthermore, the first ponds at a number of functional saltworks between Ngomeni and Kurawa could all be stocked with shrimp and a harvest taken before the water is further processed for salt extraction. It is estimated that around 800ha of reservoir ponds could be used in this way.

The chief limitations on the integration of shrimp culture and salt production are the supply of shrimp fry and the supply of shrimp feed. The natural supply of shrimp fry can be enhanced through the protection of the mangrove ecosystems, but ultimately the industry will require a more reliable supply source such as from a hatchery. This increases the demand for shrimp feed. However, shrimp feed should not be a problem since brine shrimp (*Artemia*) is already being produced at each of the seven saltworks and, through appropriate management techniques, brine shrimp cysts and biomass production could supply whatever feed is needed.

The sheltered waterways that are a feature of the Lamu, Kwale and Kilifi mangrove swamps appear to have potential for the cage or pen culture of finfish and the raft culture of oysters and other bivalves. Some species of tilapia (e.g. *Tilapia spilurus* and *T. mossambica*) are known to have adequate tolerance to salinity and have

Figure 44 : Experimental oyster farm at Gazi

been recommended for feasibility studies for cage culture in the mangrove channels and creeks. Other finfish species such as rabbit fish (*Siganus* spp), mullet (*Mugil* spp) and milkfish (*Chanos chanos*) also appear to have considerable potential.

Mangrove oysters (*Crassostrea cucullata*) are very prolific on the prop roots and lower branches of *Rhizophora* and *Sonneratia* mangrove trees where dense overcrowding is thought to be the cause of their rather small size. Experimental oyster culture at Gazi in the Kwale district, using a combination of intertidal racks and raft suspension, has provided promising results. With over 10 million oysters under culture, this is thought to be the largest such farm in Africa.

Potential for oyster farming exists along most of the Kenya Coast and the Coast Development Authority is currently popularising oyster farming with coastal inhabitants, based on oyster farming experiments at Gazi and Ramisi.

Kenya is also investigating the possibility of exploiting marine algae as a source of protein. Algae under investigation include the blue-greens, chlorophytes, red algae (Rhodophytes) and brown algae.

Since it has been concluded that natural stands of seaweeds in Kenya could not sustain commercial harvesting, phycologists at the Kenya Marine & Fisheries Research Institute have been carrying out experiments at Vipingo on the culture of some of these commercially important seaweeds. The species currently under study is *Eucheuma denticulatum* which has been farmed successfully in other countries and it would appear that it is a viable commercial crop in Kenya.

Figure 45 : Oysters growing on mangrove roots

MINERALS AND ENERGY RESOURCES

SALT

Salt can be considered as the most widespread mineral in Eastern Africa and its recovery from the sea is a comparatively simple process given certain environmental conditions. The location of solar saltworks is controlled by the rainfall regime and the occurrence of suitable impermeable soils. These conditions occur from Ngomeni northwards to the Lamu area. Extensive saltworks have been established at the Gongoni-Fundi Is area and Kurawa. The total area dedicated to salt production is over 5,000 hectares that yield an average of over 170,000 tonnes of salt annually.

The method of salt production utilised by the five established companies is very much the same throughout the area. Seawater is introduced into the ponds which are run in series. Slight variations may occur in the method of filling the ponds which utilize tidal energy. In the first pond, undesirable salts of low solubility are removed and the water then flows into concentration, evaporation and crystallization ponds. Crystallized salt is gathered from the ponds, processed and taken to market.

While it is cheaper and more rational to utilize solar energy to evaporate water naturally, fires driven by fuelwood are sometimes still used to boil off the water and recover the salt. This method of salt production, rarely used nowadays, was a common and wasteful use of mangrove and other timbers that were used for fuel. Seven tonnes of wood were used to produce a tonne of salt.

Figure 46 : Saltworks at Ngomeni

LIMESTONE AND CEMENT

Limestone deposits are extensive along the coastal zone from the Tanzania border to the Malindi area. The resource is very abundant, forming a 4-8km wide band, some 70m thick, running parallel to the coast. North of Malindi, older limestone units occur further inland but only a few exposures of isolated limestone occur on the coast between Malindi and the Lamu area. North of Lamu and the islands, limestone units occur once more parallel to the coastal zone, however, these are not well mapped. Exploitation of the limestone is widespread and is governed by local variation in the limestone texture, composition and demand for the material. In the Bamburi area north of Mombasa, limestone is used for cement manufacture and in Tiwi for lime manufacture. However, all along the coast limestone is being exploited for building stone.

Figure 47 : Limestone quarry, Mariakani

Coral limestone, the basic raw material for cement production, is excavated in shallow, heavily mechanised, opencast mines adjacent to the factory. Due to seawater intrusion, exploitation is limited to the upper levels of the limestone layer but the quarries are expected to last for many years. Weathered shale and iron ore are also required as secondary raw materials for the production of cement. The former is available in large quantities in the Mombasa area and is mined in open pits near Bamburi; while iron ore is obtained from Kilifi. Pozzolana and gypsum, also needed for the process albeit in smaller quantities, are mined near Kilifi or imported. Coal and heavy fuel oil, the other important ingredients for cement manufacture, are imported.

Cement production at Bamburi was initiated in the early 1950's and, together with a number of related downstream activities, it is recognized today as one of the major industries on the Kenya coast. The Cement industry employs over 700 workers directly and many more indirectly through its need for raw material, transport, servicing, etc. Average cement production is over 1.2 million tonnes per year and although the local building industry continues to provide a local market for the product, a significant proportion of the production is exported.

REHABILITATION AT BAMBURI

A dense green forest with imposing towers of concrete above and beyond the trees greets the ever-increasing stream of visitors to the Bamburi Portland Cement Company near Mombasa. Large plantations of *Casuarina equisetifolia* hide tracts of dry, yellow quarry, some still being exploited by the excavating machines, others bare and abandoned and awaiting rehabilitation.

For 20 years the Company has implemented a rehabilitation policy which has turned barren, dusty, disused quarry into dense forest, secretive trails and cool lakes. The reclamation comprises an ecological process meticulously planned and based on an understanding of food chains and symbiotic relationships. The achievement is made all the more impressive by the fact that no artificial pesticide, fertilizer or other chemical has ever been used at Bamburi.

The South Quarry is nowadays known as the Bamburi Nature Trail where orphaned animals ranging from a porcupine to a hippopotamus are given natural surroundings to thrive and help educate and inform visitors. The Baobab Farm Ltd integrated aquaculture system is another success story. Through judicious water use and reuse, the system produces tilapia, catfish, prawns, crocodiles, rice, other vegetables and an income from tourism.

While generating an income is an important consideration, Bamburi also reinvests some of that income into various aspects of research and conservation such as - how to increase tilapia yield, how to convert the fish farm's sludge into biogas to be used as fuel, establishing a Bamburi kaya that will be of value to scientists, medicine and the surrounding communities, etc.

The Bamburi enterprise is an excellent example of how ecological principles can be applied to obtain sustainable resource use for economic advantage. The Bamburi Portland Cement Company is justly proud of its achievement which proves that mining need not necessarily ruin the natural environment.

OTHER MINERALS

Several mineral occurrences and shows have been recognised along the coastal zone. Some of the mineral occurrences are of economic significance and a few are being exploited. Mineralization at Murima hill in Kwale district comprises of an association of Pyrochlore, Apatite, Galena, Iron ore and Manganese. Of these, Pyrochlore appears to have the highest potential.

The Vitengeni deposits in Kilifi District are being exploited for Barytes, with Galena as a by-product. However, at Kinangoni, Galena is the dominant mineral with Barytes and Silver forming the subsidiary minerals. Gypsum is mined from sedimentary deposits at Roka in Kilifi District. Other Gypsum deposits of possible economic significance have been discovered in Tana River District. At Jaribuni in Kilifi District, iron ore is being mined to supply the cement factory at Bamburi.

Sand for building is mined in many localities along the coastal zone. Among the most important sites are Tiwi in Kwale District, Mazeras which supplies Mombasa and Ngomeni for the Malindi area. Silica sands for glass manufacture are obtained from deposits in Arabuko-Sokoke and Msambweni. Clay is mined for brick works in the Port Reitz area of Mombasa.

Figure 48 : Mining iron ore at Jaribuni

HYDROCARBONS

A thick sequence of sedimentary rocks, estimated to reach a maximum of 15,000m in some areas, accumulated along the continental margin in a geosynclinal setting that preceded the opening of the Indian Ocean. The opening of the Indian Ocean was associated with the development of a major north-south basin, probably with several comparatively smaller basins. These smaller depositional areas include the Mombasa, Malindi, Lamu and Anza basins. There is a close relationship between hydrocarbon potential and the occurrence of such ancient sedimentary basins which have the potential for good source rocks. In addition to the presence of good mature source rocks, the occurrence of hydrocarbon reserves depends also on the timely evolution of good reservoir rocks, and traps. Sandstones and carbonates are good reservoir rocks while shale horizons generate good traps.

From the limited data available in Kenya, analysis of hydrocarbon potential is difficult. However, if there was to be any potential, the most promising areas along the Kenya coast would be the Lamu Basin, the Malindi High and the South Anza graben. The sediment sequences in these areas vary from Recent to Triassic. However, good source rocks are anticipated at a depth of 3,000 m to 4,000 m in the Tertiary and Cretaceous sequences. The Tertiary deposits have been penetrated by many wells, but the Cretaceous has only been penetrated in a few places. The Cretaceous occurs at a depth of 3,450 m in Lamu and therefore good mature source rocks are anticipated.

Good source rocks and reservoir rocks for hydrocarbon deposits have been observed along the Kenyan coast, with conditions becoming more favourable offshore. The possibility of hydrocarbon reserves therefore exists, however, more detailed geophysical survey, exploration and drilling is required before there can be any certainty.

Figure 49 : Oil refinery at Mombasa

PORTS AND SHIPPING

Ports, probably more than any other natural or man-made amenity, have been extremely influential in determining the course of history for the Kenyan Coast. From as far back as the 8th Century, Manda and Shanga were acting as important gateways for communication, trade and commerce between the native African people and the Arab travellers from further north. Pate, Lamu and Mombasa are recorded from not much later (between the 9th and 11th centuries) and they are still in existence today. Another two ports established a bit later but which are also still in existence today are Siyu and Malindi. Among those which have declined are the ports of Ungwana (the only Kenyan historic port not on an island), Kiunga, Omwe, Mwana, Mtwapa and Vumba Kuu.

Ports which are still currently operational along the Kenyan Coast are Mombasa, Lamu, Kipini, Malindi, Kilifi, Mtwapa, Gazi and Shimoni. All Kenyan ports are administered by the Kenya Ports Authority.

PORT OF MOMBASA

The major port on the Coast is the Port of Mombasa. It has 16 deep water berths with 10.0m draft and a total length of 3,044m; two bulk oil jetties and one cased oil jetty; three container berths with a total length of nearly 600m; two bulk cement berths with three cement silos each with a 6,000 tonnes capacity; two lighterage and dhow wharves; and one explosives jetty.

Figure 50 : Mombasa's modern port at Kilindini, Mombasa Island

The major exports from Mombasa are : coffee, petroleum products, meat and meat products, hides and skins, cement, pineapple, and tea.

Main imports include : industrial and electrical machinery, crude petroleum, assembled motor vehicles and chassis, iron and steel, agricultural machinery and tractors, pharmaceuticals, fertilizers, textiles, mineral fuels, chemicals, food and live animals.

The number of shipping movements in 1990/91 was 1,213 which amounted to nearly 11% less than the previous year. However, the net registered tonnage of this smaller number of ships, was 6,345,171, which was over 7% higher than the previous year. The total number of passengers going through the port in 1990/91 was 26,194 which was a significant increase of over 73% over the previous year. Increases of around 10% were also recorded in all types of cargo handled by the port in 1991.

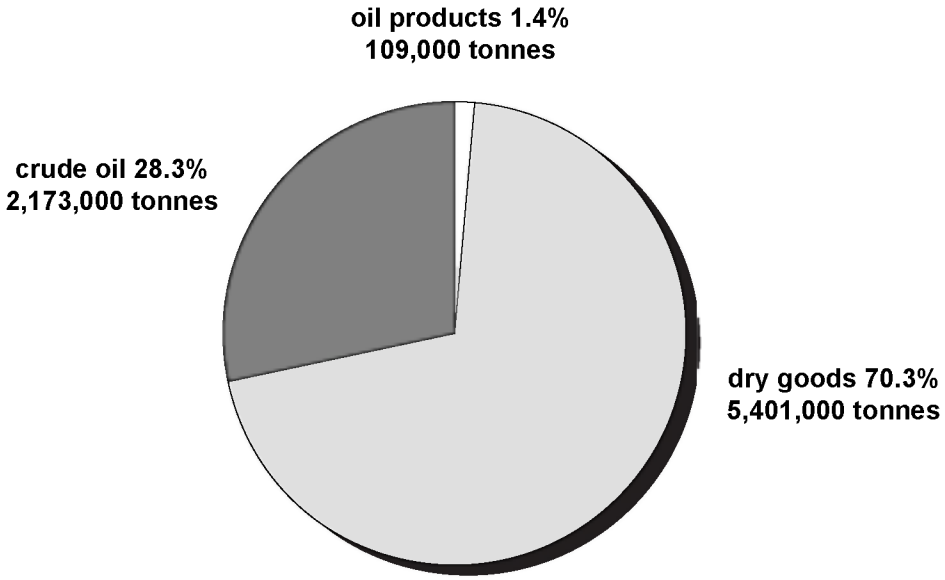


Figure 51 : Average annual cargo volumes at the Port of Mombasa

SHIPPING LANES

The Kenya coastal area is bordered offshore by a busy tanker route from the Middle East to various global destinations. It is estimated that 50 ships of various types are in the major shipping lanes off the coast of Kenya at any given time. Up to nine of these are likely to be oil tankers with capacities ranging from 50,000 to 250,000 tonnes. Most of this traffic passes more than 250 nautical miles offshore, however, tar balls originating from bilge discharges and tank washings reach the Kenya coast occasionally.

