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**Coastal Erosion Issues in Sierra Leone
Adaptation, planning and implementation relating
To the Sierra Leone coastal zone**

**Presented
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Introduction

Background on the Coastal Zone

The coastal zone of Sierra Leone extends some 460km from Kiragba in the north, to Sulima in the south occupying an area of around some 155km². Sierra Leone has about 190 km of sheltered coast. The sheltered coast is dominated by extensive mangrove systems (230 km) and mud flats. Only about 150 km of the coastline is significantly developed and this includes Freetown (the capital).

The coastal area contains about seventy (70) hotels and tourist resorts. Elsewhere the coastline is largely underdeveloped except for some fish landing sites and cold storage infrastructure used to process and store fish and shrimps. The contribution of the coastal zone of the national economy is significant.

Impacts of Climate change on the Coastal Zone

As shown in Table _2 it is projected that about 26.4 km² of land in the coastal zone of Sierra Leone will be inundated as a result of 1 metre sea level rise.

Table:2 Land at risk from a 1-m rise of sea-level

| Coastal segment | Land at Risk |
|-----------------|--------------|
| Northern coast | 9.6 |
| Central coast | 1.0 |
| Southern coast | 15.8 |
| Total | 26.4 |

About 40% of the total land loss due to inundation will be on the sheltered and sandy (beach) coast. It is clear that with a 1-metre sea level rise, the greater part of Freetown (which is built on raised beaches) will be submerged due to the fact that those areas are below 1m. (Figure _3). The mangrove systems on the northern will be lost. About 40% worth of land will be lost. Inundation will be followed by shoreline retreat, which would vary along the coast from Kambia in the cliff zone to the gently sloping sandy strand plains of the Freetown Peninsula.

Coastal erosion is one of the environmental problems affecting the coast of Sierra Leone and should be of primary concern to coastal management and development.

This paper aims at giving a general overview of the problem along the Sierra Leone Coastline. The problem of coastline erosion seems to be natural in other cases but the case of the Sierra Leone Peninsula, it seems to be directly related to man-made activities introduced along the coastline that interferes with the normal and strong flow of coastal currents in the area. In the case of the former erosion appears to have been induced by man-made activities namely expansion of the national quay and sand extraction. Already coastal erosion is threatening the traditional settlements and other socio-economic coastal

infrastructures. It is worth mentioning that the question of coastal erosion in Sierra Leone has been given very little attention and material and publication about this environmental hazard are non-existing. Very little is known about the actual rates of erosion along areas where the processes is non-negligible. It is therefore hoped that this paper will serve as a stepping stone to better understanding of the coastal erosion phenomenon.

Geology and Geomorphology of Study Area

The coastline of Sierra Leone is part of the general coastline of the West and Central Africa region, which is a low plain, sandy and surf beaten.

The general coastline orientation for Sierra Leone (according to Edward Anthony) is north-west-south-east and is strongly determined by the local structural and lithological framework. The Sierra Leone coast can also be divided into four types on the basis of geomorphology and dominant geomorphic processes (fig. 1.).

