IOC/INF-1289
Paris, 24 October 2010
English/French

INTERGOVERNMENTAL OCEANOGRAPHIC COMMISSION
(of UNESCO)

INFORMATION DOCUMENT

EXISTING AND NEEDED AFRICAN SCIENCE-BASE FOR COASTAL ADAPTATION

Summary. The following report is at a preliminary stage of preparation coordinated by the Intergovernmental Oceanographic Commission (IOC) of UNESCO at the request of the African Union Commission. This preliminary (un-edited) draft report aims to assess the existing and needed capacities of African national marine institutes to provide the science necessary for effective adaptation to climate change in coastal zones. Part II of the document provides detail of national marine institutes in Africa.

Acknowledgements

Regional Coordinating Authors: Harrison Onganda (Kenya), Anis Diallo (Senegal), Ayaa K. Armah (Ghana)

National Coordinating Authors: Jean Folack (Cameroon), Magloir Désiré Mounganga (Gabon), Alain Claver Batchy (Republic of the Congo), Zacharie Sohou (Benin), Kojovi Edjame (Togo).

The UNESCO/IOC Capacity Development sections sincerely owes its greatest appreciations to the regional and national coordinators who have worked so hard to accomplish this part; Harrison Onganda who coordinated the IOCWIO regional institutes, Anis Diallo on the Canary Current Large Marine Ecosystem, Ayaa K. Armah on the Guinea Current Large Marine Ecosystem. Many thanks to the national coordinators who facilitated the work of regional coordinators, Jean Folack, Magloir Désiré Mounganga, Alain Claver Batchy, Zacharie Sohou, and Kojovi Edjame.

Thanks to Ehrlich Desa, Director and Deputy Executive Secretary, Intergovernmental Oceanographic Commission who courageously coordinated and motivated the regional coordinators to conduct research on existing and needed African science-base for Coastal adaptation on the African marine science institutes; Mika Odido, Andrew Fanning, Joannes Berque, Stefano Mazzilli, Elena Iasyreva and Diana Dumeril who all collaborated to accomplish this task.

Finally, special thanks to all the readers who will be keen to read and discover the urgent need of African marine institutes to be effective on adaptation to climate change in coastal zones and take an action on this.

EXECUTIVE SUMMARY

The United Nations Climate Change Conference in Copenhagen held from 7th to 18th December, 2009 united many nations, scientists, and various stakeholders, who had different concerns about the climate change and the future of the planet earth.

African countries, under the African Union Commission (AUC) in collaboration with UNESCO/IOC, prepared the report which was in two parts. The first part, prepared by Dr.Pamela Aboudha, describes the "*African Science-Base for Coastal Adaptation: A continental Approach"*, describing explicitly the status of the African coastal zones with regard to climate change, challenges and the adaptation measures so far being deployed. She divided the African coastal zones into four regions, giving a visibility of the challenges and effects of climate change upon each region. This allows one to capture an idea of variabilities of the effects and challenges of climate change in the African coastal zones, hence defining different needs and strategies to be taken and enhanced.

It's due to the explicitly description of the challenges on climate change and adaptation measures on the coastal zones of Africa that, the Intergovernmental Oceanographic Commission (IOC) of UNESCO in complementing and finalizing on the AUC report, had initiated a collaboration from African marine institutes in climate-related capacity development activities, so as to assess existing needed African science-base for coastal adaptation. This was conducted on the bases of the regions defined by the report of AUC, and special emphasis was given on the marine institution within the given region. The research was done by the regional coordinators in collaboration with IOC Capacity Development Team, enabling the understanding of the national capabilities, challenges and priorities for coastal adaptation to climate change. The results from these assessments will allow the IOC/CD Section to acquire a clear perceptive on the capabilities of the African marine institutes on coastal adaptation as well as what are the needs for enhancing their capabilities; and how these needs can be met/developed and sustained.
This Part II of the report, does contain most of the needed assessments on the African science base for coastal adaptation, nevertheless, some information on certain countries are inadequate or non-existence. With this regard, the IOC/CD section intends to give access of these assessments to the African marine institutes through its website htpp//ioc-cd.org; hence these concerned institutes can update any useful left out information, or add the non-existence information on the website. This will allow the Part II to be complete and efficient for the African Union Commission and IOC to have a clear perception and grounds for the preparation of negotiation for COP 16.

Table of Contents

The African Science-Base for Coastal Adaptation:

A Continental Approach

A report to the African Union Commission (AUC) at the United Nations Climate Change Conference in Copenhagen (7-18 December 2009)

INTERGOVERNMENTAL OCEANOGRAPHIC COMMISSION OF UNESCO

November 2009

Pamela Atieno Abuodha

Table of Contents

List of Figures

List of Tables

Executive Summary

The African Science-Base for Coastal Adaptation

A Continental Approach

A Technical support to the African Union Commission at the United Nations Climate change Conference in Copenhagen 7-18 December 2009

"In Gambia ... In 1998, the high water mark (HWM) was 50 m from the new Banjul-Serekunda Highway; in 2003 the HWM was only about 15 m from the highway" *(Adaptation to Coastal Climate Change Project, ACCC, 2006a)*. Between Cape Point and the Banjul dockyard and the area between the Palm Grove Hotel and the Muslim cemetery erosion rates of between 15 and 20 m were recorded from 1964 to 1982..."

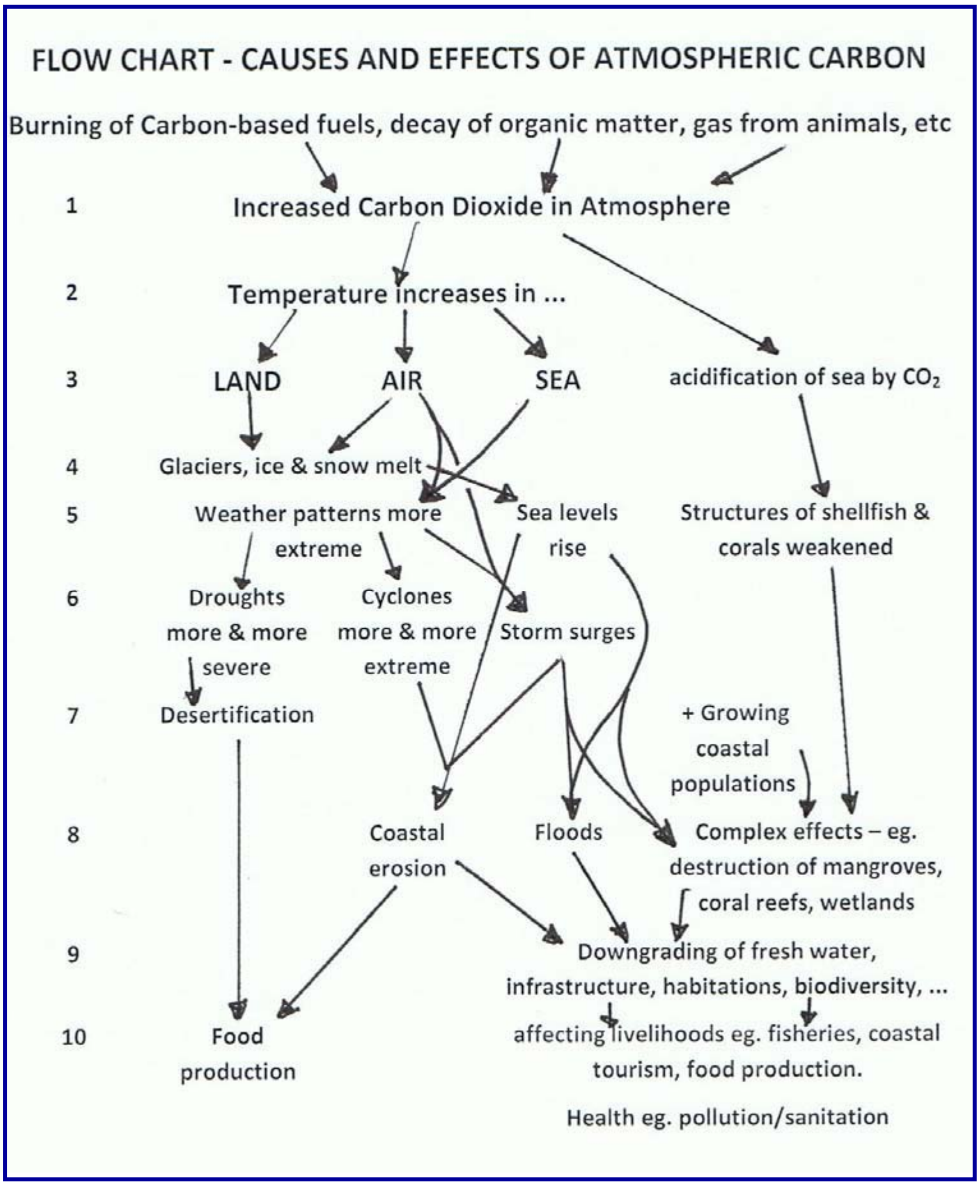
In one brief paragraph we see the relentless attacks of rising sea levels and growing storm surges on one coastline, threatening four significant elements of society – transport, trade, tourism and tradition.

Climate Change

Human societies over the ages have depleted natural resources and degraded their local environments. Populations have also modified their local climates by cutting down trees or building cities. It is now apparent that human activities are affecting the climate system at the global scale.

Global climate change (= 'Global Warming') is caused by the accumulation of greenhouse gases (such as carbon dioxide) in the lower atmosphere. The global concentration of these gases has been increasing, mainly due to human activities, such as the combustion of fossil fuels (which release carbon dioxide) and deforestation (because forests remove carbon from the atmosphere). The atmospheric concentration of carbon dioxide, the main greenhouse gas, has increased by 30 % since preindustrial times.

From global climate models and experiments, climatologists estimate that global mean surface temperature will rise by 1.5° to 3.5° C by 2100. This rate of warming is likely to cause large changes in rainfall, both increases and decreases, especially in the tropics. Climate change is very likely to affect the frequency and intensity of weather events, such as storms and floods, around the world, and will also cause sea level rise due to the thermal expansion of the oceans and the melting of the mountain glaciers. Global mean sea level is anticipated to rise by 15 to 95 cm by 2100. Sea level rise will increase coastal flooding and storm surges. The faster the rate of climate change, the greater will be the risk of damage to the environment. Most scientists agree that these changes have already begun. The flow chart below summarises the many impacts of climate change and how they interact with each other.



Definitions

Developing countries are the most *vulnerable* to the impacts of climate changes (section 1.1 – *note* – all references refer to the complete 'Report' of the same name; also the numbering in the Executive Summary is different from that of the report), given their *sensitivity* − the degree by which their systems are affected or responsive to climate. A coastal system's natural vulnerability to the effects of accelerated sea-level rise (ASLR) is a function of its natural susceptibility its resistance and its resilience. Natural susceptibility is the coastal system's potential to be affected by ASLR. This is largely independent of human influences. Resistance is the ability of the system to avoid perturbation in the first place - a seawall or a cliff is resistant, for example, whereas resilience is the ability for the system to return to its original state after being perturbed and the speed at which this occurs. At the same time, the high degree of vulnerability found in African coastlines is also due to their low mitigation and adaptive capacity, that is, the ability to reduce the negative impacts, to capture any benefits of climate change and to ensure resilience to future shocks (section 1.1). Autonomous adaptation is the coastal system's spontaneous and natural adaptive response to ASLR, a function of its resilience and resistance. Planned adaptation includes measures taken to enhance the system's natural resilience and resistance. Resilience and resistance are different aspects of the system's stability in the face of possible perturbation.

1 Primary effects of Climate-change

1.1 Atmospheric and Ocean-temperature rise and acidification

According to the estimate made by the IPCC in its fourth report (section 1.1.4.1), global warming is expected to be more intense in Africa than in the rest of the world. On average, the rise in temperatures between 1980/99 and 2080/99 would be between 3 °C and 4 °C for the continent as a whole, 1.5 times higher than the global level. The expected warming would not be uniform throughout the continent it would be less marked in coastal and equatorial areas (+3 °C) and highest in the Western Sahara region (+4 %). An increase in sea surface temperature is strongly predicted at all latitudes and in all oceans.

Rising CO_2 concentrations have lowered ocean surface pH by 0.1 unit since 1750, although to date no significant impacts on coastal ecosystems have been identified. Recent trend analyses indicate that tropical cyclones have increased in intensity. Global sea levels rose at 1.7 ± 0.5 mm/yr through the 20th Century, while global mean sea surface temperatures have risen about 0.6°C since 1950, with associated atmospheric warming in coastal areas (section 1.1.1). Temperature and rainfall pattern changes may impact water quality in coastal areas and this may lead to more beach closures, thus affecting tourism (section 1.1.1).

1.2 Sea-level rise and coastal erosion

Many coasts are experiencing erosion and ecosystem losses, but few studies have unambiguously quantified the relationships between observed coastal land loss and the rate of sea-level rise. Coastal erosion is observed on many shorelines around the world, but it usually remains unclear to what extent these losses are associated with relative sea-level rise due to subsidence, and other human drivers of land loss, and to what extent they result from global warming (section 1.1.1).

Most of the world's sandy shorelines retreated during the past century and sea-level rise is one underlying cause. Acceleration in sea-level rise will widely exacerbate beach erosion around the globe, although the local response will depend on the total sediment budget. The widely cited Bruun model suggests that shoreline recession is in the range 50 to 200 times the rise in relative sea level (section 1.1.1).

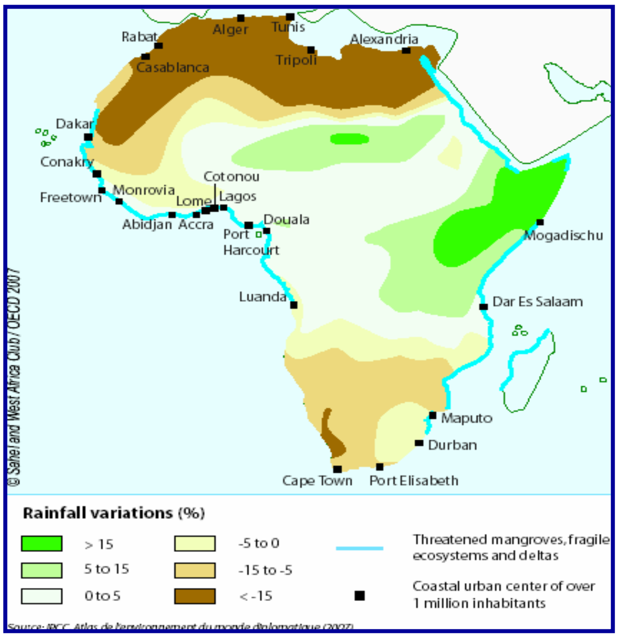
In Kenya, losses for three crops, that is, mangoes, cashew nuts and coconuts, could cost almost US$ 500 million for a 1 m sea-level rise. In Guinea, between 130 and 235 km^2 of rice fields, between 17 % and 30 % of the existing rice field area could be lost as a result of permanent flooding, depending on the inundation level considered of between 5 m and 6 m by 2050. In Eritrea, a 1 m rise in sea level is estimated to cause damage of over US$ 250 million as a result of the submergence of infrastructure and other economic installations in Massawa, one of the country's two port cities (section 1.1.1).

1.3 Precipitation and Floods

Coasts are experiencing the adverse consequences of hazards related to climate and sea level. Coasts are highly vulnerable to extreme events, such as storms, which impose substantial costs on coastal societies. Annually, about 120 million people are exposed to tropical cyclone hazards, which killed 250,000 people from 1980 to 2000. Through the 20th Century, global rise of sea level contributed to increased coastal inundation, erosion and ecosystem losses, but with considerable local and regional variation due to other factors (section 1.1.1).

Sea-level rise raises extreme water levels with possible increases in storm intensity, leading to additional climate impacts on many coastal areas, while saltwater intrusion may threaten water supplies. The degradation of natural coastal systems due to climate change, such as wetlands, beaches and barrier islands, removes the natural defences of coastal communities against extreme water levels during storms. Rapid population growths, urban sprawl, growing demand for waterfront properties, and coastal resort development have additional deleterious effects on protective coastal ecosystems (section 1.1.1).

Forecasts for changes in rainfall are mixed, but there are indications that the already large variability of rainfall over most of Africa will increase.



Forecast 100-year rainfall variations (%) in Africa. The eastern part of the continent receives increases in rainfall while the north-western and southern parts of the continent experiences decreases (section 1.1.4.3).

1.4 Drought and Desertification

In Africa, people facing water scarcity conditions are already number over 300 million (section 1.1.4.4), while 25 % of African population experience water stresses. Temperature rises of 2°C will result in 1–4 billion people experiencing growing water shortages, predominantly in Africa. By 2025, it is expected that 18 African countries will experience water stress while by 2050; areas experiencing water shortages in Sub-Saharan Africa will have increased by 29 %. Water availability is not the only water stress to be considered. Change in climate may exacerbate the already existing constraint to access to safe water and adequate sanitation. Actually, only 62 % of African population had access to improved water supplies in 2000. Even without climate change, several countries in Africa, particularly in northern Africa, will exceed the limits of their economically usable land-based water resources before 2025. About 25 % of Africa's population, that is, about 200 million people, currently experience high water stress. The population at risk of increased water stress in Africa is projected to be between 75-250 million and 350-600 million people by the 2020s and 2050s, respectively.

Approximately half of the sub-humid and semi-arid parts of the southern African region are at moderate to high risk of desertification. In West Africa, the long-term decline in rainfall from the 1970s to the 1990s caused a 25-35 km southward shift of the Sahelian, Sudanese and Guinean ecological zones in the second half of the 20th century. This has resulted in a loss of grassland and acacia, the loss of flora/fauna, and shifting sand dunes in the Sahel.

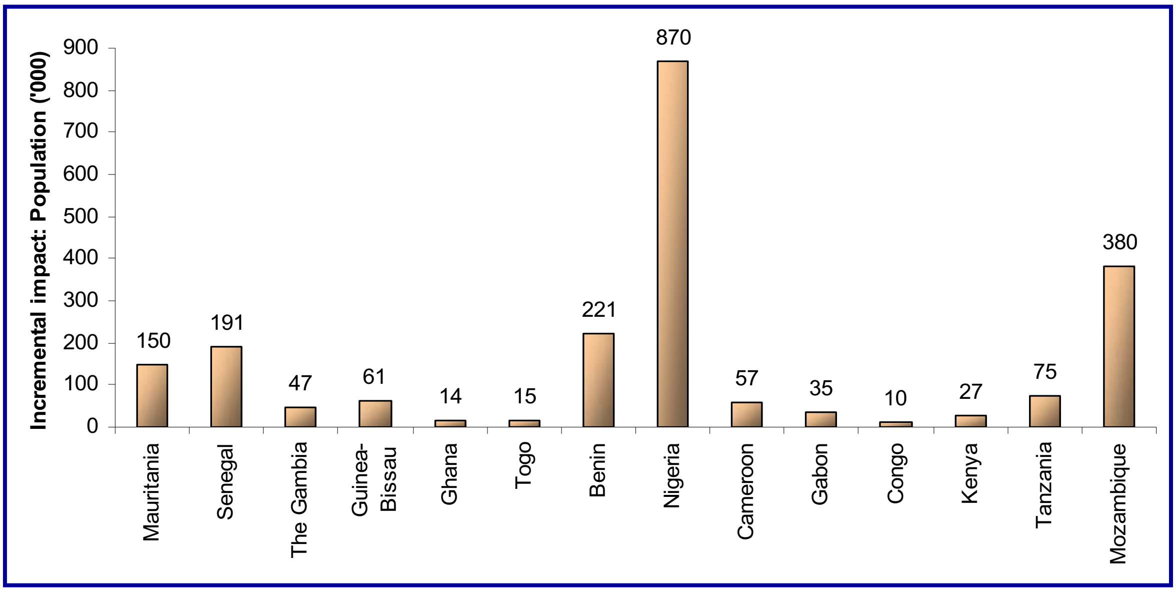
1.5 Ocean-based hazards and change in currents

Prevailing wind patterns of up to 62 km/h have been observed along the African coast and could be the reason for the heavy erosion along the coast. Extreme waves and tsunamis also have a negative impact on the coasts although these are very rare along African coasts. Larger storm surges threaten greater future destruction because they will move further inland, threatening larger areas than in the past. The scientific evidence indicates that climate change will intensify storm surges for two reasons. First, they will be elevated by a rising sea level as thermal expansion and ice cap melting continues. Second, a warmer ocean is likely to intensify cyclone activity and heighten storm surges. As storm surges increase, they will create more damaging flood conditions in coastal zones and adjoining low-lying areas. The destructive impact will generally be greater when the surges are accompanied by strong winds and large onshore waves. Of the countries forming the 5 regions in this study, surge zones are concentrated predominantly in three countries: Mozambique, Nigeria, and Mauritania (section 1.1.4.5).

Compound issues affecting the coastal zone of Africa

2.1 Coastal Population and Livelihoods

Africa's coastal population could grow from 1.2 billion people (in 1990) to 1.8 to 5.2 billion people by the 2080s, depending on assumptions about migration. Populated deltas, low-lying coastal urban areas and atolls are key societal hotspots of coastal vulnerability, occurring where the stresses on natural systems coincide with low human adaptive capacity and high exposure. In Sub-Saharan Africa, there are several coastal communities whose livelihood revolves around the exploitation of biological resources in their environment. Besides, as in other parts of the world, the coastal area is preferred for urbanisation and industrialisation as well as amenities for recreation and tourism. This multiple-usage and its socio-economic benefits can lead to degradation (section 1.1.4.6). It is estimated that by 2015, 53 million people will live in African coastal cities vulnerable to flooding, including big coastal cities such as Abidjan, Accra, Alexandria, Algiers, Cape Town, Casablanca, Dakar, Dar es Salaam, Djibouti, Durban, Freetown, Lagos, Libreville, Lome, Luanda, Maputo, Mombasa, Port Louis, and Tunis. Some estimates suggest that 150 - 200 million people may become permanently displaced by the middle of the Century due to rising sea levels, more frequent floods, and more intense droughts (section 1.1.4.6).



Projected incremental impact on population in thousands as a result of sea-level rise and intensified storm surges 2009-2100 on the countries studied in this report. The impact on population is concentrated in three countries, Nigeria, Mozambique and Benin (section 1.1.4.6)

2.2 Fisheries, Resource Management and Biodiversity

Important economic activities like fisheries, tourism, agriculture as well as crucial infrastructures such as roads, harbours and cities are located in the coastal zones of Sub-Saharan Africa. In addition, many highly productive ecosystems such as mangroves, estuaries, deltas and coral reefs, which form the basis for important economic activities such as tourism and fisheries, are located in the coastal zone (section 1.1.4.7). All these, however, are threatened by sea-level rise and storm surges, especially when combined with rapid population growth and over-exploitation of resources.

Tropical and subtropical mangrove forests and temperate saltmarshes provide 'goods and services' for their environments - they accumulate and transform nutrients, attenuate waves and storms, bind sediments and support rich ecological communities (section 1.1.4.7). Some mangroves may respond positively to higher levels of CO_2, but many are already over-exploited.

Sea-level rise poses a particular threat to deltaic environments, especially with the synergistic effects of other climate and human pressures. Coastal vegetated wetlands are sensitive to climate change and long-term sea-level change as their location is intimately linked to sea level.

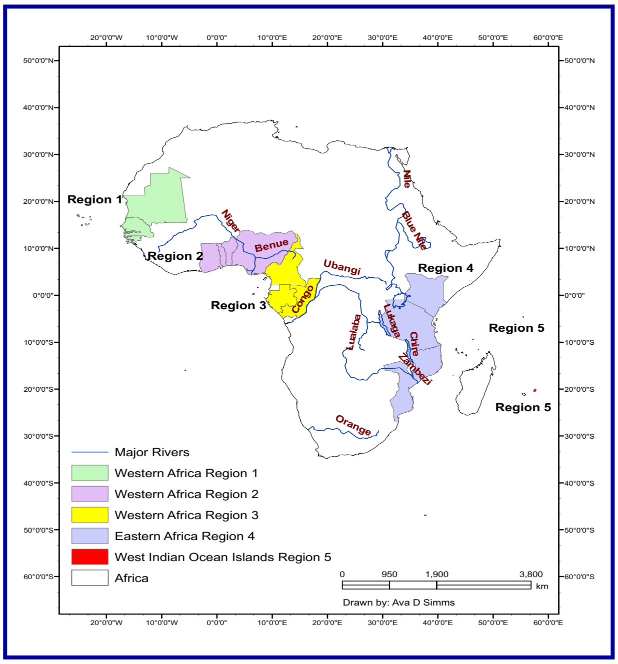
Corals are vulnerable to thermal stress and have low adaptive capacity. Increases in sea surface temperature of about 1 to 3°C are projected to result in more frequent coral bleaching events and widespread mortality, unless there is thermal adaptation or acclimatisation by corals.

2.3 Coastal Tourism

Several countries in the Sub-Saharan Africa are turning towards tourism as a viable option for economic growth. Despite Africa's small share of the global tourism market, the industry makes a significant contribution to the economies of the Sub-Saharan African region, and this is expected to grow during the first 20 years of the 21st century. But forecast sea-level rise and intensified storm surges will seriously threaten this growth. Over the course of the 21st century, Mozambique, Ghana and Togo may lose more than 50 % of their coastal GDP; while GDP loss in absolute terms will be highest in Nigeria (US$ 408 million) (section 1.1.4.8)

2.4 Fresh Water, Food Security, Pollution and Sanitation

Climate change is expected to intensify Africa's increasingly critical water situation, with southern Africa being one of many water stressed regions in which climate change could further decrease stream flow and groundwater recharge. Reduced annual average rainfall and runoff would also exacerbate desertification in southern Africa. Africa relies on water for its social, economic and environmental well-being, so prolonged drought is the most serious climate related hazard for the continent (section 1.1.4.9).



Map of Africa showing the regions and countries covered in this report (section 1.2).

The above are some examples of the main issues surrounding Climate Change. Many more examples, statistical tables, more technical information, and illustrative maps and pictures, are found in the full 110-page Report, which, however, concentrates almost entirely on the regions shown in the map above.

Adaptation measures against climate change impacts on coastal population

The impacts described have shown that climate change is happening and that the coastal zones of many countries are affected. It is not necessary to wait years for more research on climate change before adaptation can be undertaken. Adaptation needs to be employed immediately in African countries and communities on a much greater scale. Africa is one of the most vulnerable continents to climate change and climate variability. Major economic sectors are vulnerable to current climate sensitivity, with huge economic impacts, exacerbated by challenges such as endemic poverty, complex governance and institutional dimensions; limited access to capital, markets, infrastructure and technology; ecosystem degradation; and complex disasters and conflicts. These in turn have contributed to Africa's weak adaptive capacity, increasing the continent's vulnerability to projected climate change.

Adaptation costs for vulnerable coasts are much less than the costs of inaction. Without adaptation, the high-end sea-level rise scenarios, combined with other climate changes (e.g., increased storm intensity), are as likely as not to render some islands and low-lying areas unviable by 2100, so effective adaptation is urgently required. In the absence of effective protection, coastal flooding could grow tenfold or more by the 2080s, to affect more than 100 million people per year, due to sea-level rise alone. The consequences of sea-level rise will be far greater for developing countries, and protection costs will be higher, relative to those for developed countries. In the cities of Alexandria, Rosetta and Port Said on the Nile delta coast of Egypt, for example, a sea-level rise of 50 cm could result in over 2 million people abandoning their homes, the loss of 214,000 jobs and the loss of land valued at over US$ 35 billion (Nicholls et al., 2007, p. 339).

It must be noted that Africa is the region about which there is the smallest quantity of statistical information available as well as of studies and research, and the most serious lack of a reliable monitoring system. Together, these raise serious questions as to whether the necessary capacity to manage the impacts of climate change is present. The tools for assessing the necessary adaptations exist, however, and are constantly being refined. In outline, they are described in Section 1.2.7 in the main report.

Existing tools and methods for coastal adaptation is covered in section 1.3 while a case-study of the Kenyan coast applying the DIVA tool is presented in section 1.4

Acknowledgements

My sincere appreciation goes to the UNESCO team in France and Kenya for 'welcome aboard' and for being in constant communication with me during the initial preparation of this report. The team consisting of Ehrlich Desa, Mika Odido, Andrew Fanning, Joannes Berque, Stefano Mazzilli, Isabelle Niang-Diap, Julian Barbière and Elena Iasyreva provided much needed support. Thank you so much. Thanks to Ehrlich, Director and Deputy Executive Secretary, Intergovernmental Oceanographic Commission UNESCO, for proving the initial outline for the report which I have closely adapted. Mika kept on sending those 'National Reports'; Andrew provided much needed guidance into African studies by various organizations; Julian 'excavated' the much archived Phase II project proposals; Stefano provided further input into the report outline and Elena provided report logistics. Thank you very much for the team spirit and support, without which this task would not have been accomplished within the limited time. Authors of all the references used in this report are sincerely thanked for their valuable pieces of work.

Professor Geoff Brundrit, Special Advisor on Oceans and Climate Change Marine and Coastal Management, is thanked for his very useful advice on the latest reports on the African coast. Dr. Greg A. Botha, Manager, KwaZulu-Natal and Eastern Cape Business units is thanked for personal communication of his knowledge of the Mozambique and South African coasts.

Dr Ava Simms is thanked for producing Figures 12 and 18. Special thanks are due to Professor Colin Woodroffe of School of Earth and Environmental Sciences, University of Wollongong, New South Wales, Australia and Harry Cotter, (Cantab), Dip.Ed., for providing a final edit to the report. Harry Cotter is also thanked for his extensive work on the Executive Summary and for his wonderful choice of the cover image from the web which I believe covers the message of the report well.

Finally, thanks to all the readers who will 'spread the word' and work towards adaptation to a better Africa, a better world.

PART I – CLIMATE IMPACTS AND VULNERABILITIES IN COASTAL LOW-LYING AREAS

1.1 Climate-Change Effects: The Continental View

Introduction and definition of terms

Many assessments of coastal vulnerability have found it useful to adopt the framework summarised in Figure 1, distinguishing between natural system vulnerability and socio-economic vulnerability to climate change, but emphasising their interrelatedness and interdependence (Klein and Nicholls, 1999). A description of some of the terms shown in Figure 1 is presented here.

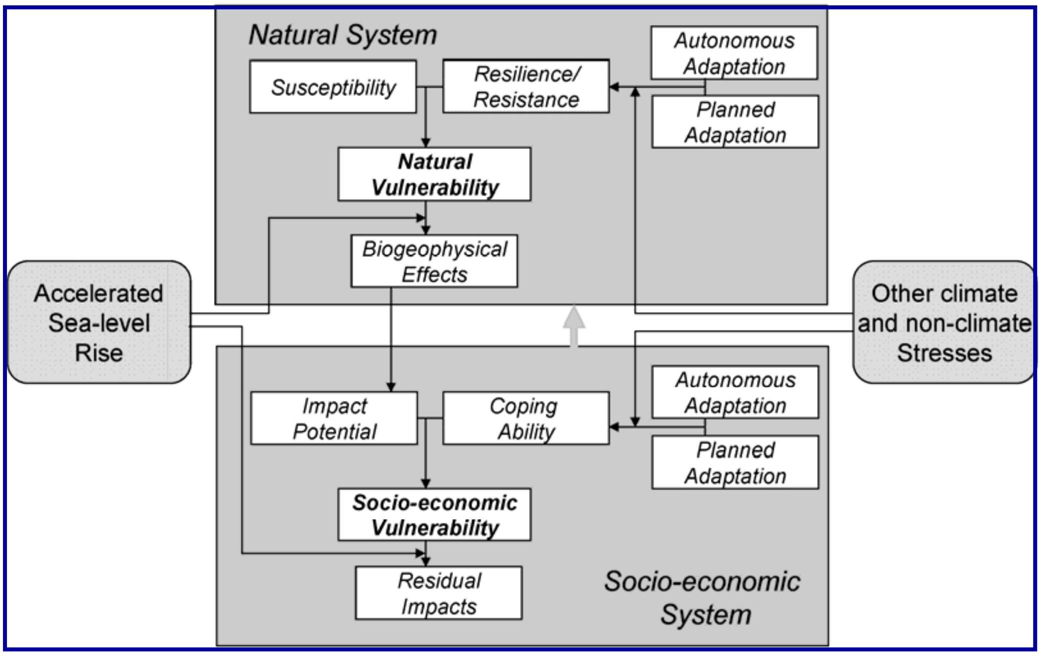


Figure 1: A conceptual framework for coastal vulnerability assessment used in UNEP and other approaches for vulnerability assessment to sea-level rise (Klein and Nicholls, 1999).

Most African countries along the coast have little financial ability to tackle the sea-level rise problem and therefore will be impacted more with climate change, as coasts are seeing a dramatic increase in human population especially in the 21st century. Developing countries are the most *vulnerable* to the impacts of climate changes (Intergovernmental Panel on Climate Change, IPCC, 2007a; Stern, 2006), given their *sensitivity* – the degree by which their systems are affected or responsive to climate – and their exposure to environmental stresses (Figure 1). A coastal system's natural vulnerability to the effects of accelerated sea-level rise (ASLR) is a function of its natural susceptibility, its resistance and its resilience. Natural susceptibility is the coastal system's potential to be affected by ASLR. This is largely independent of human influences. Resistance is the ability of the system to avoid perturbation in the first place - a seawall or a cliff is resistant, for example, whereas resilience is the ability for the system to return to its original state after being perturbed and the speed at which this occurs. At the same time, the high degree of vulnerability found in African coastlines is also due to their low *adaptive capacity that* is the ability to reduce the negative impacts, to capture any benefits of climate change and to ensure *resilience* to future shocks (Cugusi and Piccarozzi, 2009). Autonomous adaptation is the coastal system's spontaneous and natural adaptive response to ASLR, a function of its resilience and resistance (Figure 1). Human influences may be disruptive (e.g. overexploitation of an ecosystem), and can increase the coastal system's natural vulnerability to ASLR. Planned adaptation includes measures taken to enhance the systems natural resilience and resistance (e.g. create buffer zones). Resilience and resistance are different aspects of the system's stability in the face of possible perturbation. These can be strongly dependent on human influences.

1.1.1 Overview of relevant work in IPCC AR4

This section summarises the results and conclusion of the Working Group II of IPCC Fourth Assessment Report (AR4) on vulnerability, impacts and adaptation, from Chapter 6 on Coastal systems and low-lying areas. The following sections are therefore extracts from Chapter 6 authored by Nicholls and others in 2007.

Atmospheric and Ocean-temperature rise and acidification

"Late 20th century effects of rising temperature included associated coastal retreat, and more frequent coral bleaching and mortality" (Nicholls et al., 2007, p. 317). "Over coming decades coasts will be exposed to increasing risks, including coastal erosion, due to climate change and sea-level rise. Anticipated climate-related changes include: an accelerated rise in sea level of up to 0.6 m or more by 2100; a further rise in sea surface temperatures by up to 3°C; an intensification of tropical and extra-tropical cyclones; larger extreme waves and storm surges; altered precipitation/run-off; and ocean acidification. These phenomena will vary considerably at regional and local scales, but the impacts are virtually certain to be overwhelmingly negative" (Nicholls et al., 2007, p. 317).

"Rising CO_2 concentrations have lowered ocean surface pH by 0.1 units since 1750; although to date no significant impacts on coastal ecosystems have been identified. Recent trend analyses indicate that tropical cyclones have increased in intensity. Global sea levels rose at 1.7 ± 0.5 mm/yr through the 20th century, while global mean sea surface temperatures have risen about 0.6°C since 1950, with associated atmospheric warming in coastal areas" (Nicholls et al., 2007, p. 320). "Temperature and rainfall pattern changes may impact water quality in coastal areas and this may lead to more beach closures, thus affecting tourism" (Nicholls et al., 2007, p. 336).

Sea-level rise and coastal erosion

"Many coasts are experiencing erosion and ecosystem losses, but few studies have unambiguously quantified the relationships between observed coastal land loss and the rate of sea-level rise. Coastal erosion is observed on many shorelines around the world, but it usually remains unclear to what extent these losses are associated with relative sea-level rise due to subsidence, and other human drivers of land loss, and to what extent they result from global warming" (Nicholls et al., 2007, p. 320).

"Most of the world's sandy shorelines retreated during the 21st century and sea-level rise is one underlying cause. Acceleration in sea-level rise will widely exacerbate beach erosion around the globe, although the local response will depend on the total sediment budget. The widely cited Bruun model suggests that shoreline recession is in the range 50 to 200 times the rise in relative sea level. While supported by field data in ideal circumstances, wider application of the Bruun model remains controversial. An indirect, less-frequently examined influence of sea-level rise on the beach sediment budget is due to the infilling of coastal embayments. As sea-level rises, estuaries and lagoons attempt to maintain equilibrium by raising their bed elevation in tandem and hence potentially act as a major sink of sand which is often derived from the open coast. This process can potentially cause erosion an order of magnitude or more greater than that predicted by the Bruun model, implying the potential for major coastal instability due to sea-level rise in the vicinity of tidal inlets" (Nicholls et al., 2007, p. 324).

"Several recent studies indicate that beach protection strategies and changes in the behaviour or frequency of storms can be more important than the projected acceleration of sea level rise in determining future beach erosion rates. Thus there is not a simple relationship between sea-level rise and horizontal movement of the shoreline, and sediment budget approaches are most useful to assess beach response to climate change. The combined effects of beach erosion and storms can lead to the erosion or inundation of other coastal systems" (Nicholls et al., 2007, p. 324).

Precipitation and Floods

"Coasts are experiencing the adverse consequences of hazards related to climate and sea level. Coasts are highly vulnerable to extreme events, such as storms, which impose substantial costs on coastal societies. Annually, about 120 million people are exposed to tropical cyclone hazards, which killed 250,000 people from 1980 to 2000. Through the 20th century, global rise of sea level contributed to increased coastal inundation, erosion and ecosystem losses, but with considerable local and regional variation due to other factors" (Nicholls et al., 2007, p. 317).

"Sea-level rise raises extreme water levels with possible increases in storm intensity portending additional climate impacts on many coastal areas, while saltwater intrusion may threaten water supplies. The degradation of natural coastal systems due to climate change, such as wetlands, beaches and barrier islands, removes the natural defences of coastal communities against extreme water levels during storms. Rapid population growths, urban sprawl, growing demand for waterfront properties, and coastal resort development have additional deleterious effects on protective coastal ecosystems" (Nicholls et al., 2007, p. 333).

"Where cities are subsiding, there are additional risks of extreme water levels overtopping flood defences. The population exposed to flooding by storm surges will increase over the 21st century. Africa is also likely to see a substantially increased exposure, with East African countries such as Mozambique having particular problems due to the combination of tropical storm landfalls and large projected population growth, in addition to sea-level rise" (Nicholls et al., 2007, p. 333).

"Estimates of the population (in millions) of the coastal floodplain in 1990 and the 2080s show Africa to experience the largest impacts: without sea-level rise, coastal flooding is projected to diminish as a problem under the SRES scenarios while, with sea-level rise, the coastal flood problem is growing by the 2080s, most especially under the A2 scenario. Increased storm intensity would exacerbate these impacts, as would larger rises in sea level, including due to human-induced subsidence. This is assuming uniform population growth; net coastward migration could substantially increase these numbers" (Nicholls et al., 2007, p. 334).

Coastal Population and Livelihoods

"The impact of climate change on coasts is exacerbated by increasing human-induced pressures. Utilisation of the coast increased dramatically during the 20th century and this trend is virtually certain to continue through the 21st century. Under the SRES scenarios, Africa's coastal population could grow from 1.2 billion people (in 1990) to 1.8 to 5.2 billion people by the 2080s, depending on assumptions about migration. Increasing numbers of people and assets at risk at the coast are subject to additional stresses due to land-use and hydrological changes in catchments, including dams that reduce sediment supply to the coast. Populated deltas, low-lying coastal urban areas and atolls are key societal hotspots of coastal vulnerability, occurring where the stresses on natural systems coincide with low human adaptive capacity and high exposure. Regionally, Africa and small islands are most vulnerable. Climate change therefore reinforces the desirability of managing coasts in an integrated manner" (Nicholls et al., 2007, p. 317).

"Utilisation of the coast increased dramatically during the 20th century, a trend that seems certain to continue through the 21st century. Coastal population growth in many of the world's deltas, barrier islands and estuaries has led to widespread conversion of natural coastal landscapes to agriculture, aquaculture, silviculture, as well as industrial and residential uses. It has been estimated that 23 % of the world's population lives both within 100 km distance of the coast and <100 m above sea level, and population densities in coastal regions are about three times higher than the global average. The attractiveness of the coast has resulted in disproportionately rapid expansion of economic activity, settlements, urban centres and tourist resorts. Migration of people to coastal regions is common in both developed and developing nations. 60 % of the world's 39 metropolises with a population of over 5 million are located within 100 km of the coast, including 12 of the world's 16 cities with populations greater than 10 million. Rapid urbanisation has many consequences: for example, enlargement of natural coastal inlets and dredging of waterways for navigation, port facilities, and pipelines; all of these examples exacerbate saltwater intrusion into surface and ground waters" (Nicholls et al., 2007, p. 319).

The direct impacts of human activities on the coastal zone have been more significant over the 21st century than impacts that can be directly attributed to observed climate change. The major direct impacts include drainage of coastal wetlands, deforestation and reclamation, and discharge of sewage, fertilisers and contaminants into coastal waters. Extractive activities include sand mining and hydrocarbon production, harvests of fisheries and other living resources, introductions of invasive species and construction of seawalls and other structures. Engineering structures, such as damming, channelisation and diversions of coastal waterways, harden the coast, change circulation patterns and alter freshwater, sediment and nutrient delivery. Natural systems are often directly or indirectly altered, even by soft engineering solutions, such as beach nourishment and foredune construction.

"The unavoidability of sea-level rise, even in the longer-term, frequently conflicts with present-day human development patterns and trends. Sea-level rise has substantial inertia and will continue beyond 2100 for many centuries. Irreversible breakdown of the West Antarctica and/or Greenland ice sheets, if triggered by rising temperatures, would make this long-term rise significantly larger, ultimately questioning the viability of many coastal settlements across the globe. The issue is reinforced by the increasing human use of the coastal zone. Settlement patterns also have substantial inertia, and this issue presents a challenge for long-term coastal spatial planning. Stabilisation of climate could reduce the risks of ice sheet breakdown, and reduce but not stop sea-level rise due to thermal expansion. Hence, it is now more apparent than it was in the Third Assessment Report (TAR) that the most appropriate response to sea-level rise for coastal areas is a combination of adaptation to deal with the inevitable rise, and mitigation to limit the long-term rise to a manageable level" (Nicholls et al., 2007, p. 317).

Fisheries, Resource Management and Biodiversity

"Ecosystem services on the coast are often disrupted by human activities. For example, tropical and subtropical mangrove forests and temperate saltmarshes provide goods and services (they accumulate and transform nutrients, attenuate waves and storms, bind sediments and support rich ecological communities), which are reduced by large-scale ecosystem conversion for agriculture, industrial and urban development, and aquaculture" (Nicholls et al., 2007, p. 319).

"Long-term ecological studies of rocky shore communities indicate adjustments apparently coinciding with climatic trends. However, for mid latitudinal coastal systems it is often difficult to discriminate the extent to which such changes are a part of natural variability; the clearest evidence of the impact of climate change on coasts over the past few decades comes from high and low latitudes, particularly polar coasts and tropical reefs" (Nicholls et al., 2007, p. 320).

"Corals are vulnerable to thermal stress and have low adaptive capacity. Increases in sea surface temperature of about 1 to 3°C are projected to result in more frequent coral bleaching events and widespread mortality, unless there is thermal adaptation or acclimatisation by corals. Coastal wetland ecosystems, such as saltmarshes and mangroves, are especially threatened where they are sediment starved or constrained on their landward margin. Degradation of coastal ecosystems, especially wetlands and coral reefs, has serious implications for the well-being of societies dependent on the coastal ecosystems for goods and services. Increased flooding and the degradation of freshwater, fisheries and other resources could impact hundreds of millions of people, and socio-economic costs on coasts will escalate as a result of climate change" (Nicholls et al., 2007, p. 317).

"Global warming poses a threat to coral reefs, particularly any increase in sea surface temperature (SST). The synergistic effects of various other pressures, particularly human impacts such as over-fishing, appear to be exacerbating the thermal stresses on reef systems and, at least on a local scale, exceeding the thresholds beyond which coral is replaced by other organisms" (Nicholls et al., 2007, p. 320).

"Coral bleaching, due to the loss of symbiotic algae and/or their pigments, has been observed on many reefs since the early 1980s. Slight paling occurs naturally in response to seasonal increases in sea surface temperature (SST) and solar radiation. Corals bleach white in response to anomalously high SST (~1°C above average seasonal maxima, often combined with high solar radiation). Whereas some corals recover their natural colour when environmental conditions ameliorate, their growth rate and reproductive ability may be significantly reduced for a substantial period. If bleaching is prolonged, or if SST exceeds 2°C above average seasonal maxima, corals die. Branching species appear more susceptible than massive corals. Major bleaching events were observed in 1982-83, 1987-88 and 1994-95. Particularly severe bleaching occurred in 1998, associated with pronounced El Niño events in one of the hottest years on record. Since 1998 there have been several extensive bleaching events" (Nicholls et al., 2007, p. 321).

"Whereas present rates of sea-level rise are contributing to the gradual diminution of many of the world's deltas, most recent losses of deltaic wetlands are attributed to human development. An analysis of satellite images of 14 of the world's major deltas, including Niger, Nile and Zambezi, indicated a total loss of 15,845 km^2 of deltaic wetlands over the past 14 years. Every delta showed land loss, but at varying rates, and human development activities accounted for over half of the losses" (Nicholls et al., 2007, p. 326).

"Sea-level rise poses a particular threat to deltaic environments, especially with the synergistic effects of other climate and human pressures. These issues are especially noteworthy in many of the largest deltas with an indicative area $>10^4$ km^2 (henceforth megadeltas) due to their often large populations and important environmental services" (Nicholls et al., 2007, p. 326).

"Coastal vegetated wetlands are sensitive to climate change and long-term sea-level change as their location is intimately linked to sea level. Modelling of all coastal wetlands suggests global losses from 2000 to 2080 of 33 % and 44 % given a 36 cm and 72 cm rise in sea level, respectively" (Nicholls et al., 2007, p. 328). "Mangrove communities are likely to show a blend of positive responses to climate change, such as enhanced growth resulting from higher levels of CO^2 and temperature, as well as negative impacts, such as increased saline intrusion and erosion, largely depending on site-specific factors" (Nicholls et al., 2007, p. 329). “Increasing salinity and greater frequency of flooding due to sea-level rise reduces the ability of trees to generate, including mangroves which will also experience other changes” (Nicholls et al., 2007, p. 329). Figure 2 shows topographical map of Africa together with country names. Most of the African coastal zones are low-lying, especially, the northern, eastern and western coasts. These areas are likely to be impacted more by a rise in sea-level (Figure 2).

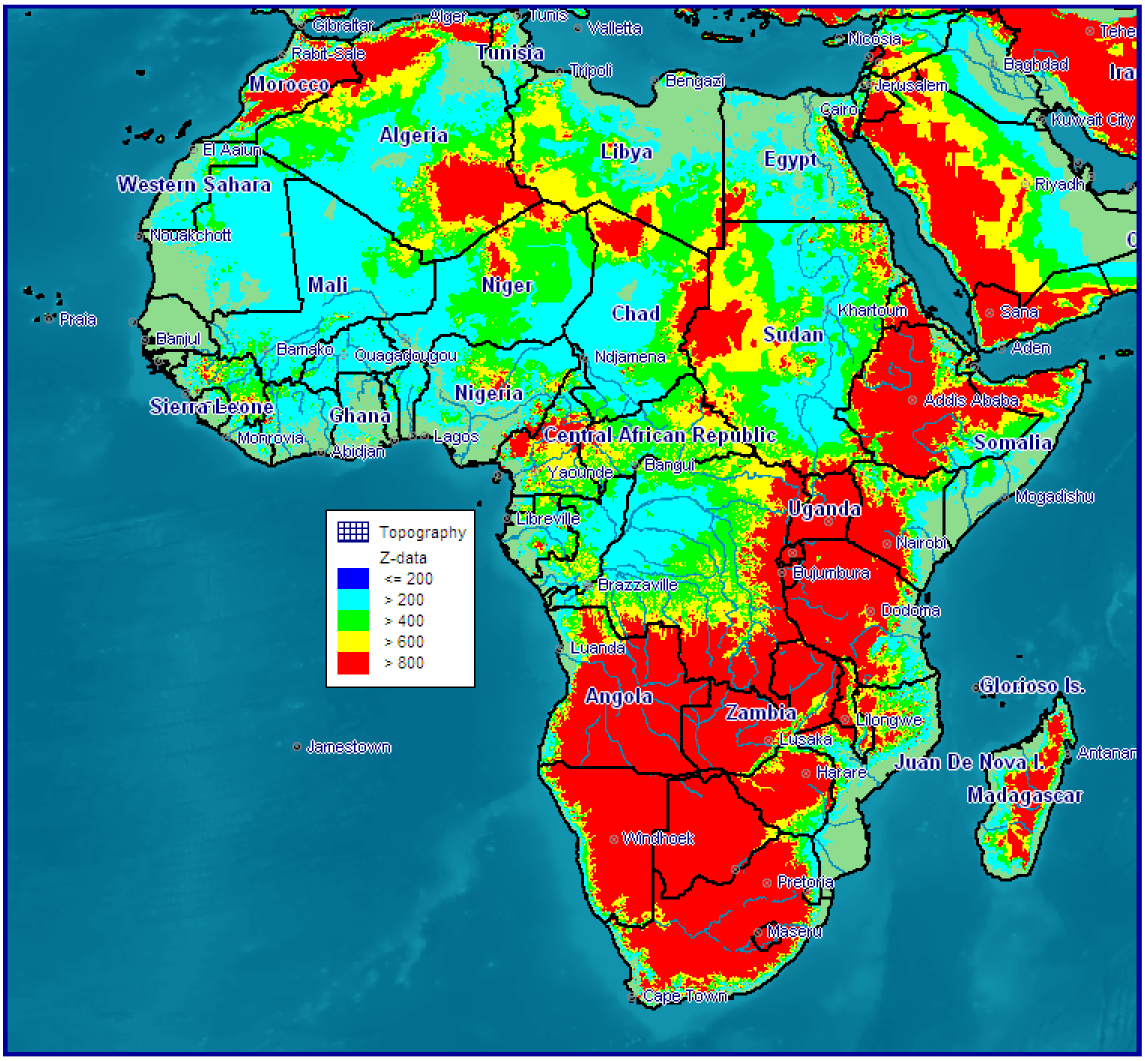


Figure 2: Topographic map of Africa showing general elevation. Low-lying areas that are prone to flooding are located in North Africa from Tunisia to Egypt; East Africa from Somalia to Mozambique and west and central Africa from Mauritania to Congo (data source: the DINAS-Coast Consortium database).

1.1.2 Overview of more recent science

A significant body of scientific evidence clearly indicates that climate change is a serious and urgent issue (Stern, 2007). Today, climate change represents one of the greatest threats for mankind. The Earth has warmed by 0.7°C since around 1900. It is an extremely complex issue, and the scientific community agrees – on the basis of the overwhelming empirical evidence – on the seriousness of the phenomenon (Cugusi and Piccarozzi, 2009). In Africa alone, 75 to 250 million people might be exposed to high water stress due to climate change by 2020 (Cugusi and Piccarozzi, 2009). Climate change is a global challenge and also an opportunity to reshape the current development model. Political willingness and commitments are needed for effective climate policies, but the economic and financial crisis affecting the globe could be a major risk and a further obstacle to concrete actions.

The case of Africa is particularly worrisome, since the continent has very low adaptation capacities. At the same time, Africa is the region about which there is the smallest quantity of statistical information available as well as of studies and research, and the most serious lack of a reliable monitoring system. Together, these raise serious questions as to whether the necessary capacity to manage the impacts of climate change is present.

Africa's 63 transboundary river basins account for 90 % of its surface water resources. Also, the region's rapidly urbanising population is vulnerable because of ill defined property rights, weak land use planning, and informal settlements often on land subject to erosion or flooding. Nearly three-quarters of the region's urban population lives in slums, and the vast majority of the 300 million additional urban residents expected in Africa over the next 25 years may also be faced with similar living conditions (World Bank, 2009).

1.1.3 Consequences of climate change on the African coast

This section summarises the results and conclusion of the Working Group II of IPCC AR4 on vulnerability, impacts and adaptation from Chapter 9 on Africa. The following sections are therefore extracts from Chapter 9 authored by Boko and others in 2007.

Atmospheric and Ocean-temperature rise and acidification

"Since the IPCC Third Assessment Report (TAR), observed temperatures have indicated a greater warming trend since the 1960s. Decadal warming rates of 0.29°C in the African tropical forests and 0.1 to 0.3°C in South Africa have been observed. In South Africa and Ethiopia, minimum temperatures have increased slightly faster than maximum or mean temperatures. Between 1961 and 2000, there was an increase in the number of warm spells over southern and western Africa, and a decrease in the number of extremely cold days. In eastern Africa, downward trends in temperature from weather stations located close to the coast have been observed" (Boko et al., 2007, p. 436).

"Detailed assessments in northern Africa based on temperature increases of 1-4°C and reductions in precipitation of between 0 and 10% show that the Ouergha watershed in Morocco is likely to undergo changes for the period 2000-2020. A 1°C increase in temperature could decrease runoff by of the order of 10 %, assuming that the precipitation levels remain constant. If such an annual change in runoff were to occur in other watersheds, the impacts in such areas could be equivalent to the loss of one large dam per year" (Boko et al., 2007, p. 445).

Sea-level rise and coastal erosion

"In Kenya, losses for three crops, that is, mangoes, cashew nuts and coconuts, could cost almost US$ 500 million for a 1 m sea-level rise. In Guinea, between 130 and 235 km^2 of rice fields (17 % and 30 % of the existing rice field area) could be lost as a result of permanent flooding, depending on the inundation level considered of (between 5 m and 6 m) by 2050. In Eritrea, a 1 m rise in sea level is estimated to cause damage of over US$ 250 million as a result of the submergence of infrastructure and other economic installations in Massawa, one of the country's two port cities" (Boko et al., 2007, p. 450).

Precipitation and Floods

"Climate variability and change could result in low-lying lands being inundated, with resultant impacts on coastal settlements. Climate variability and change, coupled with human-induced changes, may also affect ecosystems e.g., mangroves and coral reefs, with additional consequences for fisheries and tourism. The projection that sea-level rise could increase flooding, particularly on the coasts of eastern Africa, will have implications for health. Sea-level rise will probably increase the high socio-economic and physical vulnerability of coastal cities. The cost of adaptation to sea-level rise could amount to at least 5-10% of gross domestic product" (Boko et al., 2007, p. 436).

"Interannual rainfall variability is large over most of Africa and, for some regions; multi-decadal variability is also substantial. In West Africa, a decline in annual rainfall has been observed since the end of the 1960s, with a decrease of 20 to 40 % noted between the periods 1931- 1960 and 1968-1990. In the tropical rain-forest zone, declines in mean annual precipitation of around 4 % in West Africa, 3 % in North Congo and 2 % in South Congo for the period 1960 to 1998 have been noted. A 10 %increase in annual rainfall along the Guinean coast during the last 30 years has, however, also been observed. In other regions, such as southern Africa, no long-term trend has been noted. Increased interannual variability has, however, been observed in the post-1970 period, with higher rainfall anomalies and more intense and widespread droughts reported. In different parts of southern Africa such as Angola, Namibia, Mozambique, Malawi and Zambia, a significant increase in heavy rainfall events has also been observed including evidence for changes in seasonality and weather extremes. During recent decades, eastern Africa has been experiencing an intensifying dipole rainfall pattern on the decadal time-scale. The dipole is characterised by increasing rainfall over the northern sector and declining amounts over the southern sector" (Boko et al., 2007, p. 436).

“In very recent assessments of the potential flood risks that may arise by 2080 across a range of SRES scenarios and climate change projections, three of the five regions shown to be at greatest risk of flooding in coastal and deltaic areas of the world are those located in Africa: North Africa, West Africa and southern Africa” (Boko et al., 2007, p. 450).

“In Cameroon, for example, indications are that a 15 % increase in rainfall by 2100 would be likely to decrease the penetration of salt water in the Wouri estuary. Alternatively, with an 11 % decrease in rainfall, salt water could extend up to about 70 km upstream. In the Gulf of Guinea, sea-level rise could induce overtopping and even destruction of the low barrier beaches that limit the coastal lagoons, while changes in precipitation could affect the discharges of rivers feeding them. These changes could also affect lagoonal fisheries and aquaculture” (Boko et al., 2007, p. 450).