Closer inshore, the shipping lanes are more confined due to fringing coral reefs which must be negotiated. They are also more congested if the multitude of small inshore craft are also taken into account.

Figure 52 : The Port of Mombasa acts as a container gateway

RECREATION AND TOURISM

TOURISM ACCOMMODATION

The first hotels directed at tourism were built in Malindi during the early part of this century. In the last thirty years, rapid expansion in the recreation and tourism industry has occurred. The main attractions for this new industry include the warm coastal climate slightly mellowed by a cool sea breeze, the beautiful coastal scenery and foremost, the beautiful and clean sandy beaches. All the facilities that support the new expansion in the tourism industry are therefore located next or adjacent to beach environments.

In this category are the hotels with accommodation facilities located directly adjacent to the good swimming beaches. This has resulted in the concentration of tourism centres in areas with the most favourable facilities. Among the most important centres are, Diani, Tiwi and Shelly beach on the south coast, and Nyali, Bamburi, Shanzu and Kikambala in the middle sector. These are within the influence of Mombasa. North of Kilifi are Watamu, Silversands, Malindi and a new centre in Mambrui. Lamu District, in the extreme north, is also developing into an important tourist centre.

Figure 53 : Tourist facilities abound all along the Kenya coast

The new tourism centres have stimulated the development of a support infrastructure. Good examples are Diani, Kikambala and Watamu where completely new restaurants, shopping centres, banks and tour companies have developed to form major business centres on the landward side. In most of the cases, sea sport centres and marinas have developed along the shoreline attached to the main hotels. Important marinas and sea sport centres are located in Mtwapa and Kilifi Creek. There are sport fishing lodges and clubs at Shimoni, Mtwapa, Kilifi and Malindi.

At the time of writing there were 16 hotels on the Coast which boast a 5-star category, 21 hotels each of 4-star and 3-star, and 55 other standard hotels. Three hotels have 600 or more beds, while five have 400 or more.

In 1964 the share of foreign exchange earnings from tourism was only 8.0% of the total export of goods and services. By 1989 this had risen to 22.0% with an annual growth rate of around 20.6%.

In some areas, such as the coastal strip around Mombasa, the rapid development of tourism has put pressure on the sustainable use of coastal resources such as the coral reef. Demand for seafood, shells and coral souvenirs has risen sharply and as local supplies have become depleted. The pressure on the coastal ecosystem extends further and further from the resorts, spreading the impact.

DIVING, SNORKELLING, SCUBA

Diving facilities are available all along the Kenya Coast within reach of most coastal towns and tourism centres. Arguably, Kenyan waters are irresistibly attractive, constantly warm all the year round, clear and abundant with marine life. There is a variety of diving sites along the Coast offering underwater cliffs,

Figure 54 : Diving is a popular activity which is sustainable

wrecks, canyons, caves and spectacular reefs where visibility is normally in excess of 20m. The aquatic life within these waters is often very prolific and one usually sees moray eels, scorpion fish, lion fish, large groupers, octopus, lobsters, rays and, occasionally, whale sharks and manta rays.

Diani, on the south Coast, is a popular diving area with many diving and watersport centres. Just to the north of Diani is Tiwi Beach, approximately 25km from Mombasa. Tiwi reef is only 10 minutes by boat from the centre and offers diving sites marked by permanent buoys.

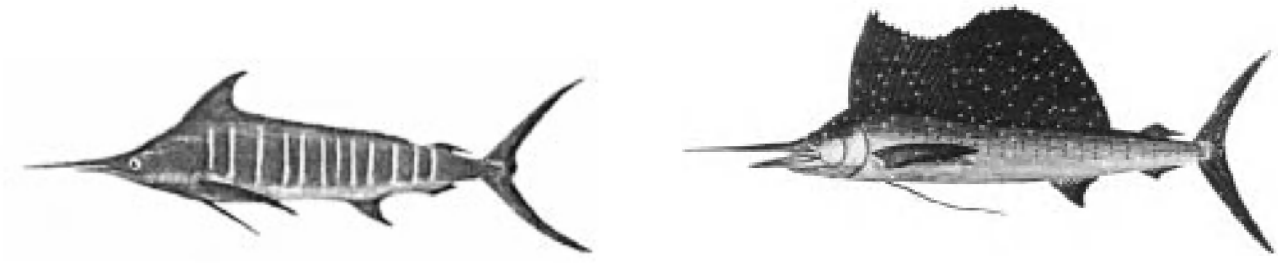
Diving has become one of Kenya's most important tourist attractions. It is a coastal resource with tremendous potential.

BIG-GAME FISHING

The Kenya Coast is fortunate in having one of the best big-game fishing spots in the Indian Ocean. Not only is there a wide variety of top sporting gamefish, but there is also a variety of sealife to be observed. Many of the All-Africa record catches are fish caught off the Kenya coast and they include five varieties of billfish. Fishing normally takes place between 1.0 and 30km offshore in open waters and the main areas are offshore from Malindi, Watamu, Kilifi, Mtwapa, Mombasa and in the vicinity of the Pemba Channel.

The fishing season starts in August and ends in April. The highlights of the early months in the season are the yellowfin tuna which can weigh up to 10kg. From December onwards it is the marlin season on which most of the clubs base their fame. Most of the marlin recorded in Kenya are caught at the Pemba Channel. Sailfish, sharks, wahoo, dorado and many other species are also caught throughout the season.

A number of charter boat operators cater for the growing number of local and visiting anglers who take part in this sport. There are also well-established Fishing Clubs and most of these are members of the International Game Fishing Association and abide by its rules.



Tetrapturus audax *Istiophorous platypterus*

Figure 55 : Striped marlin and sailfish are among the prized trophies of big-game fishing along the Kenya coast

INDUSTRY AND WASTE MANAGEMENT

MAJOR INDUSTRIES

Many industries on the Coast are based on primary production and process agricultural products both for export and for local consumption. These industries include cashew husking works, pineapple canneries, rice mills, copra drying facilities and other light processing or export preparation facilities for other crops such as coffee, groundnuts, cotton and sisal. Other industries include cement manufacture, steel rolling mills, iron smelting and oil refining.

Chemical plants located near Mombasa pose a risk of toxic effluents and spillages which may carry complex organics and heavy metals into the coastal environment. Textile mills which are also found near Mombasa, are another potential source of concern through the toxic dyes which they often discharge. On the other hand, the effluents from fish processing plants which are also common on the coast, are not expected to be toxic but they are high in Biochemical Oxygen Demand and organic nutrients leading to anoxic conditions and eutrophication respectively in the receiving waters.

The growing level of industrialization in greater Mombasa is causing considerable concern as a result of its environmental impacts. The discharge of industrial and domestic wastewater in the Creek has resulted in pollution and chemicals are known to leach from the solid waste dump established in the mangrove forest. Tar balls have also been common on some beaches.

Table 9 (below) gives an idea of the categories of industries in Coast Province and the numbers of registered firms in each category.

Table 9 : Numbers of registered firms by industry category for Coast Province

industry	registered firms
Vegetable and animal oil	13
Grain mill products	10
Bakery products	11
Textiles, knitting & weaving	24
Pulp, paper & board	6
Printing & publishing	6
Chemicals, paints, plastics & rubber	22
Sawmills & timber products	6
Petroleum refining	2
Metal products	21
Ship-building & repairs	2
Generation of electricity	3
Soap, perfume & cosmetics	3
Food, malt & soft drink	12
Cement lime & quarrying	9
Other	9
total	159

SOLID WASTE MANAGEMENT

Coastal urban centres that have refuse collection services are Mombasa, Kilifi, Malindi and Lamu. Solid waste from the Mombasa Municipality and Lamu, includes sludges from septic tanks and soakage pits, domestic rubbish and even industrial waste. This waste is disposed of at dump sites located in mangrove swamps. Refuse from Kilifi and Malindi is tipped on land sites.

LIQUID WASTE MANAGEMENT

Domestic sewage

Mombasa Municipality has separate sewerage systems for domestic sewage and storm water runoff. The domestic sewerage system was designed to serve about 17% of the current population. There are two treatment plants one located on the island and the other on the west mainland. These are designed for primary and secondary treatment, respectively. The outfalls for domestic sewage and storm water runoff are located in the Kilindini and Tudor Creeks. The rest of the town utilizes pit latrines (59%) and septic tank/soakage pit systems (24%). Sludges from septic tanks and pit latrines are usually disposed of at the Kibarani dump site on the shores of Makupa Creek.

In other coastal urban centres, the methods of domestic sewage disposal are mostly pit latrine, septic tanks and soakage pit systems.

Industrial sewage

Industrial activities are concentrated in the Mombasa District. With the establishment of Export Processing zones, industrial development is progressing beyond the District boundaries to Mazeras and Mariakani in Kilifi District. There are very few industries that have facilities for effluent pre-treatment before disposal and among those that have treatment systems is the petroleum refinery. A number of industries use septic tank/soakage pits, vertical drains or direct discharge into the sea.

Figure 56 : In addition to discharges from land-based sources there are also frequent operational and accidental discharges from ships

AGRICULTURE AND HORTICULTURE

The Kenyan coastal zone supports important agricultural activities including the production of food for local consumption and export. Important food crops include cassava, sweet potatoes, maize, coconut and cow peas, with rice being grown in irrigated areas, marshes, and floodplains. Bananas, mangoes and pineapples are also grown for domestic consumption and export while cashews and sisal are grown mainly for export. In the higher areas, coffee is becoming increasingly popular among small-scale growers. Several projects exist for the expansion of cotton cultivation as well as large scale production of other crops in the coastal zone.

The Coast combines high temperature with high humidity and apart from the Shimba Hills, much of the land is below 250m above sea level. The soils are complex but are usually low in fertility - they range from beach sands to poorly drained clays. The floodplains of the Tana and the Sabaki (Galana/Athi) rivers are fertile however, they are subject to flooding and localized salinity. East of the Tana the clay soils are prone to waterlogging.

Farms on the Coast average 6-8 hectares, with low-intensity cropping dominated by maize. Nearly 50% of the arable land is under tree crops -mostly cashews and coconuts, with some citrus and mangoes. Due to the unsuitable soils, sugar cane is no longer grown and the mill has closed down. Rice is produced locally wherever surface water levels can be controlled but the main arable cash crop is cotton, important in Kilifi, Tana River and Lamu Districts, even though yields are poor. In Kwale District, where the rainfall is high, the dye crop anatto is important.

Figure 57 : Sisal plantation

A traditional agroforestry practice on the Kenyan Coast involves the intercropping of coconut and cashew nut trees with maize, beans, simsim and cassava, especially during the early phases of tree establishment. During the dry season, when these inter-crops have died down, cattle are introduced to graze among the trees. With this system, the income from cashew nuts and dairy has been found to be double that of planting cashew nut trees alone. The trees provide windbreaks and shade that create good growing conditions for the livestock. The livestock in turn, suppress weed growth and recycle nutrients and organic matter to the soil with their wastes.

The Orma, who are pastoralists, move with large herds of cattle, sheep and goats in the lower reaches of the Tana River basin in search of grass and water. However livestock raising in the coastal lowlands is limited by the tsetse fly, and reduction of this vector through bush clearing, especially in river plains, could lead to increased livestock raising.

Mangrove forests are harvested for poles and various other timber products. Other forested areas still exist in the coastal zone and while some of these have been designated as forest reserves or national parks, many areas are milled for timber.

The high population growth has driven cultivated areas to expand into areas of marginal rainfall, dry-season pasture, slopes greater than 15° and river margins. In addition, the relatively higher potential soils that constitute only about 20% of the total national area have come under more intensive cultivation pressures, and soil conservation measures have not been sufficient to counter the impacts of emerging agricultural patterns.

Subsistence farmers throughout the region tend to practice shifting cultivation with new areas being subject to clearing and planting in a regular cycle. Fire is often used for land clearing and burning is of special concern along the Coast because it can lead to destabilization of fragile coastal soil structures such as bluffs and dunes. Small gardens known as shambas are routinely established along the banks of rivers and streams and in interdune areas. Livestock raising can also be especially destructive near the coast with tracks made by animals tending to destabilize fragile dune vegetation and leading to sand movement and serious erosion.