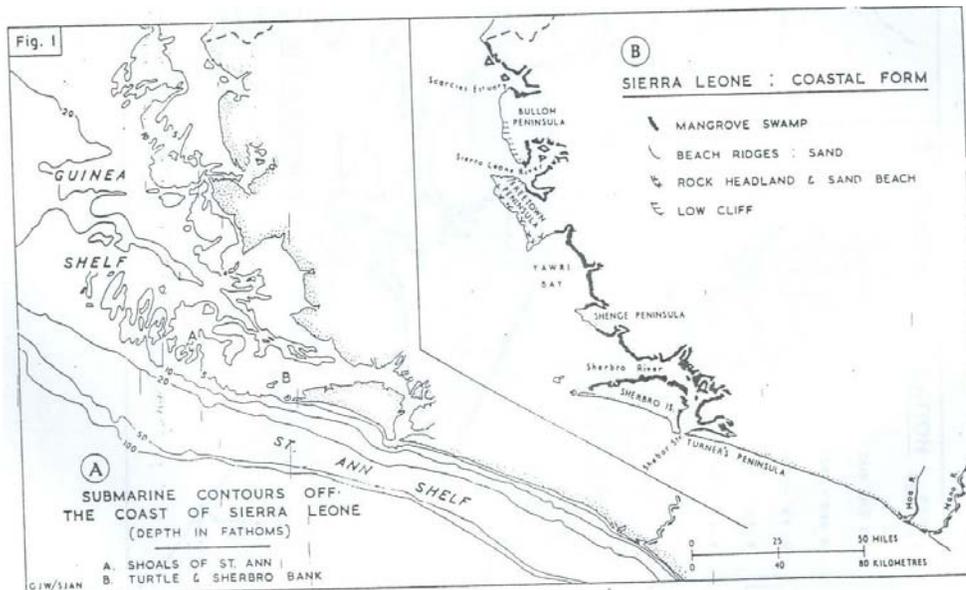
1. Low Cliffs (5-20m high) of poorly consolidated clays, sands, and gravels of Eocene to upper Pleistocene age: These deposits are locally known as the Bullom group and represent essentially sheet wash sediments of continental origin. These cliffs undergo active recession and are fronted by narrow mesotidal beaches. Bullom group cliffs represent about 6% of the coastline.
2. Sand beach ridges: These form extensive plains of medium to coarse quartz sands and occur over a total coastline length of 190 km (38% of the coastline). These wave formed post-mid-Holocene deposits are highly stable forms and show no morphological or structural evidence of Aeolian modification. In Southern Sierra Leone, they are fringed by generally steep, predominantly reflective microtidal beaches subject to low moderate energy swell from the South Atlantic and to periodic storm waves. These beaches appear to be in a state of long term equilibrium with no noticeable net progradation or regression in the last twenty years.
3. Mangrove swamps and mudflats associated with estuaries and sheltered embayment. This type of coastal landform covers about 230 km or 46% of the coastline and is associated with a mesotidal spring tide range (2-3m) and a weak wave energy regime. These two conditions favour the development of open estuaries and the deposition of fine sediments brought down by rivers. Large stretches of these estuaries and bay deposits are fringed seawards by a mixture of mud and fine sands that are extensively exposed at low tide.
4. Pocket beaches alternating with rocky headlands in the Freetown peninsula. This peninsula is a Triassic gabbro-morite complex of mountains that rise up to 890m. The pocket beaches consist of fine to medium quartz sand derived from the near shore shelf and alternate with low vegetated and sometimes cliffed headlands that are resistant to mechanical erosion. This type of shoreline of Sierra Leone is

subjected to a mesotidal spring range (2-4m) and a more energetic wave regime than that characterising the embayed and estuarine shoreline.

There are a variety of islands off the Sierra Leone coast, which can be classified into the following types:

- ❖ Depositional islands – Peipel, Banana, Tasso, Sherbro
- ❖ Erosional Islands – Bunce Island
- ❖ Elevated gabbroic islands – Bunce or Bonthe

There are combinations of these island types at other locations e.g. Yelliboya and populated by vegetation. These island types have corresponding range of coastal environments, including beaches, cliffs, mangrove swamps, etc. The coastal types of islands may vary from rugged cliffs and pocket beaches associated with relatively recent extensive coastal plains.



MARINE CLIMATE

The erosion situation requires knowledge about the wave conditions during the highest possible tide as this condition will produce maximum wave attack on the shore. On the shore of Freetown waves are from the sea generated by the local monsoon especially during the squally period of May-June and August, September and the swell generated by storms during the dry season in the southern part of the North Atlantic. (R. G. Johnson, published dissertation, 1998). The swells reaching the coast have periods varying

between 8 to 20 seconds with an average of 12 to 13 seconds. Wave height in deep waters average 0.25 – 1m. However, heights of 2 to 3 metres or more occur with directions from between south and southwest especially during stormy months (August – October).

Tides in the area are of the semi-diurnal type with an appreciable daily inequality (0.04 to 0.34 metres). The average range is about one meter. Currents are driven by the South – West monsoon and generally flows from north-west to south-east. The area east of Aberdeen falls under the influence of the strong tidal currents in the Sierra Leone river estuary. Local variations in the strengths and even temporary reversal of the current near the coast are caused by corresponding variations in wind force and direction.

Extent of coastal erosion along the Sierra Leone Coastline

Coastal erosion has been and is still posing a serious problem for coastal managers in Sierra Leone. This phenomenon which is very evident along the Sierra Leone coastline has attained rates of some 4-6 metres per year at some locations. e.g. Konakridee, Lumley, Lakka, Hamilton etc.

Coastal erosion has resulted in loss of private and public property along the northern sector of the coastline as well as posing threat to beaches, settlements and other shoreline facilities such as hotels, clubs, resorts along the coastline of the Freetown Peninsula.