“Indian Ocean islands could also be threatened by potential changes in the location, frequency and intensity of cyclones; while East African coasts could be affected by potential changes in the frequency and intensity of storm surges and coral bleaching” (Boko et al., 2007, p. 450). “Coastal agriculture such as plantations of palm oil and coconuts in Benin and Côte d’Ivoire and shallots in Ghana could be at risk of inundation and soil salinisation” (Boko et al., 2007, p. 450).

Drought and Desertification

“Climate change will aggravate the water stress currently faced by some countries, while some countries that currently do not experience water stress will become at risk of water stress. Climate change and variability are likely to impose additional pressures on water availability, water accessibility and water demand in Africa. Even without climate change, several countries in Africa, particularly in northern Africa, will exceed the limits of their economically usable land-based water resources before 2025. About 25 % of Africa’s population, that is, about 200 million people, currently experience high water stress. The population at risk of high water stress in Africa is projected to be between 75-250 million and 350-600 million people by the 2020s and 2050s, respectively” (Boko et al., 2007, p. 435).

“Changes in extreme events, such as droughts have major implications for numerous Africans. One-third of the people in Africa lives in drought-prone areas and is vulnerable to the impacts of droughts. During the mid-1980s the economic losses from droughts totalled several hundred million U.S. dollars. Droughts have mainly affected the Sahel, the Horn of Africa and southern Africa, particularly since the end of the 1960s. Recurrent floods in some countries are linked, in some cases, with ENSO events. When such events occur, important economic and human losses result such as in Mozambique. Even countries located in dry areas (Algeria, Tunisia, Egypt, and Somalia) have not been flood-free” (Boko et al., 2007, p. 437).

“Approximately half of the sub-humid and semi-arid parts of the southern African region are at moderate to high risk of desertification. In West Africa, the long-term decline in rainfall from the 1970s to the 1990s caused a 25-35 km southward shift of the Sahelian, Sudanese and Guinean ecological zones in the second half of the 20th century. This has resulted in a loss of grassland and acacia, the loss of flora/fauna, and shifting sand dunes in the Sahel" (Boko et al., 2007, p. 439).

"Water access and water resource management are highly variable across the continent. The 17 countries in West Africa that share 25 transboundary rivers have notably high water interdependency. Eastern and southern African countries are also characterised by water stress brought about by climate variability and wider governance issues. Despite progress in this area, about 35 million people in the region are still using unimproved water sources; the largest proportion being in Mozambique, followed by Angola, South Africa, Zambia and Malawi. The relevance of the problem of water scarcity is evident in North Africa, considering that estimates for the average annual growth of the population are the world's highest: 2.9 % for the period 1990-2002. The Water Exploitation Index2 is high in several countries in the subregion: greater than 50 % for Tunisia, Algeria, Morocco and Sudan, and greater than 90 % for Egypt and Libya. Attributing sensitivity and vulnerability in the water sector solely to variations in climate is problematic" (Boko et al., 2007, p. 441-442).

Coastal Population and Livelihoods

"Notwithstanding the range of uncertainties related to the accuracy of census data, the African continent is witnessing some of the most rapid population growth, particularly in urban areas. During the period 1950 to 2005, the urban population in Africa grew by an average annual rate of 4.3 % from 33 million to 353 million" (Boko et al., 2007, p. 441).

"40 % of the population of West Africa live in coastal cities, and it is expected that the 500 km of coastline between Accra and the Niger delta will become a continuous urban megalopolis of more than 50 million inhabitants by 2020. By 2015, three coastal megacities of at least 8 million inhabitants will be located in Africa. The projected rise in sea level will have significant impacts on these coastal megacities because of the concentration of poor populations in potentially hazardous areas that may be especially vulnerable to such changes. Cities such as Lagos and Alexandria will probably be impacted" (Boko et al., 2007, p. 445).

"Impacts on settlements and infrastructure are well recorded for recent extreme climate events such as the 2000 flooding event. Large numbers of people are currently at risk of floods, particularly in coastal areas, where coastal erosion is already destroying infrastructure, housing and tourism facilities such as in the residential region of Akpakpa in Benin" (Boko et al., 2007, p. 440).

Fisheries, Resource Management and Biodiversity

"In Africa, many highly productive ecosystems such as mangroves, estuaries, deltas and coral reefs, which form the basis for important economic activities such as tourism and fisheries, are located in the coastal zone" (Boko et al., 2007, p. 450).

“Changes in a variety of ecosystems are already being detected, particularly in southern African ecosystems, at a faster rate than anticipated. Climate change, interacting with human drivers such as deforestation and forest fires, are a threat to Africa’s forest ecosystems. Changes in grasslands and marine ecosystems are also noticeable. It is estimated that, by the 2080s, the proportion of arid and semi-arid lands in Africa is likely to have increased by 5-8 %” (Boko et al., 2007, p. 435). “Mangroves and coral reefs, the main coastal ecosystems in Africa, will probably be affected by climate change. Endangered species associated with these ecosystems, including manatees and marine turtles, could also be at risk, along with migratory birds. Mangroves could also colonise coastal lagoons because of sea-level rise” (Boko et al., 2007, p. 449).

“The 1997/1998 coral bleaching episode observed in the Indian Ocean and Red Sea was coupled to a strong ENSO. In the Western Indian Ocean region, a 30 % loss of corals resulted in reduced tourism in Mombasa and Zanzibar, and caused financial losses of about US$ 12-18 million. Coral reefs are also exposed to other local anthropogenic threats, including sedimentation, pollution and over-fishing, particularly when they are close to important human settlements such as towns and tourist resorts. Recent outbreaks of the ‘crown-of-thorns’ starfish have occurred in Egypt, Djibouti and western Somalia, along with some local bleaching” (Boko et al., 2007, p. 439).

“The coral bleaching following the 1997/1998 extreme El Nino is an indication of the potential impact of climate change-induced ocean warming on coral reefs; disappearance of low-lying corals and losses of biodiversity could also be expected. The proliferation of algae and dinoflagellates during these warming events could increase the number of people affected by toxins, such as ciguatera, due to the consumption of marine food sources. In the long term, all these impacts will have negative effects on fisheries and tourism. In South Africa, changes in estuaries are expected mainly as a result of reductions in river runoff and the inundation of salt marshes following sea-level rise” (Boko et al., 2007, p. 449).

1.1.4 The most important effects and uncertainties in Africa’s Climate-change adaptation

Adaptation costs are calculated as though decision-makers knew with certainty what the future climate will be, when in reality current climate knowledge does not permit even probabilistic statements about country-level climate outcomes. In a world where decision-makers hedge against a range of outcomes, the costs of adaptation could be potentially higher. Climate science tells us that the impacts will increase over time and that major effects such as melting of ice sheets will occur further into the future. Even so, the projections up to 2050 are more reliable than those beyond this period (EACC study team, 2009).

Most regions use hard adaptation measures that require an engineering response rather than an institutional or behavioural response. Soft adaptation measures often can be more effective and can avoid the need for more expensive physical investment. Uncertainty about the exact nature of climate change impacts at the local and regional level, for example in terms of precipitation and storminess makes it difficult to fine-tune adaptation measures. Adaptation decisions will be taken under uncertainty (Agrawala and Fankhauser, 2008).

There are some adaptation measures that are easy to agree on, even in the face of uncertainty, such as those known as ‘win-win measures’. These are adaptations that are justifiable even in the absence of climate change. Measures to deal with climate variability, such as long-term weather forecasting and early warning systems, are examples (Agrawala and Fankhauser, 2008, p. 25). Given the prevailing uncertainties, the best way to account for potential climate change in current investment decisions may be to increase the flexibility and robustness of systems – allowing them to function under a wide range of climatic conditions and withstand more severe climatic shocks (Agrawala and Fankhauser, 2008, p. 25). The call for increased flexibility and robustness applies to physical, natural and social systems. In the case of physical capital, the capacity of water storage systems may be increased in anticipation of future droughts or coastal protection measures may be strengthened to withstand more severe storms and floods. In the case of natural capital, measures to protect the environment may increase the ability of species to adapt to a changing climate. Institutionally, creating regulatory frameworks that encourage individual adaptability would help to increase the flexibility and robustness of economic systems (Agrawala and Fankhauser, 2008, p. 25).

Primary effects of Climate-change

1.1.4.1 Atmospheric and ocean temperature rise and acidification

“To assess the extent and nature of climate change is a very difficult task, due to the difficulties in forecasting temperature changes. According to the estimate made by the IPCC in its fourth assessment report (IPCC, 2007b), global warming is expected to be more intense in Africa than in the rest of the world. On average, the rise in temperatures between 1980/99 and 2080/99 would be between 3 °C and 4 °C for the continent as a whole, 1.5 times higher than the global level. The expected warming would not be uniform throughout the continent; it would be less marked in coastal and equatorial areas (+3 °C) and highest in the Western Sahara region (+4 %)” (Figure 3; Cugusi and Pccarozzi, 2009, p. 8).

An increase in sea surface temperature is strongly predicted at all latitudes and in all oceans. The scientific evidence indicates that climate change will intensify storm surges for two reasons. First, they will be elevated by a rising sea level as thermal expansion and ice cap melting continues. The most recent evidence suggests that sea-level rise could reach 1 m or more during the 21st century (Dasgupta, et al. 2009a). Second, a warmer ocean is likely to intensify cyclone activity and heighten storm surges. As storm surges increase, they will create more damaging flood conditions in coastal zones and adjoining low-lying areas. The destructive impact will generally be greater when the surges are accompanied by strong winds and large onshore waves.

A 2^{o}C warmer world will experience more intense rainfall and more frequent and more intense droughts, floods, heat waves, and other extreme weather events. Land areas may warm by as much as 1.6 ºC over the Sahara and semi-arid regions of southern Africa by 2050, lower than during the 1980/99 period shown in Figure 3 (NEF, 2005). In southern Africa, temperature has risen by over 0.5 ^{o}C over the last 100 years; with noticeably less rainfall over the past 20 years, again temperatures are lower over longer time periods (La Trobe, 2002).

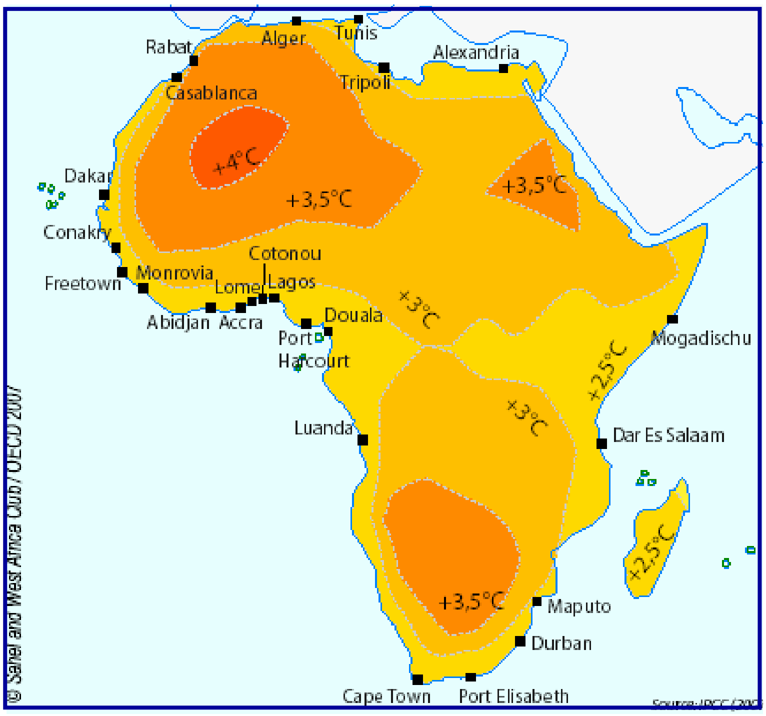


Figure 3: Projected 100-year effects of global warming (^{o}C) in Africa during the period 1980/99 to 2080/99 (Cugusi and Piccarozzi, 2009)

Based on historical records, a warming of approximately 0.7°C over most of the African continent during the 20th century is reported in the IPCC WGII TAR (2001a). Observational records show that this warming occurred at the rate of about 0.05°C per decade with a slightly larger warming in the June-November seasons than in December-May (Elasha et al., 2006). Very high temperatures records have also been indexed. The five warmest years in Africa have all occurred since 1988, with 1995 and 1998 being the two warmest years (IPCC, 2001a).

1.1.4.2 Sea level rise and coastal erosion

Sea levels around Africa are projected to rise by 15-95 cm by the year 2100 (IPCC, 2001a). More than 25 % of Africa's population lives within 100 km of the coast, and projections suggest that the number of people at risk from coastal flooding will increase from 1 million in 1990 to 70 million in 2080 (Cugusi and Piccarozzi, 2009). National communications indicate that the coastal infrastructure in 30 % of Africa's coastal countries is at risk of partial or complete inundation due to accelerated sea-level rise (Cugusi and Piccarozzi, 2009). For example, coastal settlements in the Gulf of Guinea, Senegal, Gambia, Egypt, and along the East-Southern African coast are prone to inundation. Sea-level rise resulting from global climate change threatens different coastal and marine ecosystems e.g. lagoons and mangrove forests of both eastern and western Africa, and will impact urban centres and ports, such as Cape Town, Maputo, and Dar Es-Salaam (Cugusi and Piccarozzi, 2009).

In North Africa, a study on the Nile Delta found that a 1 m rise in sea level would destroy weak parts of the sand belt, which is essential for the protection of lagoons and the low-lying reclaimed and other valuable agricultural lands. In addition, intrusion of saltwater will affect freshwater quality and so the health of freshwater fish (Cugusi and Piccarozzi, 2009). Figure 4 shows the level of impact of sea-level rise on the African coast.

Figure 4: Sea-level rise impact on the African coast. West African coast will be highly impacted by sea-level rise while the east African coast including the western Indian Ocean islands will be moderately impacted (World Bank, 2009).

Coastal erosion is a major environmental issue in Sub-Saharan Africa. Widespread and significant erosion of coasts, whether due to anthropogenic or natural causes is known to be one of the most devastating environmental problems of the coastal zone of a number of countries of the Sub-Saharan Africa, and has serious implications on the entire national economies. Figure 5 shows total sand loss in m^3/year from the African coast as a result of sea-level rise and coastal erosion.

As a result of the population growth of 4 % per year since 1980 of coastal urban areas in Africa, human-induced activities such as construction, dredging and mining for sand, and harvesting corals have led to severe problems of coastal erosion. The Niger River Delta is losing 400 000 m^2 of land per year to erosion (Cugusi and Piccarozzi, 2009).

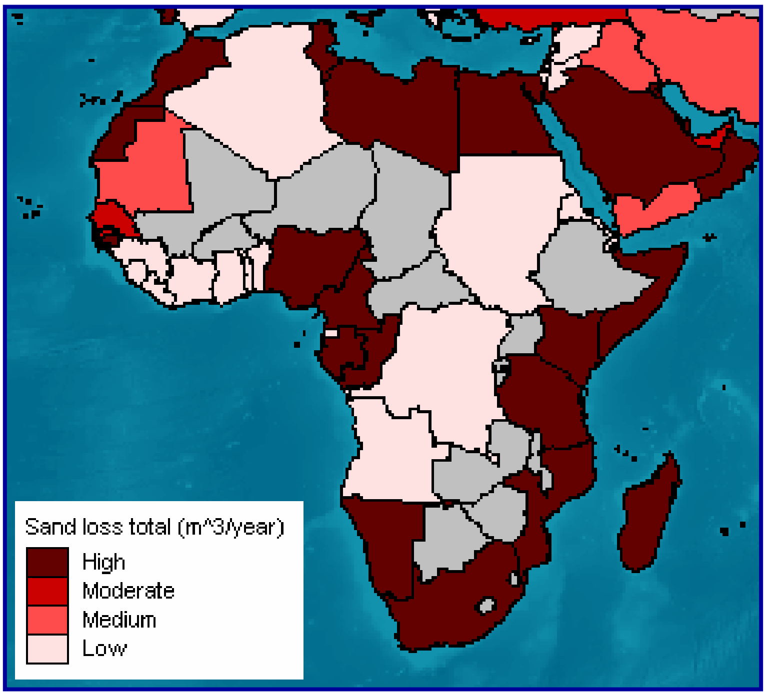


Figure 5: An overview of total sand loss as a result of sea-level rise in Africa. Northern, eastern, southern, and central and parts of western Africa will suffer a high total sand loss (data source: the DINAS-Coast Consortium 2006 database).

1.1.4.3 Precipitation and floods

"In Africa, vulnerability is not only the result of physical changes in climate, but largely depends on the environmental consequences of human activities such as mining in Burkina Faso, Niger and Mauritania as well as poaching in Sudan and other human-induced factors, such as deforestation" (Cugusi and Piccarozzi, 2009, p 9). "Northern Africa, Southern Africa and Eastern Africa are some of the regions where there is less uncertainty in regards to rainfall variability. Africa's Mediterranean coast is likely to experience a decrease in precipitation of between -15 % to -20 % during the period 1980/99 and 2080/99" (Cugusi and Piccarozzi, 2009, p. 9). "Less rainfall is expected during winter and especially in spring in Southern Africa. Along the tropical belt, the results achieved by the models show an increase in rainfall in East Africa which will extend to the Horn of Africa. However, no conclusions can be drawn regarding rainfall in West Africa" (Cugusi and Piccarozzi, 2009, p. 9).

In the Sahelian and Horn of Africa countries, extreme changes in climate are not the only ones responsible for environmental vulnerabilities affecting the region. Other factors affecting the region include the degradation and destruction of the ecosystems due to the slow onset physical changes such as desertification, land degradation and water stresses including water availability and access to safe water. Figure 6 shows rainfall variations in Africa. The figure shows that the east and western coasts of Africa have threatened coastal ecosystems as well.

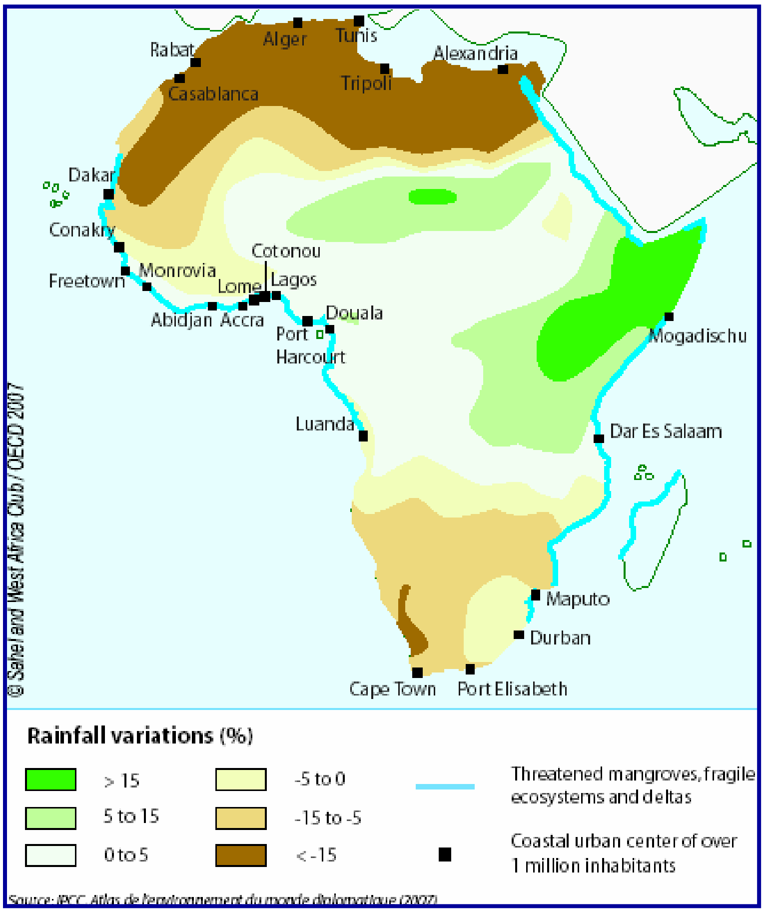


Figure 6: Projected 100-year rainfall variations (%) in Africa during the period 1980/99 to 2080/99. The eastern part of the continent receives increases in rainfall while the north-western and southern part of the continent experiences decreases (Cugusi and Piccarozzi, 2009).

Floods are recurrent in some countries of Africa; even communities located in dry areas have been affected by floods. The years 2000 and 2001 witnessed a huge flooding event in Mozambique, particularly along the Limpopo, Save and Zambezi valleys. In 2000, floods resulted in half a million people made homeless and 700 losing their lives (Elasha et al., 2006, p. 17). The floods had devastating effects on livelihoods, destroying agricultural crops, disrupting electricity supplies and demolishing basic infrastructure such as roads, homes and bridges. It is also not uncommon for some countries to experience both droughts and floods in the same year; the flooding experienced in East Africa followed periods of extended drought. Ethiopia experienced drought in early 2006, but suffered from severe floods in August 2006 leading to the death of more than 200 people with another 250 people missing in the eastern part of the country (Elasha et al., 2006, p. 17). Figure 7 shows projected coastal floodplain population for Sub-Saharan Africa with the north and east African coasts as the most vulnerable.

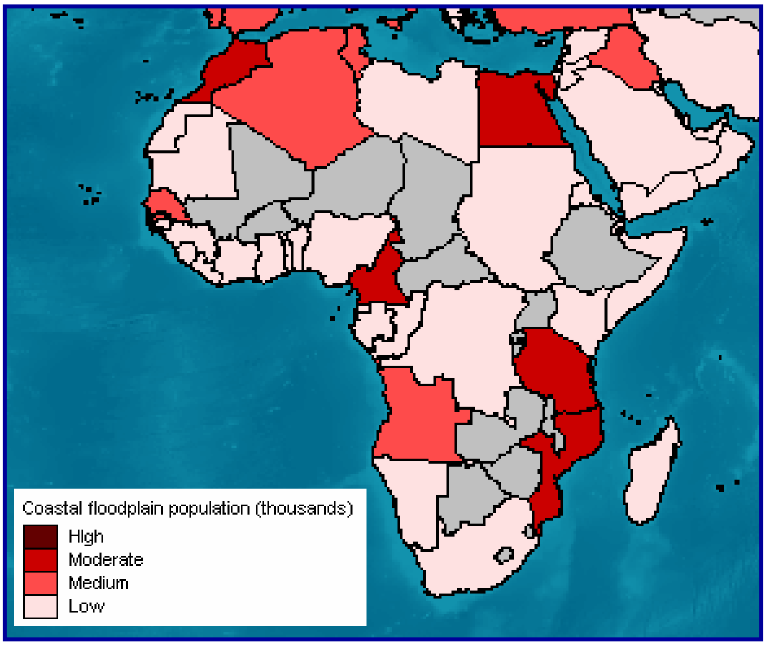


Figure 7: An overview of coastal floodplain population, in thousands, as a result of sea-level rise in Africa. The highest numbers of coastal floodplain population is projected to occur in North Africa, East Africa, sections of south, central and West Africa (data source: the DINAS-Coast Consortium 2006 database).

1.1.4.4 Drought and Desertification

In Africa, people facing water scarcity conditions are already over 300 million, while 25 % of African population experience water stresses (Cugusi and Piccarozzi, 2009, p. 12). "Temperature rises of 2°C will result in 1 – 4 billion people experiencing growing water shortages, predominantly in Africa. The volume of water estimated to have been lost from the African land mass during a three year period ending in approximately 2006 was about 334 km^3, which is as much water as Africans consumed over the same period" (Cugusi and Piccarozzi, 2009, p. 12). "By 2025, it is expected that 18 African countries will experience water stress while by 2050; areas experiencing water shortages in Sub-Saharan Africa will have increased by 29 %" (Cugusi and Piccarozzi, 2009, p. 12). "Water availability is not the only water stress to be considered. Change in climate may exacerbate the already existing constraint to access to safe water and adequate sanitation. Actually, only 62 % of African population had access to improved water supplies in 2000" (Cugusi and Piccarozzi, 2009, p. 12). Figure 8 shows water stress in Africa.

“In particular, the possible range of Africa-wide climate change impacts on stream flows may increase in all countries significantly between 2050 and 2100, respectively by 15 and 19 %” (Cugusi and Piccarozzi, 2009, p. 13). “Parts of southern Africa are projected to experience significant losses of runoff, with some areas being particularly impacted” (Cugusi and Piccarozzi, 2009). “In West Africa, for example, temperature changes in northern and southern Atlantic Ocean and Indian water surfaces as well as temperature anomalies in the Pacific, linked to El Nino phenomenon, are important driving force for West Africa’s monsoon activity. “Temperature variations in the oceans, which are sensitive to global climate changes, will undoubtedly have repercussions on the West African monsoon” (Cugusi and Piccarozzi, 2009, p. 14). “93 % of the African total surface water resources come from the 59 international transboundary rivers, which are also home to some 77 % of the African population. “This represents a very important issue when dealing with the impact of climate change in Africa, given their potential in triggering conflicts over resources” (Cugusi and Piccarozzi, 2009, p. 14).

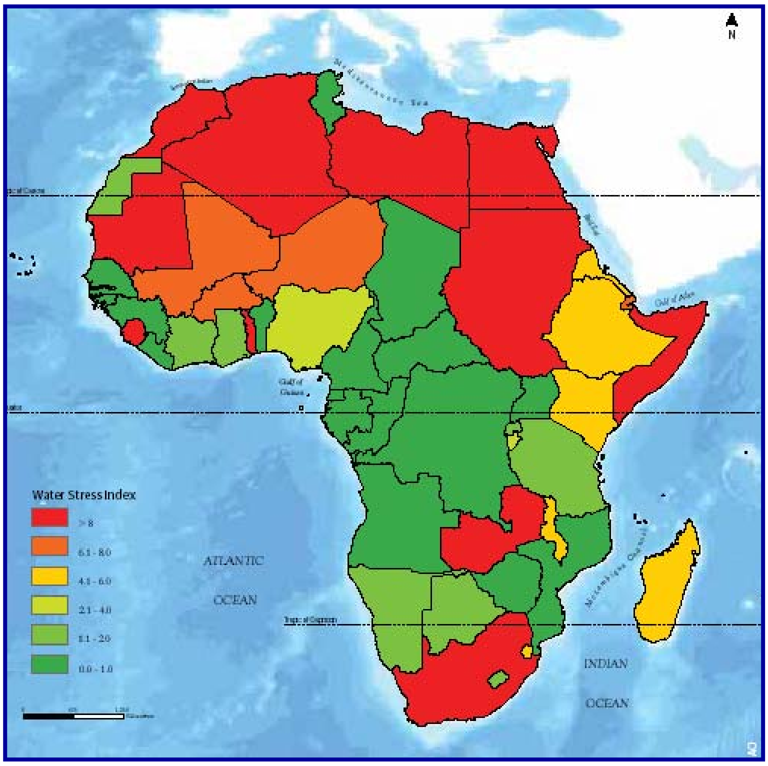


Figure 8: Water stress in Africa. The northern and southern coasts of Africa suffer the most water stress resulting into extreme droughts and desertification (Cugusi and Piccarozzi, 2009).

With regard to changes in precipitation, an average of a 25 % decrease in rainfall has occurred over the African Sahel during the past 30 years. This change has been characterised by a decrease in the number of rainfall events. A decrease in precipitation has occurred over the 20th century, particularly after the 1960s, in the subtropics and the tropics from Africa to Indonesia (IPCC, 2001a). A decrease in precipitation by about 2.4 % per decade in tropical rainforest regions of Africa has been found since the mid-1970s. This rate was faster in West Africa of up to - 4.2 % per decade and in north Congo of up to -3.2 % per decade (Elasha et al., 2006).

Increased drought risk, heat waves and water stress in tropical and sub-tropical dry land areas and their expansion, are one of the results of higher temperatures and lower overall rainfall; on the contrary, increased flood risk, especially in low-lying coastal deltas in the tropics, is a result of the combination of sea-level rise, increased rainfall in East Africa, increased intensity, though not frequency, of tropical cyclones. During the period 1971-2001, millions of people in Africa suffered from droughts, famines, floods and epidemic diseases related to natural disasters (Figure 9; Cugusi and Piccarozzi, 2009).

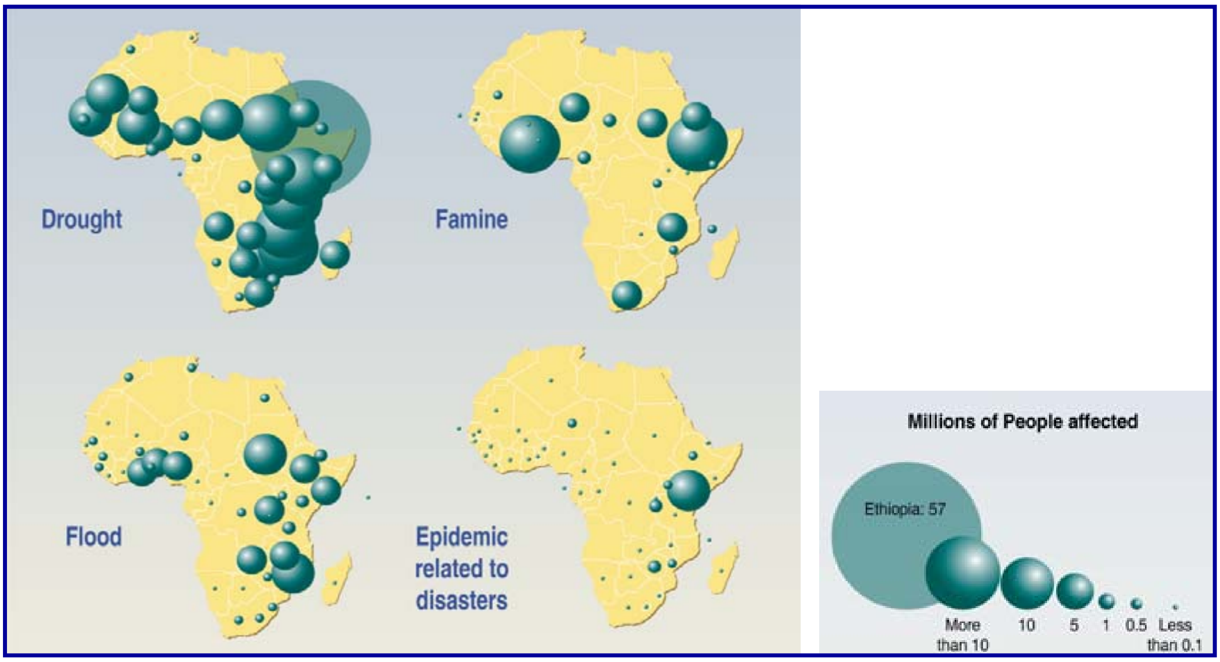


Figure 9: People affected by natural disasters during the period 1971-2001 in Sub-Saharan Africa (Cugusi and Piccarozzi, 2009).

Case studies conducted in Ghana, Mozambique, Niger and Senegal has shown a correlation between natural disasters and migration phenomena in Sub-Saharan Africa. The case studies were conducted on the droughts of; the1970s and early 1980s in the Northern part of Ghana; the droughts in the Southern regions of Mozambique over the 1980s and the floods of a number of river basins in 2000; severe droughts in Niger in the mid-1970s; and the Sahelian drought lasting from 1972 to 1984 in Senegal (Cugusi and Piccarozzi, 2009). The studies found that environmental change rarely causes human mobility in isolation from a broader range of social factors. Additional push factors are poverty, population pressures, malnutrition, landlessness, unemployment, over-rapid urbanisation, pandemic diseases and faulty government policies, together with ethnic strife and conventional conflicts (Cugusi and Piccarozzi, 2009).

Droughts have particularly affected the Sahel, the Horn of Africa and Southern Africa since the end of the 1960s. Estimates suggest that one third of African people live in drought-prone areas and that around 220 million people are annually exposed to drought (Elasha et al., 2006, p. 18). Droughts are often synonymous with famines. The 1980s witnessed very severe famines associated with the famous drought of 1984-85 that hit Sub-Saharan Africa, causing many casualties, and loss of life and assets (Elasha et al., 2006). The region attracted the attention of the international community during the catastrophic drought of the early 1970s when hundreds of thousands of people and millions of animals died due to its impact. Consecutive dry years with widespread disruption are reducing the ability of the society to cope with droughts by providing less recovery and preparation time between events. In South Africa, natural disasters, including droughts, are predicted to occur more frequently under changed climatic conditions (Elasha et al., 2006, p. 18).

1.1.4.5 Ocean-based hazards and change in currents

Prevailing wind patterns of up to 63 km/h have been observed along the African coast and could be the reason for the heavy erosion along the coast. Extreme waves and tsunamis also have a negative impact on the coasts although these are very rare along African coasts. Larger storm surges threaten greater future destruction because they will move further inland, threatening larger areas than in the past. In addition, both natural increase and internal migration are increasing the populations of coastal areas in Sub-Saharan Africa (Dasgupta et al., 2009b). The impact of cyclones is rare and occurs only on the East coast of Africa and the Western Indian Ocean islands (Figure 10).

Figure 10: Level of exposure to cyclone impact on the African coast. High impact is located in Mozambique and Madagascar while moderate impact is located in Tanzania (World Bank, 2009).

A study conducted by Dasgupta and others in 2009 has been used to present the different impacts the region will experience as a result of sea-level rise and intensified storm surges. The study used Shuttle radar Topography Mission (SRTM) 90 m data for elevation. The calculation of the storm surges took into account the current and future storm surges taking into account continental uplift/subsidence as well as sea-level rise. Details of the methodology are presented in Dasgupta et al., 2009a. Of the countries forming the 5 regions in this study, surge zones are concentrated predominantly in three countries: Mozambique, Nigeria, and Mauritania, as documented in Figure 11. These three countries alone, out of 14 countries in that study that are studied here, account for 66 % (7,286 km^2) of the total increase in the region's surge zones (10,994 km^2) resulting from sea-level rise and intensified storm surges (Figure 11; Dasgupta et al., 2009a).

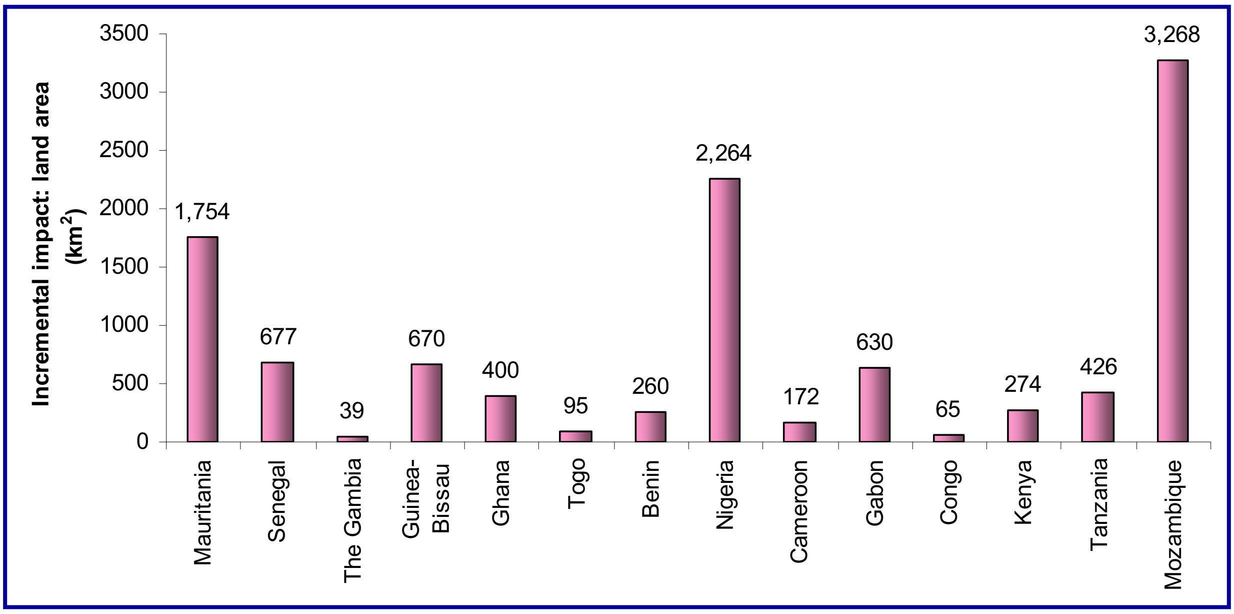


Figure 11: Projected incremental impact on land area as a result of sea-level rise and intensified storm surges on the countries studied in this report. The impact on land area is concentrated in three countries, Mozambique, Nigeria and Mauritania, accounting for 66 % of the land area (Data source: Dasgupta et al., 2009a).

The impact of sea-level rise and intensified storm surges on specific urban centres of the Sub-Saharan Africa is presented in Table 1. Table 1 lists the top-8 major cities in the studied regions that are located in storm-surge zones. Alarmingly, most of these cities are in low-income countries. This highlights the potentially deadly exposure of their inhabitants, since storm water drainage infrastructure is often outdated and inadequate in such low-income urban centres. The risks may be particularly severe in poor neighbourhoods and slums, where infrastructure is often non-existent or poorly designed and ill-maintained. In the 5 studied regions, four cities out of the 8 most impacted cities of the region are in Mozambique (Table 1; Dasgupta et al., 2009a).

Table 2 lists cities in the studied regions whose coastal areas will be most affected by future increases in storm surges, from a study conducted by Dasgupta and others in 2009.

City vulnerability was calculated in three steps. First, the cities were ranked by % increase in the future inundation area relative to the current inundation area. To weight for current vulnerability, cities were ranked by % of coastal area in the current inundation zone. The average for the two ranks was then computed for the cities by their average ranks. Table 2 includes the 7 highest-ranking cities in the studied regions, using future inundation increase weighted by current vulnerability. To illustrate, Nacala, Mozambique in region 4 has the highest future vulnerability in the studied regions. In the 21st century, 25 % of its coastal area will be added to its inundation zone (Pct 2). This is a 50 % increase in its current inundation zone, which is already 50 % of its coastal area (Pct 1). Using the same calculations, other cities were identified. In the Sub-Saharan Africa, half of the top-10 cities are in only two countries: Mozambique (3) and Cote d'Ivoire (2) (Dasgupta et al., 2009b, p. 12).

Table 1: Top 8 cities in the studied regions at risk from intensification of storm surges as a % of coastal area at risk. Nigeria in Region 2 ranks 1st and 2nd while Region 4 will be the most impacted with four cities in Mozambique listed in the top 8. Countries out of the study area are not included, thus in the rank column, some numbers are missing (modified from Dasgupta et al., 2009a).

Region	Rank	Country	City
1	7	Gambia	Bathurst
2	1	Nigeria	Bugama
2	2	Nigeria	Okrika
4	4	Mozambique	Quelimane
4	5	Mozambique	Mahajanga
4	6	Mozambique	Nacala
4	8	Mozambique	Beira
4	9	Tanzania	Tanga

Table 2: Future storm surge impacts on top 6 coastal cities in the studied regions. Region 4 will be the most impacted with three cities, all in Mozambique, followed by region 2. Pct 1 is current inundation zone as % of coastal area. Pct 2 is future Increase in inundation zone as % of coastal area and ratio = 100 x [Pct 2 / Pct 1] (modified from Dasgupta et al., 2009b).

Region	Country	City	Rank	Ratio	Pct 1	Pct 2
1	Gambia	Bathurst	7	21	60	12
2	Benin	Cotonou	2.5	62	38	24
2	Nigeria	Warri	5	50	33	17
4	Mozambique	Nacala	1	50	50	25
4	Mozambique	Quelimane	2.5	34	56	19
4	Mozambique	Beira	4	33	51	17

Compound issues affecting the coastal zone of Africa

1.1.4.6 Coastal populations and livelihoods

Africa is characterised by a high population growth rate of 1.9 % in 1992 to 2002. It has a total population of 812 million and a low population density of 249 people per 1,000,000 m^2 compared to a world average of 442 (Elasha et al., 2006). In 1980, percentage national population in coastal cities was 7.2 %, which increased to 9.1 % in 1990 and was 12.0 % in 2000 (Dasgupta, et al. 2009b). This trend shows human activities is generally increasing more rapidly in coastal zones of the Sub-Saharan Africa. Figure 12 shows a pictorial view of the population density of the African coast.

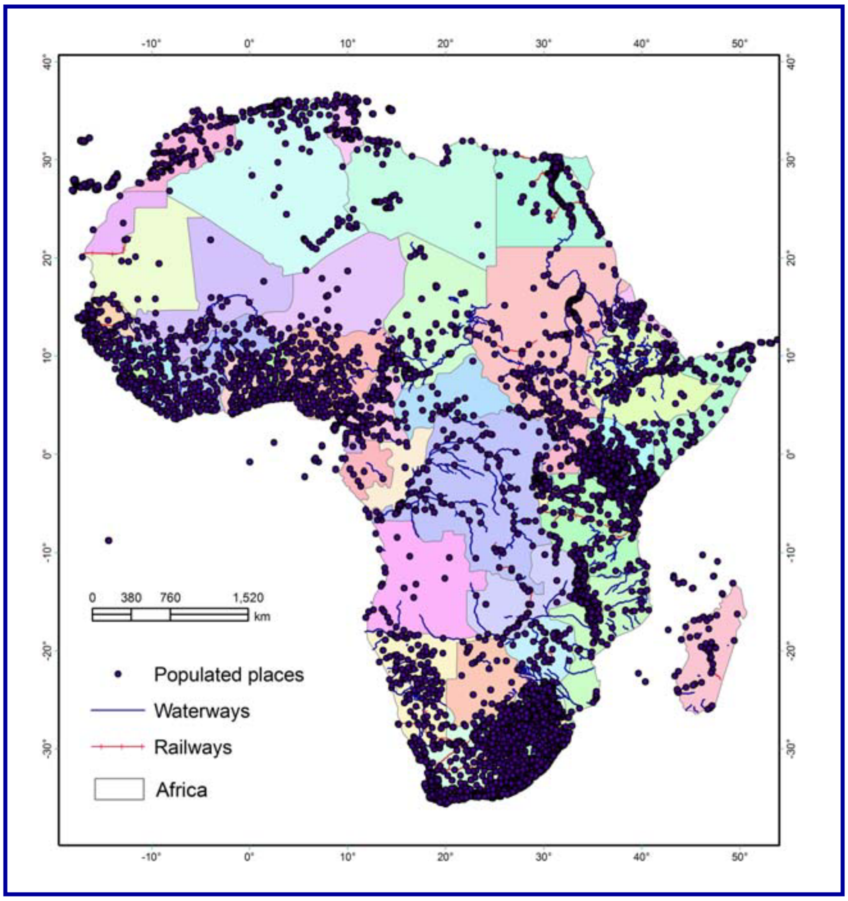


Figure 12: Relative population density on the Africa continent. South Africa is the most densely populated while West African cities are joining up to be one metropolis city. The east Africa costs are equally highly populated (Created by Ava Simms using data from http://geoengine.nga.mil).

The number of people living in cities in the developing countries is predicted to rise from 43 % in 2005 to 56 % by 2030. The population estimate for Egypt in 2005 was 72,800,000 with a population growth rate of 1.7 % (UNESCO-IOC, 2009). One of the most serious threats to the coastal zone in Egypt comes from inland pollution sources due to increased population and industrial development. Hard coastal structures have added to the problem of coastal erosion in Egypt at Alexandria.

In Sub-Saharan Africa, there are several coastal communities whose livelihood usually revolves around the exploitation of biological resources in their environment. Besides, as in other parts of the world, the coastal area is preferred for urbanisation and industrialisation as well as amenities for recreation and tourism. This multiple-usage and its socio-economic benefits can lead to degradation. Due to a concentration and increase of population and economic activities in the coastal zone in general and particularly in the vicinity of the shores, the coastal zone is highly vulnerable to many types of environmental degradation. The coastal population represents between 3 and 91 % of the total population of Sub-Saharan Africa. The World Bank indicated that in 1994, about 86.3 million people lived in the coastal zone between Mauritania and Somalia, and it was expected that this number will dramatically increase in the next decade with an intense urbanisation of the coast (ACOPS, 2002a).

United Nations projections suggest that 123 million people or over 10 % of the continent's population may be living in about 45 cities of a million people or more by 2015. Of these, 53 million will live in coastal cities vulnerable to flooding, including big coastal cities such as Abidjan, Accra, Alexandria, Algiers, Cape Town, Casablanca, Dakar, Dar es Salaam, Djibouti, Durban, Freetown, Lagos, Libreville, Lome, Luanda, Maputo, Mombasa, Port Louis, and Tunis (Cugusi and Piccarozzi, 2009). Some estimates suggest that 150 - 200 million people may become permanently displaced by the middle of the 21st century due to rising sea levels, more frequent floods, and more intense droughts.

Table 3 compares cities by estimating the vulnerability of their populations to intensified storm surges in the 21st century by considering the combined effects of projected population change, sea-level rise and storm intensification on the distribution of exposures by the end of the 21st century (Dasgupta et al., 2009b). Table 3 displays the 24 cities in the studied region with the largest population exposures, expressed as changes in affected populations and cumulative percentages of the total change for all cities.

Over 72 % of the urban population affected by future storm surges is in region 2 in West Africa with Lagos accounting for 2.1 million (Table 3). It should be noted that results in Table 3 are not closely tied to the current distribution of coastal city populations. The ranking of the cities stems from two factors: future urban growth, and coastal characteristics that make them particularly vulnerable to greater storm surges (Dasgupta et al., 2009b). The basic assumptions are a 1 m sea-level rise and a 10 % increase in the intensity of a 1-in-100-year storm and United Nations medium population projections.

The coastal population impacted by surge zones as a result of sea-level rise and intensification of storms is mainly concentrated in Nigeria, Mozambique, and Benin (Figure 13). It should be noted, however that more than one-half of coastal population in Togo (54.2 %), Mozambique (51.7 %) and Tanzania (49.9 %) would be subject to inundation risks from intensification of storm surges and sea-level rise (Dasgupta et al., 2009a).

Table 3: Sea-level rise and storm surges: Potential impact on the cities by 2100 from the countries studied in this report (modified from Dasgupta et al., 2009b, excel spreadsheet)

Region	***Rank***	***Country***	***City***	***Increase by 2100 in population exposed to storm surges***	***Cumulative % of total increase in exposed population***	***Global city population rank in 2000***
1	20	Senegal	Dakar	299,405	67.5	40
1	35	Guinea-Bissau	Bissau	127,610	76.7	203
1	72	Senegal	Saint-Louis	56,398	87.5	302
1	85	Gambia	Bathurst	43,350	89.7	248
1	136	Senegal	Mbour	21,070	95.1	342
Total increase by 2100 in population exposed to storm surge in Region 1				**547,833 (11.9 %)**		
2	3	Nigeria	Lagos	2,121,263	28.5	2
2	13	Benin	Cotonou	491,049	58.3	100
2	21	Nigeria	Warri	266,667	68.5	140
2	24	Nigeria	Port Harcourt	222,714	70.8	84
2	46	Ghana	Accra	94,911	80.8	42
2	52	Nigeria	Okrika	86,069	82.6	353
2	57	Nigeria	Bugama	78,801	84.0	348
Total increase by 2100 in population exposed to storm surge in Region 2				**3,361,474 (72.7 %)**		
3	38	Cameroon	Douala	115,466	77.9	51
3	77	Congo	Pointe Noire	52,798	88.4	131
3	141	Gabon	Libreville	20,114	95.4	127
Total increase by 2100 in population exposed to storm surge in Region 3				**188,378 (4.1 %)**		
4	32	Mozambique	Maputo	137,977	75.3	27
4	40	Tanzania	Dar es Salaam	112,163	78.7	35
4	41	Mozambique	Beira	111,202	79.1	152
4	58	Mozambique	Quelimane	77,646	84.3	276
4	113	Mozambique	Xai-Xai	29,188	93.1	360
4	131	Tanzania	Mtwara	22,506	94.7	325
4	146	Tanzania	Tanga	19,299	95.8	247
4	222	Tanzania	Zanzibar	6,931	98.9	226
4	256	Mozambique	Nacala	4,127	99.5	268
Total increase by 2100 in population exposed to storm surge in Region 4				**521,039 (11.3 %)**		
Total increase by 2100 in population exposed to storm surge for all regions				**4,618,724 (100 %)**		

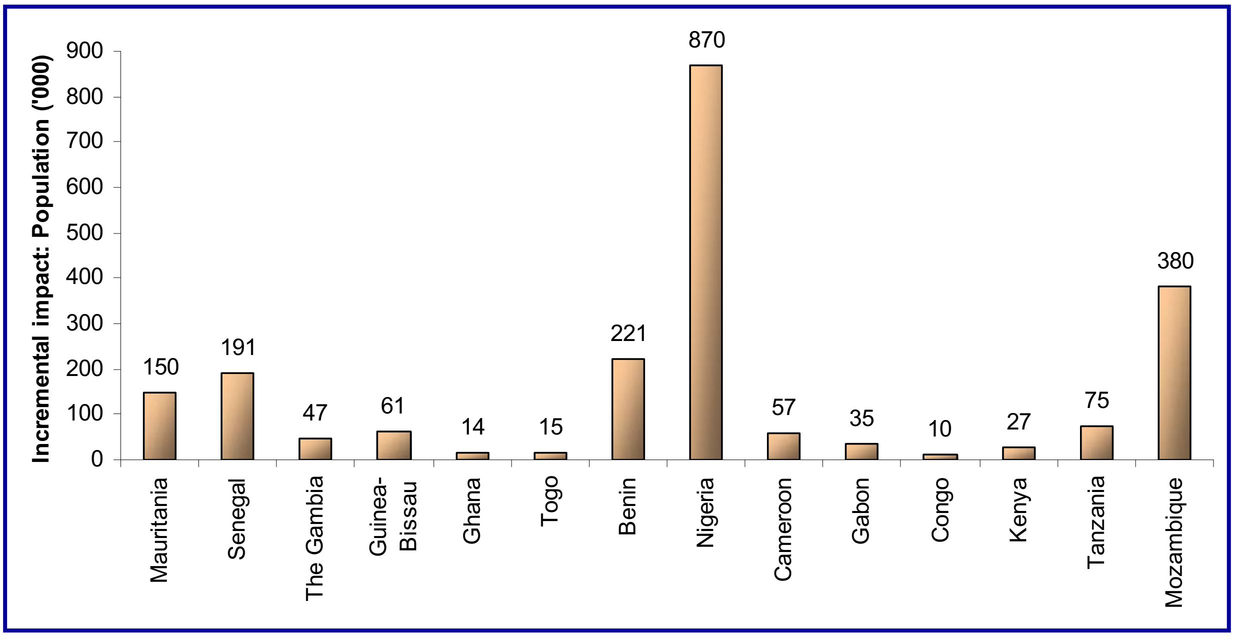


Figure 13: Projected incremental impact on population in thousands as a result of sea-level rise and intensified storm surges on the countries studied in this report. The impact on population is concentrated in three countries, Nigeria, Mozambique and Benin (Data source: Dasgupta et al., 2009a).

Numerous countries of the Sub-Saharan Africa region: Djibouti, Togo, Mozambique, Tanzania, Equatorial Guinea, Côte d'Ivoire, Namibia and Sudan will experience significant increases in the percentage of their coastal urban extent falling within surge zones with sea-level rise and intensified storm surges (Dasgupta et al., 2009a). In absolute terms, urban extent of Nigeria, Mozambique and Mauritania will be the most impacted with a rise in sea-level and intensified storm surges (Figure 14).

1.1.4.7 Fisheries, Resource Management and Biodiversity

Sub-Saharan Africa has a total coastal length of 63,124 km with important ecosystems like beaches, mangroves, coral reefs and sea grass beds that not only have a rich biodiversity but also constitute important resources upon which the society and the economy are based (ACOPS, 2002a). Important economic activities like fisheries, tourism, agriculture as well as crucial infrastructures such as roads, harbours and cities are located in the coastal zones of Sub-Saharan Africa. In Tunisia in North Africa, the most serious environmental problem is the negative ecological effects caused by the intensified use of coastal natural resources. Climate change is likely to occur too rapidly for many species to adapt. Around 15 – 40 % of land species could be facing extinction with a 2 ^{o}C of warming, with most major species groups affected, including 25 – 60 % of mammals in South Africa (Stern, 2006, p. 79).

The resources, though renewable, are limited. On the other hand, the struggle for alleviation of poverty coupled with the even increasing population growth impels the overexploitation of resources including the use of unsustainable harvesting practices and the consequent destruction of the habitats that sustains the resources. Figure 15 shows net loss of wetland area in Africa as a result of projected sea-level rise.

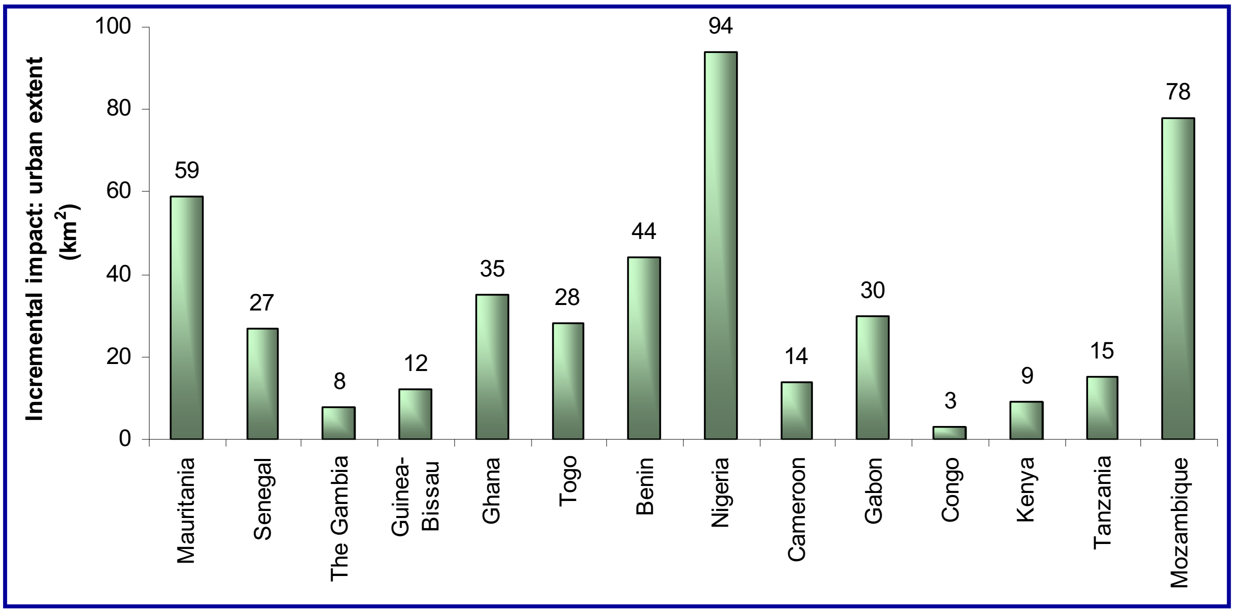


Figure 14: Projected incremental impact on urban extent in km² as a result of sea-level rise and intensified storm surges on the countries studied in this report. The impact on urban extent is concentrated in Nigeria, Mozambique and Mauritania (Data source: Dasgupta et al., 2009a).

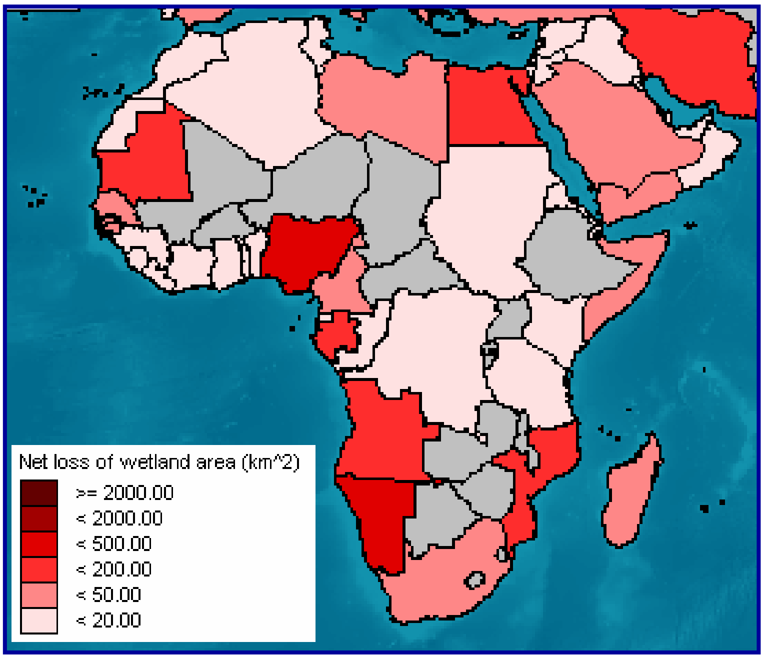


Figure 15: An overview of net loss of wetland area as a result of sea-level rise in Africa. The highest loss of wetland areas will be experienced in North Africa, South Africa, Central Africa and sections of West Africa (data source: the DINAS-Coast Consortium 2006 database).