Table 10 (below) provides a summary of the types of crops grown and tonnages produced in Coast Province in 1992, according to the Ministry of Agriculture District Annual Reports. The largest crop recorded was cassava with over 111,000 tonnes, followed by maize (61,000 tonnes), citrus (53,000 tonnes) and coconuts (52,000 tonnes). Most crops were produced throughout the Province in all Districts. However, some crops were specific to one or two Districts. For example, Mombasa was the only District to grow potatoes, cucumbers and karella; while arrowroot and coffee were only produced in Kwale; sisal was only grown in Kilifi; and cabbages and pineapples were produced in Kwale and Kilifi.

Table 10 : Agricultural crop production in 1992 from Coast districts (Data from Ministry of Agriculture District Annual Reports)

crop in tonnes	District					
	Lamu	Tana	Kilifi	Mombasa	Kwale	TOTAL
maize	2384	1317	33356	421	23837	61315
sorghum	136	0	30	5	129	300
rice	14	292	1429	70	1508	3313
millets	39	0	1	3	67	110
cow peas	432	104	3211	50	1132	4929
green grams	103	167	544	4	311	1129
beans	0	72	196	0	429	697
cassava	1771	427	71640	1620	36250	111708
arrowroot	0	0	0	0	140	140
potatoes	0	0	0	546	0	546
tomatoes	63	1776	2232	0	3339	7410
kales	82	1040	832	24	520	2498
brinjals	11	0	696	440	384	1531
chilles	23	0	235	54	255	567
capiscum	0	0	110	14	190	314
okra	4	0	205	231	90	530
onions	3	210	45	6	125	389
cucumber	0	0	0	54	0	54
cabbage	0	0	224	0	441	665
karella	0	0	0	27	0	27
water melon	24	24	320	27	441	836
amaranthus	0	0	170	2286	390	2846
bananas	4460	8530	3300	1900	16288	34478
citrus	513	95	16000	777	35640	53025
mangoes	6190	8736	21000	1376	10300	47602
pineapples	0	0	10800	0	848	11646
pawpaws	750	80	905	1947	117	3799
coffee	0	0	0	0	11	11
bixa	630	0	0	0	1512	2142
cashewnuts	860	10	3370	135	5648	10023
cotton	1897	992	73	1	7	2970
coconuts	2970	414	30750	517	18258	52909
simsim	148	1	654	5	511	1319
sisal	0	0	4334	0	0	4334
TOTAL	**23507**	**24287**	**206662**	**12540**	**159116**	**426112**

Figure 58 : Traditional coconut plantation and a more recent planting of mangrove trees

CONSERVATION AND ECOTOURISM

FOREST PARKS AND RESERVES

Arabuko-Sokoke Forest

The Arabuko Sokoke forest in Kilifi District, was gazetted in 1932 as a Government Forest Reserve and is managed jointly by the Forestry Department and the Kenya Wildlife Service. It is one of the last remaining tracts of lowland forest on the East African Coast and is the largest stand of indigenous coastal forest in Kenya. It lies near Malindi with the Sabaki River to the north and Kilifi Creek to the south and it covers an area of approximately 42,000 hectares, 4,330 hectares of which are gazetted as a nature reserve. The forest is low-lying, barely rising above 60m at its highest point and contains a number of ephemeral pools and flooded sandpits. On its eastern side, the forest reaches down to the sea where it incorporates Mida Creek with its stands of red mangrove (*Rhizophora mucronata*).

Figure 59 : Satellite view of Arabuko Sokoke Forest

The forest is part of the coastal forest mosaic in East Africa believed to be isolated at present from the other coastal forest areas because of post-Miocene climatic changes. Botanical links between particular plant families indicate that the forest has on more than one occasion formed part of a more extensive coastal forest system. It is the isolated biogeographical nature of the forest and the resultant species endemism which give this particular coastal forest its status as an area of high conservation importance.

The average annual rainfall in the forest is 800mm and the mean air temperatures are high. The diverse soils vary between white to pale brown sandy soils and the red lateritic soils characteristic of the Magarini ridge.

The forest has a high degree of plant endemism with many species occurring in only a few other coastal forests including the Kayas. It has at least nine of Kenya's rare trees and shrubs including *Buxus obtusifolia, Pteleopsis tetraptera, Ellipanthus hemandradenioides, Aristogeitonia monophylla, Lasiodiscus mildbraedii, Canthium kilifiensis, Canthium robynsianum* and *Nesogordonia holtzii*. Many of the most notable trees are M'bambakofi (*Afzelia quanzensis*). Also prominent is the spreading *Brachystegia spiciformis* which is a typical miombo tree all the way down to Mozambique. Somewhat less common and more sought after as a carving timber, is the muhuhu (*Brachylaena huillensis*).

The forest is home to over 130 species of birds including a number of rare species namely, the Sokoke Scops-owl (*Otus ireneae*), Clarke's Weaver (*Ploceus golandi*), Sokoke Pipit (*Anthus sokokensis*), Spotted Ground-thrush (*Turdus fischeri*), East Coast Alkalat (*Sheppardia gunningi*) and the Amani Sunbird (*Anthreptes pallidigaster*). Of these, the Sokoke Scops-owl and the Clarke's Weaver are found nowhere else. In fact, of the 72 bird species in Kenya that are of national and international concern, 26% are found in Arabuko-Sokoke Forest.

Spotted Ground Thrush

Sokoke Pipit

Figure 60 : Two of the bird species that abound in Arabuko-Sokoke Forest

The mammal population in Arabuko-Sokoke Forest is not very large. A small population (between 60 and 90) of elephants inhabit the forest together with three rare mammals, the Ader's Duiker, the Sokoke Bushy-tailed Mongoose and the Golden-rumped Elephant-shrew. Among the amphibians in the forest is the remarkable African Foam-nesting Frog which suspends its eggs in moist foam bubbles on tree branches above pools. The forest has many insect species including 81 species of butterfly of which four are endemic - *Acrae matuapa, Charaxes bland kenyae, Baliochila latimarginata* and *Baliochila africanus*. The termites are represented by a sole rare species, *Grallatotermes africanus*.

The attractions of this unique coastal forest are slowly coming to the notice of visitors and tourists. To cater for this interest and to exercise a controlling influence, the Kenya Wildlife Service and the Forestry Department have set up a small information centre at the Gede Forest Station. In 1990 some 500 tourists visited the forest and by 1992 the number had grown to 1,300 visitors. It is hoped that before too long, the numbers will increase to include the majority of the 40,000 tourists who visit the Gede historical ruins, only 10 minutes drive away.

Shimba Hills National Reserve

The Shimba Hills National Reserve was gazetted in 1968 under a joint management arrangement between the Kenya Wildlife Service and the Forestry Department. The Kenya Wildlife Service is responsible for animals while the Forestry Department is responsible for the production forest estate (there are about 800 hectares of *Pinus caribaea* planted for timber). Topographically, the Reserve consists of a dissected plateau rising steeply from an altitude of around 120m and comprising 19,251 hectares set aside for multiple use management combining protection for

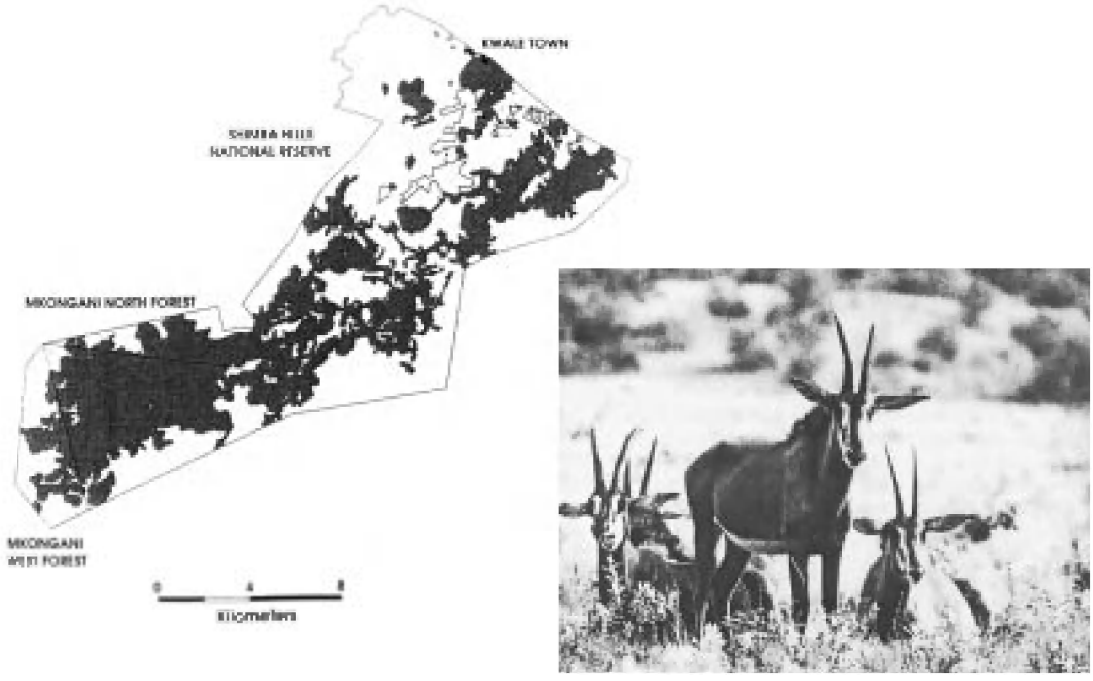


Figure 61 : Shimba Hills National Reserve and the best known of its inhabitants, the Sable Antelope

tourism, protection of fragile water catchments, and wood production. The Reserve is situated in Kwale District, about 33km from Mombasa.

The best known of its inhabitants is the Sable Antelope (*Hippotragus inger*) and although not thought to be the only population in Kenya, this was considered as the most robust at 260 individuals when studied in the late 1970's. Four types of forest exist in Shimba Hills, namely, *Paracrolobium* forest, Riverine forest, *Combretum* dry forest and *Chlorophora* wet forest. From the biodiversity point of view, the Shimba Hills forests are very important for their high proportion of endemic plants - about 25% of over 1,000 species recorded. In addition, because the area is so small, most of these are considered rare.

The prolific and varied plant life supports a vast array of insects which include nearly 300 species of butterflies - some 35% of Kenya's total. Of these, 13 species are very rare and two are endemic. The insects in turn provide food for a number of forest and coastal birds. Three of these bird species, also found in the Arabuko-Sokoke Forest, are internationally rare and a further ten are rare in Kenya. In addition, the forest supports some 35 mammal species including the bulk of the Kenyan population of the Angolan Black-and-white Colobus Monkey (*Colobus angolensis*).

The 600-strong herd of elephant is a management dilemma. The high density is not only having an impact on the forest; this impact is spilling over into people's gardens in Kwale. Monitoring is being undertaken in an attempt to resolve this direct conflict between wildlife and the rural community.

Figure 62 : Elephants, Shimba Hills Reserve

ANCESTRAL KAYA FORESTS

Until comparatively recently, the nine Mijikenda tribes and their Kaya forests have received surprisingly little attention. Few anthropologists have worked on an individual group in its own right and while their fascinating history has recently been well-documented, many aspects of Mijikenda culture are still unknown. Neither have any major botanical studies been conducted on their Kaya forests.

The nine Mijikenda tribes today are linguistically and culturally distinct. However, while the exact account might differ from tribe to tribe, the Mijikenda all agree that they derive their group identity from the common history of their migration from "Singwaya". According to the Giriama, the migration (from a location somewhere north of the Juba River in Southern Somalia) was to escape the Galla. But while that may have been the reason for the first migration, there have been many subsequent wanderings which seem to have been brought about by competition for land. These competing claims have continued to the present day.

The Kambe suggest that they were instrumental in setting up many of the Kayas such as, Wao, Rabai, Kambe, Kamboga (Ribe), Solokero, Mudzimiri near Vipingo, Mbuyuni and Jibana. However, both the Ribe and the Jibana assert that they were already settled when the Kambe arrived. Such differing accounts are to be expected from an oral tradition and do not detract at all from the historical fact that the Mijikenda tribes who are nowadays spread throughout the Kenyan Coast region, arrived here after extensive migrations and wanderings. The Mijikenda could now aspire to a more settled existence in their recently established Kayas.