Along the southern portion of the Sierra Leone coastline, coastal erosion seems to be naturally induced although visual observation revealed alarming intensity with houses and other facilities now in the sea.

On the other hand along the beaches of the Freetown Peninsula, the erosion of the sandy beaches is accelerated by sand extraction activities for construction and building purposes.

Lessons learned and best practices identified

Only a small portion of the country’s coastline is being protected by defence works (table 9). These include revetment along Lumley beach. Jetties can be found in most parts of the country’s coastline.

Table 1 provides information on coastal defence structures along the Sierra Leone coastline

Table 3. Coastal defence structures along the Sierra Leone Coastline

| Coastal Strip | Location | Erosion Status | Defence Structures | Impact |
|--------------------|----------|----------------|--------------------|--------|
| Kambia District | Yeliboya | Severe | | NA |
| Port Loko District | Lungi | Moderate | None | NA |

| | | | | |
|--------------------|-----------|----------|-------------------|----|
| Freetown Peninsula | Lumley | Severe | Gabion revetments | NA |
| -do- | Lakka | “ | None | NA |
| -do- | Hamilton | “ | “ | NA |
| Moyamba | Yawri Bay | Moderate | None | NA |
| Bonthe | MaBap | Severe | None | NA |

Source: Johnson & Johnson , 2003

NA = Not Assessed

Efforts made in the past to halt shoreline retreat along certain portions of the Freetown Peninsula, however is proving unsuccessful. Gabion revetments were erected along a stretch of the Lumley beach area but could not greatly minimize the retreat of the beach.

It is however suggested that the impacts of shoreline erosion can be minimized if appropriate passive and active approaches are adopted. Active structures can be constructed probably offshore or material dumped offshore.

Such structures should be capable of (a) dissipating of the energy of the waves and (b) reduce both longshore and cross-shore sediment exchanges along the profile of the beach.

Passive measures which are mostly adopted by least developed countries include, setback, controlled abandonment, do nothing and where funds are available, shore protection.

Setback

This measure is most suited for coastal areas that are underdeveloped (North & South Shores). Knowledge of historical rates of erosion for the particular coastal segment is required. With the assumption that this rate will remain the same in the future, a line (set back) is determined where the shoreline position will not be reached during the life of proposed structures within the area. The usual trend is to fix the setback using the projected shoreline position after 60 years. This means that if the rate of erosion is 2m per year, the set back will be set at 120m from the shoreline for the projected 60-year period.

The advantage of such a measure is that it enables nature to take its own course and avoids the need to put up expensive protection with resources that may often not be available. Even in the event that resources are available they could be used for other developmental purposes. Setbacks could be applied to the North and South coast. Average annual erosion within these segments is often less than 1m although in particular locations the erosion rate can be as high as 3m per year. The set back of these areas could

then be established at 60m These values should be regarded tentative pending the determination of accurate rates of erosion along these shores.

The adjoining areas of wetlands will have to be controlled from development particularly for those undeveloped rural communities that abound in bio-diversity. The sites selected for conservation under the Coastal Zone Indicative Management Plan need to accommodate this requirement in its management. The set back option requires an institutional organisation for its attainment.

Controlled Abandonment

In many of the communities along the north and south coasts there are isolated cases of coastal erosion reported on beaches with little sand. An initial assessment appears to indicate that the shorelines in these areas may be receding at rates less than 1m annually. Sea-level rise may flood the low-lying areas. If set backs were applied rigorously, the problem of land loss can be controlled effectively. For some of the areas affected, consideration may be given to relocating the affected buildings further inland. The cost of protection may be far more than the cost of relocation in the long-term. Rising sea levels will worsen such cases. Areas to be considered for protection of all the important areas are estimated at US\$ 590 million. The cost involves only the design and construction of a seawall and does not include the cost of maintenance.

Table 11: Important areas of protection

| Coastal Segment | Cost of Protection (US\$ m) |
|------------------------|------------------------------------|
| North Coast | 300 |
| Central Coast | 160 |
| South Coast | 130 |
| Total | 590 |

More detailed studies will be required to ascertain this rate. In a few years to come a number of the communities will be affected by shoreline recession. It would be prudent to determine this in advance and engage the affected individuals in a dialogue to determine what could be done. If relocation of some people is necessary the education of this people will have to start early enough and not when the situation becomes an emergency. The relocated people may also have to be assisted with resources to rebuild their homes.

Do Nothing

The option of do-nothing leaves the environment for nature to take its own course. No human interference is expected. This option will involve the loss of land estimated at 26.4 sq.km. and a population of 2,305,860.