Furthermore, as a consequence of climate change 81 % to 97 % of Africa's plant species could face a decrease in available areas of suitable climate. With the human population growing at rates among the highest in the world, there is increasing competition for fish stocks that are dwindling and exposed by open access. As a result, destructive fishing practices have increased as fishermen strive to maximize their catches at the expense of long-term sustainability of fish production and food security. The destructive fishing practices may result in irreversible environmental damage, increased economic hardships to the local fisher communities and serious health concerns.

In many Sub-Saharan African countries, mangrove loss through overexploitation is in excess of 70 % of the original cover. The unacceptable rate at which mangroves are being lost in the Sub-Saharan Africa, underscores the urgent need for action to be taken to avoid total loss, which inevitably will have disastrous effects on the environment and the livelihood of several coastal communities. As far as coastal wetlands are concerned, absolute impacts will be largest in Nigeria (1,365 km^2), Mozambique (1,318 km^2) and Mauritania (710 km^2) (Figure 16). Although small in terms of area measured in km^2, up to 53 % of Kenya's coastal wetlands would be susceptible to significant damages from sea-level rise and intensified storm surges (Dasgupta et al., 2009a).

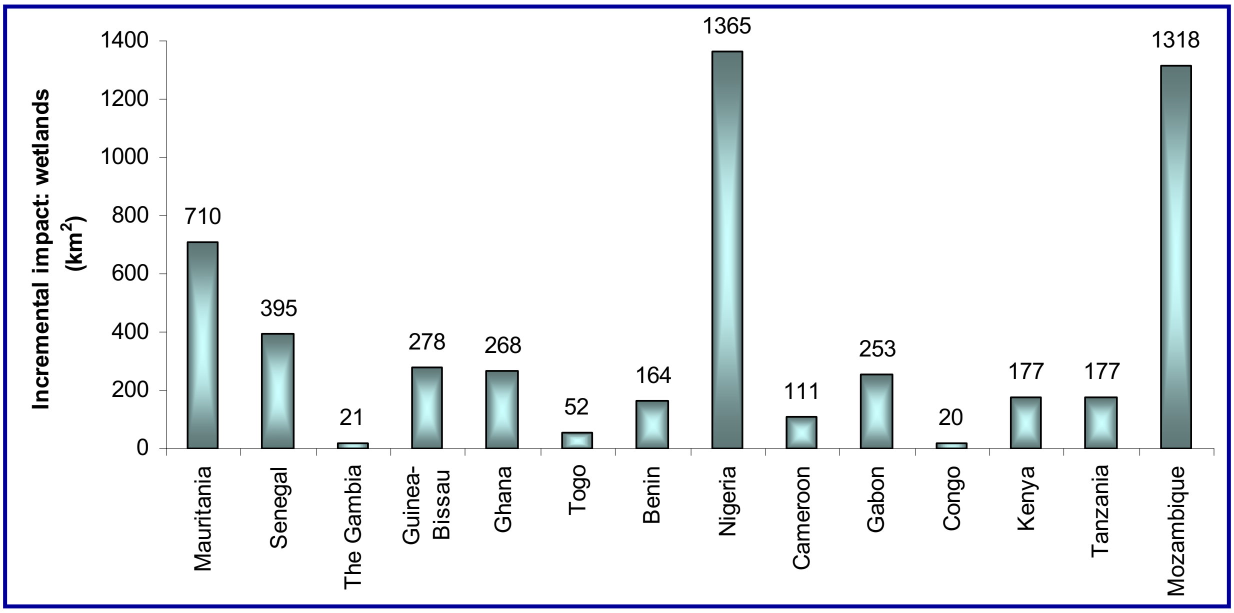


Figure 16: Projected incremental impact on wetlands as a result of sea-level rise and intensified storm surges 2009-2100 on the countries studied in this report. The impact is greatest in Nigeria, Mozambique and Mauritania (Data source: Dasgupta et al., 2009a).

1.1.4.8 Coastal Tourism

Several countries in the Sub-Saharan Africa are turning towards tourism as a viable option for economic growth. Despite Africa's small share of the global tourism market, the industry makes a significant contribution to the economies of the Sub-Saharan African region, and this is expected to grow during the first 20 years of the 21st century. International tourist arrivals to Africa as a whole grew at an average annual rate of 6.2 % between 1990 and 1995, with above average increases recorded in the Southern African region (24.2 %) and Eastern Africa (10.8 %) (ACOPS, 2002a). According to the World Tourism Organisation (WTO), arrivals in Africa will continue to increase at an average annual rate of 5.5 % per year between 2000 and 2020, with the Southern African and Eastern African regions expected to lead the way with annual growth rates of 7.5 % and 5.2 %, respectively. Africa's share of global tourist arrivals will rise from 3.6 % in 1995 to 5.0 % by 2020. The WTO estimates that international tourist arrivals to Sub-Saharan Africa, including the Indian Ocean, will increase from about 27 million in 2000 to 47 million in 2010 and to 77 million by the year 2020, and that Southern and Eastern Africa, together with the Indian Ocean islands, will experience the fastest growth rates (ACOPS, 2002a). However, this growth in income from tourism may be reduced by global warming factors.

But forecast sea-level rise and intensified storm surges will seriously threaten this growth. Over the course of the 21st century, Mozambique, Ghana and Togo may lose more than 50 % of their coastal GDP, while GDP loss in absolute terms will be highest in Nigeria (US$ 408 million) (Figure 17). Coastal agriculture, in terms of extent of croplands, will be affected 100 % in Nigeria, 67 % in Ghana and 50 % in Togo (Dasgupta et al., 2009a).

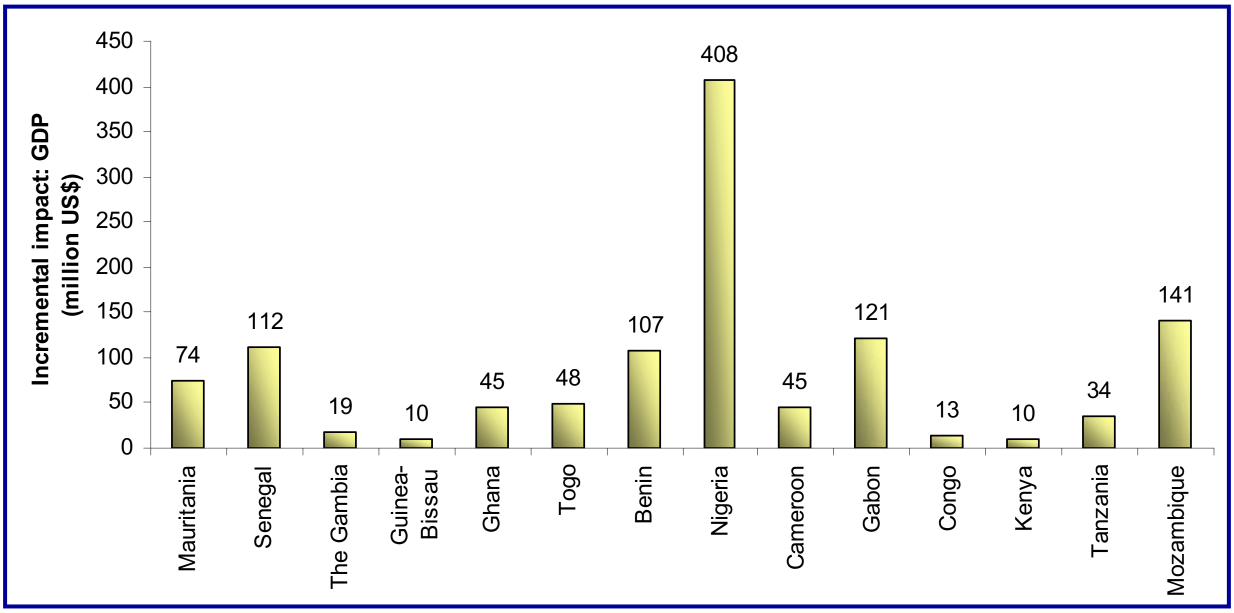


Figure 17: Projected incremental impact on GDP as a result of sea-level rise and intensified storm surges 2009-2100 on the countries studied in this report. The impact on GDP is concentrated in Nigeria. Mozambique, Gabon, Senegal and Togo follow far behind. As a % of total coast, Mozambique, Ghana and Togo may lose more than 50 % of their coastal GDP (Data source: Dasgupta et al., 2009a).

1.1.4.9 Fresh Water, Food Security, Pollution and Sanitation

Africa is already persistently afflicted by extensive drought: local droughts occur every year and continental crises appear to occur once a decade, or more recently, twice. Indeed, although the continent of Africa uses only around 4 % of its renewable freshwater resources, water is becoming one of the most critical natural resource issues. Currently around two thirds of the rural population and a quarter of the urban population lack access to safe drinking water, and the number of people suffering from water stress or scarcity is rapidly increasing as a result of population growth, urbanisation, and increased economic development. According to UNEP, currently, 14 countries in Africa are subject to water stress or water scarcity and a further 11 countries will join them in the next 25 years. Climate change is expected to intensify Africa's increasingly critical water situation, with southern Africa being one of many water stressed regions in which climate change could further decrease stream flow and groundwater recharge. Reduced annual average rainfall and runoff would also exacerbate desertification in southern Africa. Africa relies on water for its social, economic and environmental well-being, so prolonged drought is the most serious climate related hazard for the continent (La Trobe, 2002, p. 18).

As a result of unplanned high rates of population growth, many coastal urban areas in Sub-Saharan Africa generally lack adequate waste collection, treatment and disposal facilities thus creating high pollution on the coastal zones. The causes and impacts of solid waste pollution in the coastal and marine environment are common in most Sub-Saharan African countries.

1.2 Climate-change impacts: the regional view

In this section, climate change impacts on the African coast will be presented within five regions as shown in Figure 18. Region 1 consists of five West African countries, which are, from north to south, Cape Verde, Mauritania, Senegal, Gambia and Guinea Bissau. Region 2 is also in West Africa and consists of four countries, which are, from west to east, Ghana, Togo, Benin and Nigeria. Region 3 is located in West Africa and consists of three countries, namely, from north to south, Cameroon, Gabon and Congo. Region 4 is located in East Africa and consists of three countries from north to south, Kenya, Tanzania and Mozambique. Region 5 is located in the Western Indian Ocean and consists of two island archipelagos, Mauritius and Seychelles. The issues that will be presented for the regions are those that have been presented for the continent in section 1.1 above. However, more emphasis will now be given to particular issues within regions, depending on availability of studies. It is important to point out that Region 1 has several issues very different from those found in the other regions. Region 1 countries have been studied under the Adaptation to Climate Coastal Change (ACCC) (2006a) project with the aim of identifying along the eroded coasts a framework for an integrated management such as protection of mangroves, reinforcement of sand dunes, urban planning adapted to the local situation, trials of piers not disturbing the shoreline drift and legislation. This is not to be interpreted to mean that other regions have fewer issues but it is an indication of the varying number of studies that have been undertaken in the different regions. The format of the report is to emphasis on issues within a region and less on the countries within the region.

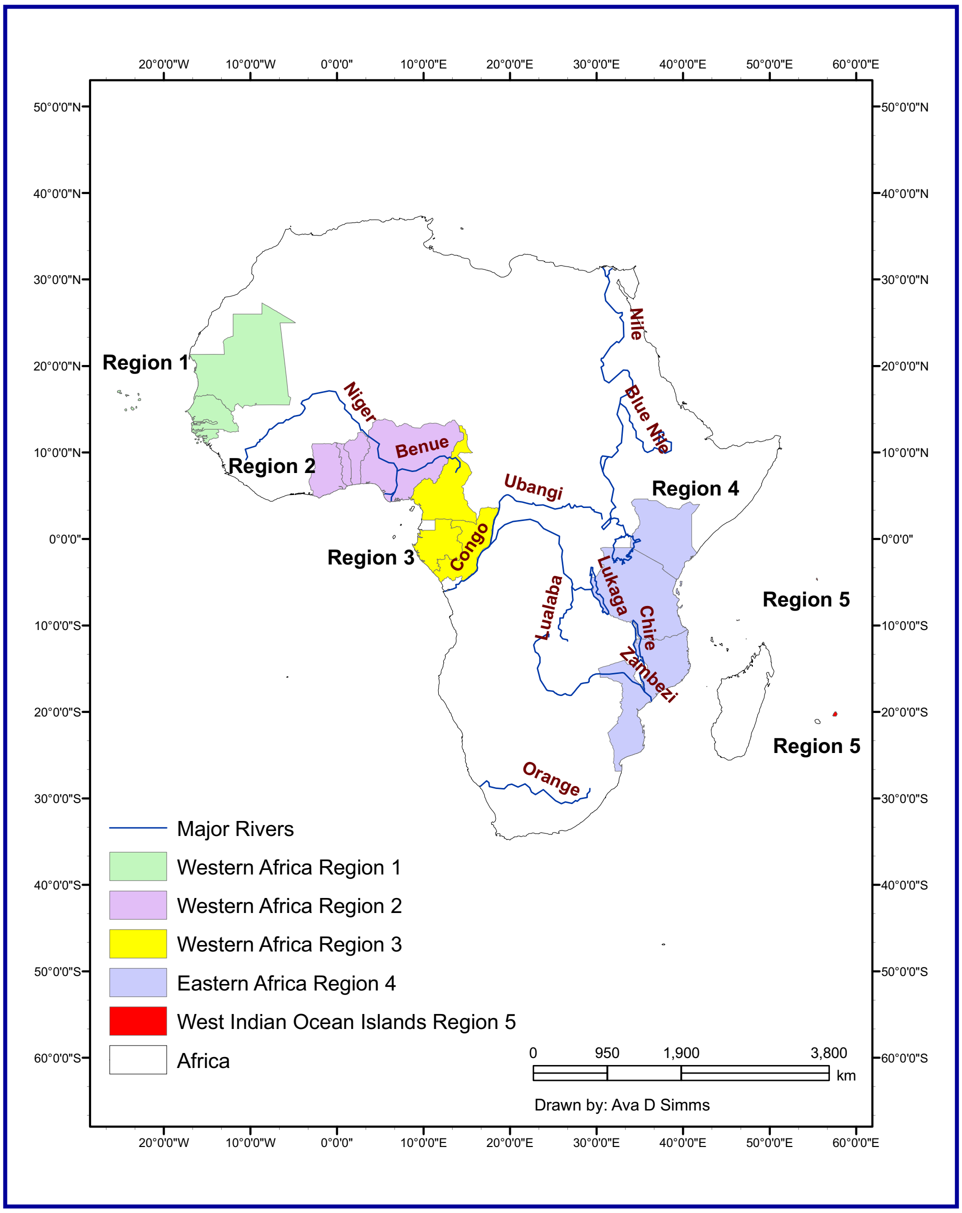


Figure 18: Map of Africa showing the regions and countries covered in this report. For country names, see Figure 1.

1.2.1 Impacts in Region 1 in West Africa - Cape Verde, Mauritania, Senegal, Gambia and Guinea Bissau

The main coastal issue for Region 1 is coastal erosion caused by natural and anthropogenic factors. Other issues are sea-level rise, precipitation and floods, droughts and desertification, depletion of mangrove and fisheries resources and pollution. With the global rise in sea-level, further considerable land loss, modification of ecosystems and other socio-economic impacts may be expected.

Cape Verde is both a Least Developed Country (LDC) and a Small Island Development State (SIDS). Cape Verde is an island archipelago comprising ten small islands and thirteen islets naturally vulnerable to effects of climate change, especially sea-level rise (Figure 19). The exposure of the islands' coasts is exacerbated by population pressure and uncontrolled development. Sal, Boavista and Maio are the lowest and flattest islands to the east of the Cape Verde archipelago (Figure 19b; ACCC, 2006a). Other issues apart from coastal erosion include sand extraction, tourism development and pollution. Cape Verde's coastal zones are negatively impacted upon by; (1) tourist activities (2) discharge of hydro-carbons into the sea, (3) sand mining (4) saline intrusion, and (5) tidal effects (NAPA, 2008). Among the expected impacts for Cape Verde predicted by IPCC 2001a are: rise in sea-level, saline intrusion, loss of biodiversity and habitats, risk of floods, and frequent droughts.

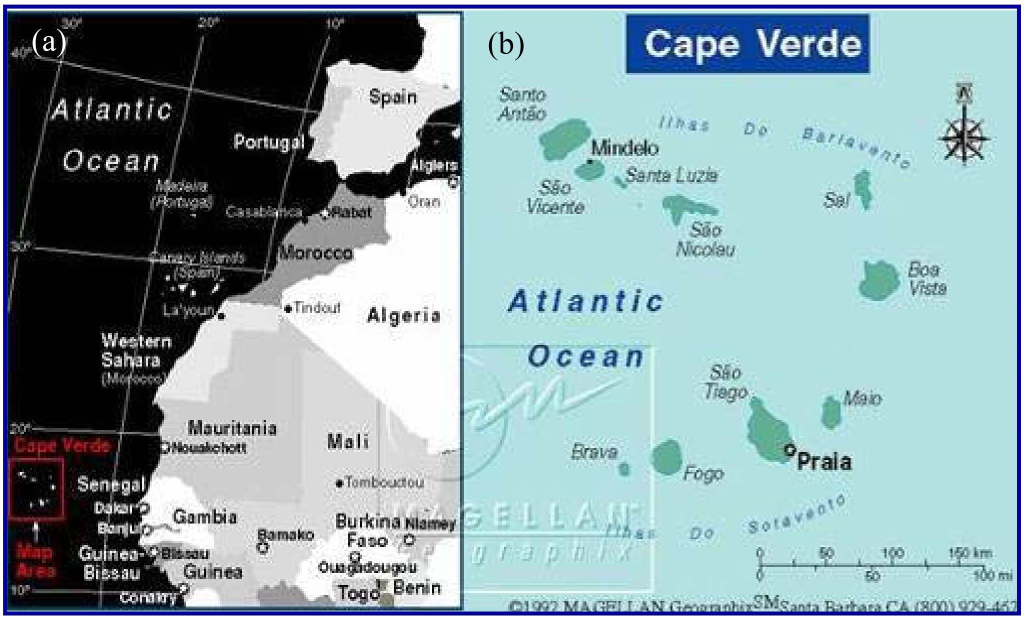


Figure 19: Map of island archipelago, Cape Verde (a) Map of West Africa coast showing the location of Cape Verde Islands, as a red box, in the Atlantic Ocean. (b) Islands of Cape Verde (ACCC, 2006b).

Main vulnerabilities in Mauritania are desertification and deforestation, pollution from iron mining, fisheries and coastal ecosystems. Mauritania is one of the driest countries in

Africa, receiving an average of only 92 mm of rain per year (Cugusi and Piccarozzi, 2009). Overgrazing and deforestation are causing the desert to expand southward. There is unsustainable exploitation of groundwater resources. Study conducted on the Mauritania coast revealed a significant level of vulnerability, related, amongst other things, to: significant degradation of arable land; degradation of pasture and loss of livestock; degradation, even disappearance, of forests; high risk of collapse of coastal dune and decrease of water resources (Ministry of Rural Development and of Environment, 2004).

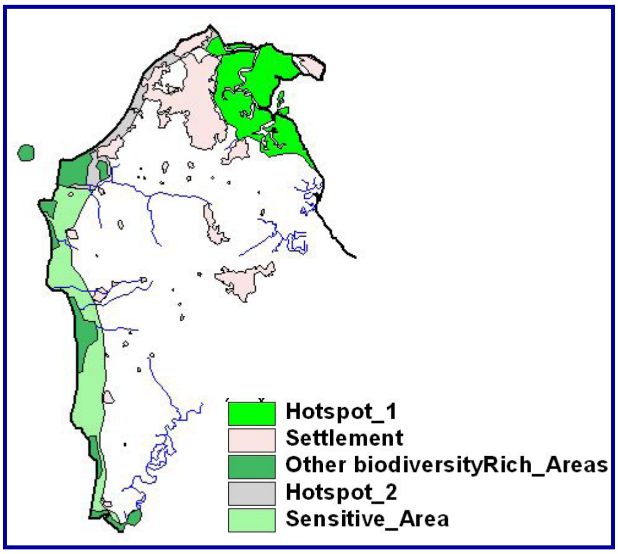


Figure 20: The Gambian coastal zone showing the shoreline change hot spots, sensitive areas and other biodiversity rich areas (ACCC, 2006a).

The Gambia forms an enclave covering 10,300 km^2 along the Senegal River. The three most important issues identified in the Gambia are loss of ecosystems and ecotones, overexploitation of natural resources, and pollution by solid waste. In the Gambia the hot spots within the coastal zone are Bintang Bolong, Tanbi Wetland Complex, Tanji River Bird Reserve and the Niumi National Park (Figure 20; National Climate Committee, 2003). The sensitive areas are the western part of the River Gambia basin, the area of Alahein River to Cape Point and Banjul Island. The Banjul Island is the capital with an area of 1.92 km^2 with a population of about 42,326 (ACCC, 2006a). Figure 20 shows the Gambian coast, hot spots and sensitive locations whereas Table 4 shows a summary of coastal threats, hot spots and sensitive areas for Region 1.

Main vulnerabilities in Senegal are urban pollution, deforestation, coastal wetlands and fisheries overexploitation. In Senegal, deforestation has been blamed for recent increases in soil erosion, desertification, and flooding (ACOPS, 2002b).

1.2.1.1 Atmospheric and ocean temperature rise and acidification

In Cape Verde, average annual rainfall of 225 mm has been decreasing since the 1960s, with negative consequences for agricultural production and water supply (ACCC, 2006a). Results of vulnerability studies of Cape Verde indicate an increase in the average temperature by 4 ºC and a decrease in rainfall by 20 % for the year 2100 (ACCC, 2006a). The increases in temperature and rainfall reduction will impact on the Cape Verde coastal zones, leading to the disruption of crop-water regimes and soil degradation. These expected impacts will be particularly pronounced in the regions that are most vulnerable to the current climatic variations, such as the coastal zone of Cape Verde.

Table 4: Summary of coastal threats, hotspot and sensitive locations along Region 1 countries

Coastal threats	*Hotspot locations*	*Sensitive locations*
Cape Verde		
Coastal erosion Sea-level rise, maximum tide amplitudes, economic importance, climate change effects	Boa Vista island Sal island Santo Antão Island Maio Island Brava Island	
Senegal		
Modification of stream flows	The Djoudj bird national park which is located in the north-western part of the Senegal delta	Saloum estuary located centrally Casamance estuary located in the south The Senegal delta – located in the north on the border with Mauritania
Modification / destruction of ecosystems **Chemical pollution**	Hann Bay located south-east of the capital Dakar Djiffere located on the Sangomar spit that limits the Saloum river	

1.2.1.2 Sea-level rise and coastal erosion

In **Cape Verde**, it is estimated that 80 % of the population in the archipelago is concentrated in the coastal zones. The threats of sea-level rise will increase the pressures on the coastal zone thus leading to the aggravation of the degradation of ecosystems, infrastructure and economic activities. Sea-level rise may also provoke flooding of the low altitude zones, displacement of populations, contamination of potable water sources thus threatening the means of subsistence of the coastal populations and limiting the development options of the country (NAPA, 2008). In Cape Verde, a population of between 1,000 and 100,000 are at risk from coastal erosion on Maio and Brava Islands with again coastal resources forming more than 50 % of the people's livelihoods.

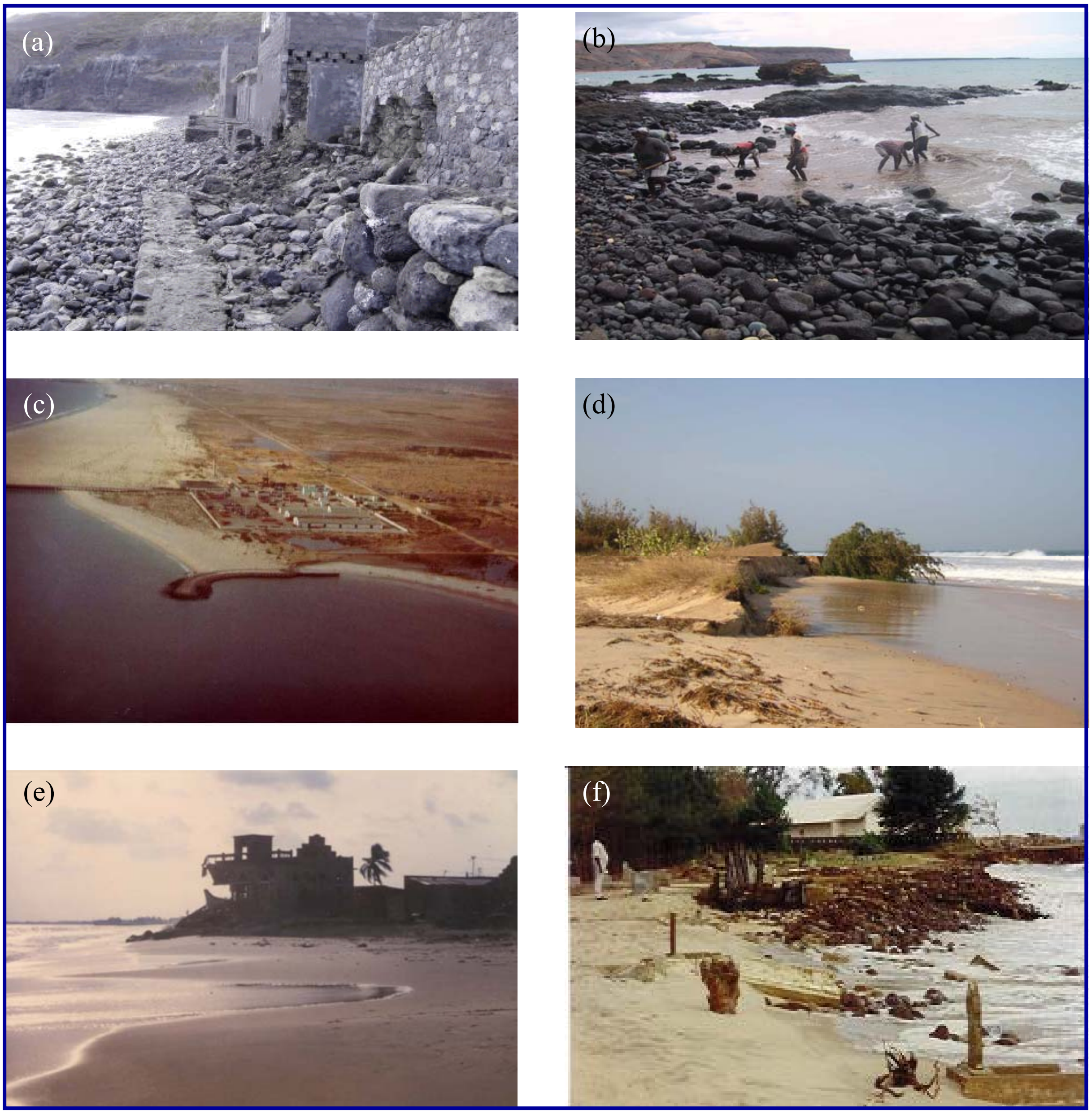


Figure 21: Examples of coastal erosion in Region 1. (a) Coastal erosion at Santo Antão Island – Paul – Vila das Pombas, Cape Verde threatening economic infrastructure (ACCC, 2006a) . (b) Coastal erosion in Cape Verde has turned sandy beaches to rocky shores (Ministry of Environment and Agriculture, 2007). (c) Aerial views of the Port de l'Amitié, Mauritania, September 1998. Note accretion on the top part of the photo and erosion on the bottom part of the photo (ACCC, 2006b). (d) Coastal erosion on the southern bank of the new mouth of the Senegal River, Senegal (ACCC, 2006b). (e) Coastal erosion in Mbao (at the start of Petite Côte), Senegal (ACCC, 2006b). (f) The Banjul community in Gambia used sea defence technology to protect the coastline. This was not enough to salvage the graves at the lower end of the image (National Climate Committee, 2003).

The socio-economic cost of erosion is already high in countries of the Sub-Saharan Africa. The Initial National Communication to the United Nations Framework Convention on Climate Change for Cape Verde identified coastal erosion and land salinisation problems in several sections of the coast such as: The Port of Paul in relation to sand extraction on Santo Antão Foya Branca, Baía das Gatas and Calhau on São Vicente where erosion has destroyed a protection wall and caused flooding in low-lying areas of Maio showing evidence of salt water intrusion into wells which have been abandoned because of the presence of brackish water in Ribiera da Lagoa, among many others (ACCC, 2006a).

The causes of coastal erosion in Cape Verde are linked to issues, such as: high population density in certain urban centres, excessive and uncontrolled sediment mining (sand and stones) and tourism development, among many others. Coastal erosion is particularly prominent on the islands of Boa Vista and Sal in Cape Verde (Figure 21a and b). At Brava Island in Cape Verde the shoreline is protected by a retention seawall, a considerable part of which has already been destroyed due to coastal erosion. A rise in sea level will endanger the entire town of Furna. The coast receives maximum tide amplitude, and high wave heights which cause considerable erosion. The destruction of tourism as a result of coastal erosion would impact greatly on Cape Verde's economy since tourism accounts for 12 % of GDP (ACCC, 2006a).

In **Mauritania**, vulnerability studies to climate change have been undertaken along the coastline, especially around Nouakchott city. The city is located at the intersection of two very low-lying zones. Sebkha of Ndrhamcha is built at levels ranging from 3 m below sea-level to 4 m above sea-level and Aftout Es Saheli from 1 m below sea level to 1 m above sea level (ACCC, 2006b). The vulnerability study projected two climate change scenarios for sea-level rises at 18 cm by 2020 and 60 cm by 2050, respectively, based on available datasets (ACCC, 2006b). Figure 21c shows islands sand channel in Mauritania.

In Mauritania, severe coastal erosion is as a result of high storm intensities and frequencies and sea-level rise (Figure 23c). Coastal erosion in Nouakchott, Mauritania is related to the construction of Amitié Port between 1979 and 1986 resulting in severe erosion to the south of the quay at a rate of over 20 m/year (a retreat of 460 m in 18 years) and deposition to the north of the quay at a rate of over 35 m/year, that is, 670 m of beach gained between 1980 and 1988 (ACCC, 2006b). The erosion and deposition processes weakened the coastal cordon which ruptured in 1987, leading to floods in parts of Aftout es Saheli, in Nouakchott. As a result of the floods, a seawall was constructed in 1987 and this has further been enhanced by a 270 m curved dike completed in 1991 to minimise coastal erosion and flooding (ACCC, 2006b).

The vulnerability of the **Senegal** coast to climate change has been the object of four studies. The first two studies examined the total vulnerability of coastal zones to sea level rise (1 m) at the global level, relying largely on existing databases. Senegal was ranked as 45th and 8th out of a total of 181 countries in the two studies, respectively. The third survey used four scenarios of sea level rise (0.2, 0.5, 1 and 2 m) and estimated what could be lost by the year 2100, and the population and economic value at risk and finally the costs of protection (ACCC, 2006b). A summary of results from these studies are presented in this report while details can be found in the ACCC, 2006b report (see reference list). According to this survey, Petite Côte and the estuaries were most vulnerable to coastal erosion and flooding. A 1-m rise in sea level could inundate and erode more than 6,000 km^2 of land, most of which is wetland, thus putting at risk at least 110,000 to 180,000 people - or 1.4 to 2.3 % of the 1990 population of Senegal (Cugusi and Piccarozzi, 2009). All of Senegal's major towns located along the coast are affected by erosion, causing damage and destruction of infrastructures and buildings thus forcing people to relocate (Figure 21d and e). For example, the village of Palmarin and the camp grounds of Djiffere are undergoing erosion. On average, sandy beaches recede by between 1 - 2 m/year with exceptional erosion rates recorded at foreland of Sangomar (ACOPS, 2002b). Rocky cliffs retreat more slowly at an average rate of 0.1 to 0.7 m/year. It is projected for Senegal coast that a rise of 1 m of sea level will lead to a loss of between 55 and 86 km^2 of beaches by 2100, due to increased coastal erosion (Figure 22a; ACCC, 2006b).

In **Gambia**, scenarios were developed for climate change, sea level rise and socio-economic changes. Regarding the coastal zone vulnerability assessment, potential land losses were assessed using topographic maps, satellite images and GIS. For the evaluation of coastal erosion, the Bruun Rule was used (ACCC, 2006b). It is projected that about 92 km^2 of land in the coastal zone will be inundated as a result of a 1 m sea-level rise (National Climate Committee, 2003). About 50 % (47 km^2) of the total land loss due to inundation will be on the sheltered coast. It is evident that with a 1 m sea-level rise, the whole of the capital city of Banjul will be lost, due to the fact that the greater part of the city is already below 1 m of mean sea level (National Climate Committee, 2003). Also, as a result of the projected sea-level rise, the mangrove systems on St. Mary's Island, Kombo St. Mary and on the strand plains in the north bank from Barra to Buniadu Point will be lost. Inundation will be followed by shoreline retreat which would vary along the coast from 102 m in the harder cliffed zone between Cape Point and Fajara, to 839 m in the gently sloping, sandy strand plain near Sanyang Point (National Climate Committee, 2003).

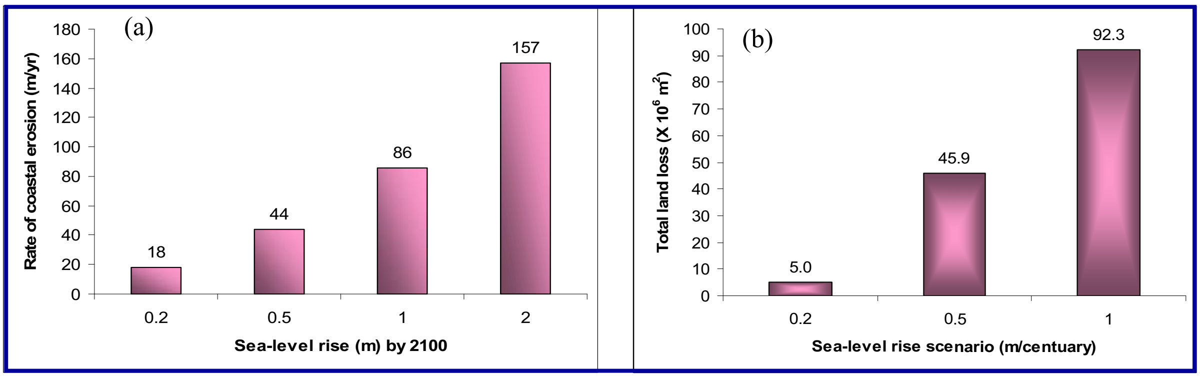


Figure 22: Climate impacts in Region 1. (a) Projected rates of coastal erosion for different sea-level rise scenarios for the Senegal coast (data source: ACCC, 2006b). (b) Projected total land loss for different sea-level rise scenarios for the Gambian coast (source data: ACCC, 2006a).

Climate change will cause flooding of low-lying areas and enhance coastal erosion in Gambia. A 1 m rise in sea-level is projected to flood the whole of Banjul Island, affecting the entire population of over 42 000 people (ACOPS, 2002c). A study conducted on the Greater Banjul Area, Gambia, concluded that for a 0.2 m and 0.5 m rise in sea level, 5.0 x 10^6 m^2 and 45.9 x 10^6 m^2 of land would be lost, respectively (see Figure 22b; ACCC, 2006a). This loss of physical infrastructure was estimated at US$ 217 million (ACOPS, 2002c). It is estimated that between 50,000 and 75,000 m^3 of sand has been accumulated at the sand spit near Cape Point since 1983 (ACOPS, 2002c).

Figure 23: Examples of coastal erosion in Region 1. (a) Coastal erosion along the Gambia coast (National Climate Committee, 2003). (b) A latent case of coastal erosion along Verala village, Guinea Bissau (ACCC, 2006b). (c) Island sand channels in the shallow part of Banc d'Arguin, Mauritania will be highly impacted on by sea-level rise (UNESCO-IOC, 2009). (d) Damaged groyne system in Gambia at the cemetery. The system has protected the coast for about 50 years. The groyne system in Gambia made of trees tied together by timber planks has been damaged by age and lack of maintenance and repairs. Concrete groynes could be used instead (National Climate Committee, 2003).

In Gambia, coastal erosion has been responsible for the loss of the coastal ecosystem between the River Allahein to the Cape Point and Banjul Island at a rate of between 1-2 m/year with the estimated land lost amounting to 200,000 - 300,000 m^3/year (ACOPS, 2002c; ACCC, 2006b). Coastal erosion is highest in developed areas around Banjul and the sand mining areas, notably at Bijilo and Kololi Beach. Coastal erosion is the most serious problem along the Gambian coast, exacerbated by sand extraction particularly at Kololi and Bijilo of between 150,000 to 200,000 m^3 per year. In 1998, the high water mark

(HWM) was 50 m from the new Banjul-Serekunda Highway; in 2003 the HWM was only about 15 m from the highway (ACCC, 2006a). The areas mainly affected by coastal erosion are: (1) Between Cape Point and the Banjul dockyard and the area between the Palm Grove Hotel and the Muslim cemetery where erosion rates of between 15 and 20 m were recorded from 1964 to 1982. About 30 m of beach have been lost along the Muslim cemetery since 1964, 10 m at the Atlantic Hotel while coastal erosion between Oyster Creek and Banjul is about 2 to 3 m/ year (Figure 21f; Figure 23a and d; ACCC, 2006b). Another area undergoing major erosion in the Gambia is between Cape Point and Bald Cape. At Cape Point, erosion rates of between 20 and 40 m were recorded between 1964 and 1982. From Koto and Kololi points, erosion rates of between 1.5 and 2 m/year have been recorded. Between Kololi Point and Bald Cape, the coast has retreated between 40 and 50 m over the past 26 years (ACCC, 2006b).

In **Guinea Bissau**, by 2050, sea level is expected to rise from 5 cm to 32 cm with high tide levels up to 6 m higher. The areas expected to be most affected by a rise in sea-level are Varela, Bubaque and Porcos (Figure23b; ACCC, 2006a). The low altitude that predominates in Guinea-Bissau, particularly in coastal areas which are below zero in mean sea level, makes the country quite vulnerable to coastal erosion. Damage from coastal erosion is particularly visible on the north-western coast at Varela Beach where a tourist undertaking made in the 1980s became flooded in 2000, with coastal erosion rates of 2 m/year (Figure 23b; ACCC, 2006a). In Guinea Bissau, coastal erosion is expected to increase at Bubaque, Maio small island and Pecixe. The causes of coastal erosion include coastal flooding due to heavy rainfall, construction of buildings adjacent to the shore, sea-level rise and swells, streams and tides.

1.2.1.3 Precipitation and Floods

In **Cape Ver**de, frequent torrential rains result into large losses of infrastructure, agricultural production, and runoff, displacement of people and loss of human lives (Figure 24; NAPA, 2008). In Cape Verde, extreme events such as devastating floods, droughts and sudden changes in temperature have a strong socio-economic impact. In the recent past, extreme events seem to be taking place more and more frequently (Figure 24). The intense, short duration rains can cover an entire watershed within a short period of time of between 3 and 6 hours. For example, torrential rains in 1984 resulted in deaths and economic losses such as destruction of roads, arable soils, the bridge of Calhetona, S. Miguel, resulting in a state of emergency in the affected areas.

Table 5 presents information on mortalities from recent floods in urban and suburban areas in the estuary of key watersheds in Cape Verde, resulting from high intensity precipitations. At times, over 200 mm of rainfall is recorded in less than 24 hours. For certain events, economic losses of agricultural soils have been estimated at about US$ 2,000,000. In the future, the number and intensity of these floods is predicted to increase (Ministry of Environment and Agriculture, 2007, p. 5).

Figure 24: (a) and (b). Examples of flooding in Cape Verde some have resulted in deaths (Ministry of Environment and Agriculture, 2007).

Table 5: Mortalities resulting from major floods in Cape Verde (Ministry of Environment and Agriculture, 2007).

Zone	***Deaths 1955***	***Deaths 1961***	***Deaths 1966***	***Deaths 1984***
Praia (Santiago) and R. Grande (S. Antão)		11		6
Galinheiro (Fogo)			15	28
S.Catarina (Santiago)	1			
Mindelo (S. Vicente)				

In its Initial National Communication to the United Nations Framework Convention on Climate Change, Mauritania assessed the vulnerability of its coastal area (mainly of Nouakchott) to climate change impacts. More recently, the National Adaptation Programme of Action identified two projects aiming at the protection of the coastal area around Nouakchott at a total cost of US$ 3.1 million (ACCC, 2006b). A summary of the results from these studies is presented in this report, detailed can be found in ACCC, 2006b (see reference list). Vulnerability and Assessment study of the **Mauritania** coast showed that flooding will become an increasingly significant problem with considerable economic consequences even without the effects of climate change by the year 2050. With the effects of climate change, the built-up areas affected by flooding will almost double in size from 4500 ha to 8700 ha (Figure 25a). On the other hand, economic damages will be almost 20 times higher, bringing the costs to US$ 6.3 billion, compare with Mauritania's GNP currently at US$ 1 billion (Figure 25b).

In **Senegal**, about 6,000 km^2 low-lying areas, mainly estuaries, could be flooded from a 1 m sea-level rise, which would mean the loss of all the mangrove ecosystems (ACCC, 2006a; Figure 25c). The economic value of these potential losses is estimated to be between US$ 500 to US$ 700 million (1999 value), or 12 to 17 % of GNP for a 1 m sea-level rise (Figure 25d). This would affect about 150,000 people or up to 2.3 % of the total population of Senegal. Key points arising from the studies of vulnerability of the Senegal coasts were; (1) the main zones vulnerable to coastal erosion are sandy, low and narrow coasts, (2) the main areas vulnerable to flooding are mangrove estuaries and creek (or *marigot*) openings, (3) the vulnerable aquifers exposed to saline intrusion are those in Dakar and those in the estuaries especially around the coastal lakes, (4) the mangroves and niayes would be particularly affected if sea level rose more than 0.5 m and (5) fishing will be affected by changes to upwelling and water temperatures (ACCC, 2006b).

Due to the arterial nature of the river Gambia, its low-lying and broad open valleys, 20 % of the land area is covered by freshwater swamp and salt marshes (National Climate Committee, 2003). With increase in sea-level rise, dry season water levels will increase throughout the estuarine part of the river Gambia, leading to permanent flooding of current intertidal areas and increasing soil salinisation in areas adjacent to River Gambia (National Climate Committee, 2003).

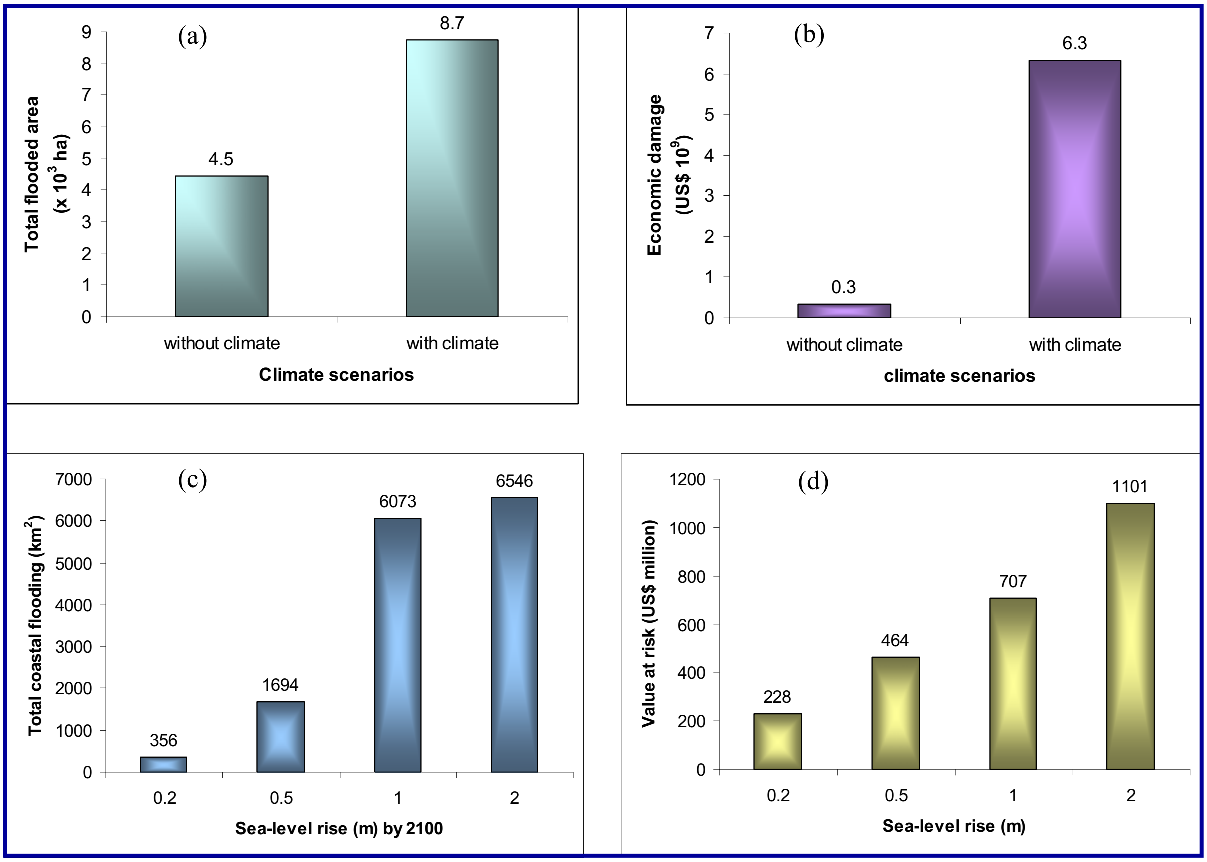


Figure 25: Projected impacts of coastal flooding with sea-level rise in Region 1. Effects on built-up areas of Mauritania coast in the absence of climate change by 2050 and with the impacts of climate change by 2050 showing (a) total flooded areas and (b) estimated economic damage (source data ACCC, 2006a). (c) Projected amount of coastal flooding under different sea-level rise scenarios for the Senegal coast (data source: ACCC, 2006b). (d) Projected value at risk in US$ millions for different sea-level rise scenarios for the Senegal coast (data source: ACCC, 2006b).

1.2.1.4 Drought and Desertification

In West Africa the long term decline in rainfall from the 1970s to the 1990s caused a 25-35 km southward shift of the Sahelian (Cugusi and Piccarozzi, 2009). In Cape Verde, livestock production has been declining since 1960s due to successive droughts. Increased local and general droughts are also foreseen. These are forecasted to contribute to the reduction of plant cover and the degradation of the ecosystem, thereby affecting livelihoods and agriculture. Figure 26 shows drought and desertification in Cape Verde.

Figure 26: Drought in Cape Verde (Ministry of Environment and Agriculture, 2007).

Three-quarters of **Mauritanian** territory is covered by Saharan desert, and the remaining one quarter is a Sahelian zone. Mauritania is therefore one of the countries most vulnerable to the effects of desertification (Ministry of Rural development and of Environment, 2004).

In **Senega**l, two decades of drought in the 1980's caused increases of salinity in Saloum and Casamance estuaries of up to 160 ppt (parts per thousands), causing a loss of biodiversity, affecting the growth of fish, and the degradation of mangrove forests (ACOPS, 2002b).

Guinea-Bissau climate change is strongly marked by an extreme fluctuation of rainfall levels and irregularity in rainfall patterns. Recent trends have shown longer dry seasons in some regions of the country, increase of yearly average temperatures of around 1 ºC, and, concurrently, of average sea level. Projections made by the meteorology office for the 2100 time horizon point to a decrease in rainfall of approximately 11.7 %, a rise in temperature of 2 degrees and a rise in the average sea level of 50 cm (Government of Guinea Bissau, 2006).

1.2.1.5 Coastal population and livelihoods

Cape Verde population was 434,812 in 2000 and approximately 451,000 in 2002. It is projected to be 623,524 by 2020 (ACCC, 2006a). It was growing at an average 2.4 % per year, and the urban population was estimated at 53.7 % (Ministry of Environment and

Agriculture, 2007). A population of 8,383 people, living in Santo Antão Island in Cape Verde is at risk due to the erosion of coastal beaches, estimated at over 2 m/year (ACCC, 2006a).

The population of **Mauritania** was 3.1 million in 2006 (World Bank, 2008). The two main coastal towns, Nouadhibou in the north and Nouakchott in the south, account for at least 25 % of the total population. In Mauritania, 39.6 % of the population live within 100 km of the coastline (ACCC, 2006b). With an area of 1,030,700 km^2 the growth rate is 2.4 %, and the population density is near 2.5 people/ km^2. Population density varies from 0.4 people/ km^2 in the north with a desert climate, to 20 people/ km^2 in the south, in the Senegal River valley. The district of Nouakchott alone, on the Atlantic coastline, accounts for about 22 % of the country's entire population living in less than 1 % of the country's surface area. Since Nouakchott city is located at the intersection of two very low-lying zones, Sebkha of Ndrhamcha and Aftout Es Saheli, these populations would be vulnerable to a rise in sea-level.

The population of **Senegal** was 11.7 million in 2006 (World Bank, 2008), and 83.2 % of the population live within 100 km from the coastline (ACOPS, 2002b). Dakar is the most densely populated area in Senegal with 2,707 people/km^2, housing 24 % of the total population (Figure 27; ACCC, 2006b). Other coastal towns are Saint Louis, Mbour, Joal, Kaolack, and Ziguinchor. Senegal's population has increased from 3 million in 1960 to slightly above 10 million in 2002. The population growth rate is estimated at 2.9 % and 2.1 % in urban and rural areas, respectively. Senegal has the highest urbanisation rate in the Sahelian region, 39.5 % for the whole country and 52.9 for Dakar (Figure 27).

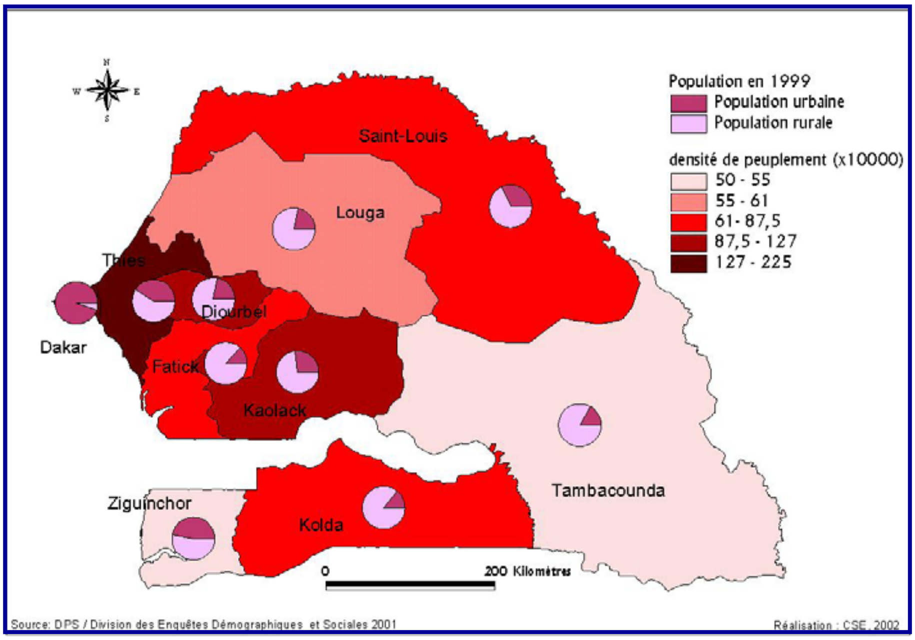


Figure 27: Distribution of the Senegal population in 1999 (ACCC, 2006b).

Several scenarios have been developed to simulate climatic change impacts for the Senegal coast. It is projected that between 174,864 and 730,249 people are at risk from the impacts of sea-level rise in Dakar, which translates into an economic cost of between 69,000 US$ and 170 US$, depending on the flood level. In the Saloum River estuary, between 74,587 and 847,191 people are at risk and costs range from 39,000 US$ 155,000US$ (ACOPS, 2002b). Figure 28 shows projected population at risk under different sea-level rise scenarios for Senegal coast.

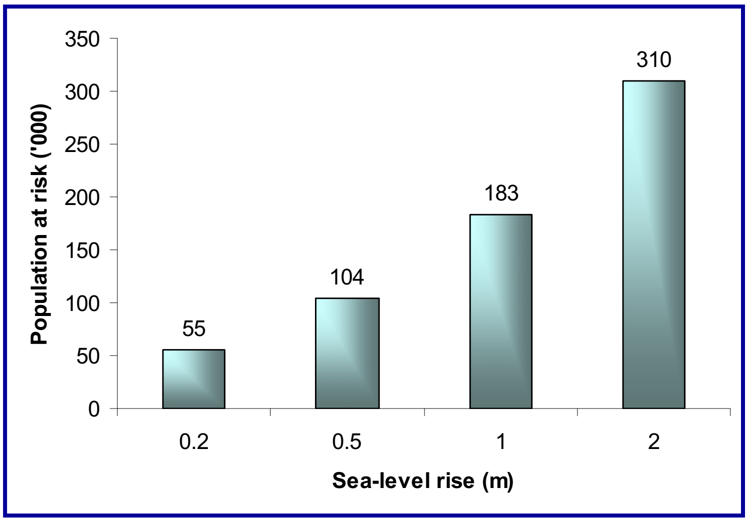


Figure 28: Projected population at risk under different sea-level rise scenarios for the Senegal coast (data source: ACCC, 2006b).

The **Gambian** coastal zone experiences the highest population growth rate of 8 % per year while the rest of the country has a population growth rate of 4.2 % per year. More than 60 % of economic activities and over 45 % of the Gambia's population live within Banjul area. Nearly 50 % of the population live in the coastal zone which is 16 % of the total land area. The population of the coastal area was estimated at 504,415 people in 1993. This was about 49 % of the total population living on less than 9 % of the total land area (ACCC, 2006b). The Greater Banjul area registered a population increase of 96.6 % between 1983 and 1993, mainly due to rural-urban migration. In April 2003, total population was 585,904, an increase of 61 % from 1993 (ACCC, 2006b). This population living at the coast may be at risk from climate change if the sea-level rises.

In **Guinea Bissau**, simulation results of the Magicc/Scengen model were used to project different parameters up to the year 2100. In 2020, the population will be 1,791,000 people and this will double by 2053 with a population growth rate of 3 % (ACCC, 2006b). In 2004, the population was estimated at 1.4 million with a population growth rate of 3 %. In Guinea Bissau, 94.6 % of the population live within 100 km of the coastline. Guinea-Bissau has a territory of 36,125 km^2 and a population estimated at slightly over 1,300,000 people distributed over 9 regions. Its population density is approximately 34 people/km^2 and the average growth rate as per 1991 census was 2.2 %. About 70 % of local population live in the rural area with main socio-economic activities as agriculture, fisheries, forestry, livestock and mining. The country's coastal zone shelters 80 % of the total population and, consists of five main protected areas (Government of Guinea Bissau, 2006).

1.2.1.6 Fisheries, Resource Management and Biodiversity

The **Senegal** coast is made up of three major geomorphological areas; sandy coasts, rocky shores and mangrove estuaries. Agriculture claims more than 800 km^2 of forest each year and wild fires, which are used for land clearing and hunting, degrade an additional 3500 km^2 per year. On the contrary approximately 50 % of mangroves along the coast have been degraded as a result of overexploitation and drought (Cugusi and Piccarozzi, 2009, p 18-19).

In Senegal, due to dam construction at Diama in Senegal and Manatali in Mali, for agricultural and electricity purposes, the Senegal River has lost biodiversity, with a resultant decrease in fish landing. In Senegal, the mangrove forests of the Saloum-Sine Delta sprawl across roughly 650 km^2 of the coast of south-eastern Senegal. Parc National du Delta du Saloum provides protection to 760 km^2 of forests and the surrounding areas, while 1800 km^2 of the delta have been designated as a UNESCO Biosphere Reserve. Nevertheless, since the late 1960s it has been recognised that these forests have been dying. They have declined in both area and density by roughly 25 % since the early 1970s (Figure 29). This is generally attributed to a decline in rainfall over the past decades and overexploitation of water reserves which have changed the mix of salt and fresh water in the estuary, making it too saline for many trees. Areas in the satellite images which have changed from dark green to grey between 1972 and 2006, particularly in the northern portions of the delta, show where the mangroves have died off (Figure 29; Cugusi and Piccarozzi, 2009, p. 47).