It is thought that Kayas flourished during the 17th and 18th Centuries. The entire tribe lived in their traditional thatch grass houses within the Kaya boundary, protected from the marauding Galla by a palisade and a forest penetrable only by two narrow paths. Along these paths were three wooden gates which were

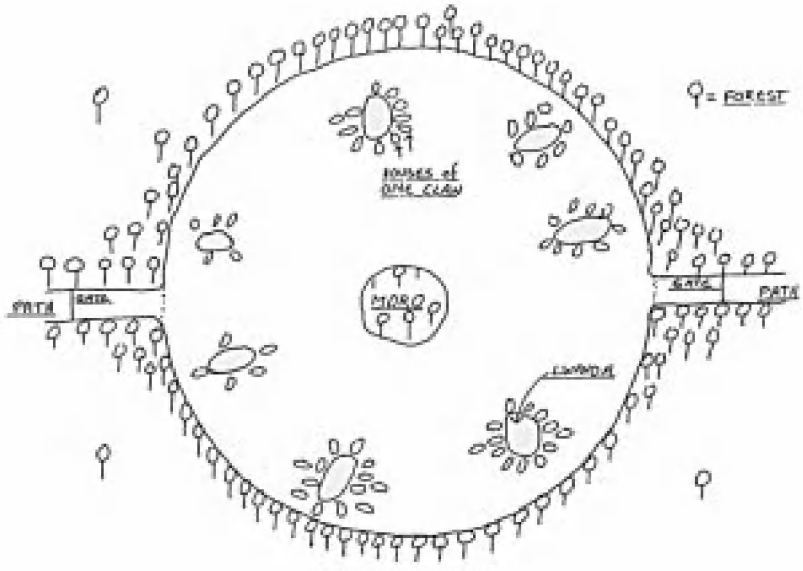


Figure 63 : A generalized plan of Kaya - protected from the marauding Galla by a palisade and a forest penetrable only by two narrow paths

heavily defended. The area immediately surrounding a Kaya forest was farmed intensively, with sorghum and millet being the staple crops at this time. Land was communally owned and its division amongst the clans and sub-clans (like the division of ground within the Kaya) was determined by the elders.

Farming was carried out on three out of a four-day week operated traditionally by the Mijikenda. The fourth day was a day for trading with other tribes, a day for rest and relaxation, and a day during which the elders would assemble at moro (the meeting place in the centre of the Kaya) to discuss the affairs of the tribe.

Various areas of the Kaya and surrounding forest are set aside as burial areas. Graves are frequently marked by either plants or posts. Some grave posts still remain in the Kaya today, but the majority have been stolen primarily for sale to collectors of "ethnic art". The wood used for grave posts was muhingo and pieces of cloth in red, blue and white, were tied onto the posts representing clothes.

By the start of the 19th Century, the Mijikenda, and the Giriama and Rabai in particular, were part of elaborate trading systems in which they acted as middlemen trading ivory and cattle from the Galla, Waata and Kamba, to the Swahili, and returning with trade goods such as cloth and beads. They also traded directly with the Swahili, exchanging agricultural and forest products such as gum copal, honey and beeswax for the Arabs' more exotic goods.

It was also around this time, and for a number of reasons, that the Kayas ceased to be the central residence of the entire tribe, although people returned to them for important ceremonies and as a place of refuge in attack. And, attacks there were, this time from the Iloikop Masai who had ousted the Galla and taken over their marauding role. This must have been the force which discouraged the total abandonment of the Kayas by the Mijikenda. However, the Duruma, Chonyi, Jibana and Ribe left their Kayas in the 1850's and 60's, while the Kambe and the Kauma were the last to leave in the 1870's

Figure 64 : Giriama grave markers and ancestral figures, Arabuko-Sokoke Forest

Also during this time, drastic changes occurred to the trade routes and the role of the Mijikenda as middlemen was diminished. Colonial rule arrived late in the 19th Century when the British established the East African Protectorate. In this, they dealt directly with the Swahili and by the time the Mombasa - Nairobi railway was complete in 1901, the Coast was in direct contact with the interior and the Mijikenda middlemen were bypassed completely.

This decline in the Kaya was probably inevitable in the face of the many changes brought about by the 20th Century. A handful of Mijikenda, mainly wazee (old men) still live in the Kayas although all are in a bad state of disrepair. Some local people go into the Kaya occasionally as representatives of their clan to do harambee

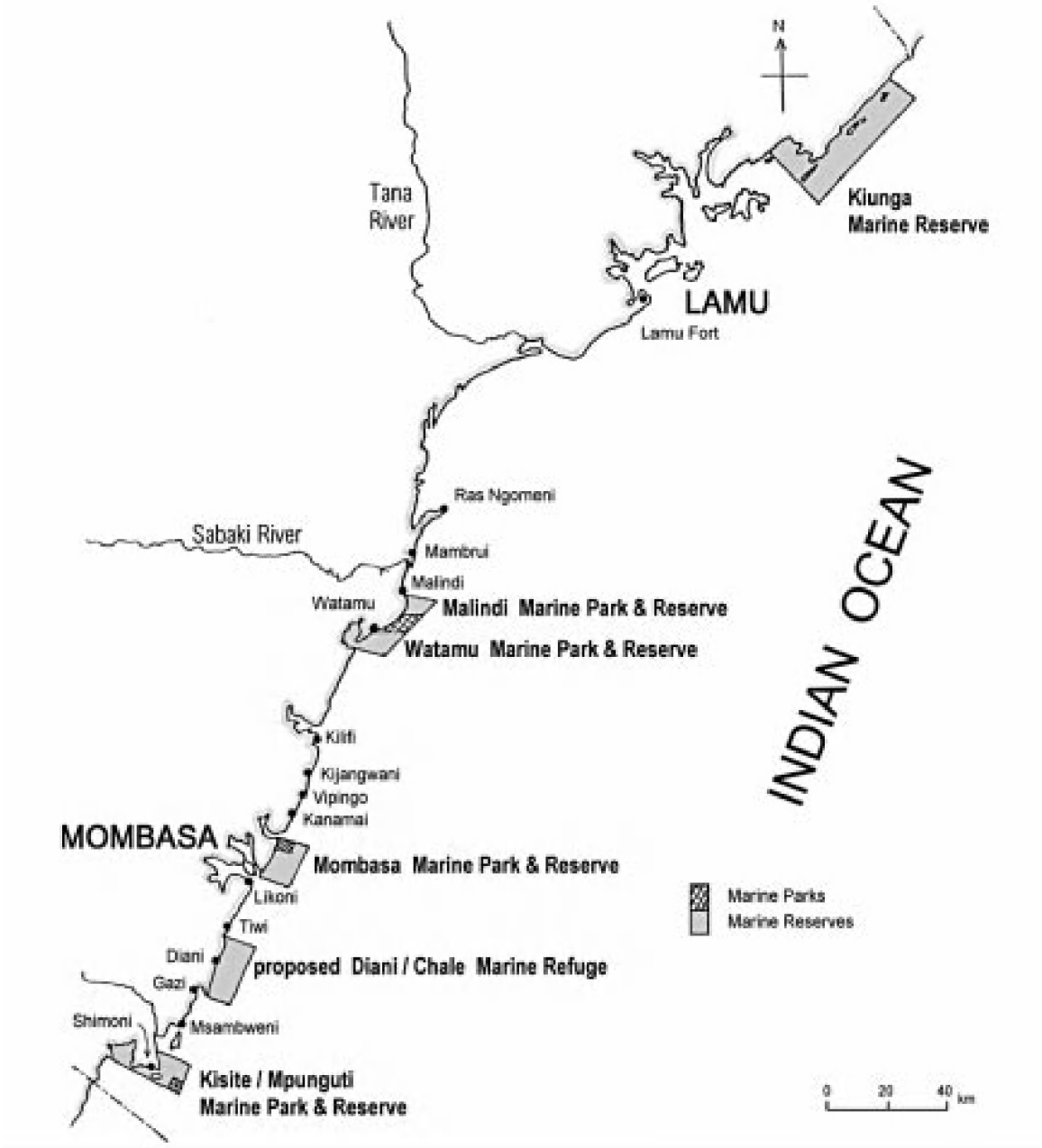


Figure 65 : Marine protected areas along the Kenya coast

work. But while the abandoned Kayas decay only slowly by a natural process, the surrounding forests are usually damaged rather quickly by opportunists who cut down trees for sale.

The increased interest being shown by ethno-botanists, the greater respect being shown for cultural heritage, the heightened sensitivity to environment and conservation issues and the effective implementation of existing legal protection measures, may enhance the survival chances of the Mijikenda Kaya forests.

MARINE PROTECTED AREAS

Kenya led Africa with the establishment of the continent's first marine protected areas in 1968. These areas are primarily designed to conserve Kenya's coral reefs which run along most of the coastline and which form a biodiversity hotspot second only to the tropical rainforests. The larger protected areas also enclose important breeding sites for migratory marine birds, marine mammals and three species of turtle.

There are four Marine National Parks in total - those at Malindi, Watamu, Kisite and Mombasa. Their total area is 54km^2 and all are managed by the Kenya Wildlife Service. Fauna and flora in the Marine National Parks are fully protected and the introduction of species is prohibited.

In addition there are five Marine National Reserves - Malindi, Watamu, Mpunguti, Mombasa and Kiunga. Their total area is 706km^2 and they are administered by the Kenya Wildlife Service with traditional fishing being allowed within their boundaries.

Two more protected areas have been proposed, one at Ras Tenewi and the other at Diani.

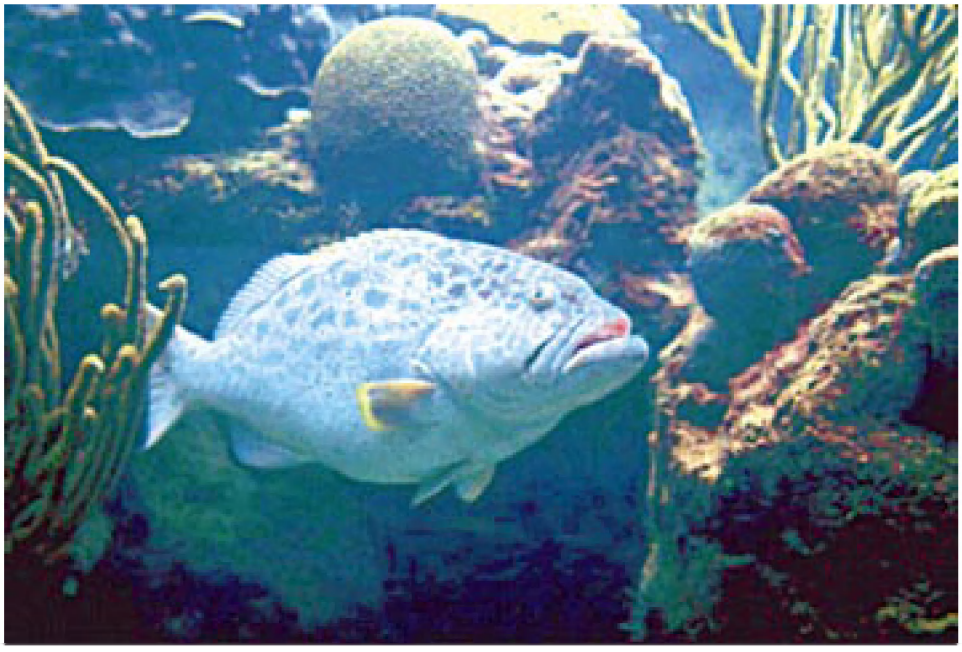


Figure 66 : Groper amongst coral

Table 11 : Summary of marine parks and reserves on the Kenyan Coast

name	area (ha)	year set up	location	resources
Malindi/Watamu Marine National Park and Biosphere Reserve	20000	1968	South of Malindi to Mida Creek. Close to Gedi Ruins and Arabuko Sokoke Forest.	Fringing reefs; coral 'gardens' in lagoons; seagrass beds; mangroves; mudflats; shorebirds.
Kiunga Marine National Reserve and Biosphere Reserve	250000	1979	South of Somali border to within a few kilometres north of Lamu. Close to Dodori and Boni National Reserves.	Coral reefs; islets with large nesting bird colonies (e.g. Roseate Tern); dugong; nesting turtles; pristine mangrove stands; remote and undisturbed.
Kisite Marine National Park and Mpunguti Marine National Reserve	39000	1978	Off Shimoni south of Wasini Island.	Coaral reefs; 4 small islets important for nesting birds; fisheries etc.
Mombasa Marine National Park and Reserve	200000	1986	To 13km offshore from Nyali to Mtwapa Creek.	Coral reef ecosystem with associated beaches. High tourist use.
Proposed Tana River Delta Wetland Reserve	20000	propos-ed	Southwest of Kipini.	Undisturbed wetland (ramsa candidate); birds, turtles, numerous fish.
Diani Chale Marine Reserve	approx 250	being set up	25km south of Mombasa from Mwachema River to Chale Island.	Coral reefs; fishing grounds; mangroves; seabird nesting sites; limestone caves; high tourist use.

In some cases, a marine national park is surrounded by, or is contiguous with, a marine national reserve with the latter serving as a sort of buffer for the more valuable marine national park resources.

Of the 0.75 million tourists who visit Kenya annually, about half are attracted to the Coast with a significant percentage of these visiting the marine parks and reserves. This means opportunities for commerce, tourist business and employment for the local people. Essentially, the Coast economy depends, to a significant extent, on the tourism industry which in turn is dependent on Kenya's coastal and marine resources.

Following below is a closer look at the three most popular marine protected areas.