Measures taken for the protection of the Coastal Zone

There is no overall legal framework for the protection of the coastal and marine environment although there are sectoral frameworks.

The coastal resources therefore fall under the jurisdiction of more than one institution. Some measures have been taken over the past few years to protect the coastal and marine environment. These steps were geared towards the maintainance of sustained fishery development and coastal marine environmental quality for other socio-economic uses. The measures include restrictions on beach sand extraction, banning of environmentally unfriendly fishing methods, mangrove reafforestation programmes, establishment of reserves and restrictions on beach face constructions.

Government Organisation

At present the following ministries are in one way or another associated with management issues pertaining to the coastal environment of Sierra Leone:-

- Ministry of Lands, Country Planning and Environment
- Ministry of Transport, Communications
- Ministry of Mineral Resources
- Ministry of Agriculture, Forestry and Food Security
- Ministry of Tourism
- Ministry of Works, Housing and Technical Maintenance
- Ministry of Energy and Power
- Ministry of Marine Resources

At times, jurisdictional rights of these ministries, overlaps. Thus attempts should be made to harmonise laws to simplify enforcement.

National Commission for Environment and Forestry

This Commission is charged with the responsibility of protecting and managing the environment. It is also mandated to managed the forest resources of the country. It is responsible for issuing licences to exploit and maintain all forests types on public lands and to monitor their harvesting so that they are sustainably and ecologically stable.

Ministry of Lands, Town and Country Planning

The Ministry was designated the role of making recommendations which concern land acquisition and transfer, land ownership and use and national development in a planning capacity and to provide advisory services to the public on land matters.

Ministry of Transport, Communications

This ministry is mandated to deal with issues related to transport on land, air and sea as well as local and international communication.

Ministry of Mineral Resources (MMR)

This ministry is charged with the responsibility to supervise mining operations in the country. It issues licences for all mining operations, enforces laws and provisions contained in the Mining Act and its amendments. It is responsible for enforcing provisions in the new mining act relating to the rehabilitation of mined out areas. The main institutional conflicts are:

1. the extent to which the Ministry has jurisdiction over marine areas with respect to marine based mineral resources, offshore dredging and its impact on marine resources and
2. the overlap of water quality monitoring with the interests of the Ministry of Marine Resources.

Ministry of Agriculture and Food Security

It supervises and promotes all agricultural activities and is also responsible for food security.

Ministry of Marine Resources

This ministry is responsible for the management of fisheries resources and related habitats in a manner, which would maximise benefit in terms of fish catch now and in the future. It is expected to develop fisheries resources and to devise methods of enhancing current production e.g. by means of aquaculture and more effective exploitation. The ministry issues licences for offshore trawling and monitors small-scale inshore and offshore large-scale fishing. It is also responsible for enforcing laws on fishing activities and concerns itself with pollution and other environmental problems, which affect water quality and fisheries resources.

Ministry of Tourism and Culture

The responsibility to promote and develop the country's tourist industry lies with the ministry of tourism and culture. It is also charged with the duty of protecting the country's heritage, monuments, and cultural and historical sites.

Ministry of Works, Housing and Technical Maintenance

The duty of road construction and maintenance as well as public buildings lies with this ministry. It enhances the improvement of road networks by securing bilateral and multi-lateral agreements with donors. It is also responsible for making recommendations, which concern housing problems, housing conditions and other housing matters.

Ministry of Energy and Power

The development of the energy sector water supply and generation of electricity are all functions of the above ministry. It is expected to develop the energy resources and enhance current production to meet and satisfy the needs of the community as well as provide adequate water supply to the nation. It enhances the improvement of water supply and delivery facilities and maintenance of existing ones.

Research Institutes/ University

The Institute of Marine Biology and Oceanography, Fourah Bay College, University of Sierra Leone has responsibilities to conduct research into the environmental characteristics as well as the living and non-living resources of the Sierra Leone waters and the seas beyond. It also carries out research on coastal processes and management issues.

Non-Governmental Organisation (NGO)

There are only a few non-governmental organisations (NGOs) in Sierra Leone with interests in coastal and marine environmental and resources management. Some of these are interested in nature conservation and monitoring of the country's wildlife and coastal ecosystems.

International Organisations

The country has received support to the management of its coastal resources from such agencies as UNDP, UNEP, IOC of UNESCO and UNIDO.