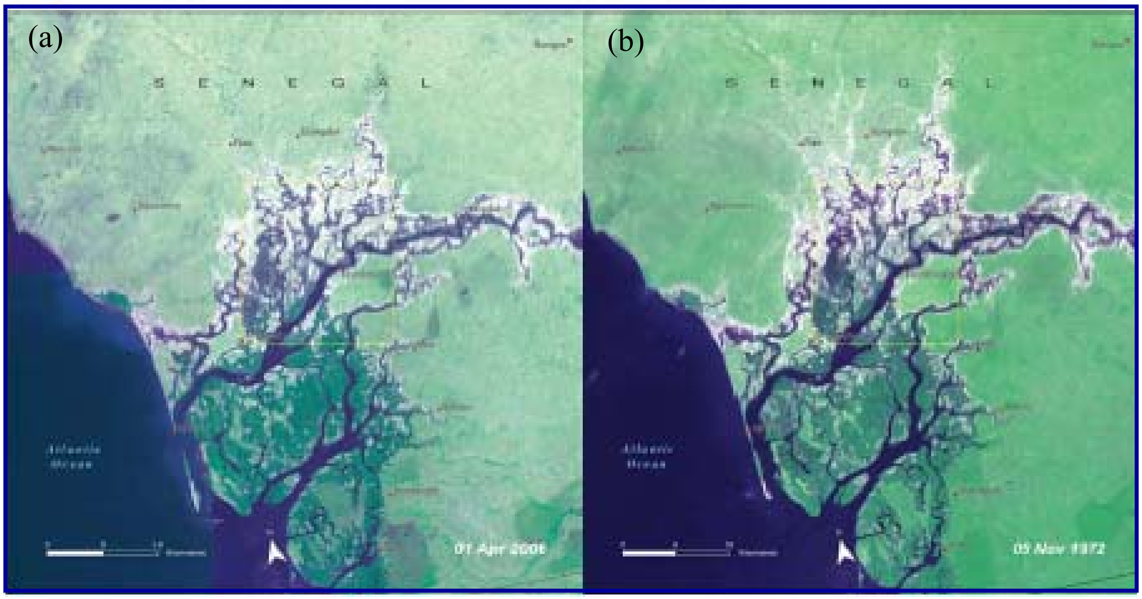


Figure 29: Depletion of mangrove forests in Saloum-Sine Delta, Senegal (a) April 2006 (b) November 1972 (Cugusi and Piccarozzi, 2009).

Coastal wetlands along the Guinea Bissau coast are projected to disappear by 2100. Almost 50 % of the mangroves and 7.1 % of forests had disappeared by 1990s (ACCC, 2006a). Annual loss of about 300 km^2 and 600 km^2 of forests could double by 2050 with complete deforestation and desertification of the country by 2100 (ACCC, 2006a). In the mangrove ecosystem, communities of rice growers cut mangroves and leave soils exposed to rains, which makes those lands lose their salt content. About 1060 km^2 of mangrove soils have been converted for rice production (Government of Guinea Bissau, 2006).

1.2.1.7 Coastal Tourism

Sea-level rise may constitute a danger for Cape Verde's economic sector, particularly the tourism sector, since tourist infrastructures (most of them hotels, airports, fishing zones, and others) are located along the coastal zones. Sal Island, due to the large tourism investments carried out there, constitutes one of the most vulnerable zones of the country (NAPA, 2008).

The tourism industry in Senegal has grown at an annual rate of around 10 % over the past 3 decades and now ranks as the second industry in terms of foreign exchange earnings 1 million US$ in 1995, and contributes about 3 % to GDP (ACOPS, 2002a). Most tourism developments are located on the coastal zone. Tourism is especially well developed along the South Coast and on the coast of Casamance. In the Saloum estuary, a big estuarine complex, tourism is one of the main activities, although it is not as developed as along the South Coast. There is an urgent need for improved planning and diversification (ecotourism, discovery, game fishing etc.) of the tourism sector. While attention is being given to the development of tourism, especially in coastal areas, far less attention is being given to the social and environmental impacts of tourism on the coastal zone (ACOPS, 2002a).

1.2.1.8 Fresh Water, Food Security, Pollution and Sanitation

In Cape Verde, amount of emitted greenhouse gases is estimated to be 635 kg of CO_2 per person annually, based on 1990 data, which is not significant (ACCC, 2006a). Maio Island in Cape Verde has experienced the greatest changes in climate resulting in saltwater intrusion. Several points along the rivers have already been abandoned due to high salt levels, posing a serious problem for the people.

In Senegal, the Bay of Hann which is considered a hot spot has more than 42,000 people and 60 % of the processing industries (ACOPS, 2002a). The main sources of pollution are therefore industrial solid waste as well as domestic throw outs. It is also seriously affected by acute sanitation problems. The Government of Senegal has come out with a policy commitment for mid- and long-term rehabilitation of the Bay of Hann. The Senegal coast also has potential for oil spills as it is near the main marine highway used by oil tankers, supplying the port of Dakar for Senegal and the land locked country of Mali.

In the Gambia no sewage services are available (ACOPS, 2002a). It is projected that a 1 m rise in sea-level would increase water salinity by 4 km upstream with groundwater being at risk of saline intrusion along a 3 km strip of land on the Atlantic coast side and a 1 km band along the Senegal estuary and around River Kuntaur (National Climate Committee, 2003). Evaporation losses of 0.3 m^3/s from the river are expected to add another 170 m to the 4 km of saltwater intrusion. Under the projected rise in mean sea level, it is estimated that maximum saline intrusion will increase upstream by 40 m/year (National Climate Committee, 2003). Also, sand mining is estimated to be between 100,000 to 150,000 m^3 per year from beaches between Kololi Point and Bald Cape along the Gambian coast (ACCC, 2006b). At Bijilo Beach, for example, more than 150,000 m^3 per year of sand has been mined between 1985 and 1993. The sand mining has created sand deficit in the area as the net southward directed sediment transport toward Bald Cape in Gambia is estimated to be between 0 to 20,000 m^3 per year (ACCC, 2006b). This in turn has caused critical erosion with the erosion rates estimated at 4 to 5 m/year.

In Guinea Bissau, it is estimated that between 60- 80 % of soils with high iron content as well as hydromorphic ones are exposed to erosion and compacting and salinity due to existing conditions on the territory's waterways and decreases in rainfall (Government of Guinea Bissau, 2006). In Guinea Bissau, there is an increase in salt water intrusion during high tides with occasional submersion of areas along the Geba and Corubal Rivers causing soil salinisation of arable lands, increased salinity of aquifers and coastal erosion of submerged areas leading to important changes in the vegetation (ACCC, 2006a).

1.2.2 Impacts in Region 2 in West Africa - Ghana, Togo, Benin and Nigeria

The main coastal issues for Region 2 are urban sprawl, coastal erosion caused by natural and anthropogenic factors and high pollution levels. Other issues are sea-level rise, precipitation and floods and depletion of mangrove and fisheries resources. Population estimate in 2005 for the region was 381 million people with average population growth rate of 2.4 %. The total area is 1,348,548 km^2 of which 2.9 % consists of water. The total length of the coastline is 1,563 km. Table 6 shows individual country estimates plus the total for Region 2.

Estimate of capture fisheries for the region in 2006 was 936,742 while that for aquaculture fisheries was only 9.2 % of the capture fisheries (Table 6). The total mangrove area estimate for 2005 was 101000 km^2 while estimate for coral reef areas is only approximated to be 50 km length as at 2001. The GDP per capita in US$ in 2005 was US$ 3608. Marine protected areas for this region are mostly not recorded and so form only 0.2 % of the total territorial waters. The region is generally low-lying as can be seen on the topographic map of Africa (See Figure 1).

There are six key issues critical to the Ghana coastal zone. These are: erosion, pollution, and impacts of crop production, impact of fisheries, biodiversity loss and habitat loss (ACOPS, 2002d). Figure 30 shows hot spots and sensitive areas in Ghana's coastal zone.

Table 6: Statistics for region 2 West Africa, covering Ghana, Togo, Benin, and Nigeria (data extracted from UNESCO-IOC, 2009).

Region's statistics	***Region 2 West Africa***				
Country	**Ghana**	**Togo**	**Benin**	**Nigeria**	**Total**
Capital city	Accra	Lomé	Porto Novo-administrative Cotonou-economic	Abuja	**-**
Population (2005 est)	22,5000,000	6,200,000	8,500,000	141,400,000	**381,100,000**
Population growth rate (%)	1.9	2.5	2.9	2.2	**2.4**
Total area (km^2)	239,460 Land-230,940 Water-8,520	72,700 Land-56,600 Water-16,100	112,620 Land-110,620 Water- 2000	923,768 Land-910,768 Water-13,000	**1,348,548** **Land-1,078,218** **Water-39,620**
Length of coastline (km)	539	50 (est)	121	853	**1563**
GDP per capita (USD 2005 est)	$2,480		$ 1 141	$1128	**c.$1300**
Coral reef area (2001 est)	-	none	50 km	0	**50 in length**
Marine protected areas (2007 est) (km^2) (% of total territorial waters)	None recorded	4.5 (0.2 %)	4 sites proposed	0 (0 %)	**4.5 (0.2 %)**
Mangrove area (2005 est) (ha)	12,400	1000 (est)	1 150	997,000	**1,010,400**
Capture fisheries prod. (2006 est) (metric tones)	366,919	17500 (est)	38, 021	552,323	**936,742**
Aquaculture fisheries prod. (2006 est) (metric tones)	1,150	50 (est)	415	84,578	**86,193**

The Togo coast faces a number of coastal issues including coastal flooding, pollution, and the potential effects of sea-level rise (UNESCO-IOC, 2009).

In Nigeria, the key issues identified in the hot spot and sensitive areas were (1) modification of ecosystems from coastal erosion, flooding, deforestation (2) pollution from oil spills, solid wastes, sewage and industrial effluents and (3) global climate change and sea-level rise (UNESCO-IOC, 2009; ACOPS, 2002e). The Nigerian coastal environment has a variety of both living and non-living resources, which account for almost 90 % of its economic growth. Table 7 shows coastal threats, hots spot locations and the sensitive areas for Region 2 in West Africa.

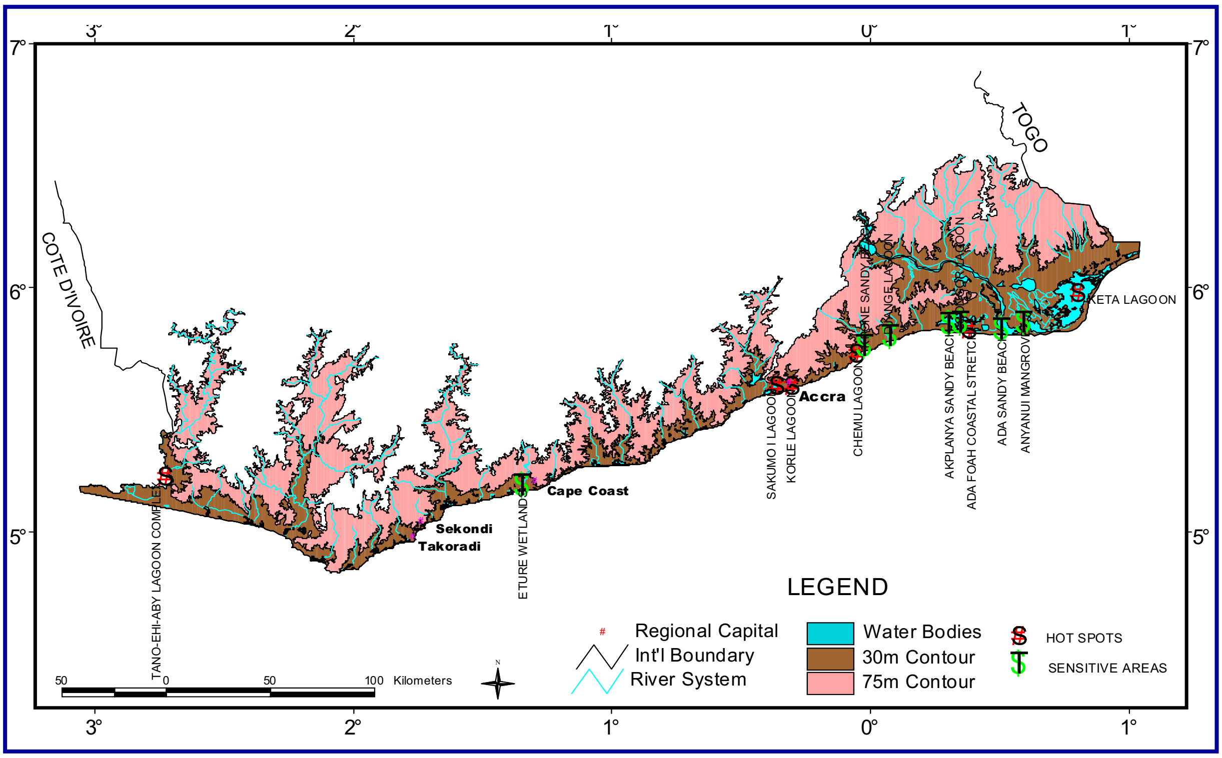


Figure 30: Map showing the hot spots and sensitive areas of the coastal zone of Ghana (ACOPS, 2002d).

1.2.2.1 Sea-level rise and coastal erosion

In Ghana, 25 locations along the coast have been identified to undergo critical erosion (ACOPS, 2002a). Coastal erosion in Ghana is due mainly to the destruction of coconut trees at Cape St Paul as well as sand and pebble mining, wave action and construction of dams. Coastal erosion in Ghana was identified as a major feature of the shoreline especially on the eastern shores in the Ada-Volta Delta Anyanui Estuary Mangrove Complex (AVDEAMC) (ACOPS, 2002a). The erosion is enhanced by mangrove overexploitation, causing erosion in the delta area of the Volta River. Erosion is also destroying turtle egg-laying sites and also exposes the eggs to predators such as dogs, pigs and humans (ACOPS, 2002a). Following the damming of the Volta River, the result of which cut off substantial amounts of sediments that reach the littoral zone, erosion has become of critical concern averaging about 2 - 3 m/year in recent times (ACOPS, 2002a). It is estimated the recession in the Keta area to have increased from 4 m/year before the construction of the dam on the Volta River in 1965 to 8 m/year after the dam construction. This is among the highest rates of coastal erosion in Ghana. The Loggerhead turtle, *Caretta caretta*, could be described as highly endangered in Ghanaian waters in the Keta Lagoon Complex hot spot and the East Central Sandy Coast sensitive area where the rate of coastal retreat is estimated at 3 m per year (Figure 30; ACOPS, 2002a).

Table 7: Coastal threats, hotspot and sensitive locations for region 2 in West Africa

Coastal threats	***Hotspot locations***	***Sensitive locations***
Ghana		
solid waste	Keta Lagoon Complex, Korle Lagoon, Sakumo I Wetlands,	Songor Lagoon; East Central Sandy Beach Ada/Volta Estuary/Anyanui Mangrove Wetlands
modification of ecosystems	Sakumo I Wetlands, Keta Lagoon Complex, Korle Lagoon	Songor Lagoon, Ada/Volta Estuary/Anyanui Mangrove Wetlands
Reduction of stream flow	Keta Lagoon Complex, Sakumo I Wetlands,	Songor Lagoon, Ada/Volta Estuary/Anyanui Mangrove Wetlands
Nigeria		
Solid wastes	Lagos Island Area,	Ibeju-Lekki West
Spills	Eket Area, Ogoni Land, Bonny Area	Opobo Area, Barrier Island between Dodo and Nun Rivers, Brass area
Modification of the ecosystem	Lagos Island Area, Eket Area, Ogoni Land, Bonny Area	Opobo Area, Barrier Island between Dodo and Nun Rivers, Brass area
Overexploitation	Eket Area, Ogoni Land, Bonny Area	Opobo Area, Barrier Island between Dodo and Nun Rivers, Brass area
Sea-level change	Lagos Island Area,	

In **Togo**, average rates of coastal erosion are about 7 m/year (UNESCO-IOC, 2009). Figure 31a shows an example of coastal erosion along the Togo coast.

In **Benin**, as a result of the significant urban sprawl, coastal erosion is a hot spot issue and the impoverishment of the soil at Sèmè along the coast in east area of the Cotonou port and Grand Popo and Agoué towns in the west (UNESCO-IOC, 2009).

In **Nigeria**, coastal erosion results from the modification of ecosystems. Affected sites include Eket, Lagos, Forcados and Ondo (ACOPS, 2002a). Figure 31b shows eroded road along Bar Beach in Nigeria. The Victoria Beach is the fastest eroding beach with average erosion rates of 20-30 m/year. From 1900 to 1959, Victoria Beach retreated by over 1 km (ACOPS, 2002e). Annual erosion rates of 25 – 30 m had been reported between 1981 and 1985 for Victoria Beach. This high rate of erosion has been linked to the construction of the moles built to stop the silting up of the entrance to Lagos harbour (ACOPS, 2002e). However, the Lighthouse Beach near the western breakwater accreted by over 500 m within the same period (Figure 31c). The average mean sea level for Nigeria between 1960 and 1970 was estimated to be 0.46 m above the zero of the tide gauge (ACOPS, 2002e).

For Nigeria, it is projected that for a 0.5 m rise in sea-level, about 9000 km^2 of land will be lost, while for a 1 m sea-level rise the land loss will double to 18 000 km^2 (Figure 32).

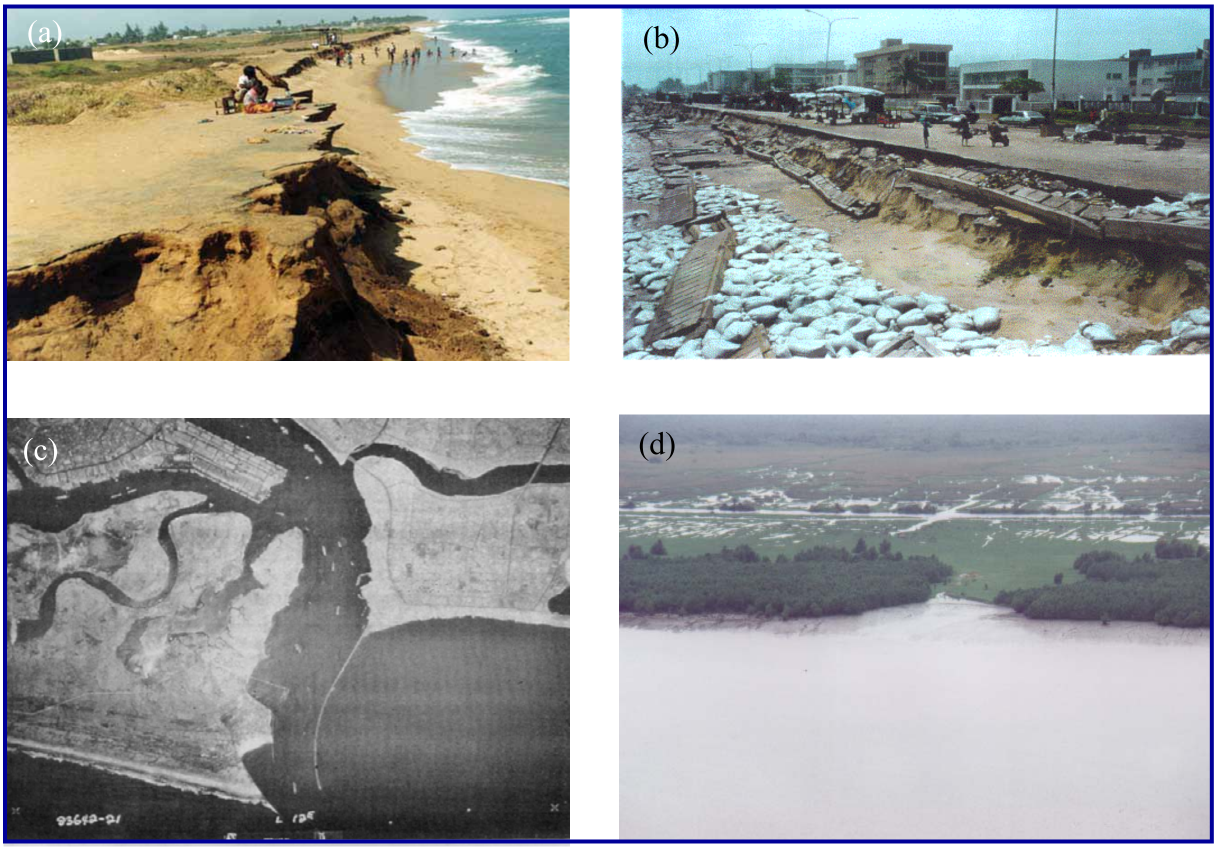


Figure 31: Examples of coastal erosion in Region 2. (a) Coastal erosion in Togo (Photo taken in 2005 by A. Blivi) (UNESCO-IOC, 2009). (b) Coastal erosion causing devastation of major road and threat to buildings fronting the Bar Beach, Nigeria. (c) Aerial view of the Bar Beach showing eroded Bar Beach and accreting Lighthouse Beach as a result of the construction of the East and West Moles, in Nigeria (d) Typical coastal vegetation, mangrove interspersed with grass, along the Mahin mud coast in Nigeria. Note the very low coastal plain susceptible to floods with spring high tides and with an increase in sea-level rise (Photos b, c, and d are from ACOPS, 2002e).

1.2.2.2 Precipitation and Floods

Recurrent floods in Togo poises a great challenge to the management of water on the coastal plains (Figure 33a).

The beaches along the Nigerian coastline are very susceptible to flooding due to their very low topography. Low-lying beaches like the Bar Beach and Mahin Mud Beach are easily flooded during high tides as they are almost at sea level (Figure 33b). Whenever storm surges coincide with spring tides most beaches up to a maximum elevation of 3 m above sea level are usually topped by waves resulting in floods (ACOPS, 2002e, p. 28). The low drainage heads of existing storm drainage channels increase the severity of flooding.

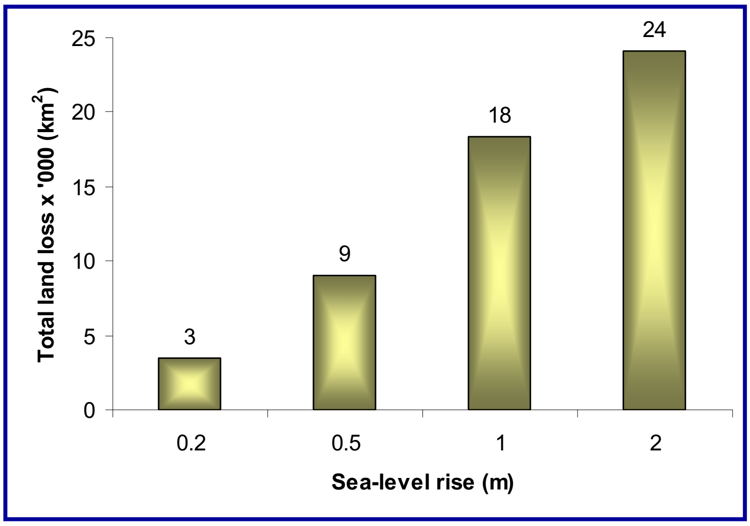


Figure 32: Total land loss due to erosion and inundation at different sea-level rise scenarios in Nigeria (data source; ACOPS, 2002e).

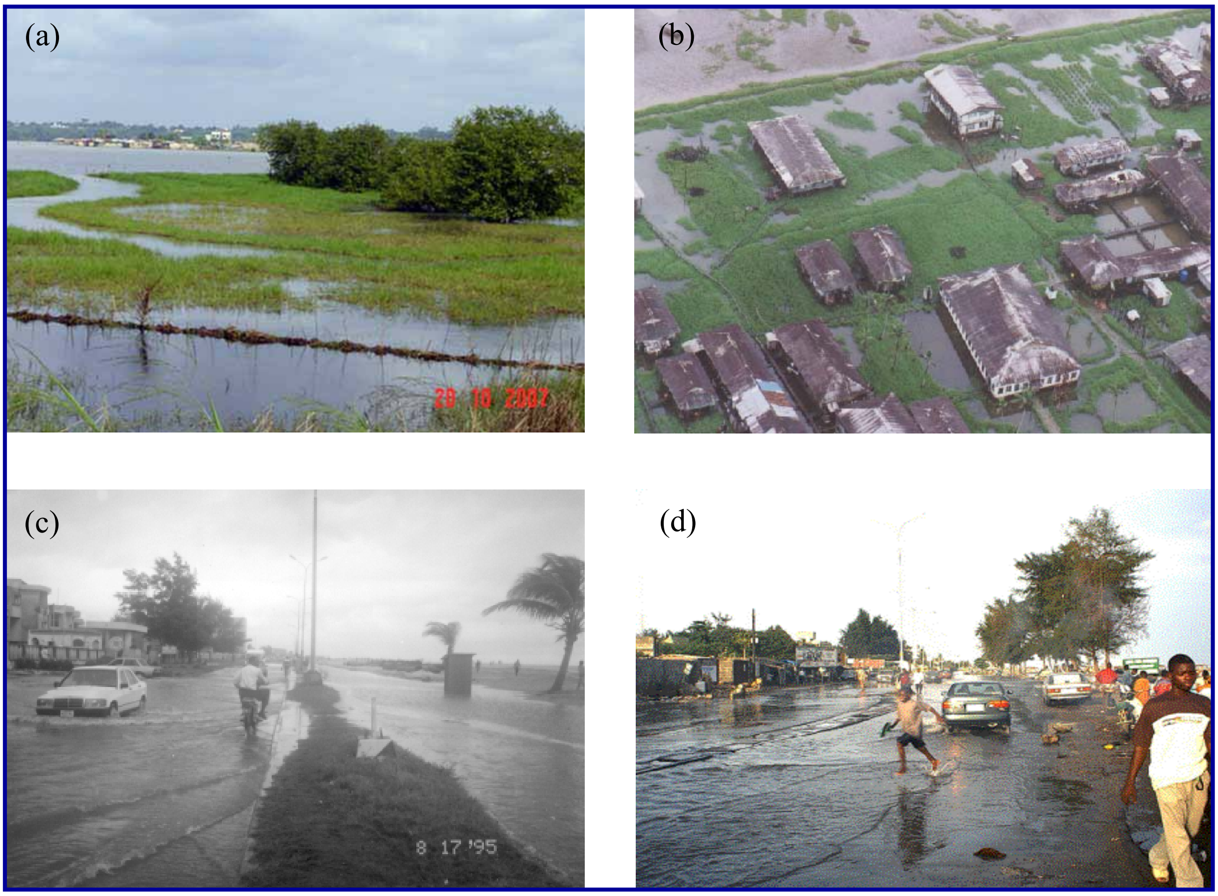


Figure 33: Examples of coastal flooding in Region 2. (a) Flooding of the coastal plains in Togo (Photo taken in October 2007 by A. Blivi) (UNESCO-IOC, 2009). (b) Flooding of Aiyetoro community along the Mahin Mud Coast, Nigeria. Flooding results from multiple causes such as coastal erosion (note the shoreline on the top side of picture), low-lying topography, sea-level rise, etc. (c) Flooding of the Ahmadu Bello Beach Drive in Victoria Island, Nigeria on 19/7/89 (d) and Flooding of the Ahmadu Bello Beach Drive in Victoria Island, Nigeria on 7th May 2001(Photos b, c, and d are from ACOPS, 2002e).

The flooding of the Victoria Island in August 1992, July 1995, April 1996 and May 1996 show that the height of the highest swells reaching the coast average about 2 m above normal high tide levels (Figure 33c and d) (ACOPS, 2002e, p. 28). The August 1984 and May 1990 storm surges resulted in the topping of the beach ridge along Victoria Island and flooding along most parts of the low-lying Nigerian coastline. Thus flooding which has characterised the Mahin mud coast has exacerbated the erosion problem along the Awoye Molume areas (ACOPS, 2002e).

Results of the sea-level rise video mapping vulnerability analysis survey of the Nigerian coastal zone show that the barrier lagoon coastline in Lagos State could lose well over 284 to 584 km^2 of land from erosion and inundation arising from sea-level rises of 0.5 m and 1 m, respectively by the end of the 21st century (ACOPS, 2002e, p. 29). On the Mahin Mud coast and the Niger Delta, native vegetation has died due to increase in saltwater levels and has been replaced by more salt tolerant vegetation like grasses (ACOPS, 2002e).

1.2.2.3 Drought and Desertification

In the West African Sahel recent studies have cast light on the use of temporary migration as an adaptive mechanism to climate change. The region has suffered a prolonged drought for much of the past three decades and one way of adapting to the harsh conditions is by both temporary and permanent migration (Cugusi and Piccarozzi, 2009). Migration, especially when it is a response to slower acting climate processes, rather than a sudden climatic event like a hurricane, typically requires access to money, family networks and contacts in the destination country. Even in the most extreme, unanticipated natural disasters – migrants, if they have any choice, will find new homes within the boundaries of their own countries (Cugusi and Piccarozzi, 2009).

Negative impacts of climate change could create a new category of refugees, who may migrate into new settlements, seek new livelihoods and place additional demands on infrastructure (IPCC, 2007b). A variety of migration patterns could thus emerge, e.g. repetitive migrants (as part of the ongoing adaptation to climate change) and short-term shock migrants (responding to a particular climate event) (IPCC, 2007b, p. 450).

Climate change impacts are expected to induce large new migration flows. Internal migration in Ghana is predominantly North-South, from poor rural areas in the North to the most industrialised and urbanised coastal zones in the South (Cugusi and Piccarozzi, 2009). Recent migrants to Accra reside in unplanned developments in highly risky sites including flood-prone and malarial marshlands. Local chiefs only give land use rights to immigrants, rather than full land rights and so immigrants can only construct temporary shelters (EACC study team, 2009). It is not only drought and desertification, however that could result in mass migrations – see the last paragraph of section 1.2.2.4.

1.2.2.4 Coastal population and livelihoods

Ghana has a coastline of 565 km. The population in 2000 was estimated over 18, million people with a growth rate of 2.6 % (ACOPS, 2002d). 42.5 % of the people live within 100 km from the coast while 25 % of the population live below the 30 m contour along the coastal zone (ACOPS, 2002d). The coastal zone of Ghana covers about 7 % of the total land area of Ghana with a population of 4.5 million people, which constitutes 43.1% of the population of Ghana (ACOPS, 2002d).

In Benin, the population density of rural Benin coast is nearly 200 people per km^2 thus having one of the largest populations in the country (UNESCO-IOC, 2009). The main cities of Benin are Grand-Popo, Ouidah, Cotonou and Sèmè with a population of nearly 1,500,000. Coastal urbanisation in these cities is due primarily to the large industrial and tertiary sectors in Cotonou with approximately 750,000 people (UNESCO-IOC, 2009). Impacts of increasingly high population density in the coastal zone are on the rise. Nigeria has a coastline of 853 km with a total surface area of 923,768 km^2. The population estimate as at July 2001 was over 126 million with a population growth rate of 2.6 % (ACOPS, 2002e). Major coastal cites include Lagos, Warri, Port Harcourt, Eket and Calabar.

The total land loss in Nigeria's coastal zone under a 0.2 m sea-level rise is estimated to be over 3000 km^2 resulting in 800,000 people being displaced (Figure 34a). Such adverse impacts will affect the residential and commercial and tourist facilities on the Victoria, Ikoyi and Lagos Island costing over US $ 12 billion in land loss (ACOPS, 2002e).

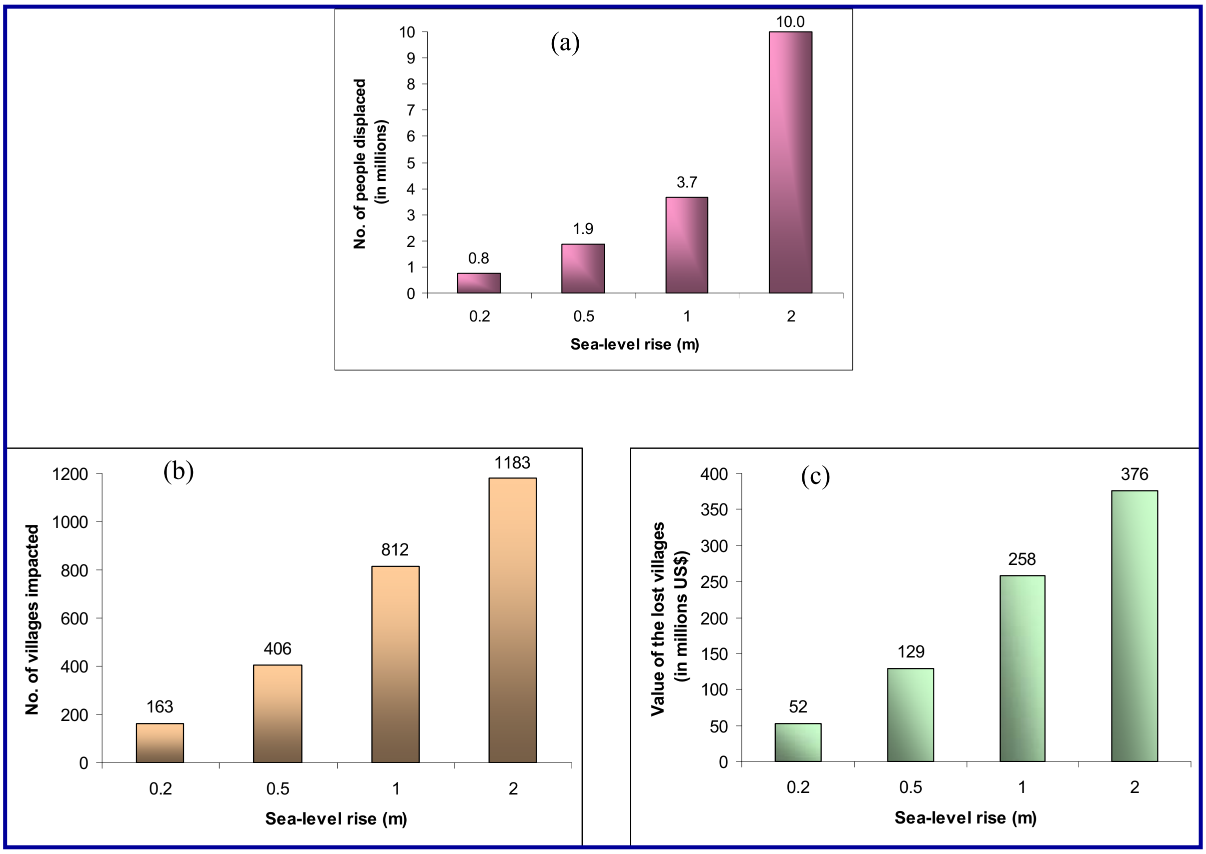


Figure 34: Impact on coastal population as a result of sea-level rise in Nigeria. (a) Estimated number of people in Nigeria (in millions) that will be displaced by sea-level scenarios. (b) Projected number of villages to be impacted by sea-level rise along the Nigerian coast and (c) their value in millions of US$ (data source; ACOPS, 2002e).

About 25.7 % live within 100 km of the coast while the population living in the coastal zone is 25 %. Lagos State has a population of 5.7 million or 6.4 % of the national population of Nigeria according to the 1991 census (ACOPS, 2002e). Since 1988, the population of Lagos has been growing at an annual rate of 8 %. The population of metropolitan Lagos is estimated to be about 13 million, which amounts to 91 % of Lagos State population (ACOPS, 2002e). The 1991 census figures put the population of the Niger Delta area at about 6 million people. Lagos, the economic nerve centre of the country, has about 60% of all industrial establishments in Nigeria.

The Niger Delta is projected to lose over 15 000 km^2 of land by the year 2100 with a 1 m sea-level rise. A sea-level rise of 0.5 m is projected to create 9000 km^2 of land loss, displacing about 1.9 million people (Figure 34a). Much of the land loss from sea-level rise will be due to inundation. A 1m sea-level rise, however, could see over 18000 km^2 or 2 % of the Nigerian coastal zone inundated, about 3.7 million people put at risk (Figure 34a) and a projected 812 villages along the Nigerian coast impacted (Figure 34b). The value at risk is estimated at US$ 258 million with 1 m sea-level rise (Figure 34c). Of all the coastal zones, the Niger delta will be the most affected with up to 350 villages impacted and 2 to 3 million people displaced (ACOPS, 2002e).

1.2.2.5 Fisheries, Resource Management and Biodiversity

In **Ghana,** marine fisheries resources especially small pelagic fisheries as well as lagoon and estuary fisheries have suffered depletion due to over-fishing (ACOPS, 2002d). Biodiversity has also suffered great loss as a result of anthropogenic impacts through overexploitation, habitat damage and pollution while coastal mangroves and wetlands have been destroyed to make way for development and settlement expansion. These coastal issues in Ghana are enhanced by the lack of research vessels and basic research facilities and equipment to enable quality coastal research for sustainable management (ACOPS, 2002d).

The overexploitation of mangroves in Ghana, as for example in the Ada-Volta Delta Anyanui Estuary Mangrove Complex (AVDEAMC) and the damming on the Volta River have caused sediment transport changes and thereby erosion and destruction of key species habitat (ACOPS, 2002a). The mangrove cover was estimated to be 20 ha based on 1986 aerial photo cover. Recent estimates, however, put the mangrove cover at 16.2 ha. This trend suggests that the mangrove stands have diminished over the past two decades (ACOPS, 2002a). Most of the mangroves have been lost through exploitation for fuel-wood and conversion of the habitats for solar salt production. In many instances, former mangrove habitats have been reduced to saline grasslands. Similar threats to mangroves exist in several countries in the western coast of Africa such as Gambia and Senegal (ACOPS, 2002a).

In **Nigeria**, the mangroves of the Niger delta, estimated to cover approximately 7000 km^2 comprise a significant regional resource, with fishing being a major activity. The pressure of a subsistence population has adversely affected the mangroves which have increased since the discovery of hydrocarbon reserves in the mid-1950s in and around the Niger delta. Nigeria currently produces around 1.6 million barrels per day from more than 4,000 oil wells spread within the Niger delta and adjacent coastal areas. 23 out of 62 oil fields are within the mangrove ecosystem (ACOPS, 2002a). Oil terminals are spread throughout the delta while 8,000 km of seismic lines (20-30 m wide) and oil pipelines criss-cross the mangrove ecosystem. Oil spills are common; between 1970 and 1982 alone, there were 1581 oil spills involving a total two million barrels. While most of the oil spills have been small, they have tended to occur within the mangrove waterways. As a result, many of the surface waters are contaminated and undrinkable, localised fisheries production has declined and in many instances, inhabitants have been forced to immigrate to other areas (ACOPS, 2002a). In addition, bottom trawling, use of explosives and chemicals, and use of wrong mesh sizes have been recognized as major causes of destruction to the fishing environment.

1.2.2.6 Fresh Water, Food Security, Pollution and Sanitation

In Ghana, sources of pollution include municipal and industrial waste, chemical runoff from agriculture activities, and oil spillage. Sinking of wells for irrigation in crop production has resulted in significant saltwater intrusion into the aquifers (ACOPS, 2002d). In most of the coastal urban centres only very small part of the population is connected to sewage. In Ghana untreated sewage is discharged into Korle lagoon which has rendered the lagoon unfit for any economic use. In Ghana, municipal or domestic input is the most common source of solid waste into the coastal environment. Fundamental causes include poverty and population pressure. Other concerns include low private sector participation in the provision of sanitation facilities. The waste, composed of 70 to 80 % organic matter, originates from households, markets, transport termini, restaurants schools and hospitals and contains, among others, plastics, food leftovers, paper, metals, glass, textiles, excreta, grass and wood cuttings, batteries and construction waste. In Accra, the environmental impacts on the Korle Lagoon and its catchment are gross pollution and changes and losses in biodiversity, including fish species and invertebrates. The main socio-economic impacts are increased diseases and loss of property and deaths arising from flooding events. There are also negative impacts on tourism (ACOPS, 2002a). In addition, the Densu Delta, which is a Ramsar Site because of its important bird population and other biodiversity characteristics, is also undergoing rapid degradation because of improper land use and water pollution activities in the river basin. As a result of the dumping of waste and other pollutants into the lagoon and its riverine system the Government of Ghana has been compelled to commit over US$ 40 million to a project called Korle Lagoon Ecological Restoration Project (KLERP).

In Togo, the dam construction at Nangbéto in 1987 led to changes in the flow of the Mono River from a freshwater source to saltwater intrusion. Wastes from mining activities such as phosphates at Hahotoé and Kpogamé comprise 40 % of the discharge which totals more than 2.5 million tones per year (UNESCO-IOC, 2009). Phosphates liquid waste is discharged into the coastal waters without any treatment (Figure 35).

In Benin, industrial pollution of the sources of fresh and coastal water is taking place mainly around Cotonou and Porto-Novo towns (UNESCO-IOC, 2009).

Figure 35: Discharges into the sea from the jetty loading phosphate in Togo (Photos August 2006 by A. Blivi) (UNESCO-IOC, 2009).

While 80 % of Nigeria's coastal cities are connected to sewage (ACOPS, 2002a), Major coastal towns and cities in Nigeria such as Lagos, Warri and Port Harcourt have large human populations invariably lack sewage treatment plants except in a few relatively new and isolated residential or industrial estates. Most residents use septic tanks whose contents when dislodged are discharged into coastal rivers, lagoons and near shore waters without further treatment. The associated problems include increases in BOD and the introduction of pathogenic micro-organisms and intestinal parasites which pose risks to swimmers and fishermen as well as the general public (ACOPS, 2002a). Solid waste constitutes a major environmental problem in the coastal areas especially in major coastal cities like Lagos, Warri and Port Harcourt. Due to the rapid increase in the coastal population, the volumes of solid waste generated by residents have quadrupled in recent years. In the Lagos Islands and other areas, human excrement is sometimes associated with solid waste dumps hence introducing health problems normally associated with human wastes (ACOPS, 2002a). Poor waste management policies and practices, inefficient collection and disposal as well as insufficient awareness and negative attitudes to the environment are some of the causes. The environmental impacts include contamination of ground water due to leachates from solid waste dumps which reduces availability of fresh water. The fiscal implication directly related to solid waste clearing for example in the Lagos runs to about US$ 10,000 per day (ACOPS, 2002a).

1.2.3 Impacts in Region 3 in West Africa - Cameroon, Gabon, and Congo

The main coastal issues for Region 3 are coastal erosion and the depletion of the mangrove ecosystem. This region is the least studied and hardly any information exists. This is not to say that there are no issues but that the documentation of issues is limited. The population estimate in 2005 for the region was 19 million people with an average population growth rate of 2.2 %. The total area is 3,088,517 km^2 of which 2.9 % consists of water. The total length of the coastline for the region is 1,324 km. Estimate of capture fisheries for the region in 2006 was 238,238 while that for aquaculture fisheries was only 0.2 % of the capture fisheries. The total mangrove area estimate for 2005 was 408 million km^2 while estimate for coral reef areas were not documented as at 2001. The GDP per capita in US$ in 2005 was US$ 9,967. Marine protected areas form 5 % of the total territorial waters. Table 8 shows individual country estimates plus the total.

Table 8: Statistics for region 3, West Africa, covering Cameroon, Gabon and Congo (UNESCO-IOC, 2009).

Region's statistics	***Region 3 West Africa***			
Country	**Cameroon**	**Gabon**	**Congo**	**Total**
Capital city	Yaoundé	Libreville	Brazzaville	
Population (2005 est)	17,800,000	1,300,000	58, 700, 000	**19,100,000**
Population growth rate (%)	1.9	1.5	3.2	**2.2**
Total area (km^2)	475,440 Land- 469440 Water- 600	267,667 Land- 257,667 Water- 10,000	2,345,410 Land- 2,267,600 Water- 77 810	**3,088,517** **Land- 2,994,707** **Water- 88,410**
Length of coastline (km)	402	885	37	**1,324**
GDP per capita (USD 2005 est)	$2,299	$6954	$714	**$c.1200**
Coral reef area (2001 est)	-		-	**-**
Mangrove area (2005 est) (ha)	250,000	150,000	8000	**408,000**
Marine protected areas (2007 est) (km^2) (of total territorial waters)	7 (0.1 %)	1055 (4.9 %)	None recorded	**1062 (5.0 %)**
Capture fisheries prod. (2006 est) (metric tones)	137,232	41,521	59,485	**238,238**
Aquaculture fisheries prod. (2006 est) (metric tones)	340	126	21	**487**

1.2.3.1 Sea-level rise and coastal erosion

The coast of Cameroon is undergoing erosion (Figure 36a).

The coast of Gabon is threatened by sea-level rise, coastal erosion, pollution, and overexploitation. Of the total population of 1,300,000, 60 % live in Libreville and Port Gentil (UNESCO-IOC, 2009). Figure 26 shows examples of coastal erosion in Region 3. Since 1950, an erosion rate of between 100 and 250 m has been reported for Cape-Lopez to the north of Port-Gentil in Gabon (Figure 36b; UNESCO-IOC, 2009). In the Owendo area, south of Libreville, an erosion rate of 3 m/year since 1980 has been reported (UNESCO-IOC, 2009). The sand bank of the Ozouri mouth has eroded by 2.5 km since 2000, and the mouth of Olendé (Bar of Arabic) has eroded by 4 km for the same period of time (UNESCO-IOC, 2009).

In Congo, severe coastal erosion is taking place at ancient royal graves in the Baie de Loango in Congo (Figure 36c, d and e).

Figure 36: Examples of coastal erosion in Region 3. (a) Coastal erosion impacts the Cameroon coastline. (b) Erosion of a beach in Port-Gentil, Gabon. (c) Coastal erosion in Congo (d) Seawall protection against coastal erosion in Congo (Photos a - d are from UNESCO-IOC, 2009). (e) Eroded graveyard with ancient royal graves in the Baie de Loango, Republic of the Congo (Theiss, 2009a).

1.2.3.2 Fisheries, Resource Management and Biodiversity

In Gabon, mangrove systems have disappeared at a rate of 0.5 km^2 per year between 1960 and 1990 (UNESCO-IOC, 2009). The absence of policy and adequate conservation of coastal ecosystems, as well as unplanned development has compounded the coastal issues in Gabon.

1.2.4 Impacts in Region 4 in East Africa - Kenya, Tanzania, Mozambique

The previous sections on West Africa have more studies that have been undertaken on vulnerability assessment. However, for the East African coast and the Western Indian Ocean islands, the data sources were fragmentary. The main coastal issues for Region 4 are coastal erosion caused by natural and anthropogenic factors, coastal flooding, decline in fisheries resources and high pollution levels. More specific threats in the region include destructive fishing practices, over fishing, and large-scale tourism development projects (ACOPS, 2002a). In Kenya and Mozambique, beach accretion has taken place, such that beach hotels have lost their beach frontage. Further north, due to the nature of the river-sediment being deposited (brown sand and silt) the aesthetic value of the beach along the Malindi Bay in Kenya has been lost making it less attractive to the development of tourism (ACOPS, 2002a). Destructive fishing practices are transboundary in nature (often involving fishers from other countries) and hard to contain. Other issues are drought, coastal populations and bleaching of coral reefs. In the whole of the Eastern Africa Indian Ocean waters, shrimp trawlers have caused widespread disturbance to the seagrass beds. Extinctions of turtle population and loss of nesting areas has been reported in Maziwe Island in Tanzania (ACOPS, 2002a). Similarly the Dugong population has suffered serious decline of 50 % in Mozambique and almost 99 % in Kenya and Tanzania (ACOPS, 2002a).

The population estimate in 2005 for region 4 was over 94 million people with an average population growth rate of 2.5 %. The total area is 2,329,327 km^2 of which 3.9 % consists of water. The total length of the coastline in region 4 is 4,266 km. Estimate of capture fisheries for the region in 2006 was 311,220 while that for aquaculture fisheries was only 0.7 % of the capture fisheries. The total mangrove area estimate for 2005 was 5652 km^2 while estimate for coral reef areas was 6070 km^2 as at 2001. The average GDP per capita in 2005 was US$ 1,075. Marine protected areas form 48.8 % of the total territorial waters. Table 9 shows individual country estimates plus the total.

In **Kenya**, the hots spots identified along the coast were Mombasa and Lamu inshore waters, Ungwana and Malindi Bays and Diani Reefs (Figure 37). At Ungwana Bay the issues include excessive by-catch and discards from trawling activities of which 98% is for foreign export (ACOPS, 2002f). Sensitive areas are Vanga Creek, Wasini Channel, Gazi Bay, Ngomeni Mangrove swamp and Malindi/Watamu Marine National Park and Reserve (ACOPS, 2002f). At Malindi/Watamu Marine National Park and Reserves, in Kenya, threats include suspended solids impacting coral gardens, and trampling on corals. The main threats include coastal erosion, destructive fishing practices, and overexploitation of fisheries resources, pollution and mangrove clearing for salt works at Ngomeni Mangrove

Swamps. Table 10 shows a summary of the coastal threats, hotspots and sensitive areas along the east African coast of Kenya, Tanzania and Mozambique.

Table 9: Statistics for region 4, East Africa, covering Kenya, Tanzania and Mozambique (extracted from UNESCO-IOC, 2009).

Region's statistics	***Region 4 East Africa***			
Country	**Kenya**	**Tanzania**	**Mozambique**	**Total**
Capital city	Nairobi	Dodoma	Maputo	**-**
Population (2005 est)	35,600,000	38,500,000	20,530,714 (est for 2007)	**94,630,713**
Population growth rate (%)	2.6	2.4	2.3	**2.4**
Total area (km^2)	582,650 Land-569250 Water-13400	945,087 Land- 886 037 Water- 59050	801,590 Land-784,090 Water-17,500	**2,329,327** **Land-1,353,340** **Water- 89,950**
Length of coastline (km)	536	1424	2306 (Africa Pilot, 2006)	**4,266**
GDP per capita (USD 2005 est)	$1240	$744	$1242	**$1,075 (av)**
Coral reef area (2001 est) (km^2)	630	3580	1860	**6070**
Mangrove area (2005 est) (km^2)	500	1250	3902	**5652**
Marine protected areas (2007 est) (km^2) (% of total territorial waters)	783 (5.8 %)	1514 (39 % est)	2803 (4.0 %)	**5100 (48.8 %**
Capture fisheries prod. (2006 est) (metric tones)	158,684	110,000	42,536	**311,220**
Aquaculture fisheries prod. (2006 est) (metric tonnes)	1012	13	1174	**2199**

In **Tanzania**, pollution is the major threat to hotspots, while sensitive areas are threatened by overexploitation; destructive fishing practices, and modification/loss of ecosystems (Figure 38; Table 10; ACOPS, 2002g). The extent and costs of the impacts is often under-estimated or has not been determined. Damage due to strong wave action is common on exposed fringing reefs and on the seaward side of patch reefs and islands all along the coast of Tanzania; however, there is no evidence of increase in storms over the years (ACOPS, 2002g).

In **Mozambique**, key coastal issues, hot spots and sensitive areas identified by a group of experts are summarized in Table 10, adopted from ACOPS, 2002h while Figure 39 shows the location of hot spots and sensitive areas for the Mozambique coast. Hotspots in Mozambique include Maputo and Beira areas. Mozambique Island is a sensitive area on the Mozambique coast.

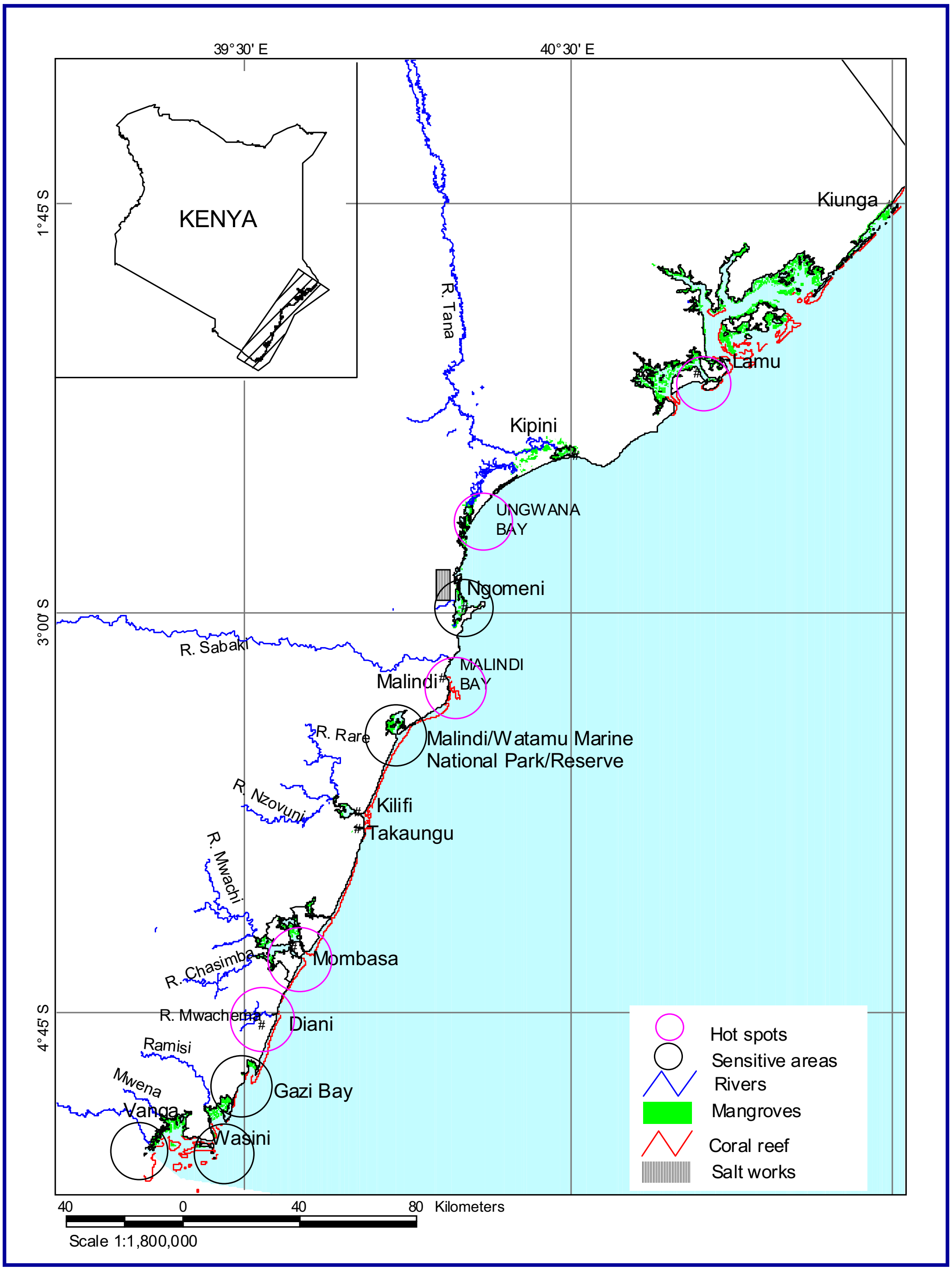


Figure 37: Coastal ecosystems, hot spots and sensitive areas along the Kenya coast (ACOPS, 2002f).

Mozambique Island is a historic world heritage site as proclaimed by UNESCO in 1990. The small island has a population density of around 12,000 people per km^2 and is showing signs of resource overuse (ACOPS, 2002a). The 100 km of coastal stretch between Inhaca

Island and Ponta do Ouro, is mainly characterized by sandy beaches which need protection from coastal erosion (ACOPS, 2002a).

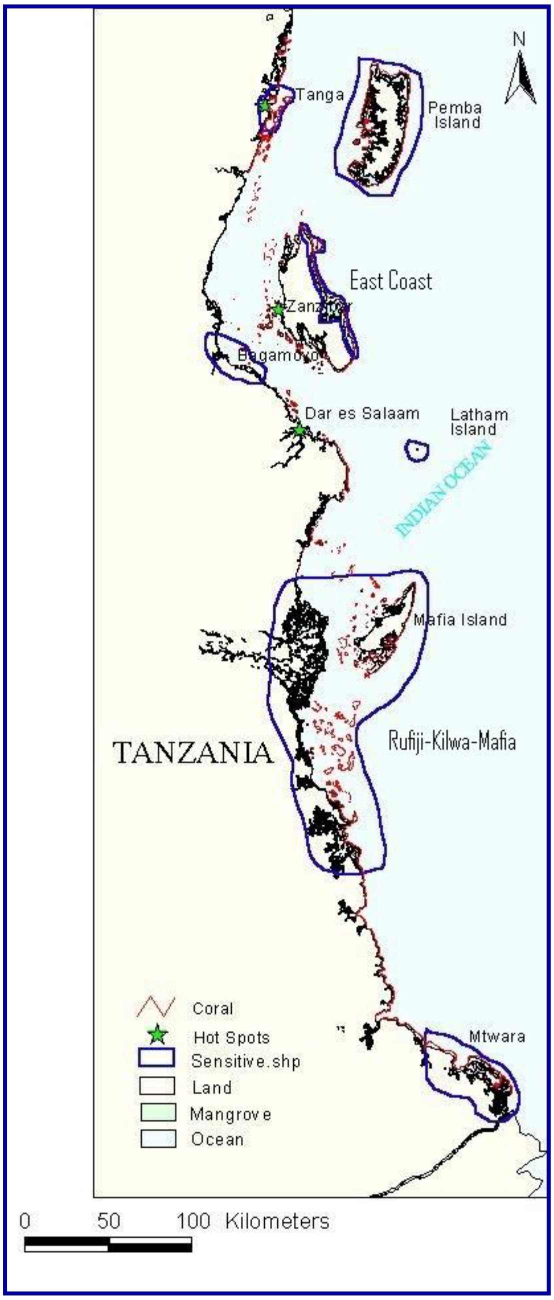


Figure 38: Priority hot spots and sensitive areas along the Tanzanian coast (ACOPS, 2002g).