Mombasa Marine National Park and Reserve

Mombasa Marine National Park and Reserve were established under the Wildlife Conservation and Management Act in 1986. They are continuous and are located between Nyali Creek and Mtwapa Creek just north of Mombasa.

The objectives of the Mombasa Marine National Park and Reserve are :

- To preserve and maintain a representative area of the coral reef ecosystem including the beaches and other ecological features.
- To encourage public understanding, appreciation and enjoyment of the natural resources through interpretation, education and provision of recreational opportunities.
- To undertake the development of these natural resources in a manner which will generate income.

The Park and Reserve have the following ecological features : the coral reef, the reef flat, the lagoon, extensive beaches and the cliffs.

As can be expected, corals abound in the Park and include the branching types (*Acropora* sp.), encrusting corals (*Turbinaria* sp.) and massive corals (*Porites* sp.). Coral fish that are commonly found in the Park/Reserve span more than 15 families and the flora is mostly *Thalassia* sp.

The reserve can be reached from the Mombasa / Malindi road through at least 19 hotels which have frontages on to the Park beach at Nyali, Bamburi and Shanzu.

Traditional sailing boats and glass bottomed boats ferry visitors into the park and reserve and vessels can be hired for sailing into the reserve.

Figure 67 : Traditional sailing canoe, popular with tourists for visits to the reef

Common recreational activities in the Park include goggling or snorkelling, jetski rides, sailing, windsurfing, sun bathing, beach walking etc.

Currently, visitors to the Park total over 50,000 annually.

Malindi and Watamu Marine National Parks and Reserves

The Malindi Marine National Park has been designated a Biosphere Reserve under the Man & Biosphere programme of UNESCO.

Among the physical features of the Parks are Barracuda Reef and North Reef, coral gardens, Turtle Island and Whale Island, many kilometres of sandy beach, cliffs and underwater caves.

The coral families that are represented in the Parks include Favidae, Poritidae and Acroporidae. The Parks also hold hundreds of species of fish from more than 12 families. The underwater flora comprises mainly Cymodocea algae, however, the Parks extend on to land where Casuarina and palm trees are common and include a significant mangrove forest in Mida Creek. The mangroves attract large numbers of migratory and resident birds. Also in the Parks, the Green Turtle is making a comeback.

Some 17 hotels provide access to the Parks through their beach frontages and visitors to the Parks are estimated at over 70,000 annually.

Siltation brought down by the Sabaki River during the rainy season has increased as a result of changing land use practices inland. This impedes visibility in the Parks and is a threat to the health of the coral ecosystem. A further threat is the domestic sewage emanating from the major population centres adjacent to the Parks and the felling of mangrove trees in Mida Creek for commercial purposes.

Figure 68 : Acropora coral

Kisite/Mpunguti Marine National Park and Reserve

Kisite Marine National Park and Mpunguti Marine National Reserve were gazetted in 1973 and 1978 respectively . Together they cover an area of 39km^2 situated south of Wasini Island in Kwale District, Coast Province. The Park Headquarters is situated at mainland Shimoni, a distance of 80km south of Mombasa and the Park/Reserve proper is about 8km from the Park Headquarters.

A list of the park resources starts with vegetation found in front of the Park Headquarters. These include a number of different ecosystems - *Bostrychia* on the shaded vertical cliff wall. Moving down the coast there are large quantities of a *Chaetomorpha* spp. in the overheated reef pools; then *Gracilaria salicornia, Acanthophora spicifera, Ulva* sp., some *Laurencia papillosa, Hypnea cornuta, Boergesenia forbes, Enteromorpha* , and *Champia* sp. etc. in the mid-littoral and the seagrasses *Halodule wrightii, Thalassia hemprichii, Syringodium isoetifolium* and *Enhalus acoroides* a bit further down. These give way first to isolated coral and then the very healthy coral growth, with some *Turbinaria decurrens* and locally very short mats of mixed small seaweeds and encrusting Corallinaceae.

The fauna on land includes the rare Colobus and Vervet monkeys, while terrestrial plants of note include *Afzelia, Baobab* (*Adamsonia digitata*), *Casuarina, Lantana, Cammelina,* various mangroves and various types of grasses on the five coral islands within the park.

The coral gardens in the Park are among the best in the world. Common families include - Pocillaporidae, Acropodae, Agaricidae, Fungidae, Poritidae, Faviidae, Oculinidae, Musidae, Pectinidae, and Milleporidae. The Park is famous for the abundance of coral fish and other marine flora and fauna including representative species of no less than nine families of coral fish and ten groups of aquatic birds.

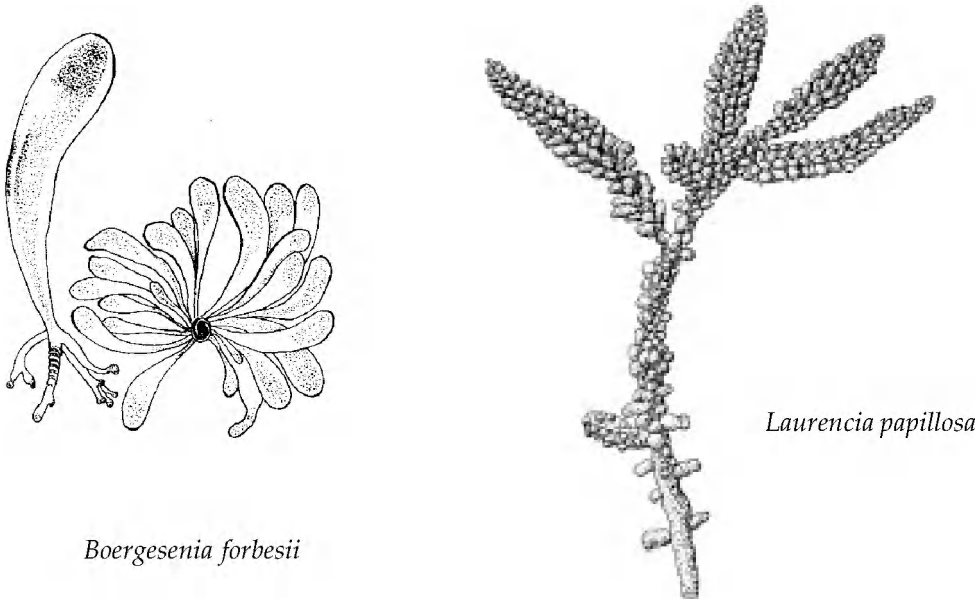


Figure 69 : Two of the seaweed species common in the marine park

The number of visitors to the Park annually has increased in leaps and bounds from 597 in 1975 to over 32,000 in 1991.

Future plans for the Park include diversifying tourism activities by finding new visitor attraction sites and implementing new ways to increase the revenue base for the Park. This will be done without compromising conservation and management aspects of the Park and the environment as a whole.

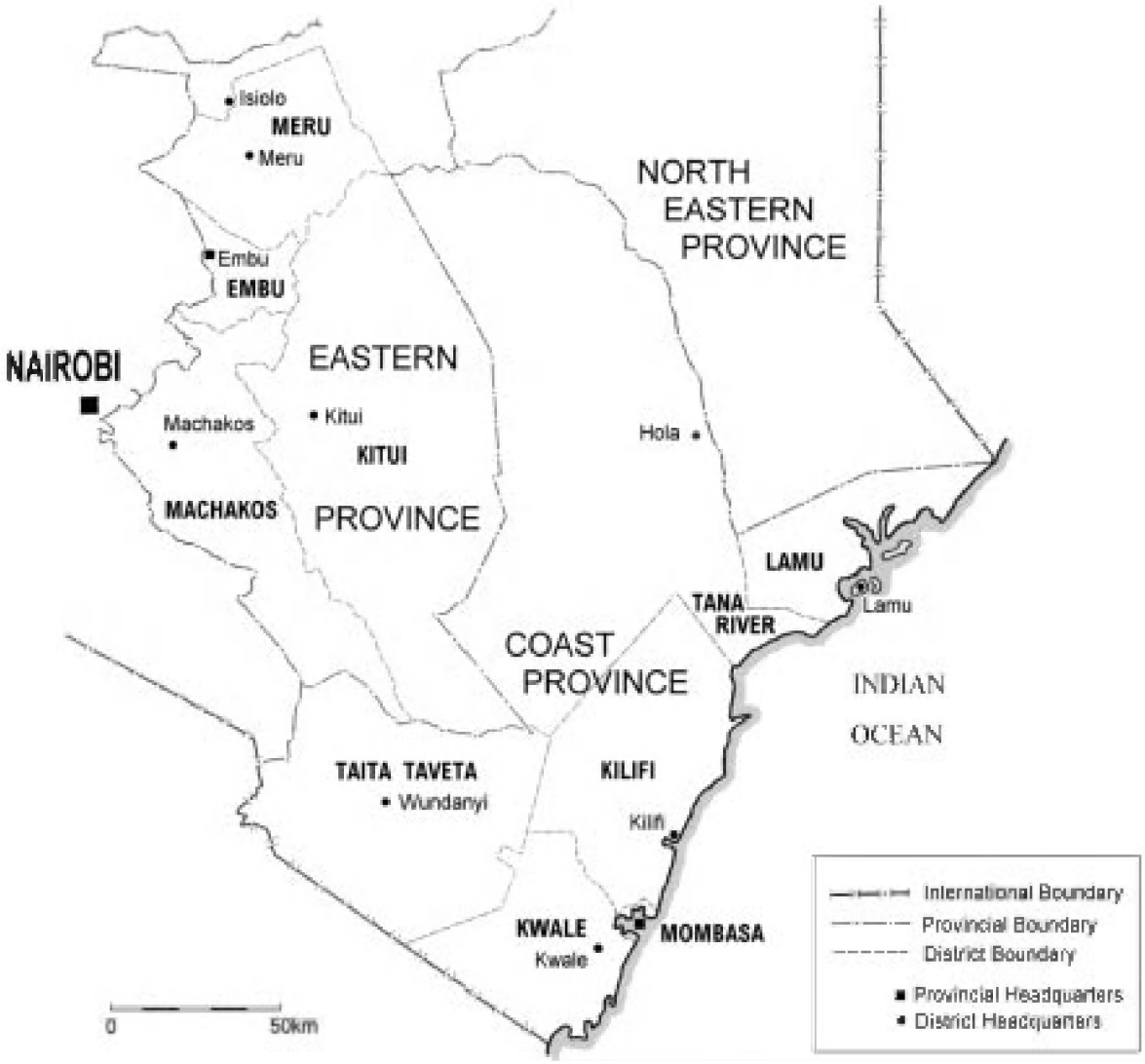
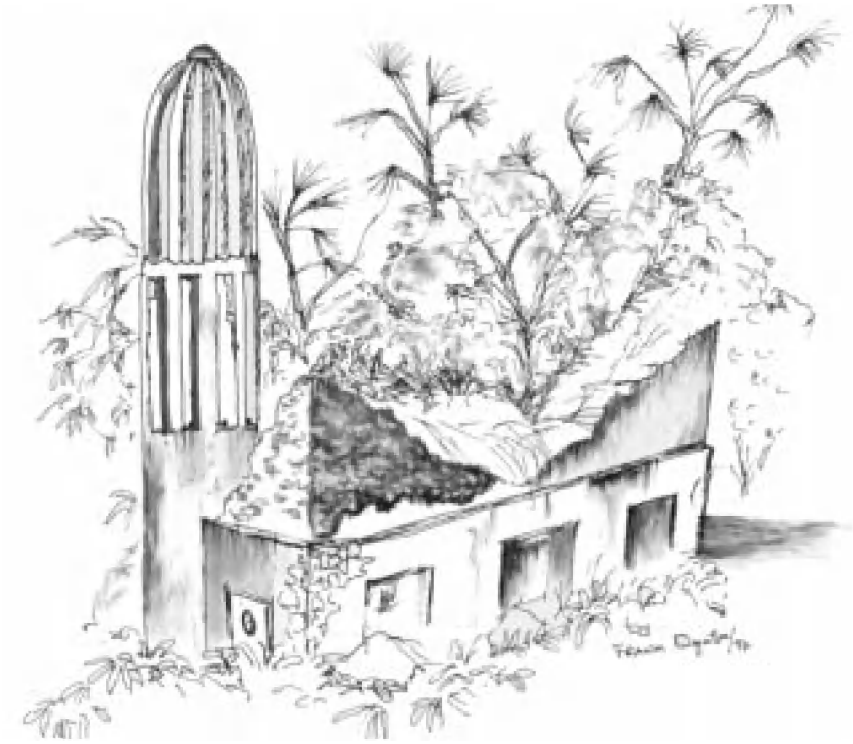


Figure 70 : Kenya administrative boundaries



Shanga Fluted Pillar Tomb, Pate Island

MANAGEMENT OF THE COAST

ADMINISTRATION

There are basically two layers of government in Kenya - central government and local government. Central Government is effected through Provincial administrations and the coastal areas of Kenya are administratively governed together as the Coast Province.