Relevant Legislation

Sierra Leone has a number of acts or legislation that provides for the management of its coastal zone. These fall under various sectors namely; fisheries, forestry, wildlife and environment.

International Agreements

Sierra Leone has ratified a number of international agreements which include;

- Convention on the Protection of the World Cultural and Natural Heritage 1972,
- Convention on the Prevention of Marine Pollution by the Dumping of wastes 1972,
- Convention on International Trade in Endangered Species 1973,
- Convention of the United Nations Law of the Sea (UNCLOS 111) 1982,
- 1989 Basel Convention on the Transboundary Movement of Hazardous Waste and their Disposal.

PROPOSED ADAPTATION PROJECTS IN THE COASTAL ZONE

The most important issues to be addressed in the management of the coastal zone in Sierra Leone are presented below as well as recommendations for addressing these issues. The issues involve

1. Establish of Coastal Management Board/Studies on coastal erosion in Sierra Leone
2. Delineation of flood and erosion hazard area
3. Further work to improve on the quality of topographic data for the coastal
4. Monitoring of the Coast
5. Establishment of a national sea-level observing system in Sierra Leone

6. Develop sand and gravel mining management plan
7. Education; and
8. Research

Establishment of Coastal Management Board

Management Issues

Following the work of the European Union Group of Experts on Coastal erosion in the involving Coasts it was recommended that a national institution be set up to manage the coastal zone. This recommendation can be duplicated for Sierra Leone. Shoreline management was one of the core issues necessitating the creation of such an institution. The various conflicts arising from the uses of the coastal zones for different objectives could be resolved through the management authority.

Recommendations

The proposed structure of the management is presented in the previous chapter. The impact of sea level rise would take decades. However, the gathering of the information required and the work of the institution to manage the coastal area would be a slow process. It is therefore necessary that the establishment of the institution be initiated now.

Delineation of Flood and Erosion Hazard Areas

Management Issues

Efficient management of coastal erosion can be achieved only through the gathering of data to enable the delineation of potential areas that are prone to erosion. Areas that could be affected by sea-level rise and areas that would be affected by flooding from the sea would also be included. Under the current study, it was not possible to assess accurately the areas that could be affected by any of these hazards. Hence further study projects should be considered.

Recommendations

The extent of land area affected by the hazards and probabilities of the hazards occurring need to be determined accurately to assist the management process. There is the need to produce accurate information on areas that could be affected by sea level rise and shoreline recession. Broad mention is made of areas perceived to be vulnerable to shoreline recession. This has to be delineated based on scenarios on sea level rise and historical shoreline data to determine future shoreline positions.

Improvement of the quality of topographic data

Management Issues

The data relied on for the current study limits the accuracy of the estimates. As a result it was not meaningful to determine the impacts of sea-level rise for the different sea-level

rise scenarios. Some areas had very limited data sets to enable an accurate determination of the Risk Zone.

Recommendations

It is proposed that further work be carried on the vulnerable shoreline identified under this study to obtain better information on the topography of the coastal zone. Possible procedures may include the Aerial Videotape-assisted Vulnerability Assessment, which has been utilised for Dennis, et al., (1995). Nicholls, et al., (1995), and Jallow et. al. (1995) provide a description and execution of this method.

Monitoring of the coast

The most vulnerable coastal areas in Sierra Leone fall under the Central Coast comprising about 149m of shorelines that are sandy. This area is expected to be affected by all the various description of impacts of sea-level rise including flooding an inundation, shoreline recession, increasing salinity of estuaries and aquifers and rising water tables and its adverse consequences on earthquake hazards and building foundations. Already, the population living within this segment is being displaced by flooding and shoreline recession. Various attempts are being made to protect the areas. Owing to its proximity to and that activities on these shores will impact on the adjoining shores of neighbouring, it will be prudent to gather more data to assist the prudent management of the coastal zone. The other coastal segments will also need monitoring to determine accurate rates of erosion input for the management of the coastal zones.

Recommendations

The monitoring of beach profiles should be carried out monthly for the first year to establish trends of erosion within all sandy shores and thence monitoring should be carried out at intervals of the three months. It will be necessary to link the monitoring of offshore profiles with those of the beaches. On account of the expensive nature of determining offshore topography it is proposed that the offshore profiles be determined at intervals of 6 months and focused on the North and South Coasts.

Establishment of a national sea-level observing system in Sierra Leone

There is evidence of increasing damage to the coastal ecosystems and local communities arising from coastal erosion and salt-water intrusion due to accelerated sea-level rise on one hand and human activities on the other.