1.2.4.1 Sea-level rise and coastal erosion

The east African coast is impacted by coastal erosion and sea-level rise. In Kenya, coastal erosion has been observed at Diani Reef, Shanzu-Bamburi area, Gazi and along some locations in Malindi Bay. Figure 40a shows impact of coastal erosion along a section of the Kenyan coast.

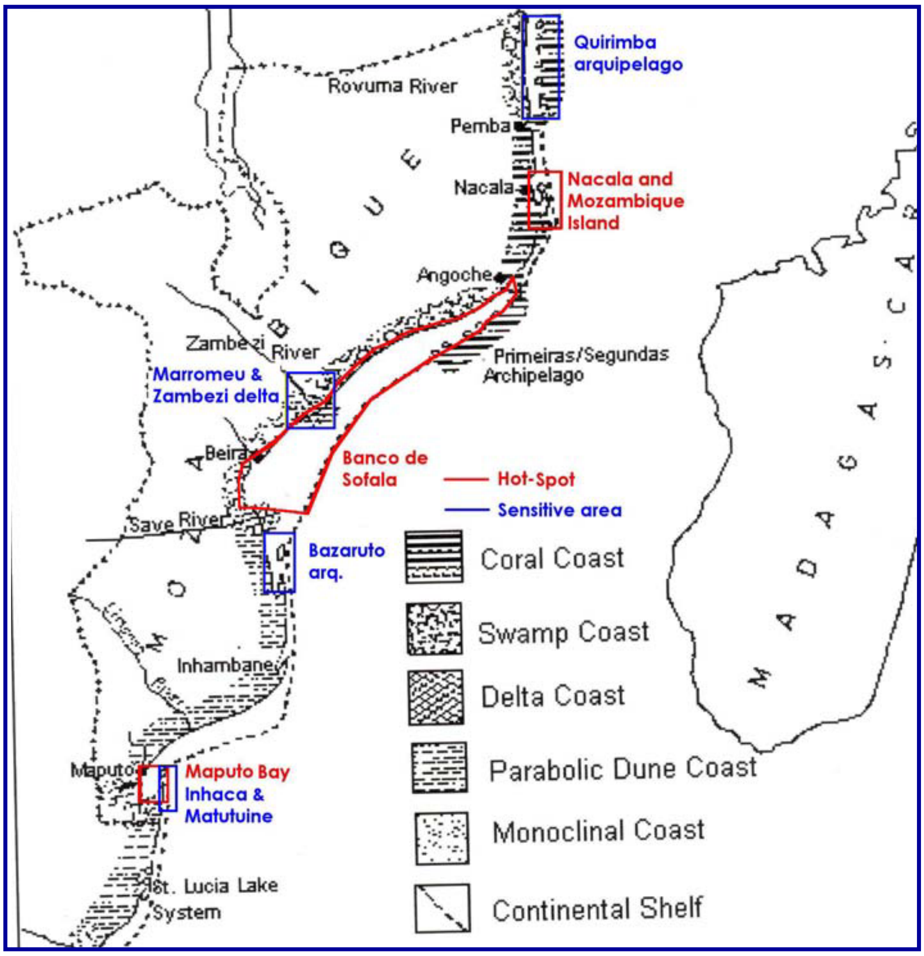


Figure 39: The Mozambique coast showing the location of hotspots and sensitive areas as well as coastal environments. The dashed line represents the 200 m depth (ACOPS, 2002h).

In Tanzania, coastal erosion is one of the major threats to the stability of the coastal zone linked to the modification of habitats. Hotspots include Dar es Salaam, Tanga, Mtwara and Zanzibar (ACOPS, 2002a). A study conducted on sea-level rise indicates that a 1 m rise in sea level would permanently flood about 500 km^2 of land, most of which is wetlands (ACOPS, 2002a). Inundation would claim about 250 km^2 for 0.5 m of sea-level rise and about 490 km^2 for 1m rise of sea level (ACOPS, 2002a). Future erosion rates were projected using the Bruun Rule for Dar es Salaam in response to global warming and accelerated sea-level rise of 1 m to about 9 km^2 (ACOPS, 2002a).

Table 10: Coastal threats, hotspot and sensitive locations along Region 4 countries (compiled from ACOPS, 2002f, g and h reports).

Coastal threats	***Hotspot locations***	***Sensitive locations***
Kenya		
Coastal erosion	Shanzu-Bamburi area, Diani, Gazi Bay, some locations in Malindi, Watamu	Gazi Bay
Over-exploitation of fisheries resources and destructive fishing practices	Mombasa inshore waters, Ungwana Bay, Malindi Bay, Diani Reefs	Vanga Creek, Wasini Channel, Gazi Bay
Pollution from industrial and household deposits	Mombasa, Malindi, Lamu	Watamu, Vanga
Sediment discharge from River Sabaki	Malindi Bay	
Mangrove destruction	Mombasa, Gazi Bay,	Ngomeni- mangrove clearing for salt works
Tanzania		
Modification/loss of ecosystems due to storms	All along the Tanzanian coast	Rufiji-Mafia-Kilwa complex Tanga coastal area Bagamoyo
Destructive fishing practices		Rufiji-Mafia-Kilwa complex Tanga coastal area Bagamoyo
Over-exploitation		Rufiji-Mafia-Kilwa complex Tanga coastal area Bagamoyo
Microbiological pollution	Dar es Salaam city Zanzibar municipality Tanga municipality	Bagamoyo, Lindi and Mtwara
Coral bleaching	Tanzanian coast, Zanzibar coast	
Mozambique		
Coastal flooding, abnormal river runoff, foods, droughts		Bazaruto Archipelago Quirimbas Archipelago Inhaca and Matutuine area Marromeu and Zambezi Delta
Coastal erosion, depletion of mangroves, destruction of corals and sea grass beds)	Nacala Bay and Mozambique island	
Over-exploitation of fisheries resources (shrimp resources, demersal fisheries)	Maputo Bay, Sofala Bank	Bazaruto Archipelago Quirimbas Archipelago Marromeu and Zambezi Delta
Destructive fishing practices (use of mosquito nets, dynamite, fish poisoning)	Sofala Bank	Bazaruto Archipelago Quirimbas Archipelago Marromeu and Zambezi Delta

Aerial videotape-assisted Vulnerability Analysis (AVVA) together with ground-truthing exercise for Dar es Salaam suggested an area of about 12 km^2 of land would be lost for a 1 m rise in sea level. This land loss would claim buildings and other structures valued at about US$ 52.8 million and US$ 90.8 million for 0.5 m and 1.0 m of sea-level rise, respectively (ACOPS, 2002a). Expected storm surges of 5 m would bring a damage of over US$ 211 million for Dar es Salaam (ACOPS, 2002a).

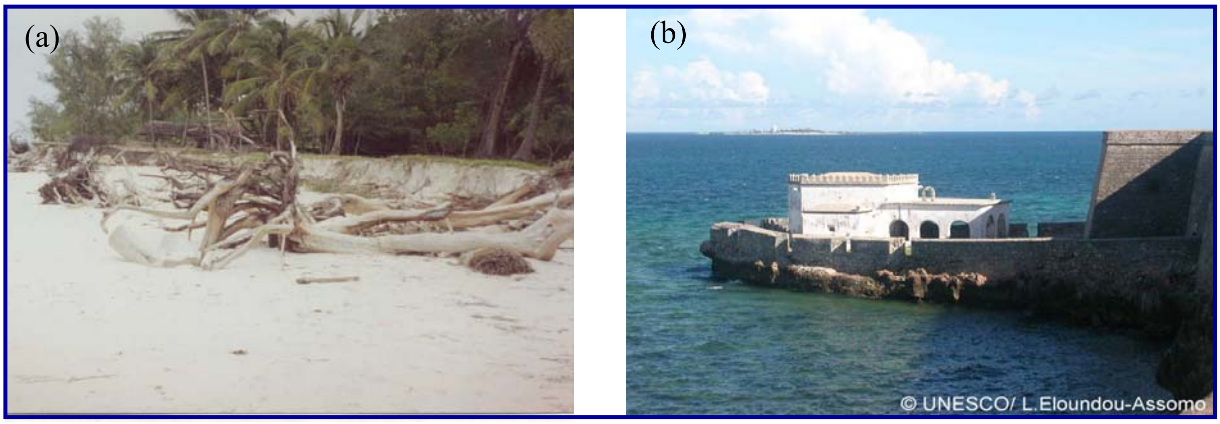


Figure 40: Examples of coastal erosion in Region 4. (a) Loss of coconut plantations as a result of coastal erosion along Diani Reef, Kenya (Photos taken in April 2005 by P. Abuodha). (b) Island of Mozambique, UNESCO World Heritage site since 1991, is threatened by coastal erosion (Theiss, 2009a).

In Nampula Province, north Mozambique coast, coastal erosion has led to saltwater entering a fresh water swamp killing the swamp forest vegetation (*Pers. Comm.* G. Botha). The South African coast was hit hard by the September 2009 equinox spring tides which coincided with swell created by a cyclone in the Mozambique Channel. This event caused massive coastal erosion on the South African coast and created similar problems on the Mozambique coast (*Pers. Comm.* G. Botha). Climatic change can lead to loss or rapid deterioration of tangible heritage. An example is provided by the fortified city on the Island of Mozambique, inscribed on the World Heritage List in 1991. The site is famous for its remarkable architectural unity which is maintained by the consistent use, since the 16th century, of traditional building techniques, building materials and decorative principles. The cyclone Jokwe on 7 and 8 March 2008 caused considerable damage to the fortress's coral base and defensive walls (Theiss, 2009a). Figure 40b shows Island of Mozambique, which is threatened with sea-level rise.

Rates of erosion and deposition at the entrance of the Chinde inlet, Mozambique, are shown in Table 11. During the period 1951-1962, the shoreline accreted by about 150 m. Overall the southern margin of the Chinde inlet eroded by about 1300 m within a period of 56 years from 1927 to 1983 (Table 11; ACOPS, 2002h).

Table 11: Rates of coastline changes at the Mouth of Chinde Inlet, Mozambique (positive values indicate coastline retreat (erosion) and negative values indicate coastline advance (accretion) (ACOPS, 2002h).

Period	***Southern margin (Chinde)***		***Northern Margin (Ponta Liberal)***	
	Advance/retreat (m)	**Average (m yr^{-1})**	**Advance/retreat (m)**	**Average (m yr^{-1})**
1927 -1941	1000	71	-2520	-180
1941 - 1951	200	20	-50	-5
1951 - 1962	-150	-14	500	45
1962 -1983	250	12	-	-
Total/average	**1300**	**22**	**-2070**	**-37**

1.2.4.2 Precipitation and Floods

In Kenya, the floods of 1997/98 cost about US$ 1.8 billion of damage property and infrastructure (World Bank, 2009a).

Major floods were rare in Mozambique for most of the 20th century (except for the 1978 event – see below), but increased in frequency and severity towards the end of the 20th century. In Mozambique, the rainy season of October 1999 - March 2000, intense rainfall occurred throughout southern Mozambique, northern South Africa and southeast Zimbabwe, with many places having their worst rains for 20-50 years (NEF, 2005). Rainfall over the South of Mozambique was almost triple average levels, and precipitated the flooding of January to March 2000 which killed 700 people (NEF, 2005). South Africa also suffered an increase in severe rainfall and floods during this period, with the number of rain events rising dramatically after 1971. Zululand University has attributed these changes to global warming; stating that in Mozambique, the latter part of the 20th century has witnessed an upward trend of extreme rainfall consistent with global warming and locally increased sea temperatures in the Mozambique Channel (NEF, 2005).

Table 12: Impacts of floods on the Zambezi Basin in Mozambique in 1978 (ACOPS, 2002h)

Location	***Zambezi basin in Mozambique***
Year	**1978**
Displaced people (number)	219,000
Destroyed cropland (ha)	59,400
Destroyed homes (number)	72,000
Destroyed school buildings (number)	155
Destroyed shops (number)	8
Others destroyed infrastructures	roads, railways
Total cost, floods damage and relief works	**101 Million US$**

Table 12 shows the impacts of floods on the Zambezi Basin in 1978 which displaced 219, 000 people and cost damages amounting to US$ 101 million (ACOPS, 2002h). In Bazaruto, Mozambique, rainfall of up to 2000 mm flooded the old raised mangrove swamp in the middle of the island causing much erosion to the foredunes on the west of the island (ACOPS, 2002h). The incision created a small temporary estuary. The major issues affecting the Mozambique coast are related to marine and coastal environments are both natural and anthropogenic. For example, fresh water shortage and/or abnormal floods are associated to both climatological factors such as droughts and floods as well as to human activity such as effect of the dams and deviation of water for irrigation purposes. Floods are of particular concern for Mozambique because it is a low-lying country and so very vulnerable to floods (see Figure 1 and Figure 39). In the beginning of 1999 the country experienced the heaviest flood ever observed in almost a century (ACOPS, 2002h). In Mozambique the floods of 2000 cost about US$ 550 million of damage property and infrastructure resulting into 1.5 % reduction of GDP growth rate (ACOPS, 2002h).

1.2.4.3 Coastal population and livelihoods

Kenya has a land area of 580,000 km^2. The coastline is 580 km. The total Kenyan population is over 34 million people (2006 Census), increasing by 25 % in 10 years (World Bank, 2008). Coastal population is 9 % of the total with a growth rate of 3.1 %, which is higher than the national average at 2.9 % (ACOPS, 2002f). The density of the population living within 100 km of the coastal zone varies from 10 to 280 persons/ km^2 (ACOPS, 2002f).

Tanzania's land area is 883,749 km^2. In Tanzania, 25 % of the national population live in the five coastal regions which cover about 15 % of the country's total land area. 21.1 % of the population live within 100 km from the coast (ACOPS, 2002g). According to the 2001 estimate, Tanzanian population was 36 million with a population growth rate of 2.61 % (ACOPS, 2002g). In the region of Dar es Salaam, the population density has been estimated as 17,450 people/km^2 compared to the national average of 36 people /km^2. However, in other coastal regions such as Lindi population density is less than 12 people/km^2 (ACOPS, 2002g).

In Mozambique, according to the 2000 census, annual population growth rate is 2.3 %. Around 42 % of the population live in coastal zone. The average population density in the coastal area is about 40 people/km^2, against overall population density of 20 persons/km^2 in the country (ACOPS, 2002h).

1.2.4.4 Fisheries, Resource Management and Biodiversity

Coral reefs in the Indian Ocean experienced massive bleaching in 1998, with over 50 % mortality in some regions (Cugusi and Piccarozzi, 2009). Damage to coral reef systems has far-reaching implications for fisheries, food security and tourism. Coral bleaching leads to increased erosion as the ability of the reef to dissipate wave energy is reduced (Cugusi and Piccarozzi, 2009). Coral reefs – already at the level of 30 % of depletion on the Indian

Ocean Coasts (IPCC, 2007b) − are expected to bleach in many areas on an annual basis, from which most will never recover. This will seriously affect tourism.

In **Kenya**, the annual prawn landings are associated with about 70-80 % by-catch in weight, which includes juveniles of commercial fish species and other marine organisms that include sea turtles and dugongs. Bottom trawling for peneid prawns adversely impact on productivity and fish diversity, while excessive by-catch and its disposal is an additional issue of concern. In Kenya, overexploitation of mangroves has resulted in shoreline instability resulting in damage to coastal infrastructure and several settlements. Further over 50 km^2 of mangroves have been cleared in the Ngomeni Swamps for the construction of solar saltpans (ACOPS, 2002a). Potential impacts as a result of mangrove clearing include a decline in recruitment for the Malindi Bay and Ungwana Bay fisheries.

In Kenya, as a consequence of the high loads of suspended solids discharged through the Sabaki estuary, the coral ecosystem extending into the Malindi National Marine Park and Reserve has been negatively impacted (ACOPS, 2002a) as evidenced by the bleaching of corals. As a result of the high sediment discharges and deposition, the sea-grass communities have been impacted on negatively resulting in a reduction of species diversity (ACOPS, 2002a).

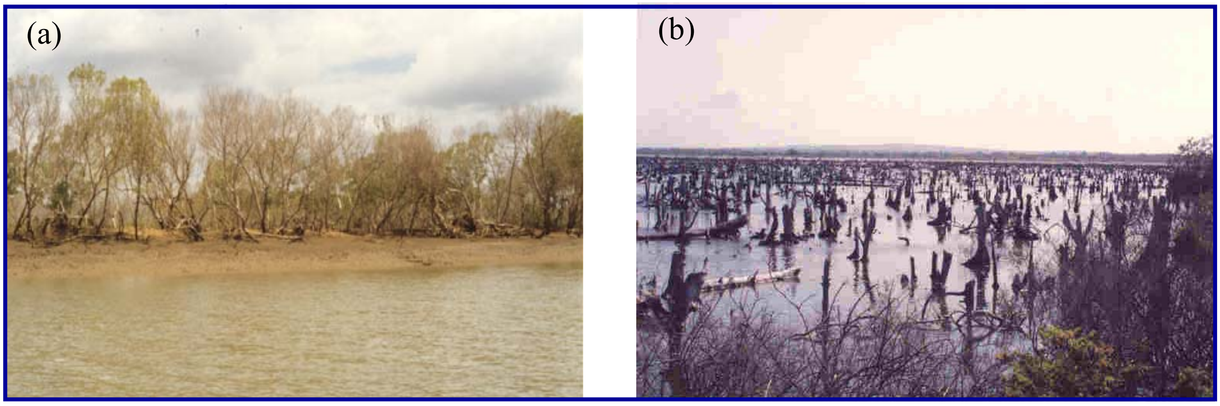


Figure 41: Impact on coastal resources along the Kenyan coast. (a) Mangrove siltation related to the 1997-98 El- Nino at Mida Creek, near Mombasa, Kenya. (b) Overexploitation of Mangroves at Gazi Bay, Kenya in 1992.

In Kenya, Mombasa and Lamu inshore waters, Ungwana and Malindi bays and Diani Reefs areas are threatened with over exploitation of trawling and artisanal fisheries through destructive fishing practices. The 1997 - 98 El Nino Southern Oscillation phenomenons was reported to bleach 50 - 90 % of corals along the entire Kenya Coast and coral mortalities ranged between 66 and 80 % in shallow waters (ACOPS, 2002f). Figure 41a shows the effects of the 1997/78 El Nino event on the mangroves along a section of the Kenyan coast. 70 % of the Kenyan coastal fishing community depends on the coral reef fishery for 80 % of its income (ACOPS, 2002f). However, fisheries and other living resources along the Kenyan coast are on the decline. `For example, between 1998 and 1999, fish catch declined by a total of 1,612 tones while the fishing effort remained high especially in the artisanal sector (ACOPS, 2002f). There is decline in aggregate marine fishery revenues amounting to US$ 450,000. Between 1998 and 1999, the decline in fishery revenue was higher at US$ 742,857, corresponding to a decline in fish catches during that period (ACOPS, 2002f). Figure 41b shows over-exploitation of mangroves at Gazi Bay in Kenya which resulted in severe coastal erosion.

In **Tanzania and Mozambique** destructive fishing practices are closely linked to degradation of particular ecosystems such as: coral reefs, mangrove forests and seagrass beds, while in Kenya they are most frequently associated with overexploitation of fisheries and other living resources (ACOPS, 2002a). The main destructive fishing methods include the use of mosquito nets (60 % of the total beach seines in Mozambique have mosquito netting), beach seining, use of poison (primarily traditional plant poison, cyanide and DDT), use of dynamite, artisanal speargun fishing, and other particular harvesting methods (ACOPS, 2002a). Dynamite fishing is notably highlighted as having caused more damage than any other fishing practices in fragile ecosystems such as coral reefs. While these activities may seem anti-social and even suicidal in their destructive, short-term nature, it may well be that behind them lies desperation resulting from the fall in catches referred to in the previous paragraph.

In **Tanzania**, mangrove over-harvesting has led to fragmentation and modification of many of the forests. Besides the common uses for firewood, charcoal and building, burning of live coral in kilns is practised in some parts of the country. Other threats have been the conversion of mangrove habitats for solar salt pans, agriculture, aquaculture, hotels, roads and housing (ACOPS, 2002a).

In Tanzania, during March to May 1998, coral bleaching was reported on all parts of the coast with variable severity (IOC-UNESCO, 2009). In Zanzibar, over 60 % of the scleractinian corals showed signs of bleaching (IOC-UNESCO, 2009). Surveys conducted after the 1998 coral bleaching event showed that 25 % of the coral reefs of Tanga had been damaged or killed by the bleaching (ACOPS, 2002g). In Tanzania, mangrove exploitation has increased to the extent that the mangroves are threatened with destruction in some areas while other mangrove areas are being converted for commercial purposes (IOC-UNESCO, 2009). Coastal communities are losing in terms of income and mangrove wood for household purposes (IOC-UNESCO, 2009). In Tanzania, decline in fisheries resources has been reported in several instances. For example, the total annual catch in Zanzibar has decreased from about 20,000 tons in 1988 to less than 13,000 tons in 1998 and pelagic fisheries in Zanzibar has significantly declined from 600 tons in 1986 to 91 tons in 1997 (ACOPS, 2002g).

In **Mozambique**, the reefs and coastal waters provide the livelihood for the 6.6 million people (42 % of the population) who live in the country's coastal communities and the fisheries earn 40 % of the county's foreign revenue (ACOPS, 2002h). Coral reefs are responsible for 70 % of fisheries catches and provide a hugely important nursery ground for many species of other commercially important marine species. In addition the reefs present the main attraction for the growing coastal tourist industry in Mozambique.

In Mozambique, about 3.6 % of mangroves were lost between 1972 and 1990 with higher rates around the cities (ACOPS, 2002h). Mangroves on the Nampula coast are being harvested and that could lead to damage as sea-level rises. Overexploitation of fishery resources of high commercial value occurs almost in all the fishing grounds all over the country. The most affected fish resource is the shallow water shrimp (ACOPS, 2002h). Its total annual production in Sofala Bank dropped from about 10,000 tons in late 70's to about 6,000 tons in late 80's and recovered to about 9,000 tons in 2000. Figure 42 shows a decline in catch rates of shrimps in Sofala Bank, Mozambique.

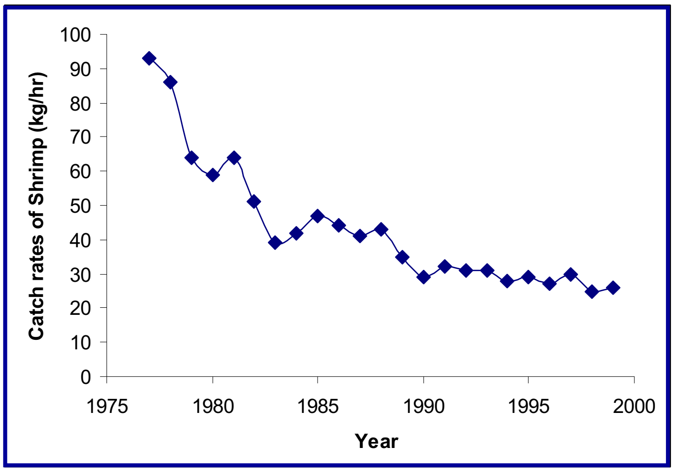


Figure 42: Decline of catch rates of Shrimp in Sofala Bank, Mozambique coast (Data source: ACOPS, 2002h).

1.2.4.5 Coastal Tourism

According to the available statistics, all the countries in the Eastern African region rank amongst the least developed countries in the Africa. The degradation of coral reefs, which has been reported in the countries of Kenya, Tanzania and Mozambique brings about potential negative effects upon the tourism industry, resulting in decreased number of tourists and hence decreased earnings and increased poverty of the coastal communities.

In Kenya, inflation is very high (at 7.4 % by June 1998) and external debt was over 60 % of GDP by 1997 (ACOPS, 2002a). Kenya receives about 800,000 visitors annually and tourism accounts for 12.5 % of Kenya's GDP. Tourism has been the main earner of foreign exchange and coastal tourism accounted for about 65 % of the total tourism earnings (ACOPS, 2002a). However sustainability of the industry has been adversely affected by inadequate planning and unmanaged growth. This coupled with shoreline erosion, degradation of the coastal systems and declining water quality has seriously affected coastal tourism development. In relation to tourism in Kenya, most coral reef decline has occurred in the popular tourists' destinations of the Diani Reefs and in the Mida Malindi tourist paradise area of Watamu (ACOPS, 2002a).

Tourism in Tanzania accounts for 8.7 % of the GNP with 400,000 tourist arrivals annually. It is generally felt that there are only limited tourism impacts, so far, on the coast (ACOPS, 2002a). In Tanzania, GDP real growth declined from 6.2 % in 1990 to 4 % in 1998 (ACOPS, 2002a).

Mozambique's economy was expanding fast; it grew from an average of 6.7 % a year during 1987-95 to 10 % a year during 1996-98, whilst inflation declined from about 50 % in 1995 to less than 1 % in 1998. Real GDP grew by 11.3 % in 1997 and 12 % in 1998 but then declined 9.7 % in 1999. It was projected to grow 7 % in 2000. The huge floods of 2000 and 2001 in the South and centre of the country, however, represented a setback in this improvement (ACOPS, 2002a). Just as is the case in Kenya, tourism in Mozambique is also dominantly located in the coastal zone. Its GDP contribution to the national economy of Mozambique also shows an increasing trend. But a negative factor in this is the reef damage that has taken place in the south of the country where tourist activities are growing.

1.2.4.6 Fresh water, Food security, Pollution and Sanitation

In east Africa the disposal of untreated sewage poses a threat to several species in the marine and coastal environment; particularly threatened are mangrove habitats. In Mombasa, Kenya only 20 % of the population is connected to a sewage system, but pollution from industrial and domestic sources is limited to the coastal cities of Mombasa, Malindi and Lamu. These are likely to increase with the growing coastal populations. Mombasa inshore waters suffer pollution through oil spills and household waste dumping. The later has since been stopped and the dump site relocated. Sewage sludge is normally dumped at designated sites, often in mangrove areas in Lamu and Mombasa. Some tourist hotels have established their own sewage treatment facilities. However, a number of beach hotels discharge wastewater in inshore water areas, which is a potential problem to sensitive marine habitats.

In **Tanzania,** pollution from various sources is one of the threats for coastal waters and some modification of coral reefs near sources of pollution has occurred (IOC-UNESCO, 2009). The coastal waters off major towns and cities such as Dar es Salaam, Tanga, Mtwara and Zanzibar are thus recipients of untreated municipal and industrial wastes. One of the most pressing issues is the use of mangrove forests as rubbish dumps. In Dar es Salaam, in Tanzania with a population of over 4 million, fewer than 15 % of the households are connected to the central sewage system (ACOPS, 2002a). In fact, about 70 % of the population live in over 40 unplanned communities where uncontrolled disposal of wastewater and solid wastes is a common problem affecting water sources and living conditions (ACOPS, 2002a). Outbreaks of water-borne diseases are thus frequent during the rainy season. Socially, the main underlying causes are poverty and unequal distribution of wealth, inadequate public awareness and general lack of education. Institutionally, the issue is linked to such factors as inadequacy of long-term monitoring data, inadequate scientific/technical capacity, and inadequate enforcement of laws and in some cases absence of regulations.

In **Mozambique**, Maputo is the only city with a central sewage system for collection and treatment of domestic sewage. However, it is estimated that only 50 % of Maputo's sewage is treated leaving the rest of the untreated waste water discharged directly into the coastal waters (ACOPS, 2002a).

1.2.5 Impacts in Region 5 in Western Indian Ocean Islands – Mauritius and Seychelles

The main coastal issues for Region 5 are sea-level rise, coastal erosion, more so because these are island countries and modification of ecosystems. Other issues are floods and coastal tourism. The **Republic of Mauritius** is an archipelago island consisting of a main island, Mauritius, and a group of small islands in the South West Indian Ocean namely Rodrigues, the Cargados Carajos, Agalega, Tromelin and the Chagos Archipelago. The total land area is about 2040 km^2 (ACOPS, 2002i), and the population about 1.2 million. Coastal area use in Mauritius is shown in Figure 43. Seychelles consists of a number of islands totaling 455 km2, with a population of about 80,000.

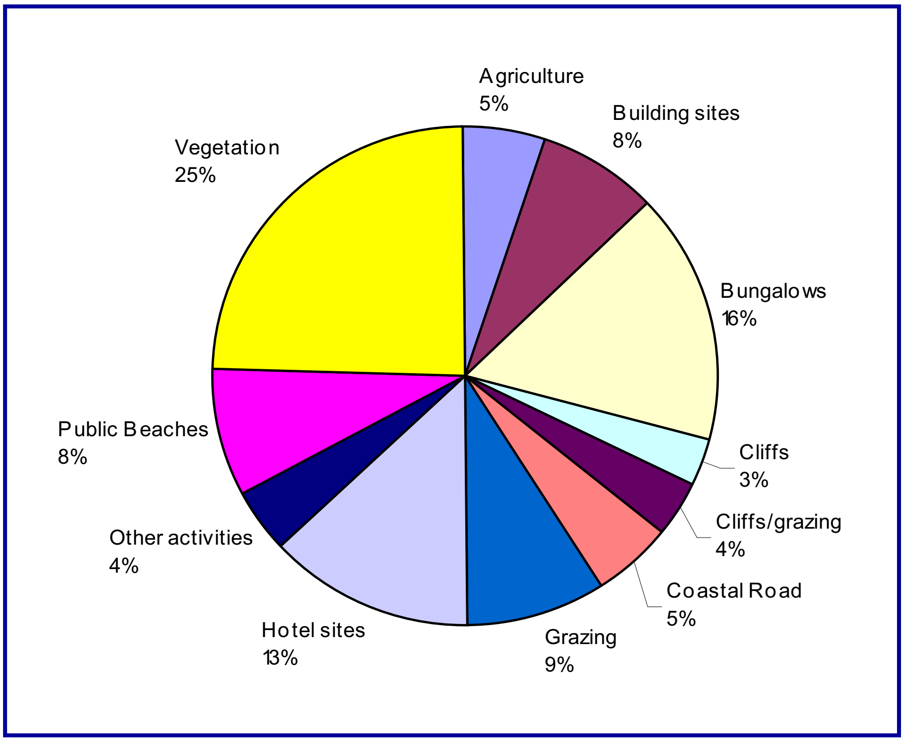


Figure 43: Distribution of coastal land of Mauritius in 1998 (ACOPS, 2002i).

In Mauritius, because of the small size of the island and the resultant proximity of all land to the sea, the entire island can be considered as a coastal zone (ACOPS, 2002i, p. 5). As such, most land-based activities have a direct or indirect impact on the marine environment. Some of the activities directly affecting the marine environment include fishing, beach hotel activities, wetland loss, tourism, sand mining, untreated sewage discharges and agrochemicals. The causal chain analysis conducted in 2001 revealed that coastal urbanization and industries (including the tourism industry) were the main factors behind the three issues, namely:- (i) Modification of ecosystems or ecotones, (ii) coastal erosion and (iii) overexploitation of marine fisheries (ACOPS, 2002a). Figure 44 shows locations in Mauritius that may be affected by climate change.

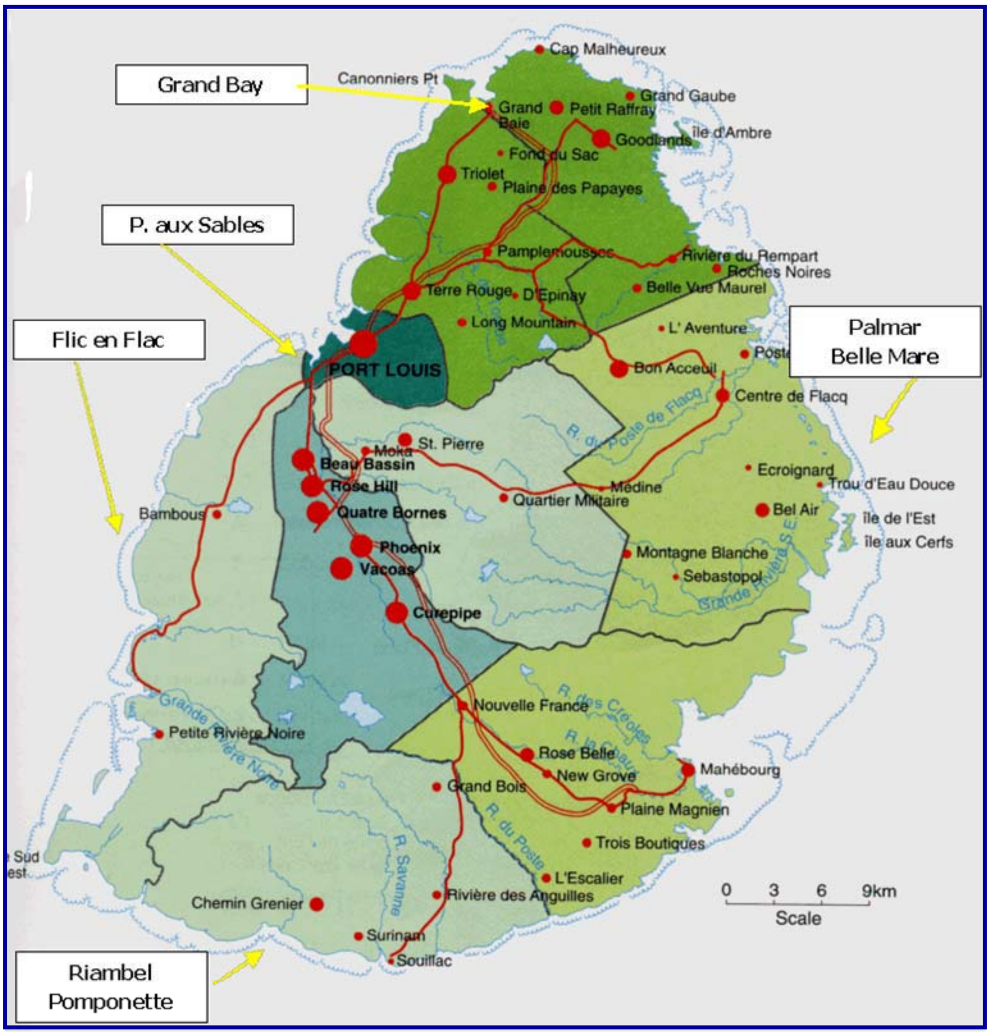


Figure 44: Map showing Mauritian sites that may be affected with climate change (ACOPS, 2002i).

Over the past two decades rapid development has taken place in tourist villages such as Grand Baie and Flic en Flac, and a similar trend towards an unplanned coastal urbanization is also evident in Trou D'eau Douce, Grand Gaube in Mauritius (ACOPS, 2002a). Environmental pressures are further aggravated by the ever-increasing demands of the local community for recreational sites. The marked increase in water sport activities within the lagoons has also contributed to water quality changes.

In **Seychelles**, coastal issues identified to impact on the coastal zone by a group of experts are; (1) pollution, (2) habitat and community modification and (3) sea-level rise (ACOPS, 2002j). La Digue in west coast plateau and east coast Mahe, from north point to Anse Forban, were named as hot spots (Figure 45). Impacts at La Digue are deforestation, loss and modification of wetlands, changes in hydrology such as coastal flooding and shortage of groundwater, increased pollution, and coral bleaching. For east coast Mahe and Praslin Island, the impacts are siltation from land reclamation, and those caused by increased tourists to the park Anse Volbert. Issues include coastal erosion, discharge of wastewater and coral bleaching from elevated sea surface temperatures (ACOPS, 2002j).

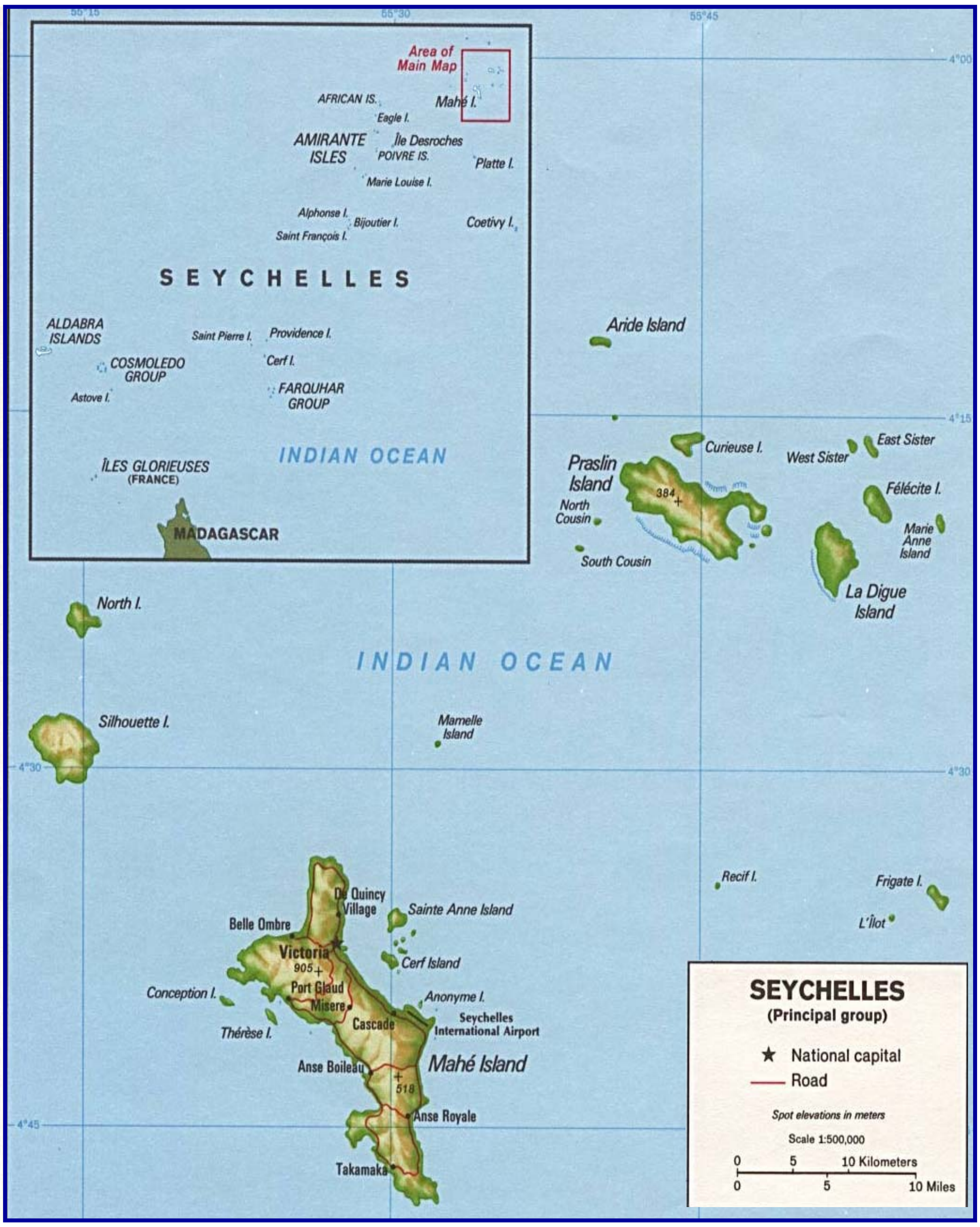


Figure 45: Island archipelago, Seychelles showing hot spots and sensitive areas mentioned in the report (ACOPS, 2002j).

Three locations were identified as sensitive areas which are likely to be subjected to some degradation in the future. These are (1) Port Launay and Baie Ternay Marine Parks, Port Glaud mangroves and islands of Conception and Thérèse, (2) Cosmoledo Atoll and (3) Mahe Wetlands (ACOPS, 2002j). In Seychelles, the threats at Port Launay and the environs include changes in water flow; pollution, modification of ecosystems such as mangroves, coral reefs, seagrass beds; overexploitation of coral reef resources and coral bleaching (ACOPS, 2002i). At Cosmoledo Atoll the threats include illegal fishing, poaching, invasive species, diseases and coral bleaching while at Mahe Wetlands the threats include ecosystem modification, runoff from agriculture and septic tanks, excess siltation, extraction of freshwater and potential salinisation of freshwater marshes from sea-level rise. Table 13 shows the coastal threats, hotspots and sensitive locations.

Table 13: Coastal threats, hotspot and sensitive locations along Region 5 countries (compiled from ACOPS, 2002i and j).

Coastal threats	***Hotspot locations***	***Sensitive areas***
Mauritius		
Modification of ecosystems or ecotones	Grand Baie, Flic en Flac, Riambel-Pomponette	
shoreline change	Flic en Flac, Belle Mare-Palmar, Riambel-Pomponette	
over-exploitation	Grand Baie, Flic en Flac, Belle Mare-Palmar, Riambel-Pomponette	
suspended solids	Grand Baie, Pointe Aux Sables	
chemical pollution	Belle Mare-Palmar, Pointe Aux Sables	
eutrophication	Pointe Aux Sables	
Seychelles		
Pollution (eutrophication)	La Digue in West Coast Plateau, East Coast Mahe (from North Point to Anse Forban)	Port Launay and Baie Ternay Marine Parks/Port Glaud mangroves and islands of Conception and Thérèse, Mahe wetlands
Habitat and community modification of ecosystems and ecotones	La Digue in West Coast Plateau	Port Launay and Baie Ternay Marine Parks/Port Glaud mangroves and islands of Conception and Thérèse, Mahe Wetlands,
Salinisation of freshwater from sea-level rise		Mahe wetlands
Coastal erosion	East Coast Mahe (from North Point to Anse Forban)	
Coral bleaching	East Coast Mahe (from North Point to Anse Forban)	Port Launay and Baie Ternay Marine Parks/Port Glaud mangroves and islands of Conception and Thérèse, Cosmoledo Atoll
Over-exploitation of fisheries resources		Port Launay and Baie Ternay Marine Parks/Port Glaud mangroves and islands of Conception and Thérèse, Cosmoledo Atoll

1.2.5.1 Sea-level rise and coastal erosion

In **Mauritius** at Belle Mare the coastline eroded by about 5 m forming erosion scarps of 1.8-2.0 m in 1988 under the influence of tropical cyclones (ACOPS, 2002i). Coastal erosion is mainly caused by natural factors such as cyclones, storms and tidal surges accounting for about 50 % of the erosion. Anthropogenic causes through the creation and widening of reef passes and the construction of artificial structures on shores account for 15 % and 35 %, respectively. During cyclone Hollanda on the 10th February, 1994 the beach line at Flic en Flac retreated by 2 m while the northern end of Flic en Flac retreated by 5 m (ACOPS, 2002i). In Mauritius, coastal erosion was identified as a major issue for one hot spot at Flic and Flac and two sensitive areas, Palmar and Belle Mare and Riambel and Pomponette, resulting in shoreline change. The worst sites for erosion are Pomponette and Riambel where a beach retreat of 4 m has been recorded during a period of 3 years (ACOPS, 2002a). Similarly sea walls built to delimit properties or mitigate the action of waves are adversely affecting the lagoon and shoreline. The compounded effects of the various hard structures such as seawalls inevitably are having long-term consequences on the shoreline and the lagoon itself (ACOPS, 2002a).

In **Seychelles**, an estimated 85 % of human settlements and infrastructure are situated on the coastal zones of Seychelles' main granitic islands, and would be severely affected by rising sea levels (ACOPS, 2002j). With a rise in sea-level, Seychelles will experience an increase in intensity of cyclones and storm surges. Coastal erosion is affecting two hot spots; the East Coast of Mahe and Anse Volbert (ACOPS, 2002j).

1.2.5.2 Precipitation and Floods

In **Seychelles,** flood plains occupy 237 km^2 or 53 % of the entire surface area (ACOPS, 2002j). The estimated total area at risk from flooding on Mahe Island is about 23 km^2, where population density exceeds 1040 people/km^2 (ACOPS, 2002j). Over 74.8 % of the surface area is very hilly with slopes exceeding 25 %. In August 1997, extreme rainfall conditions led to floods and landslides last experienced more than a hundred years ago, in 1862. Between 13 and 16th August, there were exceptionally heavy and continuous rains over Seychelles resulting in floods and landslides. More than 500 houses were damaged the cost of which was estimated at US$ 2.0 million (ACOPS, 2002j). Almost 40 % of the roads were damaged, the cost estimated at US$ 1.5 million (ACOPS, 2002j).

1.2.5.3 Coastal population and livelihoods

In **Mauritius,** the population was estimated at 1.2 million in 2000 (ACOPS, 2002i). 100 % of the population live along the Mauritius coast. Average annual population growth rate from 1998 to 2015 is projected to be 0.79 %. The coastline of Mauritius is about 200 km long with a lagoon area of 243 km^2 (ACOPS, 2002i). In Mauritius, the coastal areas are used for numerous activities as shown in Figure 44.

Seychelles is an archipelago consisting of 115 granite and coral islands that occupy a land area of 445 km^2 (ACOPS, 2002j). The country's population was around 80,410 in 1999 with 90 % of the population living on Mahe Island. The country has a per capita income of around US$ 7,000 (ACOPS, 2002j). In Seychelles, the population growth rate was estimated at 0.49 % in 2001. 100 % of the people live along the coastal zone. The population density along the coast is 176 people/km^2. 90% of Seychelles coastline is exposed to Southeast monsoon and the Northwest trade winds. Altogether there are about 482 km of beaches and about 118 km of rocky coasts (ACOPS, 2002j). Seychelles has experienced very rapid social and economic development over the past 20 to 30 years, with

GDP per capita increasing from US$ 3,600 in 1975 to US$ 7,192 in 1998 (ACOPS, 2002j). An estimated 85 % of human settlements and infrastructure are situated on the coastal zones of main granitic islands and thus would all be vulnerable to an increase in sea-level rise and extreme weather conditions (ACOPS, 2002j). Sea-level rise would result in the displacement of a large portion of the population and coastline recession would also affect infrastructure and biodiversity. These potential impacts will induce problems in the tourism sector.

1.2.5.4 Fisheries, Resource management and biodiversity

In both Mauritius and Seychelles, the popular tourist diving sites are suffering from overuse by tourists. As a result of tourism activities, coral cover is reported to have diminished through trampling, damages by boats, clearing for ski-lanes resulting in changes in the biota, decline in fish catch and the proliferation of unwanted marine organisms (ACOPS, 2002a). This has had a socio-economic impact in the decrease in fishery resources and catch. The use of mooring buoys, which can protect the fragile and sensitive coral reef marine resource by minimising the occurrence of such damages, is therefore necessary.

1.2.5.5 Coastal Tourism

In both Mauritius and Seychelles, all tourism is described as coastal, contributing 5 % to Mauritius's GDP and 12.7 % to that of Seychelles (ACOPS, 2002a). In Seychelles and Mauritius where tourism represents a major source of employment and foreign exchange, beachfronts have eroded away leading to the destruction of coastal infrastructures. In some areas in Mauritius for example unplanned and unwise land use developments by the tourism industry itself, have resulted in higher erosion rates. Tourism ranks as the third major industry in Mauritius with an annual tourist arrival of over 500,000 which visit the island mostly for its beaches. The rapid growth in the tourism sector, the limited coastal belt used by a variety of stakeholders and unplanned constructions have given rise to a number of problems including coastal erosion, shoreline change and the loss and modification of ecosystems and ecotones.

In Seychelles, the impacts of tourism are visible in the form of anchor damage to coral reefs, sale of coral and shells to tourists, increased organic pollution in the vicinity of coastal hotels, beach erosion caused by hard structures of hotels. The growth in the tourism industry has largely been the foundation for the remarkable advances in national socio-economic development achieved by Seychelles. In order to sustain previous levels of socio-economic development, and also to meet the rising expectations of the population, Government has found it necessary to promote the further growth of the tourism industry. In particular, the targeted growth in tourist arrivals from 130,046 in 2000 to around 190,000 by the year 2010 will place a huge strain on the carrying capacity of coastal areas that are considered as prime sites for tourism development, particularly on the main islands of Mahe, Praslin and La Digue, as well as on natural resources such as water (ACOPS, 2002a). A major threat of such growth in the tourism industry is related to the modification and loss of sensitive marine and coastal habitats as a result of continued beachfront development (ACOPS, 2002a).

1.2.6 Summary of regional impacts from the DIVA database

The European project, DINAS-Coast (Dynamic and Interactive Assessment of National, Regional and Global Vulnerability of Coastal Zones to Climate Change and Sea-Level Rise) has developed the Dynamic and Interactive Vulnerability Assessment (DIVA) tool to help policymakers interpret and evaluate coastal vulnerability (McFadden et al., 2007). The DIVA tool enables analysis of a range of mitigation and adaptation scenarios. It comprises a global DINAS-Coast database of natural system and socioeconomic factors, relevant scenarios, a set of impact-adaptation algorithms and a customised graphical-user interface (Vafeidis et al., 2006). Factors that are considered include erosion, flooding, salinisation and wetland loss. The DIVA tool enables users to produce quantitative data on a range of coastal vulnerability indicators for user-selected climatic and socio-economic scenarios and adaptation policies, for future sea-level rise (Vafeidis et al., 2006).

The DIVA database has been used to analyse and compare different impacts for the studied regions that may result from climate change and sea-level rise in the coastal zone. Parameters considered for impact are coastal population density (Figure 46), coastal segment vulnerability (Figure 47), GDP per capita (Figure 48) and coastal tourism added value (Figure 49). More information is provided in the caption of the individual figures. The DIVA database consists of global data for almost all coastal regions stored for different parameters from coastline segment level upwards. Different countries have different numbers of coastal segments depending on how variable the coastline is and on the length of the coastline (Table 14). In all cases the A1FI (Fuel intensive) high-regionalised scenario has been applied. It is important to note that the DIVA database consists of old data collected in the 1990s and may not reflect the current situation. The assumption is that the trends then have continued into the current which is not true in all cases. The outputs should therefore be interpreted and applied with caution.

Table 14: Number of coastal segments for regions and individual countries within the DINAS-Coast Consortium 2006 database.

Region 1	***Region 2***	***Region 3***	***Region 4***	***Region 5***
Cape Verde - 8	Ghana- 22	Cameroon - 11	Kenya - 9	Mauritius - 2
Mauritania -12	Togo – 4	Gabon - 6	Tanzania - 39	Seychelles - 2
Senegal - 34	Benin – 7	Congo - 1	Mozambique- 50	
Gambia - 12	Nigeria - 51			
Guinea-Bissau - 15				
Total - 81	**Total - 84**	**Total - 18**	**Total - 98**	**Total - 4**

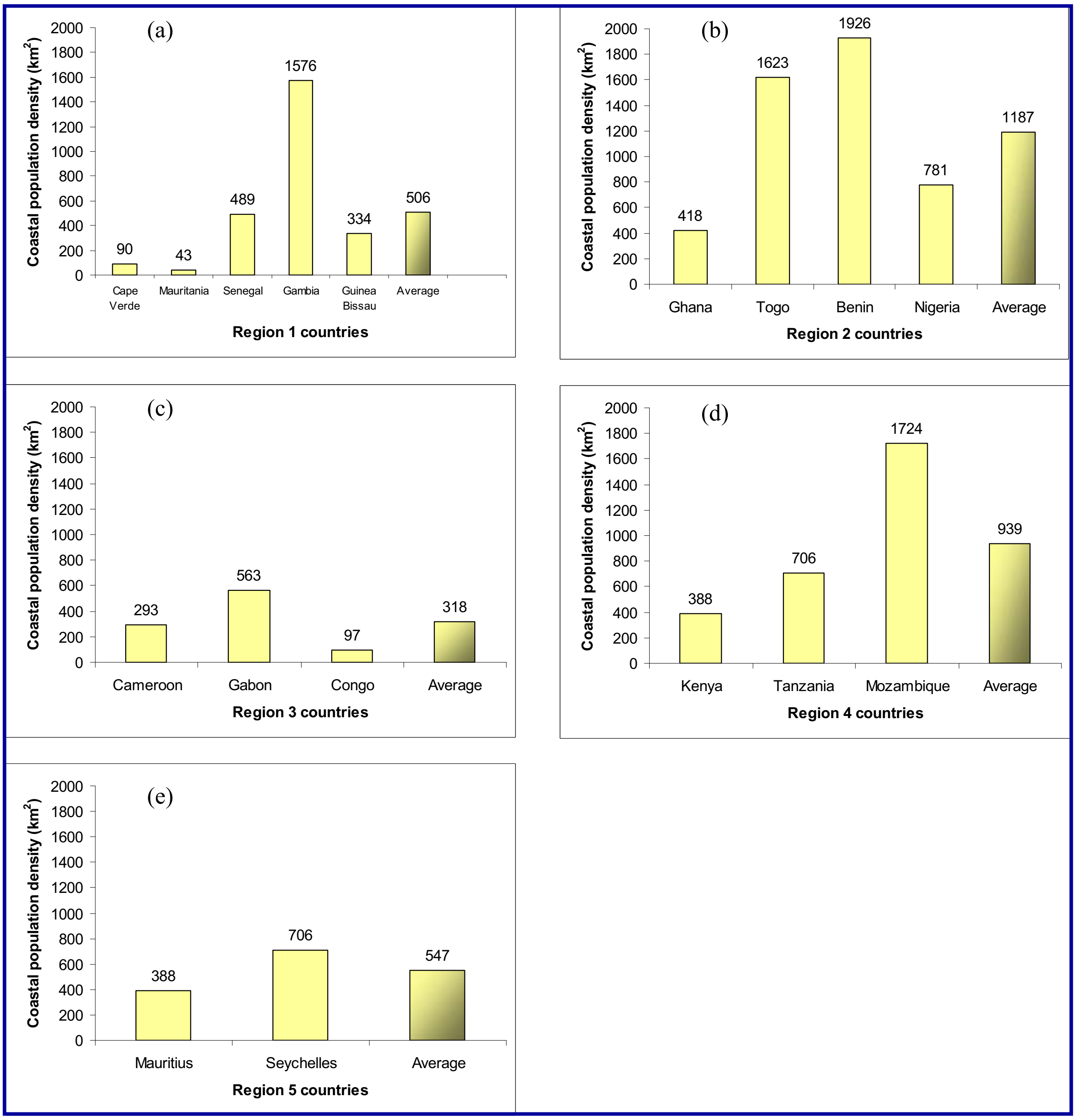


Figure 46: Summary of coastal population density for the studied regions and their averages. (a) Region 1 showing Gambia to have the highest population density of 1576 people/km^2. (b) Region 2 showing Benin to have the highest population density of 1926 people/km^2. (c) Region 3 showing Gabon to have the highest population density of 563 people/km^2. (d) Region 4 showing Mozambique to have the highest population density of 1724 people/km^2. (e) Region 5 showing Seychelles to have the highest population density of 706 people/km^2. Overall, Region 2 is the most densely populated followed by Region 4. For individual countries, Benin has the highest population density followed by Togo (data source: the DINAS-Coast Consortium 2006 database). With an average coastline segment length of about 70 km, the current resolution of the DIVA tool is likely to be too coarse in many cases to provide decision support to coastal planners and managers (Vafeidis et al., 2006).