Coast Province has six Districts namely, Mombasa, Kilifi, Kwale, Tana-River, Taita-Taveta and Lamu. The chief administrator of the Province is the Provincial Commissioner while the Districts are under the jurisdiction of District Commissioners. Each District is further subdivided into Divisions which are governed by District Officers. Locations and Sublocations, which are smaller administrative units within Divisions, are under Chiefs and Assistant Chiefs respectively. Apart from the organization of the Districts on an administrative basis, there are also political constituencies. Each Constituency has a Member of Parliament who represents it in the National Assembly.

In addition, there are also wards which are represented in Municipal, Town, Urban and County Councils by Councillors who are elected by popular vote.

The limitations of size and scale imposed on this Atlas do not allow coverage beyond approximately 50km inland from the coast, however, this still allows consideration of the majority of Coast Province. While the map coverage omits all but a small portion of Taita-Taveta District, it extends over the entire Districts of Kwale, Kilifi, Mombasa and Lamu, as well as taking in the lower reaches of the Tana-River District.

COASTAL LEGISLATION

There are a number of Kenyan statutes which impinge directly or indirectly on the coastal and marine environment, its resources and their management. The figure opposite illustrates the relative extent of their jurisdiction.

Following is a summary of the objectives and provisions of selected statutes.

The Water Act (Cap. 732)

The Water Act provides for the conservation and controlled use of water resources in Kenya. It is implemented by the Government through the Ministry of Land Reclamation, Regional and Water Development. The Act prohibits pollution of

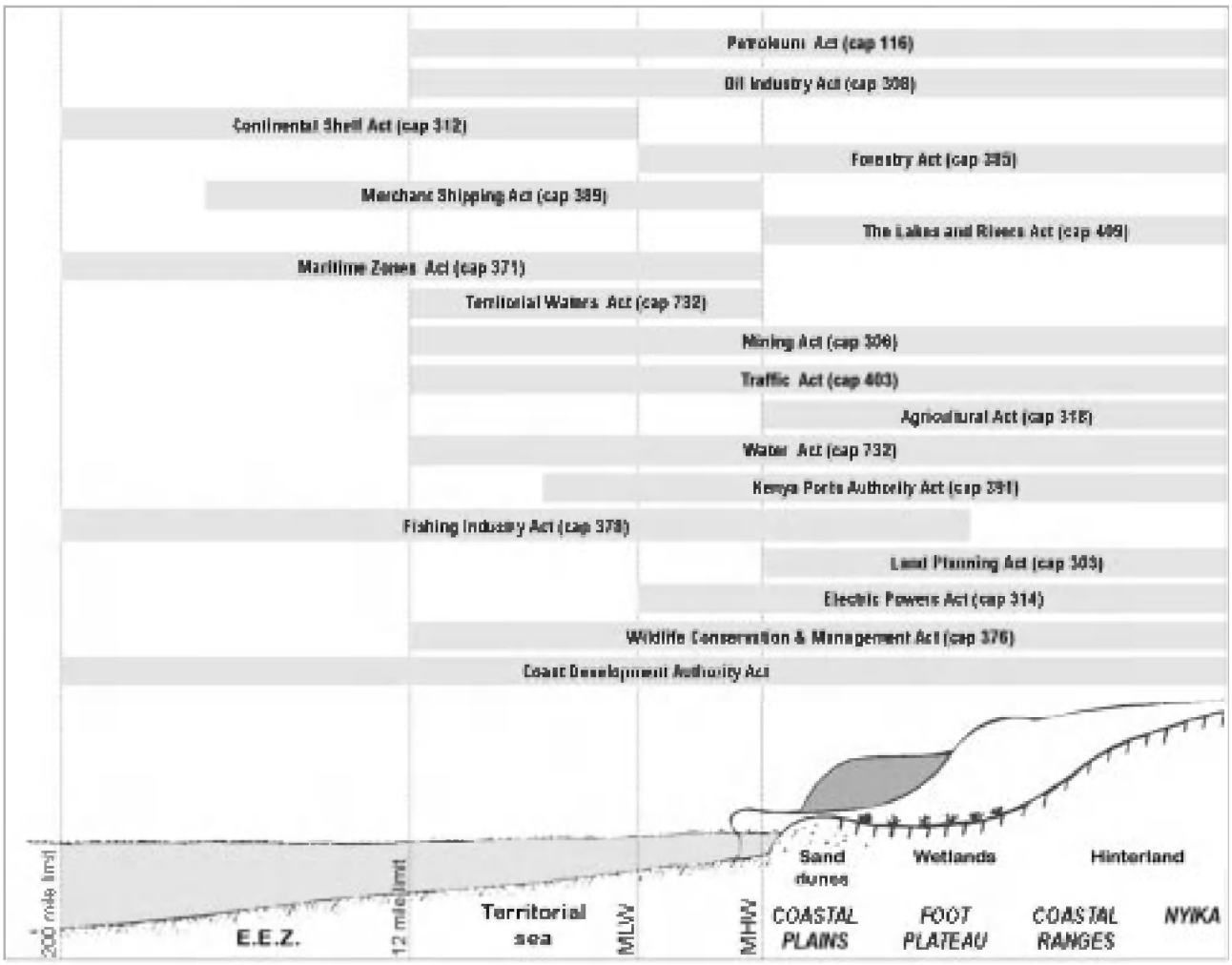


Figure 71 : Laws and Regulations applicable in coastal zone management in Kenya

water resources and controls the discharge of industrial and municipal effluents into rivers and the ocean. The Ministry has therefore established the technical mechanisms (including laboratory facilities) for monitoring the quality of various water resources of the country.

Through the judicious apportionment of river and lake water resources, the Act also ensures the constant availability of freshwater for coastal communities in Kenya.

Agriculture Act (Cap 318)

The Agriculture Act contains provisions for promoting agricultural development, and it is implemented by the Ministry of Agriculture, Livestock Development and Marketing. The long-term objective of the Act is to ensure the development of arable land in accordance with the sound practice of good land use. It therefore stresses the need for conservation of soil and its fertility and has provisions for soil erosion control. Through these provisions it has the means to control one of the most important pollutants of the Kenyan marine and coastal environment namely, sediments eroded from agricultural lands.

By regulating the utilization of different categories of land in Kenya for various agricultural purposes, the Act strives towards the sustainable utilization of land resources, including coastal lands.

Forestry Act (Cap 385)

The Forestry Act is implemented by the Ministry of Environment and Natural Resources and it has provisions for the establishment, control and regulation of central forests and other forests in Kenya. It encourages the conservation of vegetation of all types (both indigenous and exotic).

The Act applies to mangrove stands, lowland forests as well as other coastal forest resources and can provide the means through which the exploitation of these resources can be managed for sustainability.

Government Fisheries Protection Act (Cap 379)

The Government Fisheries Protection Act is implemented through the Ministry of Environment and Natural Resources. It has provisions for the control and management of certain coastal and marine species such as the pearl oyster and other resources which are threatened with depletion through commercial exploitation.

Fish Industry Act (Cap 378)

Fish Industry Act has provisions for control of fishing activities and subsequent processing in both inland and coastal waters of Kenya. The act is implemented by the Ministry of Tourism and Wildlife in conjunction with other state organizations. The act has great relevance for the management of the Kenya's coastal fisheries resources and guards against over-exploitation through over-fishing and the use of harmful fishing methods.

Merchant Shipping Act (Cap 389)

The Merchant Shipping Act which is implemented by the Ministry of Transport and Communication in conjunction with other Ministries, is the statute which provides for the control of pollution of the sea by oil from ships. The Act can be considered as the mechanism for regulating the pollution of Kenya's territorial waters arising from ship-based sources.

Wildlife Conservation and Management Act (Cap 376)

This act of parliament is implemented by the Government of Kenya through the Ministry of Environment and Natural Resources in conjunction with other relevant government agencies such as Kenya Wildlife Service. The act has provisions for the preservation and control of wild fauna and flora. The intention of the act is to ensure Kenya's fauna and flora flourish naturally in their habitats. Various marine and other national parks apply the act in protecting flora and fauna in their areas of jurisdiction.

Maritime Zones Act

The Maritime Zones Act gives the government of Kenya greater rights on the control of marine resources situated within Kenya's territorial waters as well as Kenya's exclusive economic zone (EEZ). Kenya's territorial zone and exclusive economic zone extend 12 nautical miles and 200 nautical miles respectively. In these zones the government has rights similar to those applicable on terrestrial environments. The government has rights on the exploitation and development of marine resources and the conduct of research by international research agencies.

The Continental Shelf Act (Cap 312)

The Continental Shelf Act of parliament commenced in 1975. It gives the Government of Kenya rights in respect of the management and exploitation of natural resources of the continental shelf situated within Kenya's territorial waters. Such rights include the exploitation of fisheries resources, conducting scientific research, etc.

Land Planning Act (Cap 303)

The Land Planning Act is implemented through the Ministry of Lands and Settlement. The act has provisions for planning the use and development of land. The act therefore determines the extent of use and development of land in the coastal zone of Kenya in addition to other areas of the country.

Town Planning Act

The Town Planning Act has provisions for the proper planning of urban and rural centres in Kenya. It is relevant for the management of coastal resources since the sustainability of such natural resources is affected by the nature of urban and rural centres. Such centres have to be planned taking into consideration their possible environmental impacts.

Local Authority Government Act (Cap 265)

The Local Authority Government Act (Cap 265) provides for local councils to establish and maintain sewage and drainage systems. It has also provisions for the construction of water supply systems and measures for the prevention of pollution in urban areas.

Coast Development Authority Act

This Act provides for the establishment of the Coast Planning Authority to plan and coordinate the implementation of development projects in the whole of Coast Province and the EEZ. The Act gives powers to the Authority to plan, coordinate, gather and disseminate information, and to generally manage and develop coastal resources in a sustainable manner. In an effort to avoid duplication of effort and to ensure the best use of available technical resources, the Authority maintains close links with other Government institutions and the private sector.

Kenya is therefore well served with legislation to provide for the protection and management of the coastal zone. However, implementation of the applicable statutes has not always been as efficient as the legislators intended when Parliament enacted the legislation.

Environmental Impact Assessment Process

The Environmental Impact Assessment Process is a conscious effort to determine the likely consequences on the environment of any policy or development decision; following which, ways and means are evaluated to avoid or minimize those impacts, such that they remain within predetermined, tolerable limits. The EIA Process also plans for monitoring to ensure that impacts do remain within these limits.

In Kenya, unfortunately, there is, as yet, no set environmental impact assessment procedure. This has led to many development projects (including some large scale ones) being implemented without any predictive assessment of the impacts and therefore without any attempt to minimize the impacts. However, it is heartening to note the growing awareness and concern for the environment among many groups in Kenya as well as among donor agencies. This has led to an appreciation on the part of the Government of the importance of the EIA Process.

The absence of a formal EIA Process does not mean there is an environmental protection vacuum in Kenya. Firstly, the National Environment Secretariat (NES), which is a state agency under the Ministry of Environment and Natural Resources, prepares district environment assessment reports. These reports are normally based on a general evaluation and assessment of the state of the environment at district level. Secondly, a number of non-governmental organizations (NGOs) as well as state institutions conduct research on most aspects of the environment and their findings are normally useful in environmental planning and management. Thirdly, there are several acts of parliament which address environment protection issues. These statutes can be grouped into three clusters -

- Acts providing for the conservation of natural resources,
- Acts providing for pollution control, and
- Acts providing for environment protection standards.

The more salient of these statutes have already been described above.