Recommendations

There is an urgent need to monitor sea-level along the Sierra Leone coastline with a view to provide information to coastal managers, researchers, government institutions etc for various purpose eg. Navigation, fishing, marine exploration and exploitation, forecasting and climate change studies amongst others.

Sand and gravel mining

Management Issues

The removal of sand and gravel from the beaches for construction purposes could result in the erosion of shores. Examples of these abound in the Central Coast. Although this has been prohibited, enforcing this law has been a problem.

Recommendations

The cost associated with sand and gravel removal from the beaches and the potential to cause erosion should be evaluated as part of the procedures for the Environmental Impact Statement for all developments in the coastal protection zones. A study could be made to determine alternative sources of sand other than the beach for communities within the coastal zone. Where the alternatives are not promising, detailed investigations could be conducted to determine the impact of sand removal from selected beaches.

Public Education and Sensitization

Management Issues

It is obvious that the current understanding of the public to coastal erosion processes is inadequate. For instance the removal of a few million Leones worth of sand from a beach and then having to protect that beach with expensive rock worth billions of Leones has to be understood by all stakeholders in the coast. An educated and sensitised public would be able to make informed choices in purchasing and developing coastal lands. The cost of eliminating the vulnerability of land is quite expensive. Without understanding of the issues involved in sea-level rise, it is unlikely to get the cooperation of the local people who will be impacted most by sea-level rise.

Recommendations

The public must be sensitised and educated through the media about hazards associated with the Risk Zones. The consequences of the removal of sand and gravel from the beach must be well understood by the public to enable a better management of the shorelines by the relevant authorities. More education of the consequences of sea level rise has to be carried out prior to and after the establishment of proposed Coastal Management Board.

Research

Management Issues

Current understanding of coastal processes is still poor in the country. In particular, the causes of erosion, the ability to predict erosion both in the short and long term, and the prediction of shoreline dynamics or morphology with time have a profound influence on shoreline management. Tidal gauges along the coast are necessary to provide information on sea level changes.

Recommendations

It is necessary to improve the understanding of coastal processes in Sierra Leone. This could be done through the Coastal Management Board that has been proposed for some

time now. More accurate determination of sediment input into the littoral zone is necessary. The seasonal dynamics of tidal inlets i.e. lagoons and estuaries need better understanding through research to enable a more rational management strategy for the coastal zone.

Upstream Dam Construction, Energy Production

Some of the country's rivers have been dammed for both Agricultural development and for energy production as the main source of electrical energy. The environmental concern associated with this activity is the reduction of sediments to the coast and hence accelerated coastal erosion.

Recommendation

It is recommended that an environmental impact assessment be carried out in order to reduce the negative impacts of upstream dam construction on sediment budget in the coastal zone.

CONCLUDING REMARKS

The impacts of sea-level rise on the coastal zone of Sierra Leone are expected to be largely concentrated on Freetown peninsular where about 70% of the vulnerable areas are located. The beaches here are mainly medium to coarse sand and most of the Risk Zone is sandy. The population density within this segment of coast averaging about 120 persons per square kilometre is high compared with the national average of 67 persons per square kilometre. The impacts of sea level rise can be expected from the effects of erosion, flooding and inundation, which are already occurring and devastating communities.

Incomes within the coastal zone are generally low except for the urban centres such as Freetown. For the large proportion of the districts within the coastal zone, incomes are below US\$150 per person. These low incomes further exacerbate the capacity of the communities within the coastal zone to adapt to sea-level rise. The population along the shoreline is also increasing putting further pressures on the resources of the coastal zone.

Not much of the north coast has been studied in much detail as the problem areas such as the urban centre Freetown. A preliminary assessment of the conditions of the north coast, however, suggests that this segment may suffer as much as the south coast. The area comprises beaches made of fine sand with gentle slopes. It is relatively low in population density compared with other coastal segments of the country.

Mangroves are primarily found within the north, central and south coasts. Mostly located within the estuaries, they have been utilised by local communities for fuel wood on account of the limited choices available for the local communities for energy. Mangroves also have various important functions within the wetlands that their management is now a necessity. Sea-level rise is expected to inundate many of the areas covered by mangroves along the Sierra Leone coast.

The full protection of all the vulnerable shores will demand an estimated amount of US\$1,144 million, which is about 17% of GDP (1994). The protection of important areas only will cost US\$6,000,000. In the absence of any protection, the land at risk is estimated at 1,220 km² most of which lies within the north and south coast

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