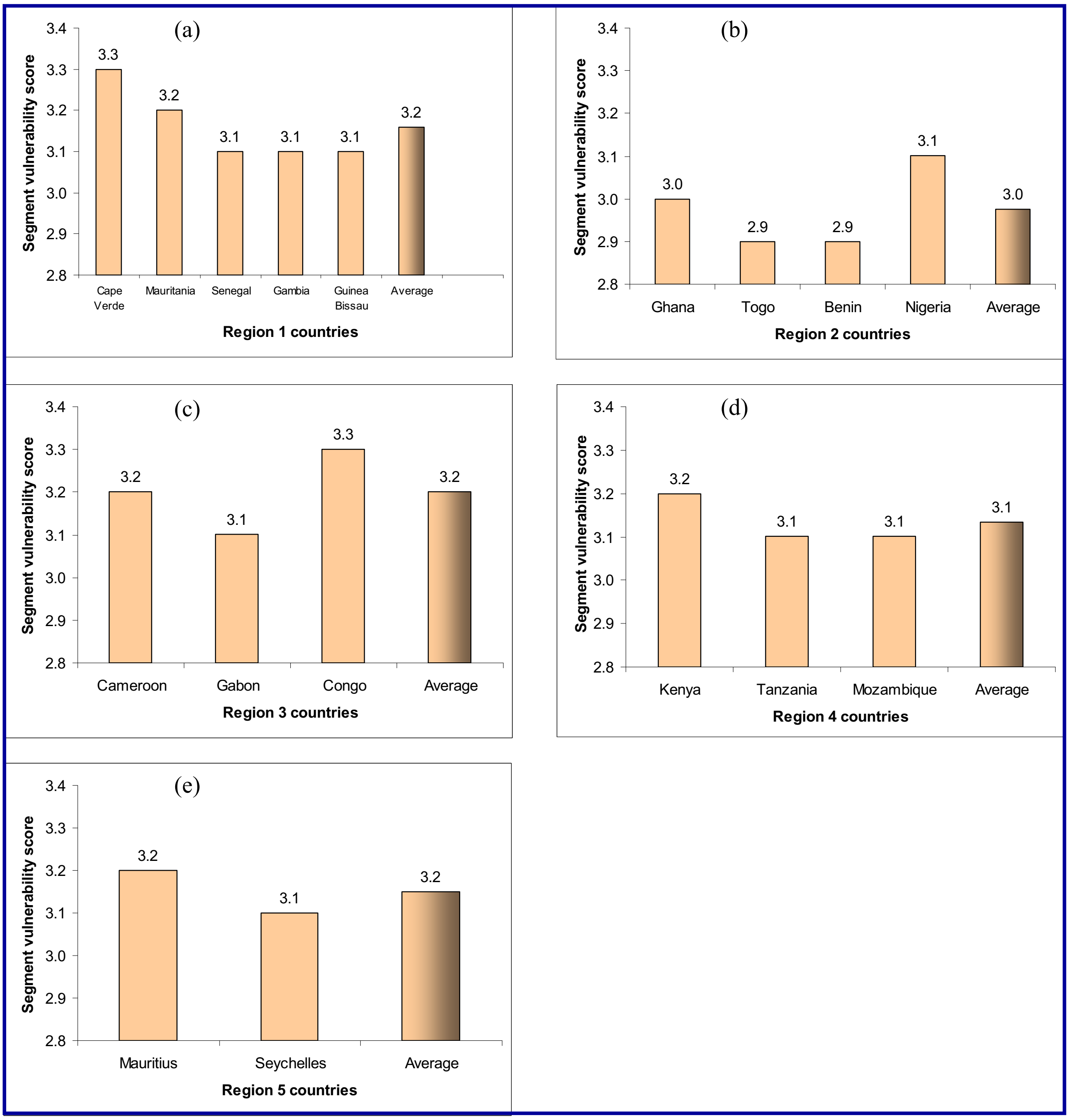


Figure 47: Summary of segment vulnerability scores for the studied regions and their averages. (a) Region 1 showing Cape Verde to have the highest segment vulnerability score of 3.3. (b) Region 2 showing Nigeria to have the highest segment vulnerability score of 3.1. (c) Region 3 showing Congo to have the highest segment vulnerability score of 3.3. (d) Region 4 showing Kenya to have the highest segment vulnerability score of 3.2. (e) Region 5 showing Mauritius to have the highest segment vulnerability score of 3.2. Overall, Regions 1, 3 and 5 have the same segment vulnerability score of 3.2 followed by Region 4. For individual countries, Cape Verde and Congo have the highest segment vulnerability score of 3.3 (data source: the DINAS-Coast Consortium 2006 database). The current segment vulnerability score of an individual wetland reflects the combined forcing resulting from four environmental forcing factors: sediment supply weight (0.3), accommodation space weight (0.2), relative sea-level rise weight (0.5) and tidal range weight (0.5). Each weight represents both the importance of a particular parameter and the confidence with which it can be estimated at the global scale (Vafeidis et al., 2006).

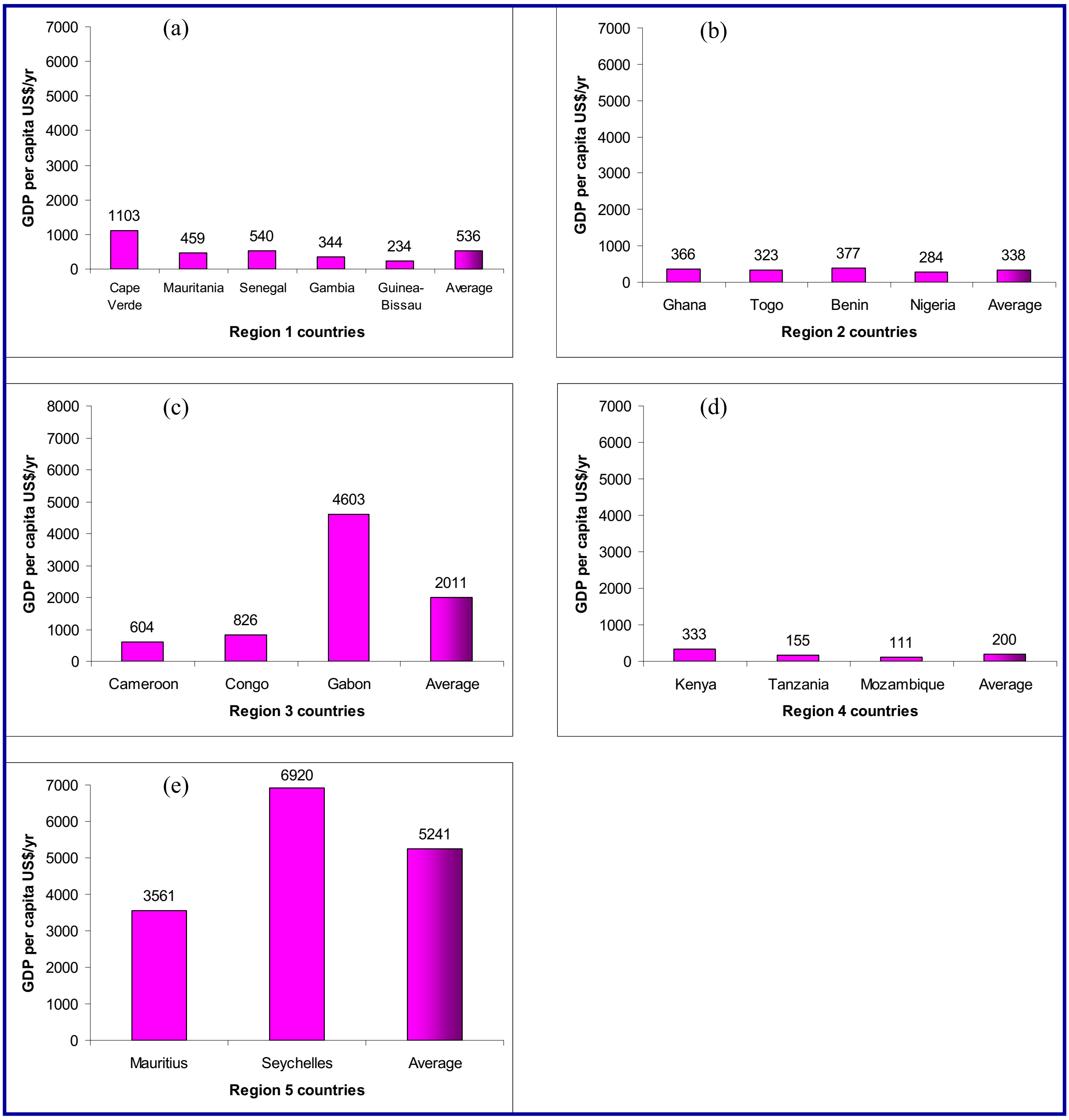


Figure 48: Summary of GDP per capita for the studied regions and their averages. GDP per capita in 1995 is the average annual income in 1995 US$ market exchange rate per person per year. It is therefore the average per capita income in the country (Vafeidis et al., 2006). (a) Region 1 showing Cape Verde to have the highest GDP per capita of 1103 US$ per year. (b) Region 2 showing Benin to have the highest GDP per capita of 377 US$ per year (c) Region 3 showing Gabon to have the highest GDP per capita of 4603 US$ per year. (d) Region 4 showing Kenya to have the highest GDP per capita of 333 US$ per year. (e) Region 5 showing Seychelles to have the highest GDP per capita of 6920 US$ per year. Overall, Region 5 has the highest GDP per capita of 5241 US$ per year followed by Region 3. For individual countries, Seychelles, followed by Gabon have the highest GDP per capita for the studied countries (data source: the DINAS-Coast Consortium 2006 database). Note the figures are presented on the same y-axis scale for easy comparison.

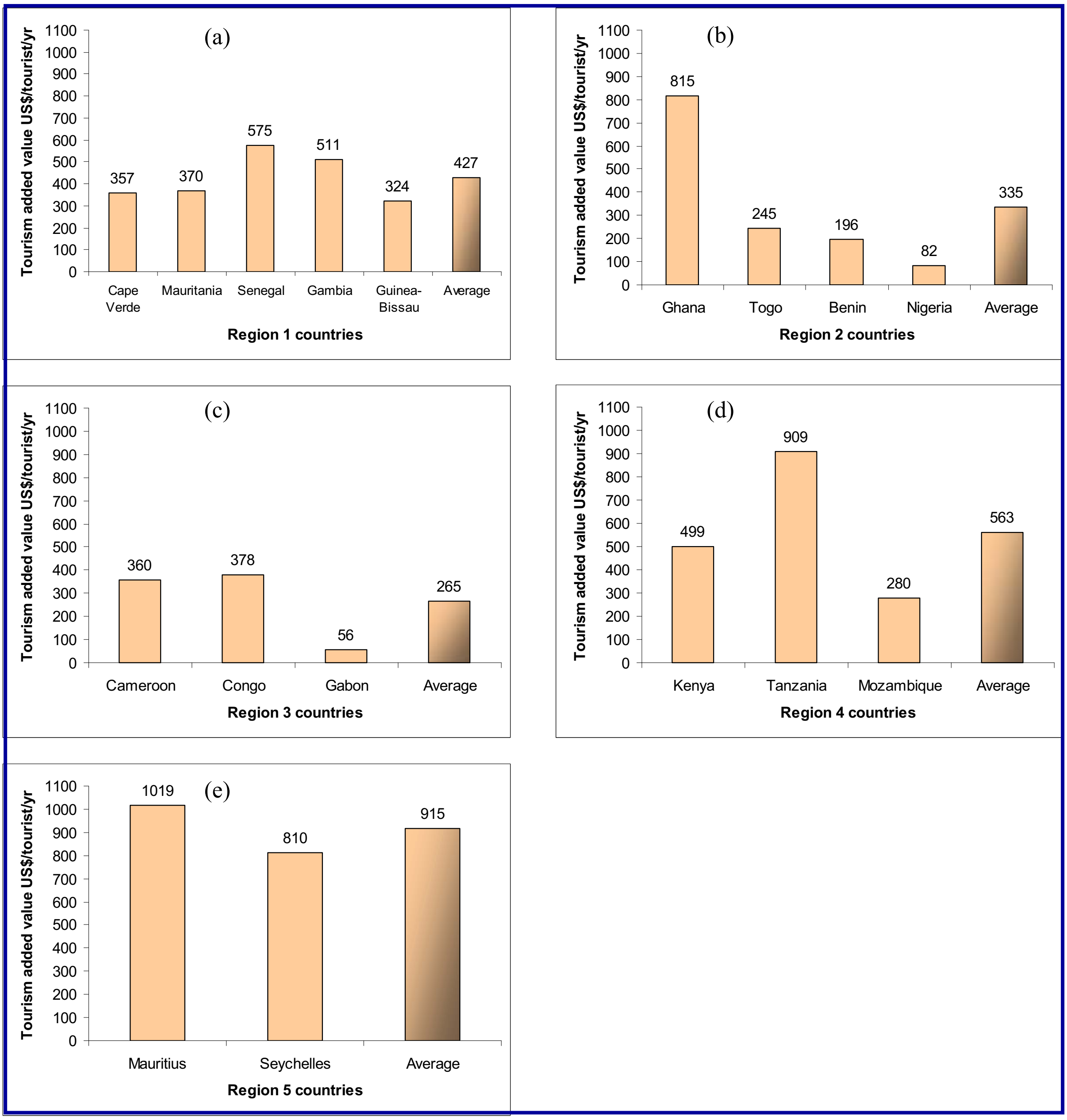


Figure 49: Summary of tourist added value for the studied regions and their averages. This is added value in US$ per tourist in 1995 for each country. (a) Region 1 showing Senegal to have the highest tourist added value of 575 US$/tourist/yr. (b) Region 2 showing Ghana to have the highest tourist added value of 815 US$/tourist/yr. (c) Region 3 showing Congo to have the highest tourist added value of 378 US$/tourist/yr. (d) Region 4 showing Tanzania to have the highest tourist added value of 909 US$/tourist/yr. (e) Region 5 showing Mauritius to have the highest tourist added value of 1019 US$/tourist/yr. Overall, Region 5 has the highest tourist added value of 575 US$/tourist/yr followed by Region 4. For individual countries, Mauritius, followed by Ghana has the highest tourist added value for the studied countries (data source: the DINAS-Coast Consortium 2006 database).

1.2.7 Adaptation measures against climate change impacts on coastal population

The impacts described in the sections 1.2.1 to section 1.2.6 have shown that climate change is happening and that the coastal zones of many countries are affected. It is not necessary to wait years for more research on climate change before adaptation can be undertaken. Adaptation needs to be employed immediately in African countries and communities on a much greater scale. Africa is one of the most vulnerable continents to climate change and climate variability, a situation aggravated by the interaction of 'multiple stresses', occurring at various levels. Africa's major economic sectors are vulnerable to current climate sensitivity, with huge economic impacts, and this vulnerability is exacerbated by existing developmental challenges such as endemic poverty, complex governance and institutional dimensions; limited access to capital, markets, infrastructure and technology; ecosystem degradation; and complex disasters and conflicts. These in turn have contributed to Africa's weak adaptive capacity, increasing the continent's vulnerability to projected climate change (Boko et al., 2007, p. 435). There follow some examples of adaptation carried out or being planned in each of the 5 regions.

Adaptation in Region 1 in West Africa – Cape Verde, Mauritania, Senegal, Gambia and Guinea Bissau

In spite of the low adaptive capacity of Africa, people have developed traditional adaptation strategies to face the great climate interannual variability and extreme events. This reinforces the observation that local people have perceived, interacted with, and made use of their environment with its meagre natural resources and changing climatic conditions in what could be seen as practical coping mechanisms. This is particularly true for the drought prone area in the Africa Sahel region, which is susceptible to frequent climatic hazards (Elasha et al., 2006, p. 33). However, the fact that the reported number of people affected by climate related disasters and dying as a result of them in Africa between 1993-2002 was 136,590,000 and 250,000 people, respectively during the Soudano-Sahelian drought of 1968-1973, together with 12 million cattle that died from starvation, means that somehow traditional adaptation measures are not sufficient to face climate change, especially on the unprecedented scale anticipated under global warming (Elasha et al., 2006).

In **Cape Verde**, for a 1 m sea-level rise, protection costs are projected to be US$ 18 million (ACCC, 2006b) (equivalent to 0.16 % of Cape Verde's Gross National Product) (ACCC, 2006b). In Senegal, the costs of protecting important lands would be between US$ 255 to US$ 845 million for a sea-level rise of 1 m (ACCC, 2006b; Figure 50).

In **Gambia**, adaptation measures to water stresses during droughts and high rainfall variability include irrigation water transfer and water harvesting and storage (Elasha et al., 2006). Protection measures for the Gambia coastal zone were estimated to cost between US$ 300,000 to US$ 400,000 in 1998 (ACCC, 2006b). Land value in the Gambia between Banjul and Kololi Beach Hotel is estimated at about US$ 217 million (ACCC, 2006b). Due to the high rate of erosion, individual hotels are undertaking protection measures for their own properties. Kairaba Beach Hotel for example has spent US$ 400,000 on sand bagging using geotextile sandbags whilst Senegambia Hotel spent about US$ 330,000 in 1998 to protect its beach by a sandbagging method (ACCC, 2006b). Kololi area in Gambia has undergone beach nourishment with 1 million m^3 of sand, widening the beach by 120 m (ACCC, 2006b). At Banjul Point to Toll Point eroded land has been reclaimed with about 2.7 million m^3 of sand (ACCC, 2006b). Coastal protection structures include wooden groynes, beach refill, revetments and sandbags. For the Gambian coastline a total value of US$ 0.96 million was estimated to be at risk with the average total relocation cost is about US$ 12000 per km.

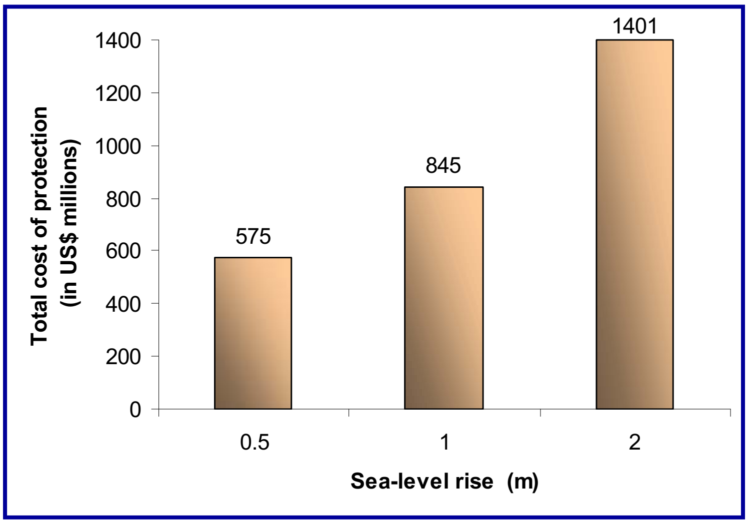


Figure 50: Projected total cost of protection for different sea-level rise scenarios for the Senegal coast (Data source: ACCC, 2006b).

Table 15: Climate change impacts on water resources status and management functions and corresponding adaptation measures in the Gambia (National Climate Committee, 2003).

	Expected impacts		***Adaptation measures***
1	Inundation of flood-plain areas	a	construction of embankments/dikes
		b	relocation of threatened activities
		c	construction of flood-proof housing
		d	institutional reforms
2	Saline intrusion into aquifers	e	relocation of abstraction points
		f	changes in pumping policies of fully penetrating/deep wells/boreholes
3	Increased saline intrusion length	g	flow regulation
		h	licensing and permits for withdrawal of river water for irrigation
4	Changes in river salinity regime	i	flow regulation
5	Decrease in groundwater recharge	j	increase water column in wells

In **Gambia**, groynes are a major technique of beach stabilisation. Trunks of palm trees are jetted into the beach and tied together with timber. In the Gambia, the existing groynes in the area between Laguna Beach and Palm Grove Hotels and Banjul Point (see Figure 23d) need to be rehabilitated. To reduce the flow of sand to the port and ferry terminal, a long and high terminal groyne need be constructed at Banjul Point between State House and Albert Market (National Climate Committee, 2003, p. 64). Table 15 summarises the expected climate change impacts and adaptation measures to countervail their potentially adverse consequences in Gambia.

Adaptation in Region 2 in West Africa – Ghana, Togo, Benin and Nigeria

In **Ghana**, migration has been used as a method of adapting to climate change. Key policy responses to environmental migration include social protection support to migrants, as Ghana is doing with its northern development strategy; and considering rights-based resettlement for populations directly displaced by climate impacts, such as sea-level rise (EACC study team, 2009).

In **Togo**, groynes have been found to be very effective in stabilizing eroded beaches (National Climate Committee, 2003). Due to coastal erosion problems, coastal protection using breakwaters and groynes has been constructed along a 12 km coast between Kpeme-Gumukope and Aneho (Figure 51; UNESCO-IOC, 2009).

Figure 51: Coastal protection at Aného, Togo (Photo taken in 1988 by G. Rossi; UNESCO-IOC, 2009).

Adaptation in Region 4 in East Africa – Kenya, Tanzania and Mozambique

In **Kenya**, coastal adaptation is practised by constructing seawalls along the coastline where impacts of coastal erosion have been greatly felt (Figure 52a and b). However, these are not sufficient to withstand the erosion problems anticipated.

In **Tanzania**, the major issues of concern identified for the coastal zone such as destruction of mangrove areas and coastal erosion are currently all being taken care of by the government and coastal communities. The seawall at Stone Town in Forodhani, Tanzania had to be raised by 75 cm (top row of boulders) to prevent ocean water from flowing over the wall during high spring tides (ACOPS, 2002g; Figure 52c). In Tanzania, the cost of protecting the entire coastline from sea-level rise is projected to be US$ 7 billion (Theiss, 2009a).

Figure 52. Examples of coastal adaptation for Region 4. (a) A seawall constructed along Malindi Beach to protect against coastal erosion is showing failure. (b) Boulder protection against coastal erosion along Bamburi Beach, near Mombasa (Photos were taken in April 2005 by P. Abuodha). (c) UNESCO World Heritage, Stone Town of Zanzibar, Tanzania (Theiss, 2009a).

In **Mozambique**, groynes are constructed from reinforced concrete, on the Maputo shoreline as a method of adapting to climate change. For every US$ 1 spent on preparing for disaster, a further US$ 7 is saved in the cost of recovering from it. Yet, as in the case of Mozambique, requests for resources to prepare for disasters before the great floods in 2000 went seriously under-funded, leaving a huge disaster-relief bill to be paid after the floods (NEF, 2005).

Adaptation in Region 5 in the Western Indian Ocean Islands – Mauritius and Seychelles

In order to adapt to the impacts of sea-level rise, Seychelles has implemented Integrated Coastal Zone Management (ICZM) which ensures a holistic approach in coastal zone management. Measures include constructing of seawalls and armours; pillar housing and raised foundation level (Elasha et al., 2006). Also, for fisheries management, the closed seasons control agreements with foreign fleets and establishment of marine reserves (Elasha et al., 2006).

Adaptation costs against climate change impacts on coastal population

A number of examples follow of projected costs of adaptive measures. Figure 53 shows sea flood costs for African coastal zones.

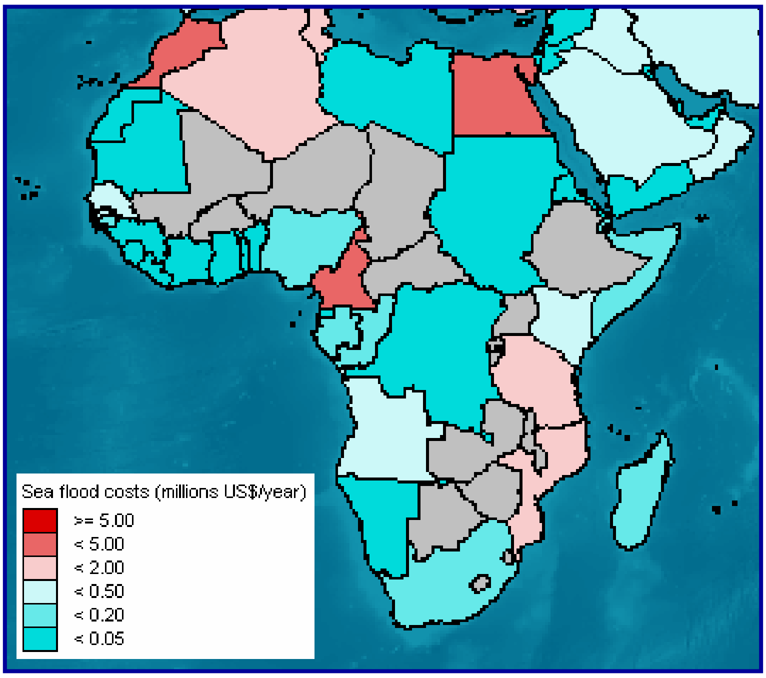


Figure 53: An overview of sea flood costs in million US$ as a result of sea-level rise in African coastal zone. North, western and central Africa is projected to have the highest costs as a result of sea floods (source: DINAS-Coast Consortium 2006 database).

Adaptation costs for vulnerable coasts are much less than the costs of inaction. Without adaptation, the high-end sea-level rise scenarios, combined with other climate changes (e.g., increased storm intensity), are as likely as not to render some islands and low-lying areas unviable by 2100, so effective adaptation is urgently required (Nicholls et al., 2007, p. 317). In the absence of effective protection, coastal flooding could grow tenfold or more by the 2080s, to affect more than 100 million people per year, due to sea-level rise alone.

The consequences of sea-level rise will be far greater for developing countries, and protection costs will be higher, relative to those for developed countries. In the cities of Alexandria, Rosetta and Port Said on the Nile delta coast of Egypt, for example, a sea-level rise of 50 cm could result in over 2 million people abandoning their homes, the loss of 214,000 jobs and the loss of land valued at over US$ 35 billion (Nicholls et al., 2007, p. 339).

Results from a study by the Economics of Adaptation to Climate Change (EACC) study team in 2009 is summarised here to give indications of the cost of adaptation to climate change for the Sub-Saharan Africa, and therefore to the studied regions. The EACC analysis considered two main types of impact; coastal erosion, and sea and river flooding and submergence. They also considered three adaptation approaches: a. beach nourishment, particularly in areas with high tourism revenue; b. sea and river dike construction; and c. port upgrade. The EACC study was undertaken using two scenarios. A drier scenario from the Commonwealth Scientific and Industrial Research Organization, CSIRO (Australia) and a wetter scenario from the National Centre for Atmospheric Research, NCAR. The results from these ‘dry’ and ‘wet’ scenarios for the Sub-Saharan Africa are summarised here.

Average annual coastal adaptation costs and residual damage, 2010-2050 for deltaic countries including Mozambique and Nigeria is US$ 4.5 billion [for 2005 prices, no discounting] while for other developing countries the cost will be US$ 14.1 billion, [2005 prices, no discounting] (EACC study team, 2009). Adaptation costs for small island states are more than US$ 1 billion per year, or over 6 % of the total cost of adaptation. In relative terms, the adaptation costs are higher still, averaging 1 % of GDP in small island states over 2010-2050 compared with 0.03–0.1 % for other developing countries (EACC study team, 2009, p. 48).

The study estimates the cost between 2010 and 2050 of adapting by 2050 to an approximately 2^{o}C warmer world. A drier scenario requires lower total adaptation costs (US$ 16.9-18.1 billion per year for the Sub-Saharan Africa) than does the wetter scenario (US$ 18.1-18.9 billion per year), largely because the sharply lower costs for infrastructure, outweigh the higher costs for water and flood management (Figure 54). In both scenarios, infrastructure, coastal zones, and water supply and flood protection account for the bulk of the costs. Infrastructure adaptation costs are highest for the wetter scenario, and coastal zones costs are highest for the drier scenario (EACC study team, 2009).

On a sector breakdown, the highest costs for Sub-Saharan Africa are water supply, flood protection and agriculture (EACC study team, 2009). The EACC study found the infrastructure sector to account for the largest share of adaptation costs in the world. Sub-Saharan Africa experiences the greatest increase in infrastructure costs over time with its adaptation costs rising from US$ 1.1 billion per year for 2010 2019 to US$ 6 billion per year for 2040- 2049 (EACC study team, 2009). Adaptation to climate change is critical on the coastal zones. The EACC study shows that coastal adaptation costs are significant and vary with the magnitude of sea-level rise, making it essential for policymakers to plan flexibly to account for the uncertainty. In the water supply sector, the EACC study shows that water supply and flood management rank as one of the top three adaptation costs in both the wetter and drier scenarios, with Sub-Saharan Africa footing by far the highest costs. Reckoned as a share of GDP, Sub-Saharan African will have the highest cost of adaptation in all cases (Figure 55).

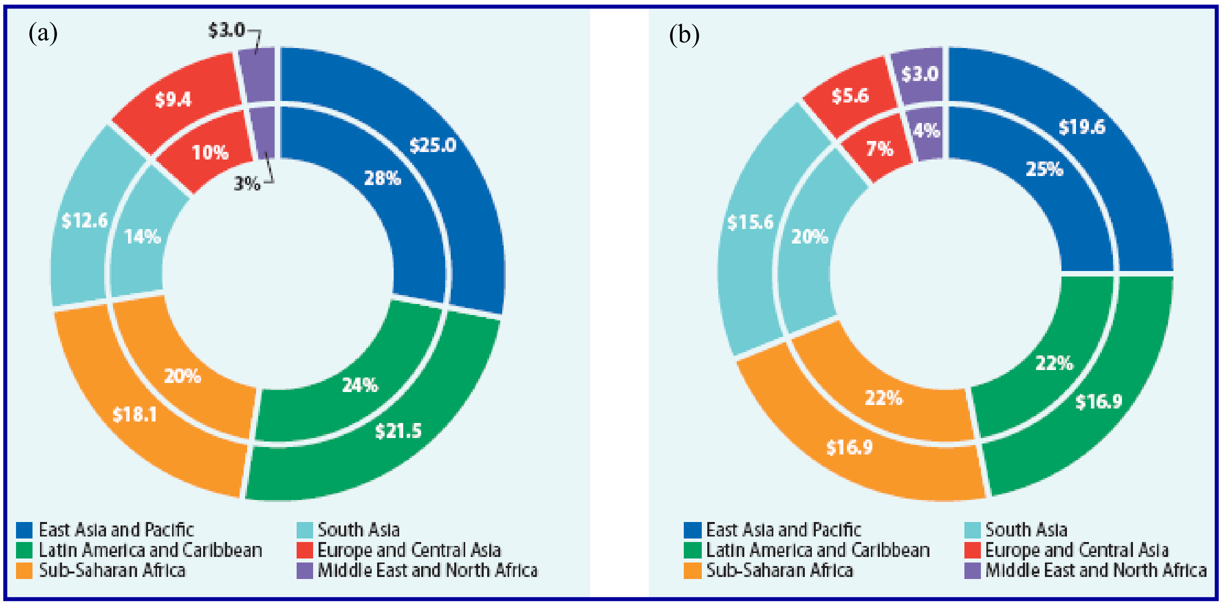


Figure 54: Total annual cost of adaptation and share of costs for (a) wetter scenario, by region (US$ billions at 2005 prices, no discounting). Sub-Saharan African forms 20 % of the total costs amounting to US$ 18.1 billion per year. (b) For drier scenario, by region (US$ billions at 2005 prices, no discounting. Sub-Saharan African forms 22 % of the total costs amounting to $US 16.9 billion per year (EACC study team, 2009).

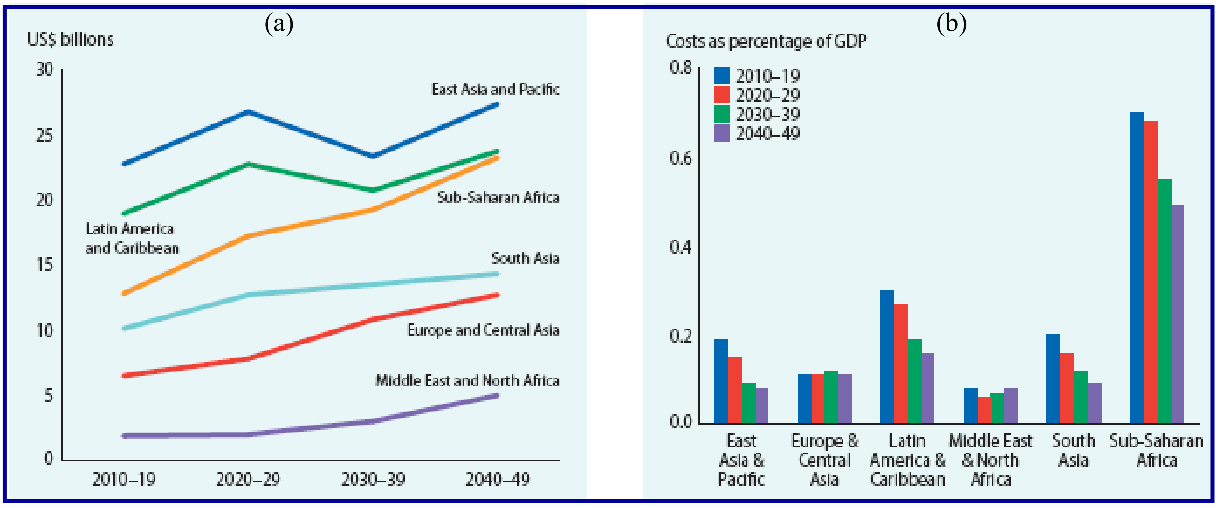


Figure 55: Total annual cost of adaptation for (a) wetter scenario, by region and decade (US$ billions at 2005 prices, no discounting) (b) drier scenario as share of GDP, by decade and region (percent, at 2005 prices, no discounting). The absolute costs of adaptation rise over time as shown in (a) but fall as a share of GDP as shown in (b) (EACC study team, 2009).

Not surprisingly, both climate scenarios show costs increasing over time, although falling as a percentage of GDP, suggesting that countries become less vulnerable to climate change as their economies grow (Figure 55). There are considerable regional variations, however. Adaptation costs as a percentage of GDP are considerably higher in Sub-Saharan Africa than in any other region, in large part because of the lower GDPs in this region (EACC study team, 2009). Table 16 shows total adaptation cost for sub-Saharan Africa to 2050. Table 17 shows gross and net costs of adaptation for sub-Saharan Africa.

Table 16: Annual cost of adaptation for coastal zone protection and residual damages for the medium seal-level rise scenario for the Sub-Saharan Africa, 2010-2050 (US$ billions at 2005 prices, no discounting) (modified from EACC study team, 2009).

Total adaptation cost				***Residual damage***			
2010-2019	2020-2029	2030-2039	2040-2049	2010-2019	2020-2029	2030-2039	2040-2049
3.2	3.7	4.2	4.8	0.0	0.0	0.0	0.0

Table 17: Gross and net annual adaptation costs for water supply and riverine flood protection in Sub-Saharan Africa, 2010-2050 (US$ billions at 2005 prices, no discounting) (modified from EACC study team, 2009).

Wettest scenario					
Gross			**Net**		
Flood protection	Water supply	**Total**	Flood protection	Water supply	**Total**
0.4	6.2	**6.6**	0.3	5.9	**6.2**
Driest scenario					
Gross			**Net**		
Flood protection	Water supply	**Total**	Flood protection	Water supply	**Total**
0.2	7.6	**7.8**	-0.2	7.3	**7.1**

The best way for governments to accelerate adaptation in Africa will be to successfully promote development, and empower communities, rendering them less vulnerable and better able to adapt to changes in their environment. Economic growth, for example, often reduces vulnerability to climate change and increases society's ability to adapt to the impacts (Stern, 2007).

Adaptation costs for fisheries are highest under the more-intensive scenario (US$ 0.15 billion 2010-2050 for Sub-Saharan Africa) and not under the overexploitation scenario (US$ 0.10 billion 2010-50 for Sub-Saharan Africa), because there are fewer fish under the overexploitation scenario to be affected by climate change (EACC study team, 2009). Table 18 shows annual costs of adaptation as a share of GDP for the Sub-Saharan Africa. Note the costs decrease with time for both the wettest and the driest scenarios.

Table 18: Total annual costs of adaptation as a share of GDP for the Sub-Saharan Africa from 2010 to 2050 (X-sums, percent, no discounting) (modified from EACC study team, 2009).

Wettest scenario				***Driest scenario***			
2010-2019	2020-2029	2030-2039	2040-2049	2010-2019	2020-2029	2030-2039	2040-2049
0.70	0.68	0.55	0.49	0.57	0.52	0.56	0.50

Summary of regional adaptation from the DIVA database

Impacts and adaptation results produced using the DIVA database are presented together for all the 5 regions on a uniform y-axis scale to facilitate comparison between regions and countries. Figure 56 shows coastal accommodation space for the regions. Accommodation space indicates the potential for wetland migration of coastal wetlands given sea-level forcing. It is a variable used to model the vulnerability of the wetland. The value of accommodation space is scaled between 1 and 5, representing low-very high vulnerability forcing. Accommodation space is based on two datasets: (1) expected morphological development of coastal landforms and the reaction of the present coastal ecosystems on these possible morphological changes, that is, wetland migratory potential. (2) Presence or absence of fixed coastal defence structures, a dynamic link to the initialised variable sea-dike models the development of sea dikes given sea level and population forcing (Vafeidis et al., 2006, p. 19).

Based on the concept of linear representation of the coastline, the DINAS-COAST project has created a model of coastal space where geographic information is represented as a collection of geographic features and is referenced to coastal segments of variable length. Given the linear nature of the coast, all the data in the DIVA database are expressed as attributes of seven principal geographic features, namely coastline segments, administrative units, countries, rivers, tidal basins, world heritage sites and grids and are all referenced to linear coastal segments which have resulted from the process of the coastline segmentation (Vafeidis et al., 2006, p. 3). This project will allow scientists and governments in each country to estimate in advance the kind of resources they would need in order to adapt to climate change.

Figure 57 shows sea-dike height for the regions as measures of coastal adaptation. Sea-dike height is the calculated height of the sea-dike. A sea dike is considered present within the segment when the height of the structure exceeds 0.5 m. This threshold value is based on expert judgement. Note that this data is now ignored by the DIVA model as the initial value is computed directly by the relevant module (Vafeidis et al., 2006).

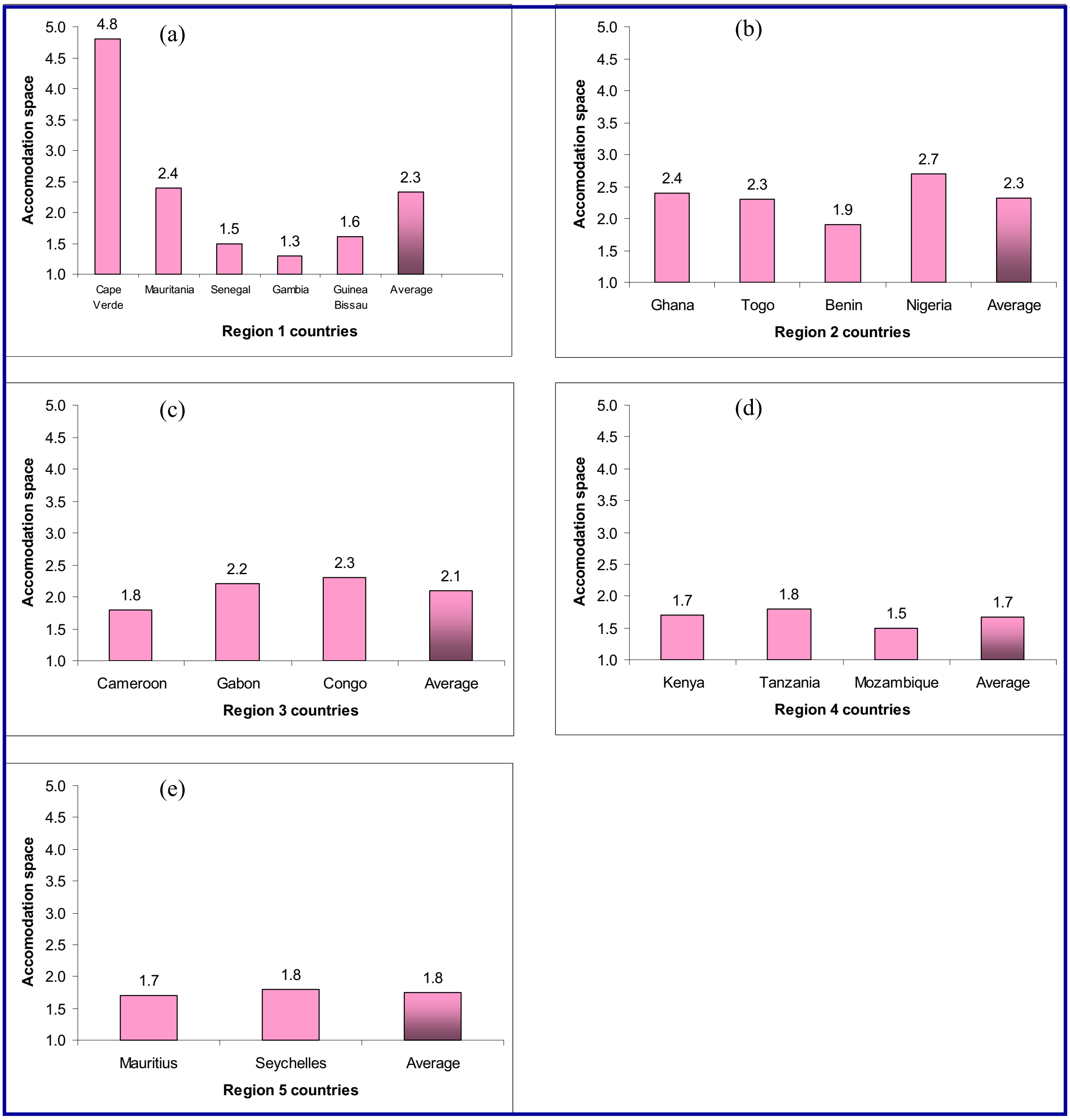


Figure 56: Summary of accommodation space for the studied regions and their averages. (a) Region 1 showing Cape Verde to have the highest accommodation space of 4.8. (b) Region 2 showing Nigeria to have the highest accommodation space of 2.7. (c) Region 3 showing Congo to have the highest accommodation space of 2.3. (d) Region 4 showing Tanzania to have the highest accommodation space of 1.8. (e) Region 5 showing Seychelles to have the highest accommodation space of 1.8. Overall, Regions 1 and 2 have the highest accommodation space both of 2.3 followed by Region 3. For individual countries, Cape Verde, followed by Nigeria has the highest accommodation space for the studied countries (data source: the DINAS-Coast Consortium 2006 database).

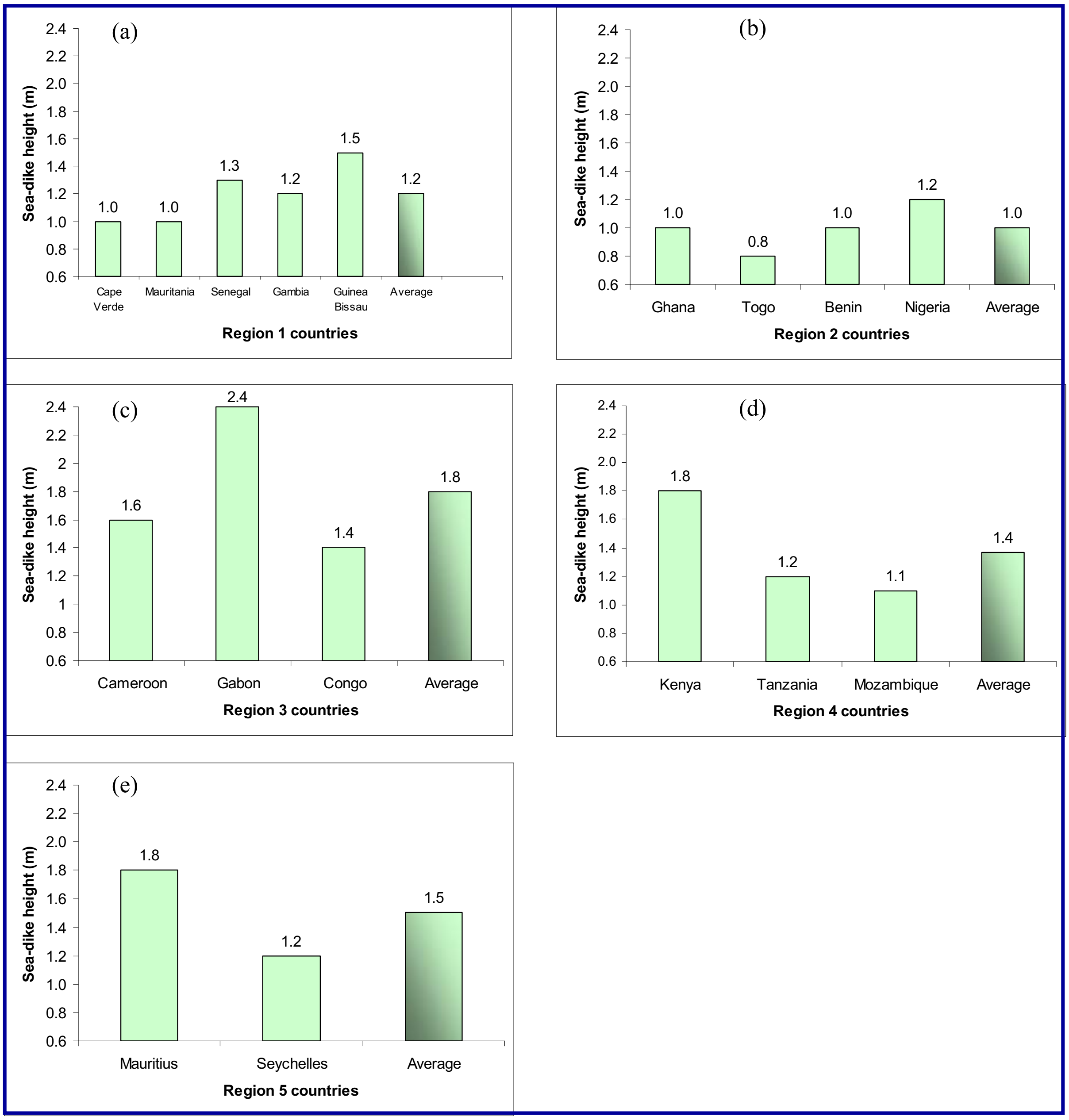


Figure 57: Summary of sea-dike height for the studied regions and their averages. (a) Region 1 showing Guinea-Bissau to have the highest sea-dike height of 1.5 m. (b) Region 2 showing Nigeria to have the highest sea-dike height of 1.2 m. (c) Region 3 showing Gabon to have the highest sea-dike height of 2.4 m. (d) Region 4 showing Kenya to have the highest sea-dike height of 1.8 m. (e) Region 5 showing Mauritius to have the highest sea-dike height of 1.8 m. Overall, Region 3 has the highest sea-dike height of 1.5 m followed by Region 5. For individual countries, Gabon, followed by Kenya and Mauritius has the highest sea-dike height for the studied countries (data source: the DINAS-Coast Consortium 2006 database).

1.2.7.1 Coastal planning/zoning

This section considers coastal planning/zoning to accommodate livelihood and economic changes to changing biodiversity and fishing regimes, sea-level rise and erosion. In general, the costs of adaptation to sea-level rise (e. g., through protection of threatened areas) are far less than the losses associated with not protecting coastal areas. The three basic options for adaptation are: (1) protect – to reduce the risk of the event by decreasing the probability of its occurrence; (2) accommodate – to increase society's ability to cope with the effects of the event and (3) retreat – to reduce the risk of the event by limiting its potential effects. A summary of the major physical impacts and potential adaptation responses to sea-level rise is provided in Table 19.

South Africa has adopted a national approach to coastal management and has legislated to incorporate climate change issues, including sea-level rise, within this approach. The key elements of the legislation require matters including sea-level rise to be included in any future land use planning. The designation of a national coastal zone within which a set of principles must be adhered to for coastal environmental protection is now enforced. In Cape Town, the inclusion of a coastal buffer zone at the local level is now a requirement while in Western Cape, the potential consequences of medium and long-term climate change and associated sea-level rise must be taken into account in all coastal planning and management. The South African method can be adopted in other African coastal countries (The State of Victoria Department of Planning and Community Development, 2009, p. 35).

Table 19: Physical impacts and examples of potential adaptation responses to sea-level rise (Agrawala and Frankhauser, 2008).

Physical impacts		***Examples of adaptation responses (P = protection; A = accommodation; R = retreat)***
Inundation, flood and storm damage	a. Surge (sea)	Dikes/surge barriers (P) Building codes/flood wise buildings (A)
	b. Backwater effect (river)	Land use planning/hazard delineation (A/R)
Wetland loss (and change)		Land use planning (A/R) Managed realignment/forbid hard defences (R) Nourishment/sediment management (P)
Erosion (direct and indirect change)		Coast defences (P) Nourishment (P) Building setbacks (R)
Saltwater intrusion	a. Surface waters Saltwater intrusion barriers (P) b. Groundwater Freshwater injection (P)	Saltwater intrusion barriers (P) Change water abstraction (A) Freshwater injection (P) Change water abstraction (A)
Rising water tables and impeded drainage		Upgrade drainage systems (P), Polders (P) Change land use (A) Land use planning/hazard delineation (A/R)

1.2.7.2 Bathymetric and inundation mapping against extreme events and flooding

Bathymetric and inundation mapping are undertaken as part of hydrographic surveys. A hydrographic survey may be conducted to support a variety of activities such as nautical charting, port and harbor maintenance (dredging), coastal engineering (beach erosion and replenishment studies), coastal zone management, and offshore resource development (National Ocean Service, 2004, p. 17). The one data type common to all hydrographic surveys is water depth, or bathymetry. Most surveys also record the nature of the sea floor material (i.e. sand, mud, rock) due to its implications for anchoring, dredging, structure construction and fisheries habitat. Bathymetric surveys determine water depths. The resulting data, depending upon accuracy, have a multitude of uses. NOAA uses such information to create and update nautical charts for safe navigation (National Ocean Service, 2004, p. 17). Figure 58 shows the various methods for bathymetric and inundation mapping.

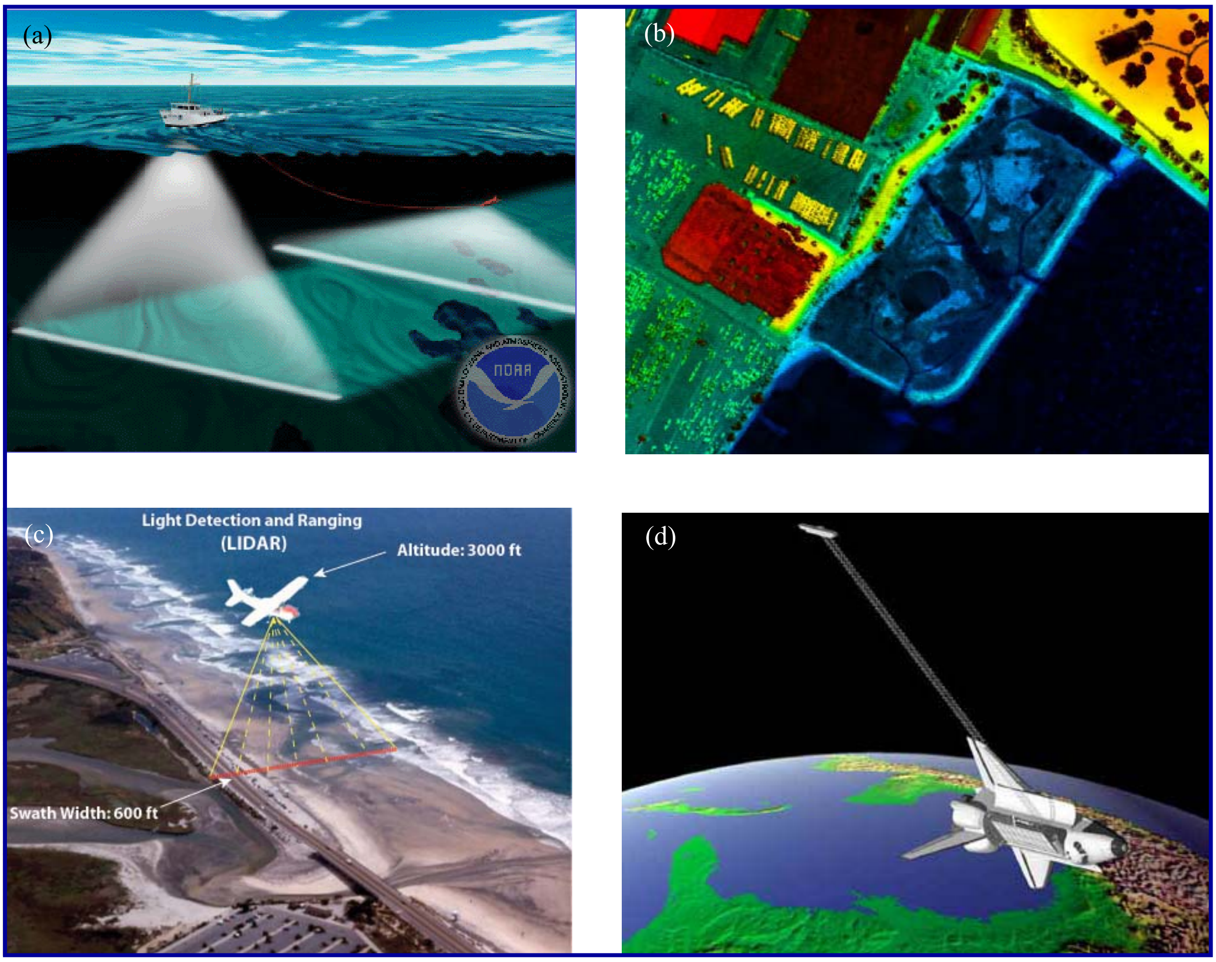


Figure 58: Examples of methods of bathymetric and inundation mapping. (a) Hull-mounted multibeam sonar (left) and towed side scan sonar (right) (b) map produced from Light Detection and Ranging (LIDAR) Imagery ((a) and (b) from National Ocean Service, 2004) (c) Shuttle Radar Topography Mission (SRTM) (d) Aircraft-based LIDAR used to produce (b) (c) and (d) from Theiss, 2009b).

The data is also used in marine geology, archaeology, modelling, marine engineering, and habitat assessment (National Ocean Service, 2004). Bathymetric and inundation mapping can also be applied to ascertain the impacts of sea-level rise or coastal hazards such as storm surges, hurricanes and tsunamis (Theiss, 2009b). Major tools for bathymetric surveys are single and multibeam sonar systems and bathymetric Light Detection and Ranging (LIDAR) systems (flown on aircraft platform). 'Feature search' surveys employ side-scan sonar. Bottom type surveys are useful for habitat assessment. The most accurate ground-based method of measuring bathymetry is through single or multi-beam echo sounders (sonars). The benefit is that it has high accuracy while the drawbacks are that it is slow and covers a small space (Theiss, 2009b). The remote sensing tools used to determine bottom type are multibeam and side-scan sonar systems (Figure 58a) and LIDAR (Figure 58b and d). Acquired data are then processed through software capable of unsupervised pattern recognition, signal classification and time series analysis. Once the data is processed, it is usually necessary to 'ground truth' the resulting polygonal regions with bottom samples, or by diver/remote video observations to determine actual composition. The four general types of remote sensing surveys are Bottom- typing, sub-bottom profiling, bathymetry, and feature search. Sub-bottom profilers are a direct extension of echo-sounders; by transmitting a relatively low frequency acoustic pulse, a portion of the outgoing pulse is transmitted below the seabed and will reflect off layers in the sediment pile, thus producing a pseudo-cross-section of the subsurface. This is analogous to digging a trench on land. However, the major advantage of sub-bottom profiling is that it is a non-invasive technique (National Ocean Service, 2004, p. 17).

To accurately predict the flooding due to a tsunami the coastal bathymetry is also required in order to determine whether the energy of the tsunami is being focused on or deflected from the coast. Many aspects of integrated coastal area management, such as which areas would be best for mangrove forest reforestation, depend strongly on accurate coastal topography and bathymetry maps. Accurate coastal modelling is therefore only possible if accurate bathymetric maps exist (Theiss, 2009b, p. 7).

Topography and bathymetry data has already been measured by a number of satellites. However, the vertical accuracy of several meters is far too low for the proposed applications of the resulting coastal topography and bathymetry maps. The Shuttle Radar Topography Mission (SRTM), however, achieves a higher accuracy of 16 m (Figure 58c). Combined with ground-based measurements the accuracy can be improved by a factor of up to 4. This could prove to be sufficient to produce low-quality coastal topography and bathymetry maps for some applications. The benefits of SRTM are that it has nearly full global coverage and the data exists already. Its low accuracy can be improved in combination with ground-based measurements, i.e. ground truthing. A LIDAR instrument deployed on an aircraft would measure the topography and bathymetry with high accuracy, fast, and completely (Figure 58d). This would be the ideal method, but it is very expensive, about US$1,700/km (Theiss, 2009b, p. 10). Figure 59 shows inundation map of a section of Mozambique coast.

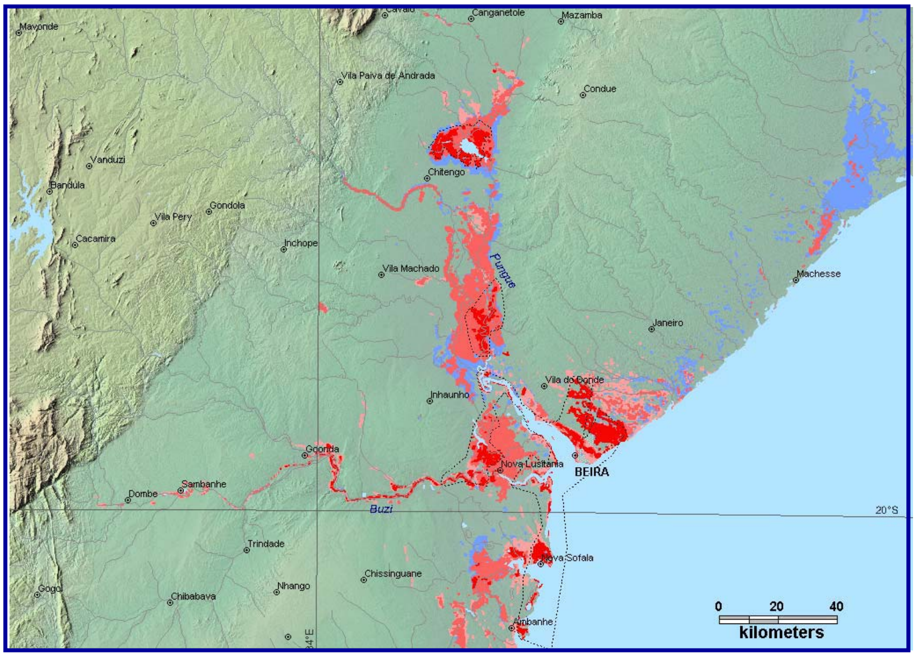


Figure 59: Mozambique, Sofala province rapid response inundation map. Red colour shows flooding for January, 28, 2008. Pink colour shows flooding for December 11-16 2007 and January 3-13 2008. Blue colour shows flooding from 1997-2007 (Image from Dartmouth Flood Observatory, 2007).