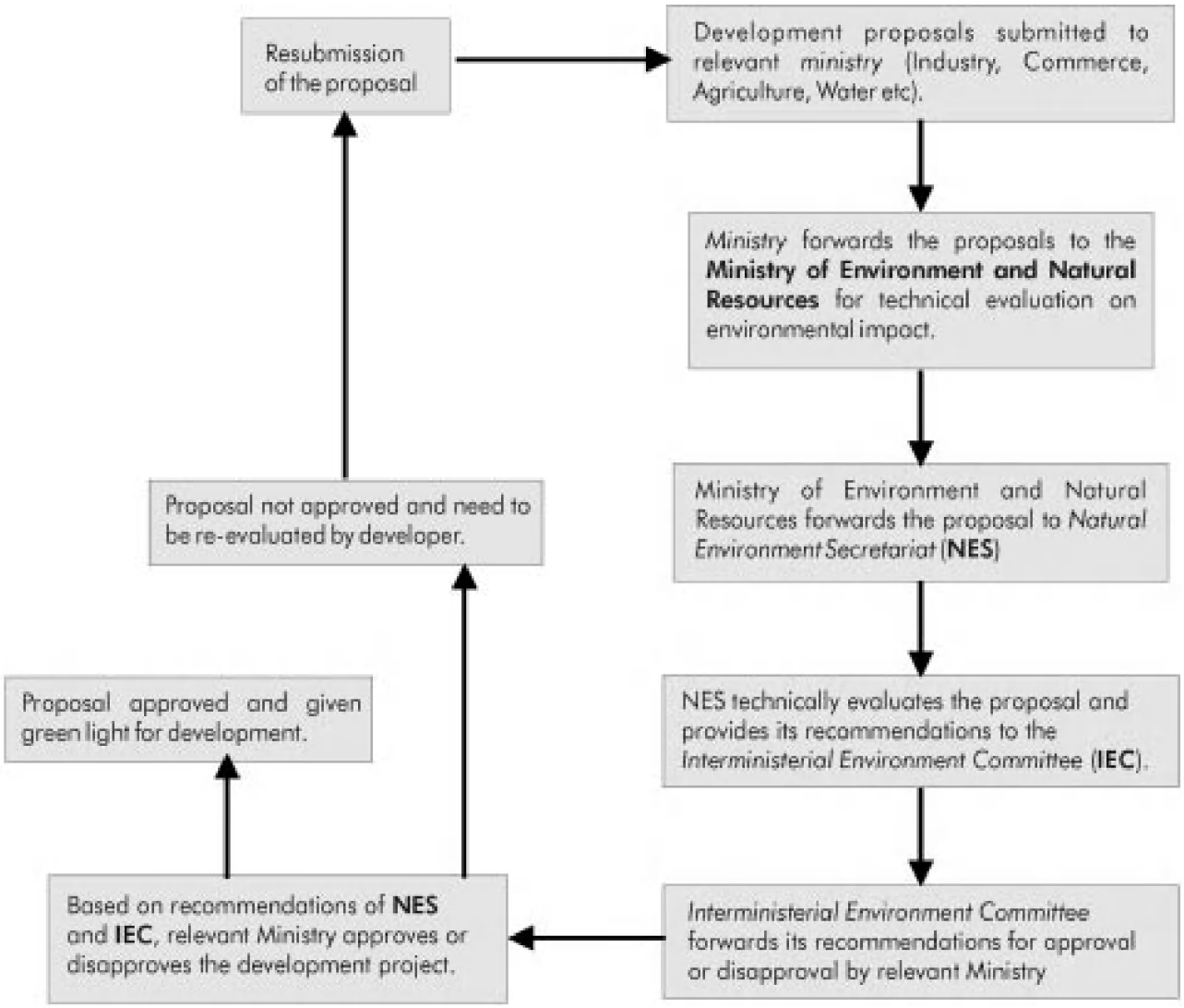


Figure 72 : Environmental Impact Assessment (EIA) process applicable to development proposals in Kenya

COASTAL PLANNING

The Coast Development Authority

The leading coastal planning agency in Kenya is the Coast Development Authority (CDA) which was established by an Act of Parliament in 1990. The CDA, which is a corporate body and which is under the Ministry of Land Reclamation, Regional and Water Development, is required to plan, initiate, coordinate and monitor development activities within the administrative districts of Coast Province, the Southern half of Garissa District, and Kenya's exclusive economic zone.

Among the functions and powers of the CDA as listed under the Act, are the following -

- to plan for the development of the Coastal Area and initiate projects;
- to develop a long range development plan for the Coastal Area;
- to initiate studies, carry out surveys, and assess alternative demands on the natural resources of the Coastal Area, and to initiate, operate or implement projects in agriculture, forestry, wildlife, tourism, power generation, mining and fishing;
- to monitor and evaluate project performance leading to improved future planning;
- to coordinate and monitor the abstractive use of water;
- to take initiatives to protect and utilize water and soil resources;
- to identify, collect, collate and correlate data on the use of water and other resources as may be necessary for efficient forward planning;
- to avoid the duplication of effort by maintaining liaison with operational agencies of government, the private sector and others;
- to examine hydrological effects and ecological changes and evaluate how these affect people dependent on the river environment;
- to implement projects with a primary objective of socioeconomic development;
- to plan and liaise with relevant agencies in the exploration and development of fishing and marine activities in the EEZ.

The prime goal of the CDA can be summarized as - the improvement of the standard of living of all coastal people without impairment of the resource potential. In order to achieve this goal, the Authority has developed strategies which will lead to self-sufficiency in food production for the Coastal Area, the creation of wealth from available resources, the provision of meaningful opportunities for public participation, and development on a sustainable basis. These strategies in turn, have resulted in the criteria by which development proposals and projects are either deemed to merit promotion, or discouraged by the Authority.

As a development agent, the CDA advocates for the effective management of natural resources. It encourages development projects that minimize negative impacts on natural resources since this is the most effective path to sustainable development.

Other agencies involved in coastal planning

In addition to the key contribution made by the Coast Development Authority which, by definition is focused on the coast, there are a number of other agencies involved in planning for the development and wise use of lands and other resources in Kenya. The main ones are -

- Ministry of Planning and National Development
- Ministry of Lands and Settlements
- Tana and Athi Rivers Development Authority (TARDA)
- Local Government Planning functions of
    - Mombasa Municipal Council
    - Tana-River County Council
    - Malindi Municipal Council
    - Kilifi County Council
    - Kwale County Council
    - Lamu County Council
    - District Development Committees

Between them and in collaboration with other organizations, the above lead agencies cover economic development planning, land use planning and urban planning nationwide, including the Coastal Area.

The Ministry of Planning and National Development is responsible for coordinating economic development planning at National and District level. Each operational Ministry prepares its own sectoral economic development plans and forwards them to the Planning Ministry for incorporation with other plans to become National and District Development Plans.

Towns and other urban and rural centres are managed and planned by the Municipal, County or Town Councils in liaison with the Ministry of Local Government. The recently-created Coast Development Authority (see above) will work within this framework to satisfy its responsibilities for planning and coordinating development and managing resources in the Coastal Area.

On the other hand, physical and land use planning are mainly the responsibility of the Ministry of Lands and Settlements. The Physical Planning Department of the Ministry prepares District as well as Provincial Land Use Plans. These plans are not restricted to a particular region in Kenya and also cover most of the urban and rural areas. Before a physical plan is produced and accepted for implementation, it has to undergo a procedure aimed at ensuring that the proposed land-use development is acceptable to the majority.

The Physical Planning Department starts the planning process by judiciously examining topocadastral information, aerial photographs and boundary plans. Some of this information is provided by the Survey Department of the same Ministry. The proposed plans are then submitted to the Lands Department for circulation to various public implementing agencies. The public implementing agencies are normally various Ministries and state organs such as the Ministry of Land Reclamation, Regional and Water Development, the Ministry of Agriculture Marketing and Livestock Development, the Ministry of Environment and Natural Resources, etc. These agencies are invited to undertake a technical evaluation of the proposed plans and make recommendations to the Lands Department giving explicit reasons for acceptance or rejection of the proposed plans. The Lands Department then approves or rejects the proposed land-use plans, based on the

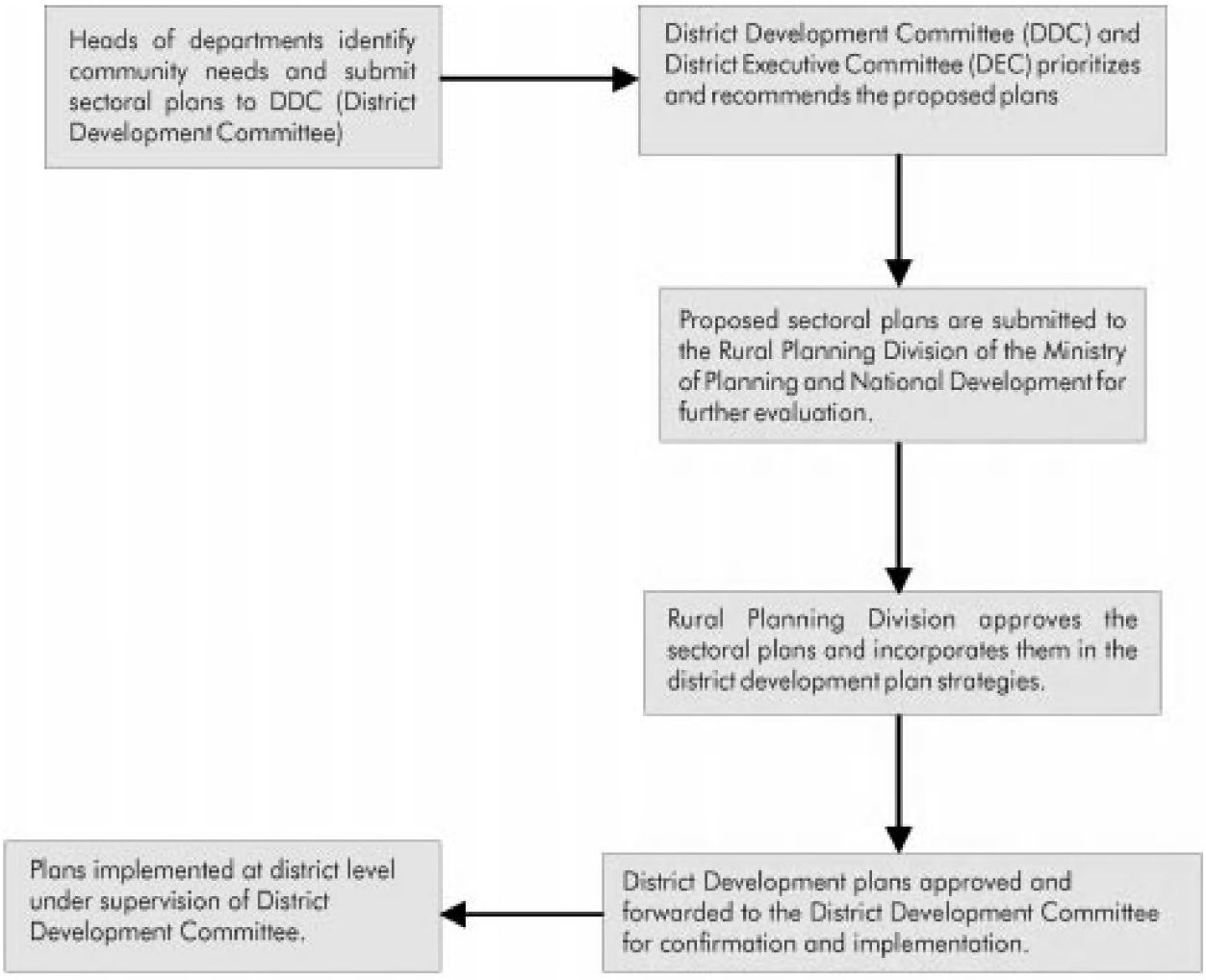


Figure 73 : The development planning process in Kenya

recommendations of the public implementing agencies. When the plans are approved by the Lands Department, the department goes ahead with registration and the issuing of titles to the land.

The Town Planning Department which has existed since 1947, produces short and long term development plans for central government and all local authorities except Mombasa and Nairobi. For the latter two cities it prepares some plans and advises on the feasibility of others prepared by the municipalities themselves. The Department is also involved in the preparation of national physical development strategies. The larger municipalities such as Mombasa and Malindi have been encouraged to carry out and implement their own plans with recommendations and policy advice from central government and government planning agencies.

It is important to note that the integration of physical planning with social and economic planning and development, is also the responsibility of the Physical Planning Department and this is met by liaising with the various development authorities at national, provincial and district level.

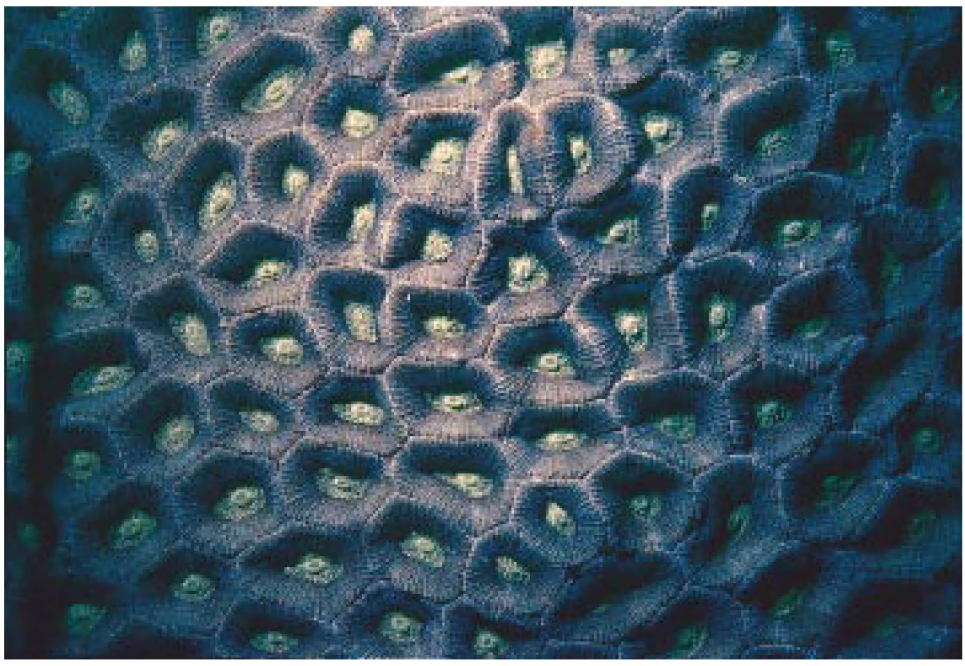


Figure 74 : Kenya's valuable coral parks need protecting from marine pollutants

CONTINGENCY PLANNING

The Kenya Ports Authority (KPA), under the Kenya Ports Authority Act, has the responsibility for controlling pollution in the territorial waters of Kenya, that is all inshore waters and those extending up to 100 nautical miles (about 160km) offshore. In fulfilment of this responsibility, the KPA, together with representatives of the oil industry, the oil refinery, the shipping industry and bunkering services, has set up the National Oil Spill Response Committee (NOSRC) which has developed a National Oil Spill Response Contingency Plan.