I.3 Overview of existing science-based tools and methods for coastal adaptation

1.3.1 Monitoring: in situ and remote sensing

In situ measurements are taken in the natural place or in the original place where a system occurs in nature. On the coastal zones of Africa, a program of in situ monitoring as well as remote sensing should be encouraged so as to acquire data over the mid- and long-term that could be used for coastal studies and adaptation in the near future. In situ measurements are necessary to perform ground truthing. The data obtained through ground truthing would in turn be of benefit to validate and/or calibrate the models under application. Remote sensing can be used for many purposes. An example of such use is to monitor water resources for Mozambique (Figure 60). To a large extent, Mozambique depends on water resources that originate in neighbouring countries, where around 54 % of the annual surface flow comes from.

The country is also characterised by great climatic diversity, with annual rainfall varying from 400 mm in the south to 1800 mm in the north and a complex hydrological network with nine shared rivers. The floods in Mozambique in 1999-2000 and 2000-2001 wet seasons highlighted the need for urgent action, and the need for a mechanism for communicating those needs (World Bank, 2007). Data from 2004 indicate that only 26 %

of the population in rural areas in Mozambique had access to improved sources of drinking water, compared with 72 % in urban areas. The total coverage was only 43 % in the entire country. This is still below the Millennium Development Goal (MDG) target for Mozambique which is to have a 68 % coverage with improved sources of drinking water by 2015 (World Bank, 2007).

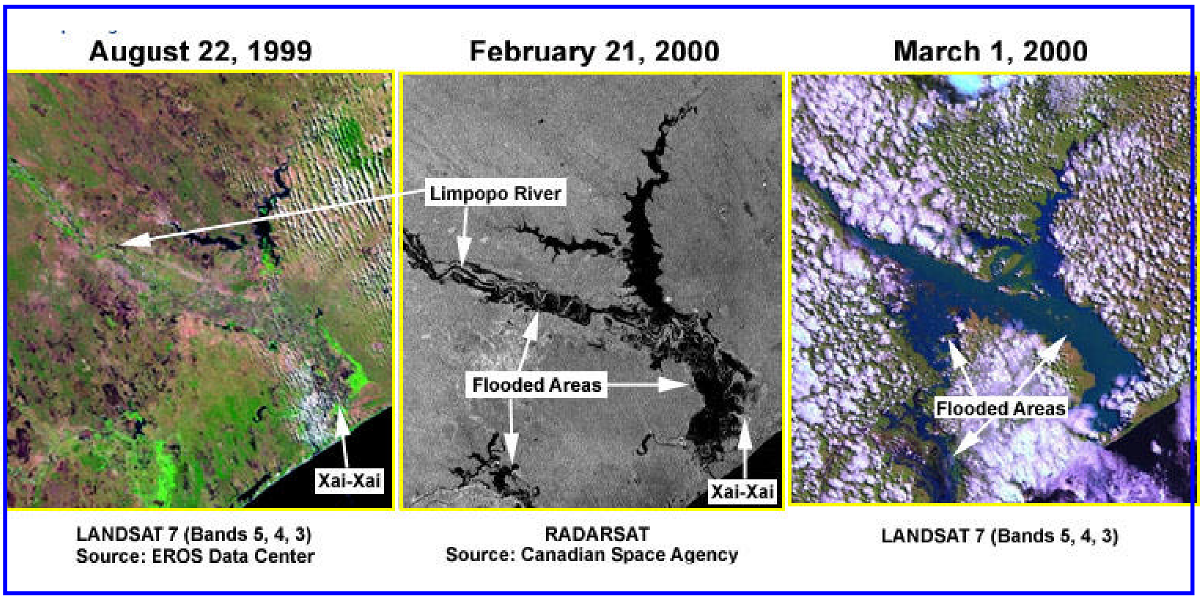


Figure 60: Remote sensing used to monitor coastal flooding in Mozambique. Compare the Limpopo River in August 1999 during a dry season with one in February and March 2000 during floods (World Bank, 2007).

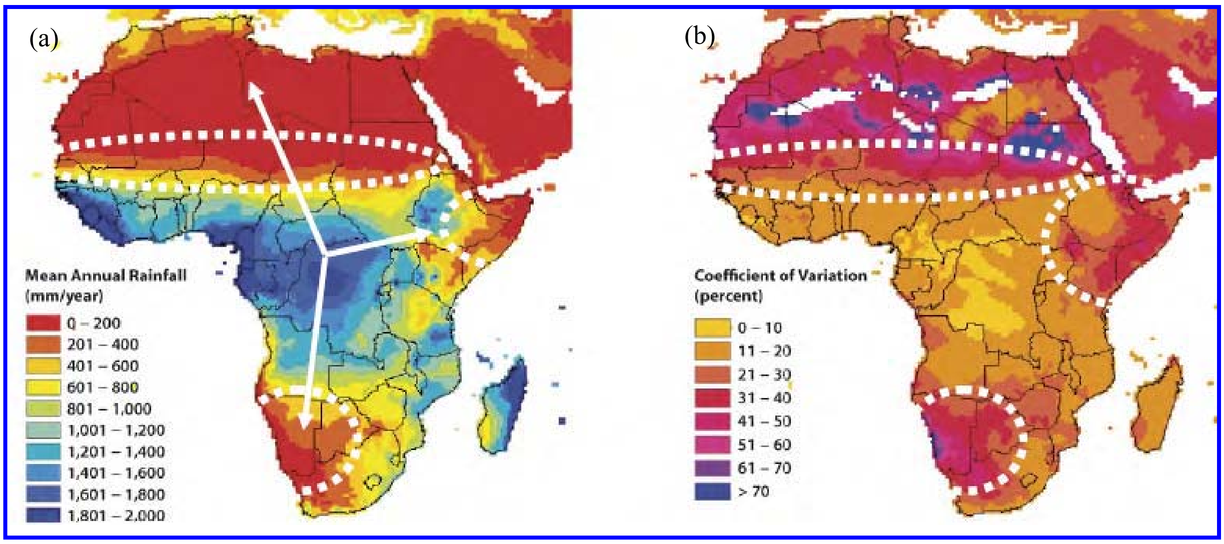


Figure 61: Remote sensing applied to monitor rainfall variability in Africa from 1951 to 2000 (World Bank, 2008).

Similar to in situ monitoring, remote sensing can be used to study large regional variations in rainfall and high annual variability (Figure 61) as well as study frequent floods and droughts with significant costs. Figure 61 shows rainfall variability using remote sensing for the African coast.

1.3.2 Decision Support Tools: Coastal Modelling, Remote Sensing and GIS Tools

Coastal planners will always face a certain degree of uncertainty, not only because the future is by definition uncertain, but also because knowledge of natural and socio-economic coastal processes is and always will remain incomplete. Limits to predictability require planners to assess the environmental and societal risks of climate change with and without adaptation. The information thus obtained can help to determine the optimal adaptation strategy and timing of implementation. There are a number of decision tools available to assist in this process. Examples of these tools include cost-benefit analysis, cost-effectiveness analysis, risk-effectiveness analysis and multi-criteria analysis (IPCC, 2001b).

Many of the studies on assessment impacts and adaptation conducted for Africa, e.g. for the purpose of national communications to the UNFCCC provide results that show how different sectors, systems and communities might be impacted by climate change. In these studies, African countries depended on generated climate scenarios based on inputs from general circulation models (GCMs), which are generally designed in developed countries, e.g. through downscaling using MAGIC-SCENGEN (Elasha et al., 2006). The results of these studies confirmed that these scenarios could provide important information which provides a good indicator of future climate change and that, the use of Global Climate Change models could provide for long-term climate risk assessments at a general level (Elasha et al., 2006, p. 10).

While global climate models (GCMs) simulate changes to African climate resulting from increased greenhouse gas concentrations, two potentially important drivers of African climate variability, namely the El Niño/Southern Oscillation and land cover change are not well represented in the models. A number of characteristics of GCM models are critical for model prediction performance including: (1) the ability to capture reasonably well the simulation of mean, large-scale patterns of contemporary climate (e.g. temperatures, wind, precipitation), as well as the broad response to Pacific Ocean forcing (ENSO) and to ocean temperature patterns in surrounding basins (Indian, Atlantic and Mediterranean); (2) capturing, to a lesser extent, the precise positioning, timing and intensity of specific features such as the onset of the Sahel precipitation, the precipitation gradient across southern Africa, and the orientation of tropical convection over East Africa and (3) the interaction of Saharan dust with climate is not included in most models and inadequate information on the coupled land-surface atmosphere feedbacks (Elasha et a., 2006, p. 11).

Compared to many parts of the world, scientific understanding of the African climate system as a whole is low, and variations in capacity exist among different African region. A specific example is the Congo Basin, for which very little information is known, although it is one of the most important ecosystems affecting the global climate. Some efforts are being undertaken, and Regional Circulation Models (RCMs) with a higher resolution, typically 50 km^2, are currently being developed for smaller areas and for shorter timescales, approximately 20 years (Elasha et al., 2006, p. 13). Figure 62 shows coastal modelling applied on the Tanzanian coast.

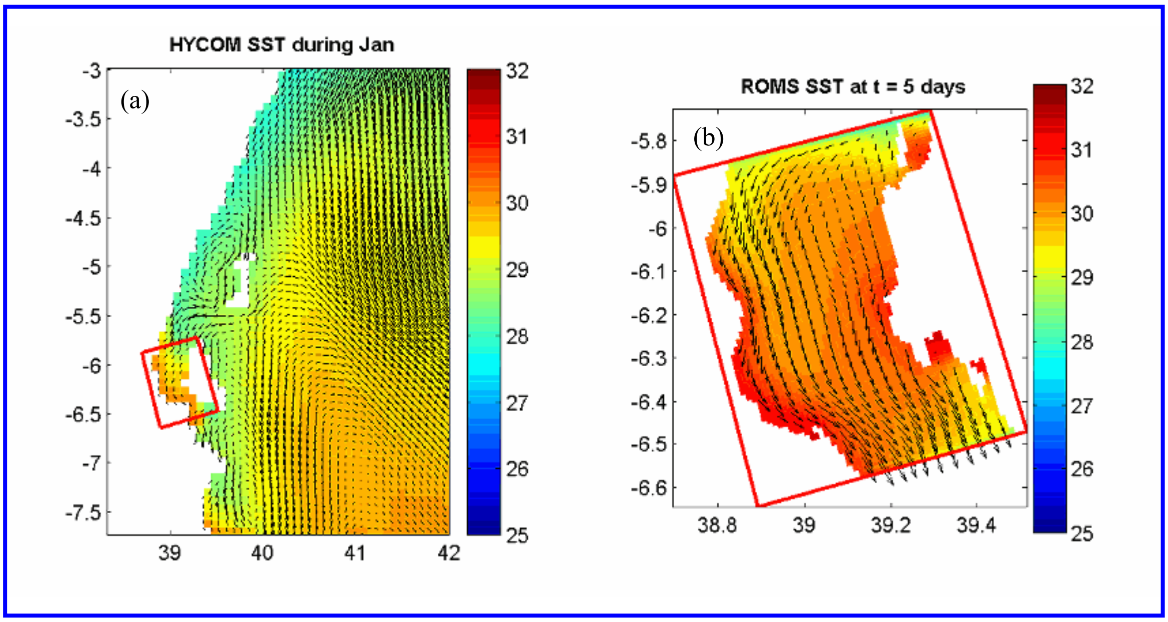


Figure 62: Coastal modelling applied on the coast of Tanzania (a) inset (b) expanded section of the coast. Simulation of one typical year (Arrows: Ocean currents; Color: Ocean temperature) (Theiss, 2009a).

Local or rural communities are most vulnerable to climate change, and approaches that emphasise a bottom-up approach, recognising local coping strategies and indigenous knowledge and technologies, hold the most promise, as these will more easily add to local adaptive capacities (Elasha et al., 2006, p. 13). In Senegal, remote sensing has been applied to monitor mangrove depletion (see Figure 29).

Geographical Information Systems (GIS) are an important technology for spatial planning as well as contribute to other adaptation steps and indeed to all aspects of coastal management. GIS combines computer mapping and visualisation techniques with spatial databases and statistical, modelling and analytical tools. It offers powerful methods to collect, manage, retrieve, integrate, manipulate, combine, visualise and analyse spatial data and to derive information from these data (IPCC, 2001b, Box 15.1). In spite of its clear utility, the application of GIS for developing countries is limited due to; (1) the costs of computer hardware and most GIS software; (2) the lack of raw data to input to the system; (3) the lack of consistency between data sets; (4) restrictions on free access to information for strategic, political, economic or other reasons; (5) limited salaries and career opportunities for GIS-literate operators compared to the industrialised world; (6) the prevailing Western conceptual model of geographical space, which may be different from local ways of perceiving and interpreting spatial relationships and (7) the fear that the introduction of GIS could lead to or facilitate oppressive government, misuse of power, civil unrest or other non-democratic activities. The rapid ongoing developments of all aspects of GIS may remove some of these concerns. There is no doubt that GIS presents great potential for societies wishing to anticipate and understand the consequences of climate change and develop adaptation strategies to cope with the potential impacts (IPCC, 2001b). However, the limitations inherent in all models must not be overlooked. Human expertise remains essential for the intelligent use of models.

1.3.3 Risk/Vulnerability assessment

1.3.3.1 Dynamic Interactive Vulnerability Assessment (DIVA) Tool

A brief explanation of the DIVA tool has been presented in section 1.2.6. Several outputs are possible from the DIVA tool as is evident from its application in section 1.2.6. Adaptation costs for coastal zones are derived mainly from the (DIVA) model, based on coastal segments that make up the world's coast (except for Antarctica) and a linked DINAS-Coast database and set of interacting algorithms (McFadden et al., 2007). A segmented linear representation of the coastline and a wide range of attributes associated with each segment from the DIVA tool can be downloaded from http://diva.demis.nl/. The sea-level rise scenarios are downscaled with an estimate of the vertical land movement in each segment. The coastal erosion analysis considers only sandy coasts and takes account of the Bruun Rule effect and indirect effects of sea-level rise, as well as beach nourishment where it occurs. The indirect effects occur at major estuaries and lagoons. Protection from coastal flooding through the building of dikes or the use of beach nourishment can be analysed using the DIVA tool. The results are provided globally, for all coasts for which data is available.

The DIVA tool analyses a limited set of adaptations in a uniform manner. This has the advantage of applying a uniform method that can account for local and regional differences in conditions such as value of threatened areas. However, it has the disadvantage of not accounting for unique local circumstances or varying decision criteria that may be applied around a region (UNFCCC, 2009, p. 116). For this report, the socioeconomic conditions for all scenarios were assumed to be the conditions in the SRES A1FI high-regionalised scenario. The DIVA tool estimates a number of impacts from sea-level rise including beach nourishment costs, land loss costs, number of people flooded, costs of building dikes, and losses from flooding. Of these, only the costs of beach nourishment and the costs of building dikes were counted as adaptation costs. The other categories are damages as a result of the impacts. In reality, adaptation costs would likely be involved in responding to the damages (UNFCCC, 2009).

The DIVA tool implements the adaptation options according to complementary adaptation strategies. For beach nourishment, a cost-benefit adaptation strategy balances costs and benefits of adaptation, including the tourist value of beaches. For dike building, the demand function for safety is applied over time, subject to population density. Dikes are built only when population density exceeds 1 person/km^2; with an increasing proportion of the recommended height being built as population density rises, for example, 98 % of the dike height is built at densities of 1,000 people/km^2. Local adaptation measures related to infrastructure would be building of coastal embankments while adaptation measures for coastal zone management would be land-use planning, regulations and relocation.

1.3.3.2 Coastal Vulnerability Index (CVI)

An innovative approach to developing a coastal vulnerability assessment for the US was undertaken by Gornitz and Kanciruk (1989). They considered inundation, flooding and susceptibility to erosion. It was proposed by Gornitz and others (1991) that the index, termed the coastal vulnerability index (CVI), might be applied worldwide, although its application was only demonstrated for the US in her study. The CVI has been applied on several coasts of the world with modification. Abuodha (2009) applied a coastal sensitivity index (CSI) which is similar to CVI, however, it applies physical variables only, to study a section of the south eastern coast of Australia. This method yields a semi-quantitative value that can be equated directly with particular physical effects, highlighting areas where sea-level rise may have the greatest impact. The CVI is a dimensionless index, obtained by manipulating scores of 1 to 5 attributed to each of the nine variables, using Equation 1 to aggregate them:

$$\text{CSI} = \sqrt{\frac{a*b*c*d*e*f*g*h*i}{9}} \qquad \text{…………………………..…..…. Equation 1}$$

where a, b, etc. refer to values given, respectively, to variables, (a) rock type, (b) geomorphology, (c) barrier type, (d) shoreline change, (e) segment exposure, (f) coastal slope, (g) relative sea-level rise (h) mean wave height and (i) mean tidal range.

The CSI is derived to show relative vulnerability; it combines the coastal system's susceptibility to change with its natural ability to adapt to changing environmental conditions, yielding a relative measure of the system's natural vulnerability to the effects of sea-level rise. The purpose of CSI calculation is to assess the impacts of a rise in relative sea-level on a vulnerable coastal zone. Figure 63 shows an example of a coastal sensitivity index for the south-eastern coast of Australia.

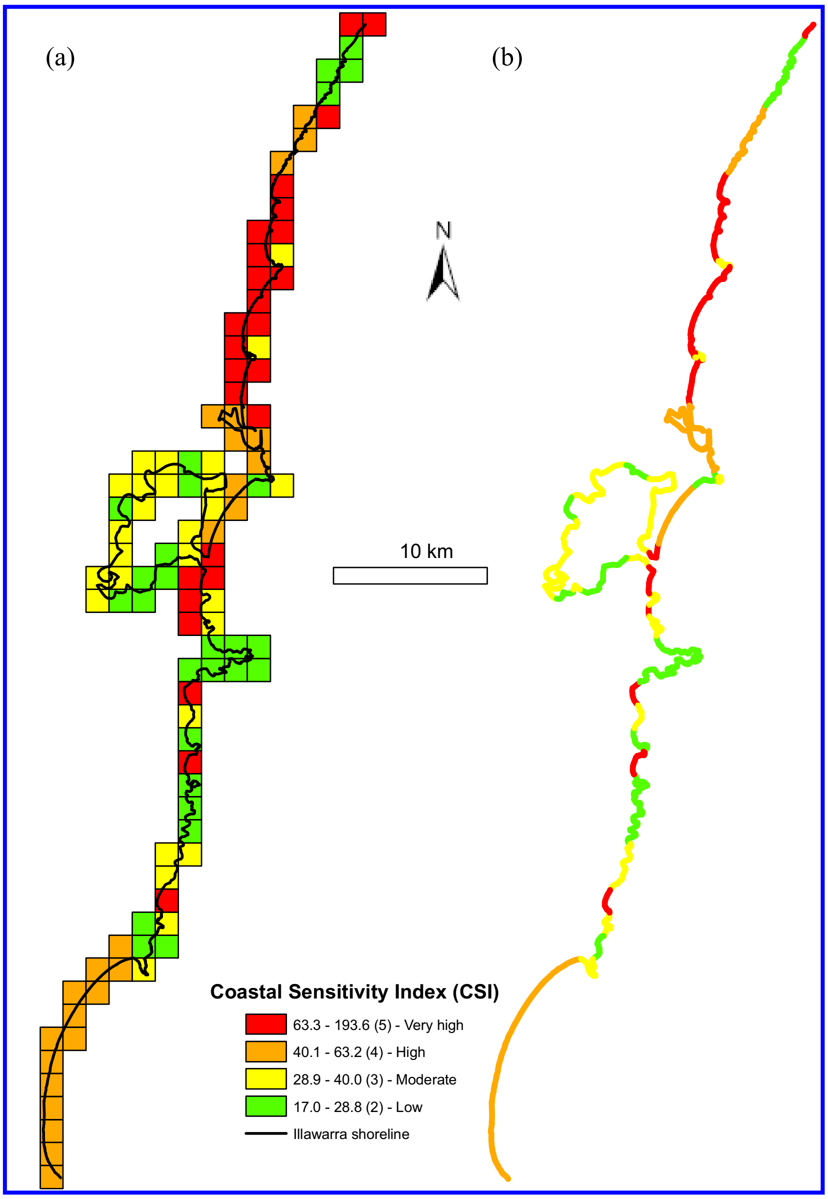


Figure 63: An example of the overall coastal sensitivity index (CSI) for a section of South Eastern coast of Australia (Abuodha, 2009).

1.3.3.3 Geomorphic Stability Mapping (GSM) Approach

A different approach, although also adopting segmentation of a shoreline, has been developed in Australia by Sharples (2004). It was applied initially in Tasmania, but has subsequently been upgraded for application to the coast of the mainland also. In his 2004 study, updated and extended in 2006, Sharples examined both the vulnerability to inundation and the physical stability of the shoreline and, hence, its potential for erosion (Sharples, 2006).

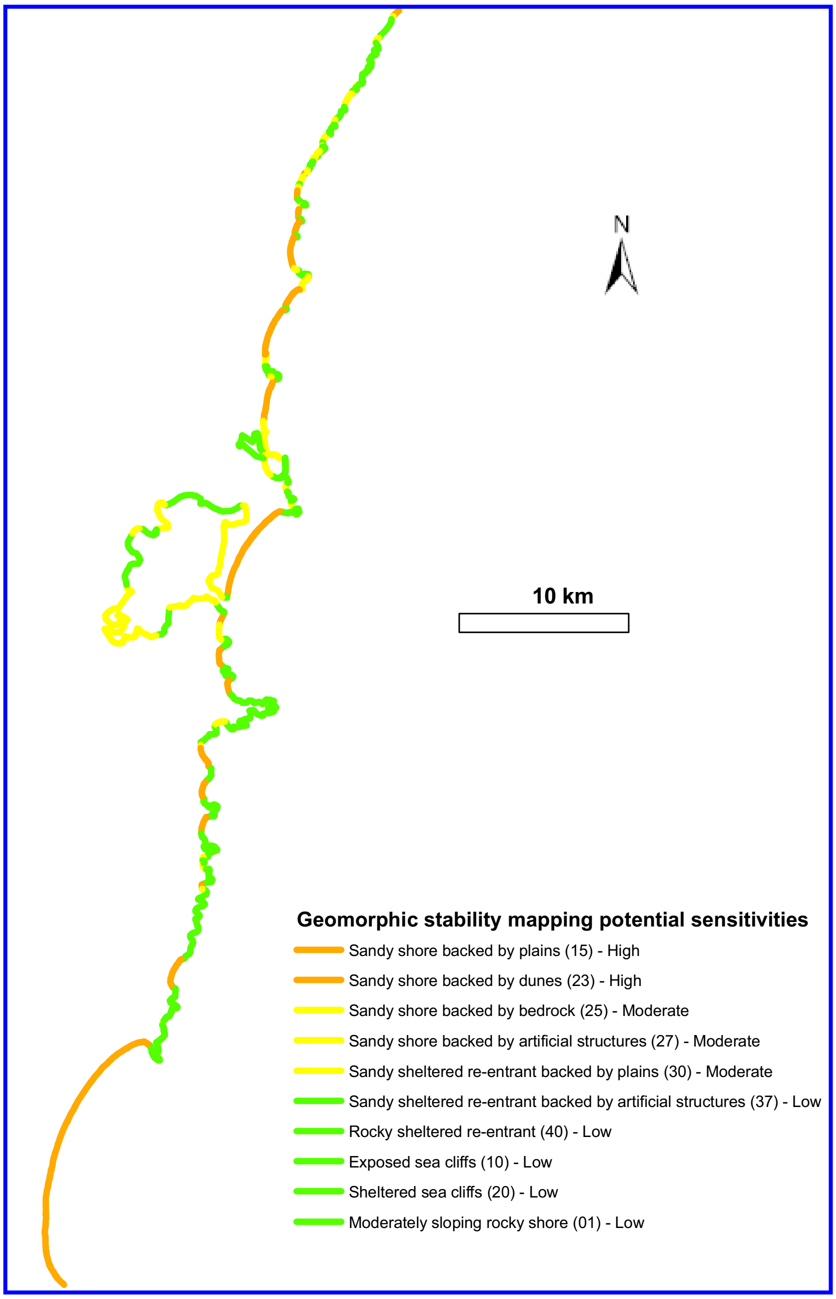


Figure 64: An example of the geomorphic stability mapping approach for a section of South Eastern coast of Australia (Abuodha, 2009).

The shoreline geomorphic mapping has several advantages compared to traditional polygon mapping. A key advantage of the model is its ability to capture a very wide range of information for a coastal zone at different levels of detail depending on available data. It also allows many types of data analysis to be undertaken efficiently, and can utilise a hierarchical system where insufficient data are available to adequately describe landform characteristics. The line map format enables the creation of a complete coastal map faster than would be possible for polygon mapping, and it can be queried easily for a wide range of purposes.

The GSM approach is based on defining fundamental sensitivity factors for different landforms. Fundamental sensitivity factors are basic but crucial geomorphic characters that predetermine sensitivity of a shoreline and physical changes that are expected to occur on the shoreline as a result of sea-level rise. The fundamental sensitivity factors for open sandy shore and coastal re-entrants, sea cliffs and moderately sloping hard rocky shore are therefore described here.

Sharples (2006) identified three key fundamental sensitivity factors to be considered for providing an indicative assessment of Open Ocean sandy shores, namely: (1) those composed of unconsolidated sand-grade sediments such as sandy beaches and dune (2) open ocean coasts exposed to oceanic swells and storm waves; and (3) backed by low-lying plains underlain by unconsolidated sandy sediments in the backshore.

Sea cliffs are vertical cliffs in hard lithified bedrock rising above the high water mark (HWM) and exposed to storm wave action. For sea cliffs, three key fundamental sensitivity factors considered by Sharples (2006) to provide indicative assessment are namely: (1) gently to moderately sloping hard bedrock shores (2) without significant colluvial or talus mantles; and (3) without vertical cliffs rising over roughly 5 metres, immediately above the high water mark. Figure 64 shows an example of the geomorphic stability mapping approach applied on the coast of southeast Australia.

I.4. The DIVA tool applied to Kenyan coastal issues: A case study

1.4.1 The DIVA tool projections on impact from climate change

This section considers the projections from the DIVA tool for the Kenyan coast. In all cases the A1FI high-regionalised scenario was applied. The total sand loss due to coastal erosion as a result of sea-level rise on the Kenyan coast is projected to increase from 3,389,000 m^3 per year to 7,389,000 m^3 per year by 2050 (Figure 65a). This increase will suddenly decrease and even become coastal accretion in 2100. This may be due to total adaptation by 2100 through the construction of breakwaters, sea-dikes and seawalls. As a result of sea-level rise, the total residual damage costs on the Kenyan coast will be on the increase with maximum costs felt in 2070 of 34 million US$ per year (Figure 65b). The total residual costs are projected to decrease slightly to 27 million US$ per year by 2100.

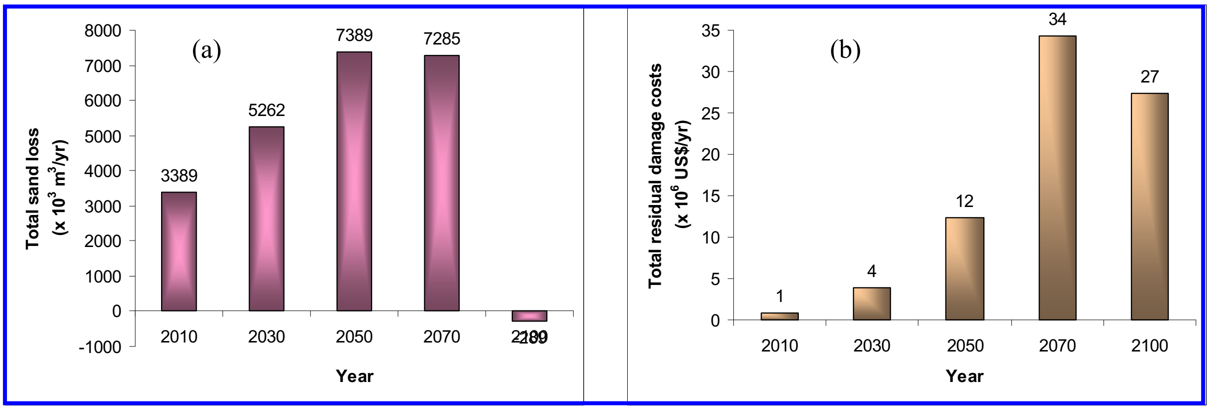


Figure 65: Projected impacts on the Kenyan coastal zone for (a) total sand loss in thousands m^3 per year (b) total residual change costs in millions US\$ per year (data source: the DINAS-Coast Consortium 2006 database).

Figure 66 shows different impacts of climate change as projected using the DIVA tool for Kenya. By 2050 the sea level is projected to rise by 0.3 m while by 2100, the projected sea-level rise will be 1 m (Figure 66a). The coastal floodplain area by 2050 is projected to be 1411 km^2 while by 2100, the projected coastal floodplain area will be 1532 km^2 (Figure 66b).

The coastal floodplain population by 2050 is projected to be 349,000 people while by 2100, the projected coastal floodplain population will have decreased slightly to 340,000 people (Figure 66c). Compared to 2070, there will be a drop in the number of people in the coastal floodplain. This may be as a result of more awareness being created and people moving out of floodplain zone as well as improved standards of living which will make people better adapt to the impacts of climate change. In line with this, the number of people actually flooded is projected to decrease from 5100 people in 2010 to 1300 in 2050 (Figure 66d). With the rise in sea level, the net loss in wetland area is projected to increase from 56 km^2 in 2010 to 225 km^2 by 2050 (Figure 66e). It is also projected that the mangrove area along the Kenyan coast will decrease from 938 km^2 in 2010 to 860 km^2 in 2050 (Figure 66f). This may be due to saltwater intrusion upstream on the Sabaki and Tana Rivers, causing the death of mangrove ecosystems due to saltwater intolerance. As such, it is anticipated that the fisheries production will decrease since the breeding grounds for most fishes will have been destroyed.

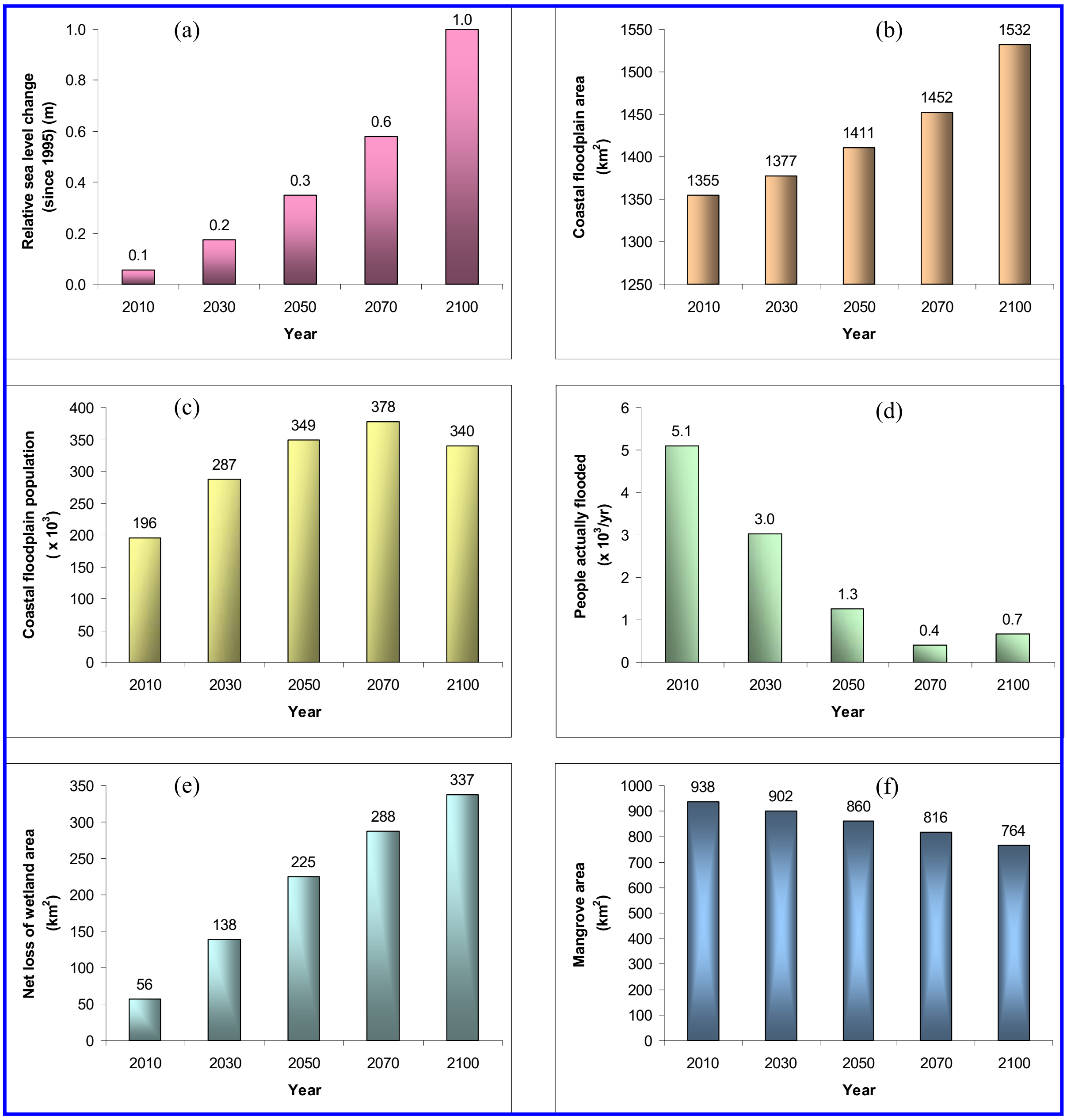


Figure 66: Projected further impacts on the Kenyan coastal zone for (a) sea-level rise (b) coastal floodplain area in km^2 (c) coastal floodplain population in thousands (d) people actually flooded in thousands per year (e) net loss of wetlands in km^2 and (f) mangrove area in km^2 (data source: the DINAS-Coast Consortium 2006 database).

1.4.2 The DIVA tool projections on adaptation from climate change

For these impacts, the projected total adaptation cost for the Kenya coast will be 60 million US$ per year by 2010 which is projected to increase continually (Figure 67a). By 2050, the cost of adaptation is projected to have almost doubled, being 107 million US$ per year. As a means of adaptation, beach nourishment is projected to be undertaken along the Kenyan coast, with the cost continually increasing from US$ 0.3 million by 2030 to US$ 3.4 million by 2050 (Figure 67b). By 2100, the cost of beach nourishment is projected to have increased enormously to 83.4 million US$ per year, most likely a cost too high for the government to meet.

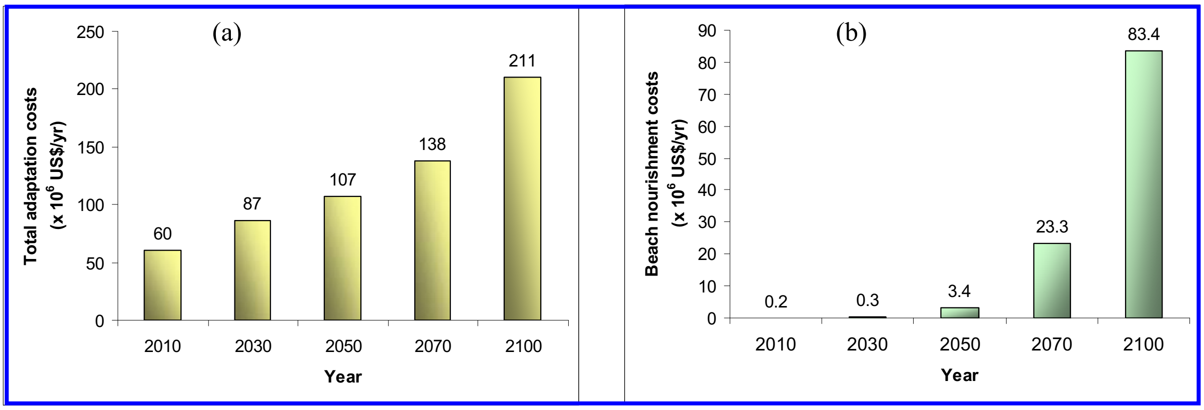


Figure 67: Projected adaptation costs on the Kenyan coastal zone for (a) total adaptation costs in millions US per year (b) beach nourishment costs in millions US$ per year (data source: the DINAS-Coast Consortium 2006 database).

List of References

Abuodha, P. A., 2009**.** Application and Evaluation of Shoreline Segmentation Mapping Approaches to Assessing Response to Climate Change on the Illawarra Coast, South East Australia Unpublished PhD Thesis, University of Wollongong, Wollongong, Australia. 286 pp.

ACCC, 2006a – ACCC national reports- Adaptation to climate change- responding to shoreline change and its dimensions in West Africa through integrated coast area management (Cape Verde, Gambia, Guinea Bissau, Mauritania, Senegal) (GEF/UNDP-UNESCO/IOC) (PDF-B Phase), 130 pp.

ACCC, 2006b – Inventory of coastal resources vulnerable to climate and shoreline changes in Cape Verde, The Gambia, Guinea Bissau, Mauritania and Senegal). Adaptation to climate change - responding to shoreline change and its dimensions in West Africa through integrated coast area management, 145 pp.

ACOPS - Advisory Committee on Protection of the Sea. 2002a. Portfolio of project proposals for the Global Environment Facility project on Development and Protection of the Coastal and Marine Environment in Sub-Saharan Africa (GF/6010-0016). Jointly undertaken with UNESCO-IOC, UNEP and GPA, 336 pp.

ACOPS - Advisory Committee on Protection of the Sea. 2002b. Senegal National Report: Phase 1: Integrated Problem Analysis. Authored by Niang-Diop I., Dansokho M., Ibrahima L.Y., Niang S., for the Global Environment Facility project Development and Protection of the Coastal and Marine Environment in Sub-Saharan Africa (GF/6010-0016), jointly undertaken with UNESCO-IOC, UNEP, and GPA 76 pp.

ACOPS - Advisory Committee on Protection of the Sea. 2002c. The Gambia National Report: Phase 1: Integrated Environmental Problem Analysis. Authored by Cham, M. A, Njai, S., Barnet, L., Bittaye, A., Bojany, L., Saine, A., Sanyang, F., Sarr, M.B., Jammeh, B., and Njie, M. for the Global Environment Facility project Development and Protection of the Coastal and Marine Environment in Sub-Saharan Africa (GF/6010-0016), jointly undertaken with UNESCO-IOC, UNEP, and GPA, 99 pp.

ACOPS - Advisory Committee on Protection of the Sea. 2002d. Ghana National Report: Phase 1: Integrated Problem Analysis. Authored by Wellens-Mensah, J., Armah, A. K., Amlalo, D. S. and Tetteh, K. for the Global Environment Facility project Development and Protection of the Coastal and Marine Environment in Sub-Saharan Africa (GF/6010-0016), jointly undertaken with UNESCO-IOC, UNEP, and GPA, 94 pp.

ACOPS - Advisory Committee on Protection of the Sea. 2002e. Nigeria National Report: Phase 1: Integrated Problem Analysis. Authored by Awosika, L., Osuntogun, N, Oyewo, E and Awobamise, A. for the Global Environment Facility project Development and Protection of the Coastal and Marine Environment in Sub-Saharan Africa (GF/6010-0016), jointly undertaken with UNESCO-IOC, UNEP, and GPA, 80 pp.

ACOPS - Advisory Committee on Protection of the Sea. 2002f. Kenya National Report: Phase 1: Integrated Problem Analysis. Authored by Kazungu J., Munga D., Mwaguni S.M., and Ochiewo J. for the Global Environment Facility project Development and Protection of the Coastal and Marine Environment in Sub-Saharan Africa (GF/6010-0016). Jointly undertaken with UNESCO-IOC, UNEP and GPA, 109 pp.

ACOPS - Advisory Committee on Protection of the Sea. 2002g. Tanzania National Report: Phase 1: Integrated Problem Analysis. Authored by Francis J., Wagner G M., Mvungi A., Ngwale J. and Salema R. for the Global Environment Facility project Development and Protection of the Coastal and Marine Environment in Sub-Saharan Africa (GF/6010- 0016), jointly undertaken with UNESCO-IOC, UNEP, and GPA, 61 pp.

ACOPS - Advisory Committee on Protection of the Sea. 2002h. Mozambique National Report: Phase 1: Integrated Problem Analysis. Authored by Hoguane A.M., Lopes S. and Menete Z. for the Global Environment Facility project Development and Protection of the Coastal and Marine Environment in Sub-Saharan Africa (GF/6010-0016), jointly undertaken with UNESCO-IOC, UNEP, and GPA, 113 pp.

ACOPS - Advisory Committee on Protection of the Sea. 2002i. Mauritius National Report: Phase 1: Integrated Problem Analysis. Authored by Dulymamode, R., Bhikajee, M and Sanassee, V. for the Global Environment Facility project Development and Protection of the Coastal and Marine Environment in Sub-Saharan Africa (GF/6010-0016), jointly undertaken with UNESCO-IOC, UNEP, and GPA, 79 pp.

ACOPS - Advisory Committee on Protection of the Sea. 2002j. Seychelles National Report: Phase 1: Integrated Problem Analysis. Authored by Jones T., Payet R., Beaver K. and Nalletamby M. for the Global Environment Facility project Development and Protection of the Coastal and Marine Environment in Sub-Saharan Africa (GF/6010-0016). Jointly undertaken with UNESCO-IOC, UNEP and GPA 127 pp.

Agrawala, S. and Fankhauser, S., 2008. Economics aspects of adaptation to climate change: costs, benefits and policy instruments, 133 pp.

Boko, M., I. Niang, A. Nyong, C. Vogel, A. Githeko, M. Medany, B. Osman-Elasha, R. Tabo and P. Yanda, 2007: Africa. Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds., Cambridge University Press, Cambridge UK, 433-467.

Cugusi, B., and Piccarozzi, M., 2009. Climate change and human mobility in Africa. A thematic literature and organisational review. Prepared for the International conference towards the G8 summit. CeSPI working papers 59/2009, 57 pp.

Dasgupta, S. Laplante, B., Murray, S. and Wheeler, D., 2009a. Sea-level rise and storm surges : a comparative analysis of impacts in developing countries, Policy Research Working Paper Series 4901, The World Bank, 41 pp.

Dasgupta, S. Laplante, B., Murray, S. and Wheeler, D., 2009b. Climate change and the future impacts of storm-surge disasters in developing countries. Working paper 182. Centre for Global Development, 26 pp.

DINAS-Coast Consortium, 2006. DIVA coastal database version 1.0. Accessed at http://diva.demis.nl/

Economics of Adaptation to Climate Change (EACC) study team, 2009. The cost to developing countries of adaptation to climate change. New methods and estimates. The global report of the Economics of Adaptation to Climate Change (EACC). Consultation Draft, 102 pp.

Elasha, B. O., Medany, M., Niang-Diop, I., Nyong, T., Tabo, R. and Vogel, C., 2006. background paper on impacts, vulnerability and adaptation to climate change in Africa for the African workshop on adaptation implementation of decision 1/CP.10 of the UNFCCC Convention. Accra, Ghana, 21-23 September, 2006, 54 pp.

Government of Guinea Bissau, 2006. National programme of action of adaptation to climate changes, 90 pp.

Gornitz, V. and Kanciruk, P. (1989) Assessment of global coastal hazards from sea level rise. Proceedings of the 6th Symposium on Coastal and Ocean Management, ASCE, 11-14 July, Charleston, SC.

Gornitz, V.M., White, T.W. and Cushman, R.M. (1991) Vulnerability of the US to future sea-level rise. Coastal Zone '91, Proceedings of the 7th Symposium on Coastal and Ocean Management, American Society of Civil Engineers, pp. 1345—1359.

IPCC, 2001a. Climate Change 2001: Impacts, adaptation and vulnerability**.** Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) In McCarthy, J. J., Canziani, O. F., Leary, N. A., Dokken, D. J., and White, K. S. (eds.). Cambridge University Press, UK. pp 1000.

IPCC, 2001b. Special report on methodological and technical issues in technology transfer.

IPCC, 2007a. Climate Change 2007: The physical science basis. Contribution of Working Group I to the fourth assessment report of the Intergovernmental Panel on Climate Change. In Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (eds.). Cambridge University Press, Cambridge, UK, 996 pp.

IPCC, 2007b. Climate Change 2007: Impacts, adaptation and vulnerability. Contributing of Working Group II to the fourth assessment report of the Intergovernmental Panel on

Climate Change. In Parry, M. L., Canziani, O. F., Palutikof, J. P., van der Linden, P. J. and Hanson, C. E. (eds). Cambridge University Press, Cambridge, UK, 976 pp.

Klein, R.J.T. and Nicholls, R.J. (1999) Assessment of coastal vulnerability to climate change. Ambio, Vol. 28, pp. 182—187.

La Trobe, S., 2002. Climate Change and Poverty- A discussion paper, 52 pp.

McFadden, L., Nicholls, R.J., Vafeidis, A. and Tol, R.S.J. (2007) A methodology for modeling coastal space for global assessment. Journal of Coastal Research, Vol. 23, pp. 911—920.

Ministry of Environment and Agriculture, 2007. National adaptation programme of action on climate change. Republic of Cape Verde 2008-2012. Executive version, 34 pp.

Ministry of Rural Development and of Environment, 2004. national adaptation of action to climate change (NAPA-RIM). Islamic Republic of Mauritania, 77 pp.

NAPA, 2008- National Adaptation Programmes of Action- Summary of projects on coastal zones and marine ecosystems identified in submitted NAPA as of September 2008, 106 pp.

National Climate Committee, 2003. First national communication of the Republic of the Gambia to the United nations Framework convention on climate change, 144 pp.

National Ocean Service, 2004. Addressing elevation and inundation issues in habitat restoration Planning and Implementation: a guidance document, 75 pp.

NEF, 2005 – New Economics Foundation. Africa – Up in smoke? The second report from the Working Group on Climate Change and Development, 40 pp.

Nicholls, R.J., Wong, P.P., Burkett, V.R., Codignotto, J.O., Hay, J.E., McLean, R.F., Ragoonaden, S. and Woodroffe, C.D. (2007) Coastal systems and low-lying areas. In Parry, M.L., Canziani, O.F., Palutikof, J.P., Van Der Linden, P.J. and Hanson, C.E. (eds) Climate Change 2007: Impacts, Adaptation and Vulnerability, Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge, pp. 315—356.

Sharples, C., 2004. Indicative Mapping of Tasmanian Coastal Vulnerability to Climate Change and Sea Level Rise: Explanatory Report, 1st edition, Tasmania, Department of Primary Industries, Water and Environment, pp 126.

Sharples, C., 2006. Indicative Mapping of Tasmanian Coastal Vulnerability to Climate Change and Sea-level Rise Tasmania, 2nd edition, Consultant Report to Department of Primary Industries and Water, pp 173.

Stern, N.H., 2006. The Economics of Climate Change: The Stern Review, Cambridge University Press, Cambridge, pp 692.

Theiss, J., 2009a. The cost of adaptation in coastal zones of Africa. UNESCO. African Ministerial Conference on the Environment. Special Session on Climate Change. Nairobi, Kenya, 25-29 May 2009

Theiss, J., 2009b. A concrete project suggestion underpinning Africa's road to the Copenhagen Climate change conference 2009 and beyond, 11 pp.

UNESCO-IOC. 2009. African Oceans and Coasts. Odido M. and Mazzilli S. (Eds). IOC Information Document, 1255, UNESCO Regional Bureau for Science and Technology in Africa, Kenya, 163 pp.

UNFCCC, 2009. Investment and financial flows to address climate change, pp 192 pp.

Vafeidis, A.T., Boot, G., Cox, J., Maatens, R., McFadden, L., J., N.R., Spencer, T. and Tol, R.S.J., 2006. The DIVA database documentation. DIVA documentation CDROM. 33 pp.

World Bank, 2007. Mozambique climate risk factsheet.

World Bank, 2008. Making development climate resilient for sub-Saharan Africa. Joint World Bank- African Development Bank Climate Change Strategy consultations May-June, 2008.

World Bank, 2009. Africa's development in a changing climate. Key policy advice from World Development Report 2010 and making development climate resilient: A World Bank strategy for Sub-Saharan Africa, 12 pp.

PART II

The Existing and Needed African Science-base for Coastal Adaptation

2.1	**The African Asset Base in Marine Sciences –** National Institutes and their capacities to address climate issues in coastal zones		
2.1.1	**Institutes of Sub-Region 1: West Africa – Senegal, Mauritania, Gambia, Guinea-Bissau, Cape Verde**		
2.1.1.1	Senegal	*National Synopsis*	
		Oceanographic Research Centre of Dakar Thiaroye (CRODT-ISRA)	
		Senegal National Agency for Meteorology (ANAMS)	
		Ecological Follow-Up Center (CSE)	
		Direction of Marine Fisheries (DPM)	
		Autonomous Port of Dakar (PAD)	
2.1.1.2	Mauritania	*National Synopsis*	
		Mauritanian Oceanographic Research and Fisheries Institute (IMROP)	
		Direction of Protected Areas and the Coast (DAPL)	
		Direction of the Prevention and Fight Against Pollution (DPLP)	
		Direction of Environment(DE)	
		National Office for Meteorology (ONM)	
2.1.1.3	Gambia	*National Synopsis*	
		Department of Fisheries and Water Resources (DFWR)	
		Department of Parks and Wildlife Management (DPWM)	
		Department of Water Resources (meteorological mandate) (DWR)	
		National Environment Agency (NEA)	
2.1.1.4	Guinea-Bissau	*National Synopsis*	
		Centre for Environmental Studies and Appropriate Technology of the National Institute of Studies and Research (CEATA/INEP)	
		Applied Fisheries Research Centre (CIPA)	
		Coastal Planning Cabinet (GPC)	
		Institute of Biodiversity and Protected Areas (IBAP)	
2.1.1.5	Cape Verde	*National Synopsis*	
		National Institute for the Development of Fisheries (INDP)	
		University of Cape Verde – Department of Engineering and Marine Sciences (DECM)	
		National Institute for Water Resource Management (INGRH)	
		National Meteorology and Geophysics Institute (INMG)	
2.1.2		**Institutes of Sub-Region 2: West Africa – Cote D'Ivoire, Benin, Togo, Ghana, Nigeria**	
2.1.2.1	Cote D'Ivoire	*University of Cocody*	
2.1.2.2	Benin	*Benin Fisheries and Oceanographic Research Centre*	
2.1.2.3	Togo	*Togolese Institute of Agronomic Research / Coastal Zone Agronomic Research Centre (ITRA/CRAL)*	
2.1.2.4	Ghana	*Marine Fisheries Research Division (MFRD)*	
		Department of Oceanography and Fisheries(DOF) – University of Ghana	
2.1.2.5	Nigeria	*National Synopsis*	
2.1.3		**Institutes of Sub-Region 3: West Africa – Cameroon,**	

		Gabon, Republic of the Congo, Angola, Namibia	
2.1.3.1	Cameroon	*National Synopsis*	
		Institute of Agricultural Research for Development (IRAD)	
		National Institute of Cartography (INC)	
		Institute of Mining and Geological Research (IRGM	
		National Direction of Meteorology (DMN)	
2.1.3.2	Gabon	*National Synopsis*	
		National Centre of Scientific and Technological Research (CENAREST) - Department of Marine Science (DESMAR)	
2.1.3.3	Republic of Congo	*National Synopsis*	
		General Delegation of Technical and Scientific Research (DGRST)	
2.1.3.4	Angola		
2.1.3.5	Namibia		
2.1.4		**Institutes of Sub-Region 4: East Africa and Western Indian Ocean Islands – Kenya, Tanzania, Mozambique, Mauritius, Seychelles**	
2.1.4.1	Kenya	*National Synopsis*	
		Kenya Marine and Fisheries Research Institute (KMFRI)	
		Fisheries Department (FiD)	
		Kenya Wildlife Service (KWS)	
		National Museums of Kenya (NMK)	
		Moi University – Department of Fisheries and Aquatic Sciences	
2.1.4.2	Tanzania	*National Synopsis*	
		Institute of Marine Sciences (IMS)	
		Institute of Resource Assessment (IRA)	
		Mbegani Fisheries Development Centre	
		The National Environment Management Council (NEMC)	
		Tanzania Fisheries Research Institute (TAFIRI)	
2.1.4.3	Mozambique	*National Synopsis*	
		Institute for Hydrography and Navigation (INAHINA)	
		National Meteorological Institute (INAM)	
		Ministry of Coordination of Environmental Affairs - (Unit for Coastal Zone Management)	
		Fisheries Research Institute (IIP)	
		Eduardo Mondlane University – School of Marine and Coastal Sciences (UNESCO Chair in Marine Sciences and Oceanography)	
2.1.4.4	Mauritius	*National Synopsis*	
		Mauritius Oceanography Institute (MOI)	
		Meteorological Services	
		Albion Fisheries Research Centre	
		Central Information Bureau (CIB)	
		Ministry of Environment	
2.1.4.5	Seychelles	*National Synopsis*	
		Department of Environment – coast/ocean	
		Seychelles National Parks Authority (SNPA)- includes terrestrial and marine parks	
		Island Conservation Society -ICS)	
		Seychelles Island Foundation	

PART II – THE EXISTING AND NEEDED AFRICAN SCIENCE-BASE FOR COASTAL ADAPTATION

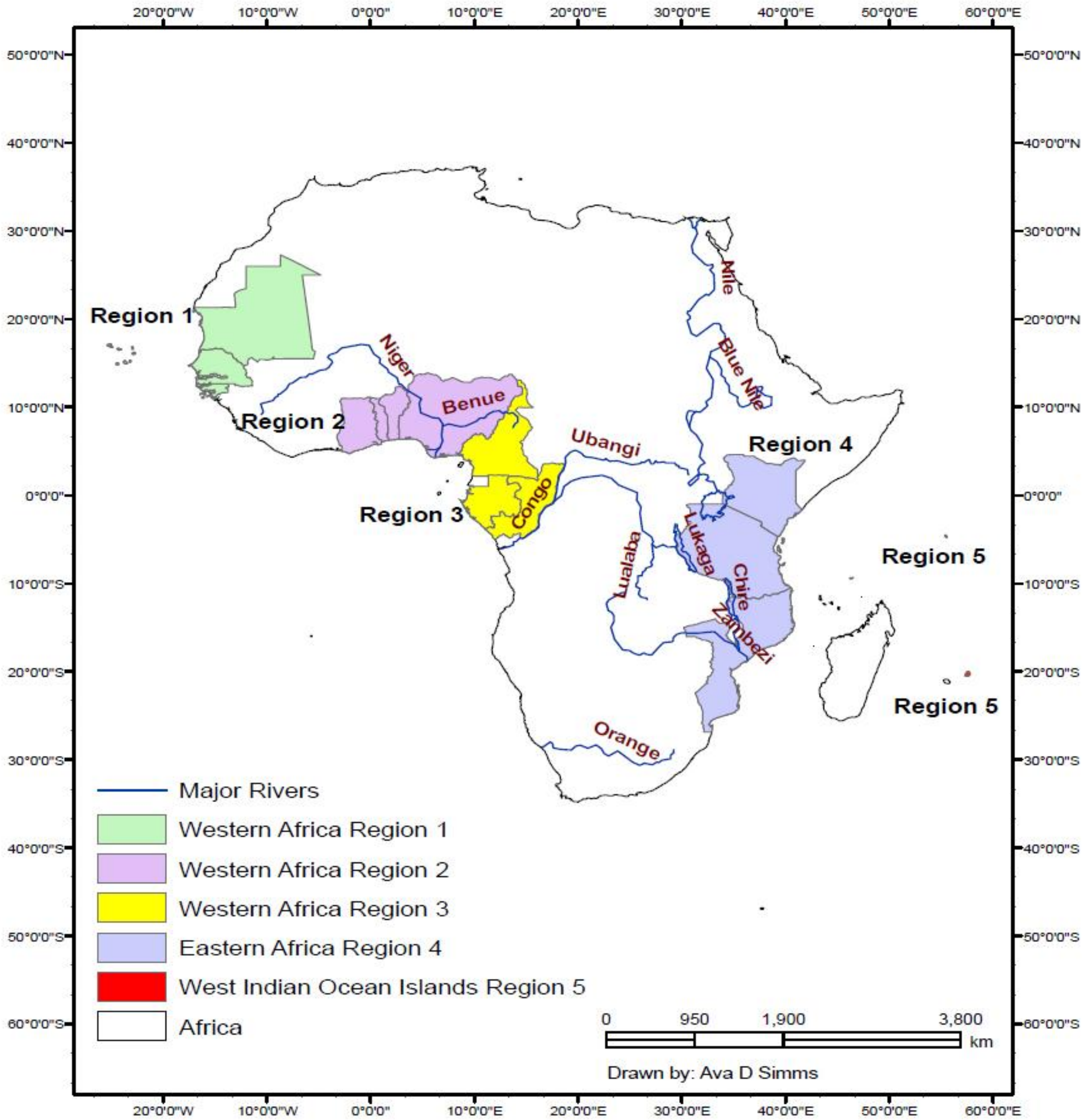
Introduction

With the recognition of the threats of climate change, particularly on the African coastal zones, African marine institutes are important in providing the science- base for coastal adaptation in Africa. However, this is a critical challenge, as most of these marine institutes do possess limited qualified human resources, infrastructures and services for addressing climate issues in coastal zones, and also they lack self-driven capacity development. Therefore, UNESCO/IOC in realizing this, has conducted an assessment for evaluating the existing needed African science-base for coastal adaptation. This will allow one to have an explicit understanding of the capabilities of these marine institutes in their attempts for coastal adaptation, and where and how these identified gaps can be addresses for these marine institutes to be capable, self-driven and able to sustain in addressing climate issues on the coastal zones of Africa.
Furthermore, there are very few Ministries which possess full authority to manage coastal zones effectively in Africa, (as they might be under one or more Ministry, as an agency or within a national committee) this hinders the marine institutes to effectively conduct their researches, to impact the decision-makers on marine science issues or being defined as the national priorities. There is a need of African governments to establish a well defined Ministry responsible for the marine institutes, to define the marine institutes as national priories, if they are to imply the necessary adaptation and mitigation measures for coastal erosion and climate change.