The Plan recognizes three levels of potential oil spill incidents within Kenyan territorial waters. Tier One incidents will involve spillages of up to 100 tonnes of oil and are expected to be dealt with primarily by the operators responsible, if within their own installations. Only spills into the sea will activate the Plan and the NOSRC.

Tier Two spillages will comprise up to 1000 tonnes of oil and are the level of spill on which the Plan will focus most. These moderate size spills are beyond the capability of one single operator and the cooperative effort provided by the Plan will be applied. However, depending on the extent of the spill, climatic and other conditions at the time, and the resources that are threatened, even a Tier Two spill may need to be treated as a Tier Three incident.

Tier Three incidents involve larger spills, probably over 500 tonnes and those greater than 10,000 tonnes. In such cases, the NOSRC will provide "first aid" but will be unable to cope adequately within its own resources and will require external assistance which has already been identified by the Plan.

Having identified the potential magnitude of spills in Kenyan waters and acknowledged its own limitations, the Plan also identifies the resources that are at risk, assesses the level of risk involved and provides guidelines for shoreline cleanup depending on the type of shoreline contaminated.

Finally, the Plan provides a list of what needs to be done when oil is discovered to have been spilled; who is responsible for particular tasks; the lines of communication to ensure coordination of effort; and a directory of equipment, contractors, suppliers, experts, and maps of sensitive areas.

The discovery of an oil spill, or any other chemical spill, or the detection of likelihood of such a spill, by any person, should be notified immediately to :

The Manager, Marine Operations
Kenya Ports Authority
Mombasa
Tel (Office) 011-311 409; Tel (After Hours) 011-471 590; Fax 011-311 867

or,

The Oil Spills Response Administrator
c/o Esso Kenya Limited
Mombasa
Tel (Office) 011-495 762; Tel (After Hours) 011-432 184; Fax 011-494 515

INTERNATIONAL PERSPECTIVES

Kenya has made a number of international commitments for the protection of the coastal and marine environment and its resources. Among its laudable obligations are those prescribed by the following international conventions, protocols and other agreements :

- International Convention for the Prevention of Pollution of the Sea by Oil, London, 1954, as amended in 1962, 1969 and 1971 - Kenya ratified these amendments on 12 December, 1975.
- International Convention for the Prevention of Pollution from Ships, London, 1973 (MARPOL). -Kenya ratified this convention on 12 September, 1975.
- Conventions on the High Seas, Geneva, 1958. - Kenya ratified this convention on 20 July, 1969.
- Convention on the Continental Shelf, Geneva, 1958. - Kenya ratified this convention on 20 September, 1969.
- The Treaty for East African Cooperation, 1967.
- Conventions on the prevention of marine pollution by dumping of wastes and other matters, London, 1972. Kenya ratified this convention on 17 January, 1976
- Treaty on the Prohibition of the Emplacement of Nuclear Weapons and other Weapons of Mass Destruction on the Seabed and the Ocean Floor and in the Subsoil Thereof, Washington/London/Moscow, 1971. Kenya ratified this treaty.
- African Convention on the Conservation of Nature and Natural Resources, Algiers, 1968. Kenya ratified the convention on 16 June, 1969.
- Convention on International Trade in Endangered Species of Wild Fauna and Flora, Washington, 1973. Kenya ratified this convention on 13 March, 1979.
- United Nations Convention on the Law of the Sea, Kingston, 1982. Kenya ratified this convention on 10 December, 1982.
- The Phyto-Sanitary Convention for Africa, South of Sahara, London. Kenya has not yet ratified.
- Kenya and Tanzania signed an agreement concerning the delimitation of territorial waters boundary between the two states in 1975 and was effective from 9 July 1976. (Also provides for fishing and fisheries).
- The International Plant Protection Convention (Rome, 1951). Kenya ratified this convention on 1 July, 1983.
- Convention Concerning the Protection of the World Cultural and Natural Heritage, Paris, 1972. (Protection of coastal ecosystems). Kenya has not yet ratified.

- Economic Commission for Africa (ECA): - several programmes concerns the protection of the coastal environment.
- Indian Ocean special committee, 1972. Established by UN - General Assembly. Kenya is a member of the committee.

TERRITORIAL SEA AND EXCLUSIVE ECONOMIC ZONE

Kenya's territorial sea and Exclusive Economic Zone extend 12 nautical miles and 200 nautical miles respectively with the total area of EEZ being 118km^2 . Most of the Kenyan statutes that deal with various aspects of coastal area management are applicable within the territorial sea. The EEZ is administered partly under the Continental Shelf Act and partly under the Merchant Shipping Act. Within Kenya's territorial seas the government has rights and responsibilities equal to those it has over the land. While within the EEZ, the Kenya government has the responsibility of regulating fisheries, research and resource exploration and exploitation.

Figure 75 : Mudflats near Ngomeni

Figure 76 : Shells for sale

FURTHER INFORMATION ON THE KENYA COAST

The following organizations play a major role in the management, development and protection of the Kenya Coast and its resources. They are able to provide specialist information on particular aspects of coastal resources management.

COAST DEVELOPMENT AUTHORITY

The Authority has as its prime goal "the improvement of the standard of living of all coastal people without impairment of the resource potential". It strives for self-sufficiency in food production for the Coast, the creation of wealth from available resources, the provision of meaningful opportunities for public participation, and development on a sustainable basis.

For information on any aspects of resource development and management on the Kenya Coast, contact :

The Managing Director
Coast Development Authority
Mama Ngina Drive
P O Box 1322
Mombasa, KENYA
Tel 011-311 119, 311 277, 224 406; Fax 011-490 615, 224 411

KENYA MARINE AND FISHERIES RESEARCH INSTITUTE

The Institute conducts research and survey work on various aspects of aquatic science. These include marine and freshwater fisheries, aquatic biology including environmental and ecological studies and chemical and physical oceanography. The Institute also monitors pollution, investigates and promotes aquaculture and carries out socioeconomic research on topics related to fisheries and aquaculture. The Institute is also the repository and manager of the Kenya Geographic Information System for the Eastern African Coastal and Marine Environment Resources Database from which this Atlas was produced.

For information on any of the above specialist disciplines or for information on the Kenya GIS of the Eastern African Coastal Resources Database, contact :

The Director
Kenya Marine & Fisheries Research Institute
Mkomani Street
P O Box 81651
Mombasa, KENYA Tel 011-475 150/6 ; Fax 011-472 215

NATIONAL MUSEUMS OF KENYA

The National Museums of Kenya have an extensive coastal programme ranging from the conservation of historical and cultural environments to the identification and protection of archaeological and historical remains. They manage a number of archaeological and historical resources, such as Fort Jesus, which are open to the public and very popular with visitors.

To report possible archaeological finds, or to seek any information on the Coast's archaeological, historical and cultural heritage, contact :

Head of Coastal Archaeology
Fort Jesus Museum
P O Box 82412
Mombasa, KENYA
Tel 011-312 839, 220 058; Fax 011-227 297

KENYA WILDLIFE SERVICE

The Kenya Wildlife Service (KWS) is responsible for the protection of Kenya's indigenous animals and plants and their habitats. It achieves this through the management of Kenya's parks and reserves which have been set aside as protected areas under the Wildlife Conservation and Management Act. All marine and terrestrial parks and reserves on the Coast (as elsewhere in Kenya) are available for public access and enjoyment as long as certain rules are observed. The KWS provides research and education programmes, management planning and interpretation, camping and visitor centres, park patrols, community wildlife programmes and general assistance to the numerous visitors to marine and terrestrial protected areas.

For general information about Kenya's indigenous flora and fauna, or for information about any of the marine and terrestrial parks and reserves, contact any ranger station usually located at the entrance or other vantage point in the protected area, or :

The Chief Ranger
Kenya Wildlife Service
P O Box 82144
Mombasa, KENYA
Tel 011-312 744/5; Fax 011-227 774

NATIONAL OIL SPILLS RESPONSE COMMITTEE

The Committee, which comprises representatives of the oil industry, the Kenya Ports Authority and scientific and related institutions, is responsible for responding to and coping with oil spills of any size. Any person who becomes aware of an oil spill should report it, urgently, to :

The Manager,
Marine Operations
Kenya Ports Authority
Kilindini Port
P O Box 95009
Mombasa, KENYA
Tel (Office) 011-311 409; Tel (After Hours) 011-471 590;
Fax 011-311 867

For information on the work of the Committee or on any aspect of oil pollution prevention and control on the Kenya coast, you can contact :

The Oil Spills Response Administrator
c/o Esso Kenya Limited
P O Box 80394
Mombasa, KENYA
Tel (Office) 011-495 762; Tel (After Hours) 011-432 184;
Fax 011-494 515

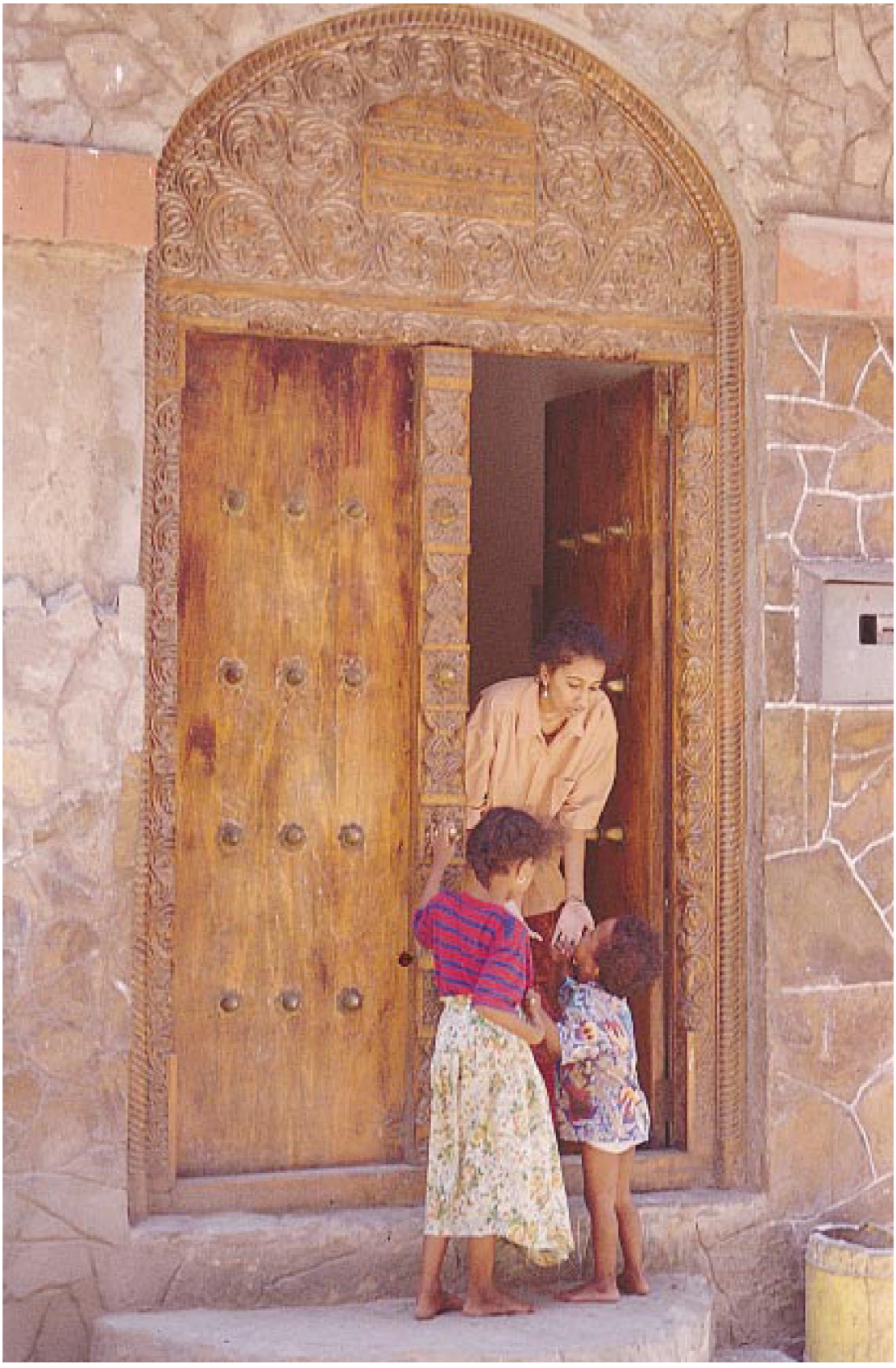


Figure 77 : Carved door, Mombasa old town