However, the high degree of the vulnerability on the coasts of Africa requires an assessment of the capacities of national institutes that are involved in coastal and marine sciences, this is important for the mitigation and adaptability of climate change. Therefore, below are the national marine institutes and their capacities, involved in addressing marine issues widely across the continent.

2.1 **The African Asset Base in Marine Sciences –** National Institutes and their capacities to address climate issues in coastal zones**.**

Map of Africa and the given regions



Institutes of Sub-Region 1: West Africa – Senegal, Mauritania, Gambia, Guinea-Bissau, Cape Verde (Regional Coordinator: Anis Diallo (Senegal)) "The main coastal issue for Region 1 is coastal erosion caused by natural and anthropogenic factors. Other issues are sea-level rise, precipitation and floods, droughts and desertification, depletion of mangrove and fisheries resources and pollution. With the global rise in sea-level, further considerable land loss, modification of ecosystems and other socio-economic impacts may be expected."

2.1.1.1 Senegal

National Synopsis

**CCLME MARINE SCIENCE INSTITUTES
NATIONAL ASSESSMENT OF CAPACITIES TO SUPPORT CLIMATE CHANGE ISSUES
(SENEGAL)**

Senegal has defined a national policy and framework for adaptation to climate change: **CCNUCC,** 1997, SNMO, 1999 with the settlement of the National Committee (**COMNACC**) in 2003.

The identified priorities to fight against negative impacts of climate change were:

- Turning into desert and land degradation (salinisation);
- Integrated Management of Water resources ;
- The biodiversity;
- Marine and coastal areas Management;
- Waste and Pollution Management;
- Wetlands conservation ;
- The promotion of energy efficiency and of new and renewable energies; and the rational use of traditional energies.

This national committee is composed by 25 members (Ministries, Parliament, NGOs, research institutes, universities and professionals (economic operators) its missions are; to manage and follow up identified activities within the framework on the implementation of measurements for reduction of the gas emissions, with greenhouse effect; and the adaptation to negative impacts of climate changes.

Capacities of involved institutes, NGOs and technical services were identified. On this basis, several projects were settled covering different issues impacted by climate changes. These projects and programme were identified in the framework of the National Action for Adaptation to climate change as:

- Attenuation of green house gases effect project by carbon sequestration by the afforestation and forest protection ;
- Green house gas reduction project by promoting new and renewable energies;
- Research project for the development of Information System for Decision-making with regard to the management of environment and natural resources;
- Pilot project for protection of Dakar coastal zone ;
- Development of the hollows and the plains of flood project.
- Reinforcement of the capacities in information and research development ;
- Project of Air Quality (survey) in Dakar city (**QADAK**)

Most of these projects and programme have financial supports for a total cost of approximately US$ 30 millions.-

Senegal through different studies has identified scenarios and mechanisms to prevent and/or minimize risk and natural catastrophes, national marine science institutes realized or participated in these different workshops such as; integrated practices and tool systems of

evaluation and management on climate risks (République du Senegal, 2008; Sène, 2008 and Diallo, 2009).
In terms of preparation and adapting strategies on climate change impacts, joined efforts and collaborations of several Senegalese institutes were very useful and well appreciated.

National Capacities

But the country still has some constraints and difficulties in which more international collaboration and additional financial support are needed:

- ✓ Insufficiency of the data and absence of forecasts on pollution;
- ✓ Insufficiency of material and logistics for the collection, the analysis and the follow-up and the control of pollution;
- ✓ erosion and draining of the coasts;
- ✓ salinisation of water;
- ✓ degradation of mangroves, and wetlands
- ✓ Biodiversity conservation
- ✓ Reinforcement of institutional capacities (human & laboratory equipments)
- ✓ Reforestation & conservation of biospheres
- ✓ Coastal preservation occupation plan mapping
- ✓ Marine Spatial Planning & Ocean Mapping

The main structures and institutes working in network for climate change impacts are (no exhaustive list):

- **DEEC**
- **CSE**
- **UCAD/LPAO-SF**
- **UCAD/LERG**
- **UCAD/Dpmt GEO**

- **UCAD/ISE**
- **UCAD/IST**
- **ISRA/CRODT**
- **ANAMS**
- **UGB**
- **ISRA/CERAAS**
- **ISRA/CNRA**
- **DPM**
- **DPN**
- **PHARES & BALISES**
- **PSPS**
- **HASMAAR**
- **PAD**
- **MINISTRIES**
- **NGOs (ENDA, WWF, CONGAD, etc.….)**
- **OPS (Professional civil organisations)**

Consulted documents

1. République du Sénégal, 1997. Communication initiale du Sénégal à la convention cadre des Nations Unies sur les changements climatiques, 118p.
2. République du Sénégal, 1999. Stratégie Nationale initiale de mise en œuvre (SNMO) de la Convention cadre des Nations Unies sur les changements climatiques (CCNUCC), 53 p.
3. République du Sénégal, 2008. Etude de priorités des secteurs du tourisme et des infrastructures routiers face à la vulnérabilité aux changements climatiques, 38 p.
4. Abdoulaye Sène, 2008. La Région de Fatick (Sénégal) face aux défis du changement climatique.

5. Sorry DIALLO, 2009. Narrative discussion on the importance of the Marine meteorological activities

Additional consulted documents

6. Moussa Gueye, 2009. Rapport de l'Atelier de concertation sur l'état des systèmes de veille environnementale pour la mise en place d'un plan de réponse écologique en Afrique de l'ouest, 38 p.
7. Boubacar Fall & Serigne Kandji (CONGAD), 2008. Atelier régional CLACC sur l'adaptation aux changements climatiques, 35 p.
8. Institue de l'Energie et de l'Environnement de la Francophonie (IEPF). ENDA, 2009. Etude préliminaire d'adaptation aux changements climatiques en Afrique. ENERGIE : Contribution au projet négociation climat pour toute l'Afrique réussie (NECTAR), 60p.
9. ENDA. Renforcement des capacités en matière d'évaluation de la vulnérabilité et des stratégies d'adaptation aux changements climatiques. Guide du formateur, 9 p.

CENTRE DE RECHERCHES OCEANOGAPHIQUES Dakar-Thiaroye (CRODT/ISRA)

Oceanographic Research Center of Dakar-Thiaroye

Vision: Management, Research and Sustainable Development of Fisheries.

Priorities:
1. Marine resources evaluation biomasses
2. Follow up of marines resources and fishing systems
3.Produce techniques and knowledge's for Fisheries management
4. Make available knowledge and techniques for sustainable aquaculture

Coastal Adaptation Strategy: [YES]

1. 1974 Strategic Plan for research actions
2. 1984 Strategic Plan for research actions
3. 2004 Strategic Plan for research actions
4. 2009 Strategic Plan for research actions

Collaborating Organizations:
NATIONAL: (www.nodc-senegal.org/reseauanis.htm)
INTERNATIONAL:
- IOC
- FAO
- IRD
- Several Research Institutes in Europe, USA and Asia. Organizations in west Africa region and in the CCLME

Phone: +221 33 832 82 65
Fax: +221 33 832 82 62
Email: crodtisra@isra.sn
Web: www.nodc-senegal.org/crodtanis.htm; www.isra.sn
Address: Parc de Recherches ISRA/HANN, BP 2241 Dakar, Sénégal.

Director:
Dr. Hamet Diaw DIADHIOU
Email: hamet_diadhiou@yahoo.fr

Ministry: Ministry of Agriculture, of Fish culture and Biofuels (www.agriculture.gouv.sn)

Institute Strengths:
Human Resources: The CRODT currently has 82 professional and administrative staff. Of the 75 professional staff, 07 have PhD, 08 have a M.Sc/M.Tech and 14 have a B.Sc/B.Tech

Infrastructure: The CRODT has a good power supply. The internet link is ADSL and the connection speed is 100 Mbps/s with 40 personal computers connected. There are 04 laboratories specializing in seawater (physical & chemical analysis; fish biology and acoustic. Data collection at sea is done using research vessel (N/O Itaf DEME), moored, drifting buoys and installed equipment (Meteo stations and tide gauge).

Publications: In the last 5 years, 27 researchers affiliated to CRODT & ISRA; have received approximately 32 publications (per year) related to marine and coastal zone issues. The CRODT has provided information concerning coastal management, marine environmental variations and fish landing, fishing effort and aquaculture practices to government (development), NGOs, Professionals actors and students.

Financial Resources: The CRODT has a total budget of approximately 878,000 with 43% allocated towards projects addressing coastal/marine management issues.

Capacity Development Needs to Address Climate Issues in Coastal Zones

Issues:	**Currently Available Services:**	**Services needed for Adaptation:**	**Capacities Needed for Services:**
[Coastal Erosion]	1. Tidal variation (sea level rise)	1. Softwares for tide analysis	1. Short training in experimented laboratory.

•			
[Marine Meteorology]	1. Waves prediction at surface (1-5m) 2. Wind at surface (1-5m) 3. Swell at surface (1-5m)	1. Buy and Upgrade softwares 2. " 3. "	1. Training (reinforcement of capacity building)
[Aquaculture]	1. Production Techniques (fry, fingerlings & grout out/ feeding composition & rate) and production systems	1. Development & adaptation of native marine species over exploited or scarce because of infrastructures settlement.	1. Training and experience exchange .
[Fish Biodiversity]	1. Fish diversity 2. Lost of biodiversity 3. Fish biomass & Acoustic evaluation	1. Settlement of Ecosystem Based Management (EBM)	1. Training on EBM and softwares. And on Marine Spatial Planning

CRODT Capacity Development Needs

In ad equation with its mission, the CRODT/ISRA has to develop and reinforce its capacities on Marine Spatial Planning, Marine meteorology prediction and models; Sea level rise prediction and models with intertidal ecology.

To achieve these objectives and respond correctly to national demands, the center needs:

- ✓ reinforcement of the capacities for the development of research and oceanographic services;
- ✓ production of knowledge, measurements of attenuation for adaptation to climate changes
- ✓ the transfer of marine techniques in the management of oceans (ICAM, ICOM & EBM) in a Marine Spatial Planning (MSP)

For research and ocean services, support of needs must be done thru:

- organization of trainings in favor of professionals (in experimented laboratories)
- mission of assistance
- granting of purse to Senegalese students (Master or/and PhD)

Vision: To collect, the treatment, the analyzes and the diffusion of the data and information on the territory natural resources, by using space technologies, for the improvement of the management of these resources and the environment Priorities: 1. Environmental Survey 2. Natural stock management and Environmental Studies 3. Cartography & System development d' information 4. Training on the trades of Geomatic Coastal Adaptation Strategy: [Y] 1. Senegal Biodiversity Strategy (2004) 2. National Strategy initiative for CCUNCC (1999) 3. National Action Plan for the Environment (2004) 4. Action Plan for Environment in NEPAD (2002) Collaborating Organizations: NATIONAL: www.nodc-senegal.org/reseauanis.htm INTERNATIONAL: • UN • AGRYMET	**CENTRE DE SUIVI ECOLOGIQUE (CSE)** **Ecological Follow Up Center** Phone: +221 33 825 80 66 Fax: +221 33 825 81 68 Email: dt@cse.sn Web: www.cse.sn Address: Rue Léon Gontran Damas, Fann Résidence, BP. 15532 Dakar, Sénégal Ministry: **Ministry of Environment, Protection of Nature, Retention Ponds and Artificial Lakes** (www.environnement.gouv.sn)	 Dir Dr. Assize TOURE Email: assize.toure@cse.sn

Institute Strengths:
Human Resources: The CSE currently has 40 professional and administrative staff. Of the 24 professional staff, 12 have PhD, 6 have a M.Sc/M.Tech and 6 have a B.Sc/B.Tech

Infrastructure: The CSE has a very good power supply. The internet link is ADSL and Wireless and the connection speed is 2064 Mbps with approximately 35 personal computers connected. There is 01 laboratory specializing in teledetection (GIS Mapping). Data collection at sea is done using installed equipment (satellite receiver).

Publications: In the last 5 years, 24 researchers affiliated to CSE have received 45 publications related to marine and coastal zone issues. CSE has provided information concerning added value of natural resources, geographic data to government, NGOs, etc….

Financial Resources: CSE has a total budget of approximately (not available) with approximately 35% allocated towards projects addressing coastal/marine management issues.

Capacity Development Needs to Address Climate Issues in Coastal Zones

Issues:	**Currently Available Services**:	**Services needed for Adaptation:**	**Capacities Needed for Services:**

[Coastal Erosion]	1. Map of land use and occupation 2. Wetlands in Senegal	1. Regular follow up	1. More training & sharing experience with experimented laboratories
Other Services (http://services.cse.sn)	1. Satellite images treatment 2.Environmentals follow up	1. Regular follow up	1. More training & sharing experience with experimented laboratories

The CSE Capacity Development Needs

The Ecological Follow up center needs is:

- ✓ Sharing experiences with experimented laboratories in providing services In environmental evolutions, hazards and upgrade equipment for rapid respond to demands for users.

Vision: To ensure the development and the follow-up of the implementation of the policy as regards maritime fishing Priorities: 1. to work out and put in work plans of installation of the maritime fisheries, in connection with the public structures and	**DIRECTION DES Pêches Maritimes (DPM)** **Direction of Marine Fisheries**	

private professional organizations concerned

[Fisheries Management]

1. Statistics (annually)

2. to ensure the management of the maritime fisheries exploited pursuant to the plans of installation
3. to take care of the application of the regulation relating to the exercise of maritime fishing
4. to ensure the experimentation and the popularization of the equipment, the techniques and the results of research in the field of maritime fishing

Coastal Adaptation Strategy: [Y]
1. Sectorial Political Letter (2007)
2. Marine Policy (2007)
3.Development Plan (2009), (new)
4. Code of Fishing 2009 (new)
5. Data policy (2001)

Collaborating Organizations:
NATIONAL: www.nodc-senegal.org/reseauanis.htm
- MEMTMP
- CRODT
- PAD

INTERNATIONAL:
- IOC-UNESCO
- FAO
- UE
- CSRP
- UA

Phone: +221 33 823 01 37
Fax: +221 33 821 47 58
Email: dopm@orange.sn
Web: www.ecomaritime.gouv.sn ; www.ecomaritime.gouv.sn/spip.php?article17
Address: 1, rue Joris. BP 139 Dakar, Sénégal

1. Monthly statistics of landing & market price

Director:
Dr. Pape Namsa KEITA
Email: pnkeita@gmail.com; pnkeita@orange.sn

1. Biodiversity management for Alert on biodiversity lost & over fishing

Ministry: **Ministry of Marine Economy, Marine Transport and Fisheries** (www.ecomaritine.gouv.sn); www.ecomaritime.gouv.sn/spip.php?article17

Institute Strengths
Human Resources: The DPM currently has more than 200 professional and administrative staff. Of the 55 professional staff, 12 have PhD, 12 have a M.Sc/M.Tech and 15 have a B.Sc/B.Tech

Infrastructure: The DPM has a good power supply. The internet link is ADSL and the connection speed is 2048 Mbps with approximately 75 personal computers connected. There is 01 laboratory specializing in fish sanitary control. No Ocean Data are collected.

Publications: In the last 5 years, 5 researchers affiliated to DPM have received 55 publications related to marine and coastal zone issues. The DPM has provided information concerning fish landing and management strategy to the government and the private sector including NGOs.

Financial Resources: The DPM has a total budget from the government approximately US$3,000,000 with 40% allocated towards projects addressing coastal/marine management issues.

Capacity Development Needs to Address Climate Issues in Coastal Zones

Issues:	**Currently Available Services**:	**Services needed for Adaptation:**	**Capacities Needed for Services:**

DPM Capacity Development Needs

The main needs are:

- Equipments (computers & softwares)
- Training on dissemination of scientific results

Phares et Balises /Port Autonome de Dakar (PAD)

Lighthouses and Beacons / Autonomous Port of Dakar

Phone: +221 33 849 45 45/ 33 849 79 51
Fax: +221 33 823 36 06
Email: contacts@ssms.sn
Web: www.ssms.sn
Address: 21, Boulevard de la Libération. BP. 3195, Dakar, Sénégal.

Dir
Email: mbaidythioub@yahoo.fr

Admin:
Abdoulaye DIA
Email: abdoulaye.dia56@yahoo.fr

Ministry: Ministry of Marine Economy, Marine Transports and Fisheries (www.ecomaritime.gouv.sn)

Vision: Navigation and Marine Security

Priorities:

1. The maintenance of the public works of maritime indication on the extent of the national territory
2. Assistance with private within the framework of the installation of works E indication maritime
3. The hydrography of the navigable interior ways within the framework of the control or the establishment of channels
4. The hydrography of the water level of the PAD and the control of the operations of dredging
5. Transmission of all nautical information necessary to the safety of navigation for their publication, diffusion and update
6. Diffusion and transmission of the opinions to the navigators to allow, as much as possible, the up to date behavior of the maritime charts and nautical publications

Coastal Adaptation Strategy: [N]

Collaborating Organizations:

NATIONAL:

- ✓ PAD
- ✓ HASMAR
- ✓ CRODT/ISRA
- ✓ UCAD
- ✓ MEMTMP

INTERNATIONAL:

- ✓ PANPA
- ✓ PAN (Mauritania)
- ✓ PB (Gambia)
- ✓ PB (Guinea Bissau)
- ✓ IALA
- ✓ OMI
- ✓ OHI
- ✓ AISM

Institute Strengths:

Human Resources: Phares & Balises currently has 61 professional and administrative staff. Of the 11 professional staff, 03 have a M.Sc/M.Tech and 07 have a B.Sc/B.Tech

Infrastructure: Phares & Balises has a good power supply. The internet link is ADSL and the connection speed is 100 Mbps/s with 07 personal computers connected. There are 01 laboratory specializing in Hydrographic and Mapping. Data collection at sea is done using research vessels (Léon–Bourdelles & 02 small Boats), installed equipment (Tide gauge).

Publications: No specific publications. Just an annual report of effective services in the year for the Administration Consulting.

Financial Resources: (From the Government).

Capacity Development Needs to Address Climate Issues in Coastal Zones

Issues:	**Currently Available Services**:	**Services needed for Adaptation:**	**Capacities Needed for Services:**

[Hydrographic & Mapping]	1. bathymetric maps of the coastal zone (EEZ)	1. Rapid responds with new technologies.	1. Training on GIS Mapping & Ocean Mapping
[Balisor]	1. Installation of the floating national maritime mark out 2. Assistance at the public agencies within the framework of the installation of maritime works 3.	1. Real time Data on marine meteorology (tide, swell & wind)	1. Equipment for Marine meteorology & softwares for data processing (short training on)

Phares & Balises Capacity Development Needs

The needed capacities development still:

- ✓ Reinforcement of capacity building on bathymetric & geophysics
- ✓ GIS mapping & use of new technology (satellite data, Google Earth & Google Mapping)
- ✓ Equipment for marine meteorology for real time data display and,
- ✓ Short Training on their utilization & analysis.

2.1.1.2 Mauritania

National Synopsis

CCLME MARINE SCIENCE INSTITUTES NATIONAL ASSESSMENT OF CAPACITIES TO SUPPORT CLIMATE CHANGE ISSUES (MAURITANIA)

Since the 2000s, Mauritania has a 'National Environment Action Plan' (**NEAP**) in the framework of the 'National Adaptation Programme of Action' (**NAPA**), establish in order to settle actions priorities for adaptation to climate changes (Islamic republic of Mauritania, 2004).
Appropriate solutions to adaptation to climate change for the Livestock farming sector focus on the reduction of risks related to the restriction of grazing land, and the development of animal health and production. To ensure that pastoral land is not partitioned, the establishment and the implementation of a pastoral code promoting free access to resources and mobility are essential.

Epidemiological studies should be carried out and broadened to enable the development of an epidemiological map, and a schedule of the various prophylactics for the most prevalent diseases of the different species, depending on systems of husbandry, eco-climatic conditions and categories of animal.
To improve animal products, an open core selection programme ought to be thoroughly researched in an attempt to ensure effective participation of livestock herders. The main effort should focus on improving the conditions of local poultry farming (prevention of disease, housing, watering and feeding conditions). Once the basic foundations have been laid, pedigree cockerels of mixed rustic lineage could be introduced to improve local species. Popularization of village poultry farming should be organized using women nominated by their respective communities.

Breeders should be given strong support to advise them to feed their chickens a more balanced and economical diet. This will also involve agreed activities to disseminate adequate techniques to improve the nutritional and quantitative value of fodder, and to implement provisions designed to provide animals with supplementary minerals (small workshops for making salt-licks and multi-nutritional blocks).

Livestock herders' organizations should make it their business to facilitate the spread of information and to supply and stock supplementary feed for strategic periods. The strengthening of marketing potential should focus on

improving networks for marketing milk, red and white meat, leather and hides by taking action on conservation equipment, types of conservation, and collection systems.
As far as agriculture is concerned, adaptation devices relate mainly to rain-fed crops, aiming at:

- ✓ improving agricultural methods in pluvial zones and introducing new drought-resistant, high-yield cereal species;
- ✓ promoting economical irrigation techniques in oasis areas (drip irrigation pilot schemes); and
- ✓ training and informing producers, their Socio-Professional Organizations (SPO), and Community Educators (CE). For irrigated crops, the appropriate solutions involve the intensification and the diversification of agriculture to promote crops with high yields and small-scale irrigation.

In forestry, the strategy advocated to control the prevention of the adverse effects of drought by promoting collaboration between the different structures involved in collecting, analyzing, and monitoring of pastoral and agricultural information, and the structure following up plant diseases.
To save forest resources, an alternative source of energy should be used to meet the needs of communities.

Development of forests is another adaptation device. Forestry development helps organize what is currently a chaotic area of exploitation. It integrates the concepts of management and control. The very existence of forests in Mauritania is under threat because they are being used without any form of renewal. Sustainable development of these forests therefore requires that production activity there should be limited to their capacity for regeneration.
As regards to water resources, appropriate solutions to adaptation to climate change should be sought in the effective implementation of the Integrated Water Resource Management approach, which is based on the following criteria:

• *Regular assessment of availability of water resources and requirements. In fact, good management of water resources requires a good knowledge of the resources, both as regards their development in quantity and quality as well as from the perspective of demand. It is therefore important to establish a functional evaluation network (quantity and quality) properly distributed throughout the country*

• Establishment of a system of monitoring and mitigation of impacts related to the dynamics of sustainable socio-economic development which respecting the conservation of the environment.

• Establishment of a communications strategy to promote rapid dissemination and circulation of information among partners in an effort to organize periodic submission of results and to draft priority action plans.

• Establishment of a schedule for division of water and management regulations to prevent conflict of use. Knowledge of the resource must be taken into account at various levels so as to enable short, medium and long term projections and to share the resources equitably.

• Establishment of instruments of legal and economic regulation to promote improved use of water resources.

• Prior reinforcement of capacities to ensure the perfect implementation of Integrated Water Resource Management through the creation of viable institutions responsible for monitoring and evaluation of the status of water resources and the provision of reliable information to the various partners.

The measures for adapting to climate change in the arid and semi-arid ecosystems of Mauritania consist, first, of developing measures designed to put an end to the causes of the degradation of these areas and, second, measures for their restoration (République Islamique de Mauritanie, (CNI), 2001) . They are mainly measures relating to three principal exploitation sectors of land ecosystems (wood and charcoal, pasture-land and agricultural production) and adequate developments ensuring sustainable management of the various land ecosystem types (wetlands, agricultural ecosystems, forests, pasture-land ecosystems).

To respond to climate change, the land ecosystems of the country can also be strengthened by additional measures which might focus on reforestation for energy purposes (agro-forestry projects) and production (building plants for quickset hedges or wind-breaks, notably) and assisted plantation of trees (manual or aerial sowing of seed, hoeing).

Regarding coastal and marine ecosystems, appropriate adaptation solutions could take the form of development of fisheries, the general control and monitoring of the fish resources and creating awareness among of the various stakeholders. Other response strategies concern chiefly the protection and strengthening of the coastal belt and the integrated management of wetlands.

National Capacities with regards to administration

- The absence of an institutional framework specific to the implementation of actions benefiting from operational support; the bodies

National Centre for Development and Environment (NCDE), Technical Centre for Development and Environment (TCDE), Regional Centre for Development and Environment (RCDE) and others bear witness to a lack of driving force;

- The obsolete nature of the laws which exist on the environment in relation to the conventions;
- The as yet informal nature of the project as perceived by the decision-makers in general;
- The diversity of the mechanisms engaged at national level in the area of the environment without any obvious connecting relationship, which necessarily weakens institutions involving in environment.
- The lack of human resource (professionals) and funds for materials and softwares

One or two institutes are really able to accomplish their task in the national network.

Capacity building needs for the strengthening of national institutions:

- ✓ Methodology development ;
- ✓ Technical and analytical skills

The training strategy must be:

- ✓ Short term targeted courses
- ✓ Long term formal degree courses
- ✓ Joint research & development (R&D) and development (D) activities.

The main structures and institutes working in network for climate change impacts are:

- **DALP**
- **DENV**
- **DPLP**
- **DRTE**
- **DSFSC**
- **IMROP**
- **NADWS**
- **NCAARD**
- **NCSAR**
- **NCWR**

- **NPBA**
- **ONM**

Consulted documents

1. République Islamique de Mauritanie (CNI), 2001. Première Communication sur Convention Cadre des Nations Unies sur les Changements Climatiques
2. Islamic Republic of Mauritania, 2004. National Adaptation Programme of Action to Climate Change, 78 p.

Vision: Provide knowledge necessary to management and the durable exploitation of the resources and aquatic environments Priorities: 1. de contribuer au développement durable des pêcheries	**Institut Mauritanien de Recherches Océanographique et des Pêches (IMROP)** **Oceanographic and Fisheries Mauritanian Research Institute**	

2. Operating Systems and Fisheries Management plan: 1. five-year plan 1998-2002 2. five-year plan 2003-2007 3. five-year plan 2008-2012 Collaborating Organizations: NATIONAL: ➢ DAPL ➢ DE ➢ DPLP ➢ DPCIC INTERNATIONAL: ➢ CSRP ➢ CRODT ➢ IFREMER ➢ IRD ➢ IOC ➢ UE ➢ UN	Phone: +222 574 51 24 / 574 84 49/574 53 79/ 574 50 23 Fax: +222 574 50 81 / 574 53 79 Email: courier@imrop.mr Web: www.imrop.mr Address: BP 22, Nouadhibou, Mauritania	Director: **Dr DIA Alion** Email: dvis@toptechnology.mr Director of Resource & Environment: Mohamed Fall KHALLAHI Email: medfall_khall@yahoo.fr
	Ministry: **MINISTRY OF FISHERIES AND MARITIME ECONOMIE** (www.mpem.mr)	

Institute Strengths:
Human Resources: IMROP currently has 170 professional and administrative staff. Of the 110 professional staff, 20 have PhD, 18 have a M.Sc/M.Tech and 27 have a B.Sc/B.Tech

Infrastructure: IMROP has a very good power supply. The internet link is ADSL AND VSATand the connection speed is 2064 Mbps with approximately 65 personal computers connected. There are 02 laboratories specializing in physical & chemical oceanography and fish biology. Data collection at sea is done using 02 research vessels and installed equipments.

Publications: In the last 5 years, 55 researchers affiliated to IMROP have received 115 publications related to marine and coastal zone issues. IMROP has provided information concerning statistics, ocean pollution & environment to government, NGOs, etc... in preparation for COP-15.

Financial Resources: IMROP has a total budget of approximately 2,000,000 Euros with 45% allocated towards projects addressing coastal/marine management issues.

Capacity Development Needs to Address Climate Issues in Coastal Zones

Issues:	**Currently Available Services**:	**Services needed for Adaptation:**	**Capacities Needed for Services:**
[**Aquatic Ecosystems and Uses**]	1. Quality Ocean Data & information	1. Knowledge on the ecosystems and their interactions with the social systems and economic, in particular in terms of impact of the human activities	1. Capacity for Ocean mapping & map server
[**Halieutic Resources and Environment**]	1. Evaluation of the resources related to the support with the decision with the concern of developing research activities	1. To develop and apply new models and approaches including the aspects environmental and being able to lead to diagnosis more reliable of the resources.	1. Exchange experiences with experimented labs on resources evaluation & on EBM

IMROP Capacity Development Needs

IMROP, to achieve his mission and respond correctly to national demands, needs:

- ✓ A reinforcement of the capacities for the development of research and oceanographic services;
- ✓ A production of knowledge, measurements of attenuation for adaptation to climate changes
- ✓ The transfer of marine techniques in the management of oceans (ICAM, ICOM & EBM) in a Marine Spatial Planning (MSP) project.

For research and ocean services, support of needs must be done thru:

- Organization of trainings in favor of professionals (in experimented laboratories)
- Mission of assistance & collaboration
- Granting of purse to students (Master or/and PhD) thesis.

Vision: Design the national policy as regards conservation of the protected areas and the littoral

Priorities:

1. To develop the network of the protected areas with a view to sustainable development
2. To implement the national policies of protection and stock management of the littoral
3. To ensure the safeguarding of the threatened species d' extinction, including the migrating species itinerant or resident in the protected areas and the littoral

Coastal Adaptation Strategy: [Y]

1. Action Plan: 2008

Collaborating Organizations:

NATIONAL:

- IMROP
- DE
- DPLP
- DPCIC

INTERNATIONAL:

- UN
- UICN
- CSRP
- PRCM
- RAMPOA

Direction des Aires Protégées et du Littoral (DAPL)

Direction of Protected Areas and the Coast

Phone: +222 529 01 15 / 525 83 86
Fax: +222 525 83 86
Email:
Web: www.environnement.gov.mr/index.php
Address: Rue 21-185 N° 834- Ksar, PO Box. 170 Nouakchott - Mauritania

Director:
Amadou Diame BA
Email: gaonadio@yahoo.fr
Deputy:
Mohamed Lemine Ould Cherif
Email: micherif@yahoo.fr

Ministry: MINISTRY OF THE ENVIRONMENT AND SUSTAINABLE DEVELOPMENT (www.environnement.gov.mr)

Institute Strengths:

Human Resources: DAPL currently has [XX] professional and administrative staff. Of the [YY] professional staff, [ZZ] have PhD, [WW] have a M.Sc/M.Tech and [VV] have a B.Sc/B.Tech

Infrastructure: DAPL has a good power supply. The internet link is ADSL and the connection speed is 2048 Mbps with approximately 19 personal computers connected. There are no laboratories specializing in [Please insert fields researched]. Data collection at sea is done using [research vessels, moored and/or drifting buoys, installed equipment].

Publications: In the last 5 years, [XX] researchers affiliated to DAPL have received [YY] publications related to marine and coastal zone issues. DAPL has provided information concerning [Insert Issue] to [Organization(s)] in preparation for COP-15. [If Applicable]

Financial Resources: DAPL has a total budget of approximately [XX] with [YY%] allocated towards projects addressing coastal/marine management issues.

Capacity Development Needs to Address Climate Issues in Coastal Zones

Issues:	**Currently Available Services**:	**Services needed for Adaptation:**	**Capacities Needed for Services:**
[APMs services]	1. To ensure the safeguarding of the threatened extension species, including the species migrating or resident in the protected areas and the littoral.	1. To promote new models of protected areas	1. More training in Biodiversity management & site restoration
[Littoral Services]	1. to set up a process of participative governorship of the littoral	1. Management of the Littoral in the optics of an environmental good governance of the coastal area.	1. Exchange knowledge on Coastal Management (ICOM & ICAM)

[Biodiversity Services]	1. Quality collected data necessary to the improvement of knowledge on the biodiversity of the protected areas and the littoral	1. Settle measures for the safeguard and the conservation of the migrating species in the protected areas throughout the littoral.	1. Training on Ocean Data management & interpolarity Databases

DAPL Capacity Development Needs

DAPL, to achieve his mission and respond correctly to national demands, needs:

- ✓ A reinforcement of there capacities on resources biodiversity and conservation;
- ✓ A production of knowledge, measurements of attenuation for adaptation to climate changes
- ✓ The transfer of marine techniques in the management of coastal zones (ICAM, ICOM & EBM) in a Marine Spatial Planning (MSP) project.

Vision: To work out and implement national strategies intended for the prevention and the fight against chemical, biological, radioactive, sound pollutions; and harmful effects as well as the risks natural and/or related to human activities.

Priorities:

1. To incite the local companies to take into account l' environment in their industrial strategy and commercial and to encourage the development of the own techniques and the products with ecological high-quality
2. To take part in the management of the hazardous substances, out-of-date or obsolete and to follow their destruction as a need.

Coastal Adaptation Strategy:
1.Action Plan: 2002

Collaborating Organizations:
NATIONAL:

- IMROP
- DE
- DPLP
- DPCIC

INTERNATIONAL:

- UN
- UICN
- CSRP
- PRCM
- DAPL

DIRECTION DE LA PREVENTION ET DE LA LUTTE CONTRE LES POLLUTIONS (DPLP)

DIRECTION OF THE PREVENTION AND THE FIGHT AGAINST POLLUTION

Phone:
Fax:
Email:
Web: www.environnement.gov.mr
Address: Rue 21-185 N° 834- Ksar Nouakchott, Mauritania

Director:
Sidi Ould Aleoimine
Email: aloueimine01@yahoo.fr

Ministry: MINISTRY OF THE ENVIRONMENT AND SUSTAINABLE DEVELOPMENT (www.environnement.gov.mr)

Institute Strengths:
Human Resources: The DPLP currently has [XX] professional and administrative staff. Of the [YY] professional staff, [ZZ] have PhD, [WW] have a M.Sc/M.Tech and [VV] have a B.Sc/B.Tech

Infrastructure: The DPLP has a good, power supply. The internet link is ADSL and the connection speed is2048 Mbps with approximately 15 personal computers connected. There are no laboratories specializing in [Please insert fields researched]. Data collection at sea is done using [research vessels, moored and/or drifting buoys, installed equipment].

Publications: In the last 5 years, [XX] researchers affiliated to The DPLP have received [YY] publications related to marine and coastal zone issues. The DPLP has provided information concerning [Insert Issue] to [Organization(s)] in preparation for COP-15. [If Applicable]

Financial Resources: The DPLP has a total budget of approximately [XX] with [YY%] allocated towards projects addressing coastal/marine management issues.

Capacity Development Needs to Address Climate Issues in Coastal Zones

Issues:	**Currently Available Services:**	**Services needed for Adaptation:**	**Capacities Needed for Services:**
[Coastal Erosion]	1. 2. 3.	1. 2. 3.	1. 2. 3.

[Salinization of Aquifers]	1. 2. 3.	1. 2. 3.	1. 2. 3.
[Coastal flooding]	1. 2. 3.	1. 2. 3.	1. 2. 3.

The DPLP Capacity Development Needs

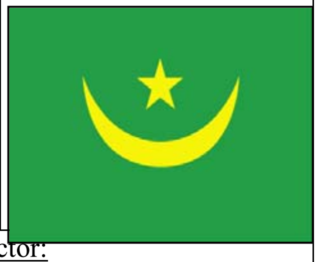
As administrative service, the needs focus on:

- A strong organization for:
  - Standardization of controlled products, guidelines
  - Capacity building on laboratory chemical analyze

Sharing experience with ex**perimented services on the field.**

Direction de l'Environnement (DE)

Direction of Environment



Vision: To maintain or to reinforce the resistance of the ecosystems to the climate changes along the coast

Priorities:

1. Better integration of the problems involved in the climate changes in the activities in progress or envisaged fascinating charges with it the integrity with the ecosystems, in particular the management and the use of the resources of the biodiversity
2. Maintenance of the stability of the ecosystems taking into account the climate changes for a better management of the biodiversity.

Coastal Adaptation Strategy: [Y]

1. Action Plan: 2002

Collaborating Organizations:

INSERT NATIONAL:

- IMROP
- DAPL
- DPLP
- DPCIC

INTERNATIONAL

- UNEP
- UNFCCC
- CSRP
- AGRIMET
- FAO
- IOC

Phone: +222 202 55 20/ 524 39 85
Fax: +222 524 31 38/ 524 31 38
Email: dear@mauritel.mr
Web: www.environnement.gov.mr
Address: B.P. 170, Nouakchott, Mauritania

Director:
Dr. Mohamed Yahya LAFDAL
Email: lafdal@environnement.gov.mr
National Coordinator UNFCC & ACCC:
Sidy Mohanmed O. S.B. Ould El WAVI
Email: wafi@environnement.gov.mr

Ministry: MINISTRY OF THE ENVIRONMENT AND SUSTAINABLE DEVELOPMENT (www.environnement.gov.mr)

Institute Strengths:

Human Resources: The Direction of Environment currently has [XX] professional and administrative staff. Of the [YY] professional staff, [ZZ] have PhD, [WW] have a M.Sc/M.Tech and [VV] have a B.Sc/B.Tech

Infrastructure: The Direction of Environment has a good, power supply. The internet link is ADSL and the connection speed is 2048 Mbps with approximately 13 personal computers connected. There are no laboratories specializing in [Please insert fields researched]. Data collection at sea is done using [research vessels, moored and/or drifting buoys, installed equipment].

Publications: In the last 5 years, [XX] researchers affiliated to The Direction of Environment have received [YY] publications related to marine and coastal zone issues. The Direction of Environment has provided information concerning [Insert Issue] to [Organization(s)] in preparation for COP-15. [If Applicable]

Financial Resources: The Direction of Environment has a total budget of approximately [XX] with [YY%] allocated towards projects addressing coastal/marine management issues.

Capacity Development Needs to Address Climate Issues in Coastal Zones

Issues:	**Currently Available Services:**	**Services needed for Adaptation:**	**Capacities Needed for Services:**
[Coastal Erosion]	1. 2. 3.	1. 2. 3.	1. 2. 3.

[Coastal flooding]	1. 2. 3.	1. 2. 3.	1. 2. 3.
[Salinization of Aquifers]	1. 2. 3.	1. 2. 3.	1. 2. 3.
[Insert Issue]	1. 2. 3.	1. 2. 3.	1. 2. 3.

The Direction of Environment Capacity Development Needs

- ✓ A reinforcement of there capacities environment with data acquisition and analysis;
- ✓ A production of knowledge, measurements of attenuation for adaptation to climate changes
- ✓ The transfer of marine techniques in the management of coastal zones (ICAM, ICOM & EBM) in a Marine Spatial Planning (MSP) project.

OFFICE NATIONALE DE METEOROLOGIE (ONM)

NATIONAL OFFICE FOR METEOROLOGY

Vision: Analyzes and the exploitation of the weather and hydrological data as well as the state of the sea

Priorities:

1. To help the country with better knowing and using the resources climatic
2. To allow to better take precautionary measures counter the effects of the destroying weather forces

Coastal Adaptation Strategy: [N]

Collaborating Organizations:

NATIONAL:

- IMROP
- DE
- DPLP
- DPCIC

INTERNATIONAL:

- OMM
- ECMWF
- EUMATSAT
- HIRLAM
- EUROMET
- ACMAD
- AGRYMET
- ASECNA
- EAMAC

Phone: + (222) 524 35 32, 646 62 44, 602 72 58 , 209 81 42, 209 81 45
Fax: (+222) 524 35 30
Email: **onm.depm@yahoo.fr ; onm.depm@gmail.com**
Web: www.onm.mr
Address: BP 1330, Nouakchott **Mauritania**

Director: Mohamed Béchir Ould Md Laghdaf
Email: **onm.depm@yahoo.fr**

Ministry: MINISTRY OF TRANSPORT (www.transports.gov.mr)

Institute Strengths:

Human Resources: The ONM currently has [XX] professional and administrative staff. Of the [YY] professional staff, [ZZ] have PhD, [WW] have a M.Sc/M.Tech and [VV] have a B.Sc/B.Tech

Infrastructure: The ONM has a good power supply. The internet link is ADSL and the connection speed is 2048Mbps with approximately 13 personal computers connected. There is 01 laboratory specializing in weather forecasting. Data collection at sea is done using [research vessels, moored and/or drifting buoys, installed equipment].

Publications: In the last 5 years, [XX] researchers affiliated to The ONM have received [YY] publications related to marine and coastal zone issues. The ONM has provided information concerning [Insert Issue] to [Organization(s)] in preparation for COP-15. [If Applicable]

Financial Resources: The ONM has a total budget of approximately [XX] with [YY%] allocated towards projects addressing coastal/marine management issues.

Capacity Development Needs to Address Climate Issues in Coastal Zones

Issues:	Currently Available Services:	Services needed for Adaptation:	Capacities Needed for Services:
[Meteo bulletin]	1. Daily forecasting	1. Adapted technology & the reinforcement of building on service delivery, forecasting & alert system.	1. Short & long training in order to supplement ONM in sufficient professional staff.

[Climatic Maps]	1. Monthly Maps (rainy season) 2. Seasonal Maps	1. Adapted technology & the reinforcement of building on service delivery, forecasting & alert system.	1. Short & long training in order to supplement ONM in sufficient professional staff.
[Marine Meteo]	1. Daily forecasting	1. Adapted technology & the reinforcement of building on service delivery, forecasting & alert system.	1. Short & long training in order to supplement ONM in sufficient professional staff.

The ONM Capacity Development Needs

- The ONM, deplore the deficiency of professionals in all Mauritanian meteorological stations. The more needed capacity is to train students on meteorological purposes.
- The deployment drifter buoys in the open ocean and along the Mauritanian coast.
- The use and develop numerical models;
- Implementation of WAM model covering West Africa AND Gulf of Guinea.
- Costal Modelling (200 500 m resolution), Swan MODEL, communication (VPN);
- Modelling High resolution for the Ports with communication
- To analyse the different products

2.1.1.3 Gambia

National Synopsis

**CCLME MARINE SCIENCE INSTITUTES
NATIONAL ASSESSMENT OF CAPACITIES TO SUPPORT
CLIMATE CHANGE ISSUES
(GAMBIA)**

The Gambia adopt thru the 'National Action Plan for Adaptation' to climate change, different strategies and actions in different sectors (Republic of the Gambia, 2007):

Agriculture: on the basis of projected climate change, adaptation options/activities in the agricultural sector can be linked to two general objectives:

- ✓ enhancing food security, and;
- ✓ enhancing agriculture-based livelihoods (uplands/lowlands).

A thrust of adaptation is made with 3 objectives:

1) **Reduce exposures to climatic stressors**
2) **Reduce climate sensitivity**:
3) **Increase climate resilience and adaptive capacity**

Potential adaptation measures

- Select drought, pest and disease, weed, salinity resistant and high yielding crop varieties for the local conditions. For this purpose the genetic potential of local crop species must be investigated and specimens stored in seed banks,
- Enhance and maintain soil fertility, to improve the economic water consumption for agriculture,
- Change planting dates and replace long duration upland & lowland crop varieties for short duration varieties,
- Restructure present irrigation system through the use of sprinkler and drip irrigation system with the objective of reducing water consumption and wastage;
- Introduce and promote integrated agricultural management system, which will provide the improvement and application of innovative agricultural technologies that will increase the efficiency of agriculture,
- Develop early warning system to inform farmers and other stakeholders on possible

  climate change and its impact on agriculture and to sensitise them in order to be ready to implement the adaptation measures,

- Introduce, promote and encourage the adoption and diffusion of improved post harvest technologies that will reduce post-harvest losses in the field and in storage. This will have the long-term effect of reducing extensive cultivation of marginal lands.

The adaptation strategy should be developed within the context of global, regional and national biodiversity conservation priorities (Department of Water Resource, 2003). A large number of habitat management and intervention techniques can be used as part of an overall adaptation strategy. Many habitat management and intervention techniques are already in use and the techniques themselves can be adopted for use under a new set of climatic conditions. The following adaptation measures are recommended:

1) Develop strategies that seek to maintain ecological structure and processes maximise evolutionary and ecological potential in species and ecosystems, and increase ecological resilience;

2) Maximise reserve connectivity, size, and number; discourage fragmentation and encourage corridors that will serve as habitat migration lanes; and
3) Adopt flexible zoning of reserve boundaries and develop more effective buffer zone management.

In the coastal zone of The Gambia, the suggested response to sea level rise and particularly to coastal erosion is to protect only the important areas.

Wetland preservation and mitigation: The estuary of the Gambia River contains economically important wetlands and mangrove systems. The mangrove systems on the Kombo St. Mary Island and Kombo Peninsular are important breeding grounds for various aquatic species. Efforts should be made to protect these areas by declaring them as protected wetlands.
This would discourage exploitation of the resources in these wetlands. The possible impacts of upstream dams on the Gambia River in terms of reduced sediment supply should be investigated (Republic of the Gambia, 2007).

Coastal zone management plan: Land-use planning in coastal zones, such as the use of building setbacks or allocating low-lying vulnerable lands to lower value uses (e.g., parks rather than housing), will help reduce the overall vulnerability to sea-level rise. Other land use planning mechanisms, such as construction standards, reduce the risks of living in coastal areas.
Additional risk-reduction measures can be encouraged through appropriate financial mechanisms. Each of these policies reduces the risks from current

climatic variability and protects against potential sea-level rise impacts. When put together in the form of a programme, they constitute a Coastal Zone Management Plan (Davidson, 2002).

The fish catch potential of the Gambia river fishery is not known because no research work to estimate fish stock biomass has been undertaken in and along the river given that demersal fish resources are over-exploited, the fisheries strategic and management plan calls for stricter control of the exploitation of resources (Department of Water Resource, 2003). This will require a reduction in the number of fishing licenses issued to foreign vessels, improved surveillance of the fisheries The Gambian population will have to develop potential adaptation options and measures to enable them have continuous access to the benefits provided by the forest resources. Adaptation options and measures that may be adopted in The Gambia include:

- ***Development of seed banks***
- ***Promotion of effective management practices and flexible criteria for intervention***
- ***Rangelands and livestock***

The rangelands at the Bakendik Flats may degrade under warmer climate due to the projected decrease in precipitation and increase in evaporation, especially soil evaporation potential adaptation measures can be spontaneous and human assisted. It will be necessary to utilize a combination of efforts to reduce land degradation and foster sustainable management of the natural resources.

Suggested adaptation options include:

- **Development and implementation of effective policies on integrated natural resources**
- **Management**
- **Restoration of rangeland landscape**
- **Ecological** vulnerability (degradation of the environment), and **organisational** vulnerability (lack of strong national and local institutions), If sea level rise projections turn out to be accurate, dry season water levels will increase throughout the estuarine part of the river Gambia, leading to permanent flooding of current inter-tidal areas. The fluvial component of water levels in the rainy season will however be reduced due to reservoir routing of the annual flood wave by higher river water levels.

Adaptation (option/strategies)

Major climate change impacts on water resources status and management functions have been identified as:

- inundation of areas that are below the 1-metre contour line and contiguous to the River Gambia estuary and its tributaries;
- risk of saline intrusion into aquifers in hydraulic connection with the estuary and sea; and;
- increased saline intrusion length in the River Gambia estuary.

To a somewhat lesser extent (i) changes in river salinity regime, and (ii) decrease in groundwater recharge, also crystallise impacts that may require adaptation measures on the part of affected communities/parties.

National Institute Capacities

As regards to administration

- The absence of an institutional framework specific to the implementation of actions benefiting from operational support action plan (project & programmes) declined in the National Action Plan.
- The diversity of the mechanisms engaged at national level in the area of the environment without any obvious connecting relationship, which necessarily weakens institutions involving in environment.
- The lake of resource persons (professionals) and funds for materials and software

Capacity building needs for the strengthening of national institutions:

Great efforts must be done in a strong national network, sharing data & informations and resources (human & financial). The follow aspects are needed:

- Methodology development ;
- Technical and analytical skills

The training strategy must be:

- Short term targeted courses
- Long term formal degree courses
- Joint research & development (R&D) and development (D) activities.

The main structures and institutes working in network for climate change impacts are (no exhaustive list):

- **DPPH**
- **DPWM**
- **DWR**
- **GREC**
- **IWRM**
- **NADA**
- **NARI**
- **NEA**

Consulted documents

1. Republic of the Gambia, Department of Water Resources, 2003.
2. First National communication of the Republic of the Gambia to the United Nations Framework Convention on climate change, 163 p
3. Republic of the Gambia, 2007. Gambia National Adaptation Program of Action on climate change, 105 p.
4. Ogunlade R. Davidson, 2002. Capacity building in climate change: African lessons.

Vision: Plan, manage and develop the fisheries sector throughout the country, the Department caters for fisheries policy and legislations frameworks Priorities:	**Department of Fisheries & Water Resources (DFWR)**	

1. Provides advice and service to fishing users 2. Protection and development of the resources and for monitoring 3. Control and surveillance of all fisheries and fisheries-related activities within fisheries waters and on land. Coastal Adaptation Strategy: 1. Fisheries development policies (1985 to 1995) 2. Strategic Plan for the Fisheries Sector 1994/1995-2004 3. The Agriculture and Natural Resources sector (ANR) (1996-2020) Collaborating Organizations: NATIONAL: ➢ FCMC ➢ GAMFIDA ➢ DPWM ➢ DWR ➢ NEA ➢ AIFC INTERNATIONAL: ➢ FAO ➢ UNDP ➢ WB ➢ UE	Phone: +220 422 33 73 / 422 87 27/ 992 48 34 Fax: +220 422 39 87 Email: dwr@gamtel.gm Web: www.accessgambia.com/information/fisheries-sector.html Address: 6, Marina Parade – Banjul, The Gambia Ministry: **Fisheries, Water Resources & National Assembly Matters**	Director: Mr. Nfamara Jerro DAMPHA Email: d.nfamara@yahoo.com

Institute Strengths:

Human Resources: **DFWR** currently has [XX] professional and administrative staff. Of the [YY] professional staff, [ZZ] have PhD, [WW] have a M.Sc/M.Tech and [VV] have a B.Sc/B.Tech

Infrastructure: **DFWR** has a good, power supply. The internet link is ADSL and the connection speed is 1024Mbps with approximately 09 personal computers connected. There are 02 laboratories specializing in fish biology & water analysis. Data collection at sea is done using research vessel and moored buoys.

Publications: In the last 5 years, [XX] researchers affiliated to **DFWR** have received [YY] publications related to marine and coastal zone issues. **DFWR** has provided information concerning [Insert Issue] to [Organization(s)] in preparation for COP-15. [If Applicable]

Financial Resources: **DFWR** has a total budget of approximately [XX] with [YY%] allocated towards projects addressing coastal/marine management issues.

Capacity Development Needs to Address Climate Issues in Coastal Zones

Issues:	Currently Available Services:	Services needed for Adaptation:	Capacities Needed for Services:

[Coastal Management]	1. statistics (landing) 2. biodiversity	1. GIS Software & analysis 2. GIS software, Resources mapping	1. Training n GIS Mapping.
[Salinization of Aquifers]	1. 2. 3.	1. 2. 3.	1. 2. 3.
[Coastal flooding]	1. 2. 3.	1. 2. 3.	1. 2. 3.

DFWR Capacity Development Needs

- Vessel for data acquisition
- Capacity building on fish biomass evaluation
- Ocean & biological data analysis
- Software & required equipments

Vision: Wildlife Conservation
Priorities:
1. To protect and conserve The Gambia's remaining wild fauna as well as their natural environment for the present and future
2. To create educational and leisure facilities for present and future populations through prudent use of wildlife resources
3. To preserve archetypal natural examples of Gambian flora and fauna with the aim of a view to preserving genetic diversity;
4. To accumulate and disperse revenue, which has built up from the use of our wildlife resources to the Government as well as to nearby rural communities

Coastal Adaptation Strategy: [N]

Collaborating Organizations:
NATIONAL:
- FCMC
- GAMFIDA
- DFWR
- DWR
- NEA
- AIFC

INTERNATIONAL:
- FAO
- UNDP
- WB
- UE

Department of Parks and Wildlife Management (DPWM)

Phone: +220 437 58 88 / 437 69 73/ 991 69 93/ 984 52 01
Fax: +220 439 21 79 / 422 89 98/ 422 47 65
Email: wildlife@gamtel.gm
Web: www.gambiaparkswildlife.net; www.accessgambia.com/information/parks-wildlife-department.html
Address: State House, Banjul, The Gambia

Alpha Omar JALLOW
Email: alphaojay@gmail.com; alphaojay@yahoo.com
Senior Wildlife Conservation Officer: Alagie MANJANG
Email:

Ministry: MINISTRY OF FORESTRY & ENVIRONMENT

Institute Strengths:
Human Resources: **DPWM** currently has [XX] professional and administrative staff. Of the [YY] professional staff, [ZZ] have PhD, [WW] have a M.Sc/M.Tech and [VV] have a B.Sc/B.Tech

Infrastructure: **DPWM** has a good power supply. The internet link is ADSL and the connection speed is 1024 Mbps with approximately 07 personal computers connected. There are no laboratories specializing in [Please insert fields researched]. Data collection at sea is done using [research vessels, moored and/or drifting buoys, installed equipment].

Publications: In the last 5 years, [XX] researchers affiliated to **DPWM** have received [YY] publications related to marine and coastal zone issues. **DPWM** has provided information concerning [Insert Issue] to [Organization(s)] in preparation for COP-15. [If Applicable]

Financial Resources: **DPWM** has a total budget of approximately [XX] with [YY%] allocated towards projects addressing coastal/marine management issues.

Capacity Development Needs to Address Climate Issues in Coastal Zones

Issues:	Currently Available Services:	Services needed for Adaptation:	Capacities Needed for Services:
[Coastal Erosion]	1. 2. 3.	1. 2. 3.	1. 2. 3.
[Salinization of	1. 2.	1. 2.	1. 2.

Aquifers]	3.	3.	3.
[Coastal flooding]	1. 2. 3.	1. 2. 3.	1. 2. 3.

DPWM Capacity Development Needs

- More equipment for data acquisition (GPS)
- Reinforcement on the capacity on data monitoring
- Data & Products analysis
- GIS training

Department of Water Resources with the mandate to carry out meteorological functions (DWR)

Vision: Predict & Weather forecasts

Priorities:

1. To maintain the network of weather stations and pluviometer stations installed on the national territory
2. To ensure acquisition, the treatment, the exploitation and the diffusion of national weather data

Coastal Adaptation Strategy: [N]

Collaborating Organizations:

NATIONAL:

- DOSFNRE
- NEA
- DFWR

INTERNATIONAL:

- CILSS
- ACMAD
- WMO

Phone: +220 422 82 16 / 420 15 59
Fax: +220 422 50 09
Email: dwr@gamtel.gm
Web: www.metoffice.gov.uk/commonwealth/members/gambia.html
Address: 7, Marina Parade, Banjul, The Gambia

Director:
Pa Ousmane JARJU
Email: pajarju@yahoo.com

Ministry: **MINISTRY OF FISHERIES, WATER RESOURCES**

Institute Strengths:

Human Resources: DWR currently has 63 professional and administrative staff. Of the 63 professional staff, 04 have PhD, 05 have a M.Sc/M.Tech and 42 have a B.Sc/B.Tech

Infrastructure: DWR has a good power supply. The internet link is ADSL and the connection speed is 1024 Mbps with approximately 07 personal computers connected. There are no laboratories specializing in [Please insert fields researched]. Data collection at sea is done using [research vessels, moored and/or drifting buoys, installed equipment].

Publications: In the last 5 years, [XX] researchers affiliated to DWR have received [YY] publications related to marine and coastal zone issues. DWR has provided information concerning [Insert Issue] to [Organization(s)] in preparation for COP-15. [If Applicable]

Financial Resources: DWR has a total budget of approximately [XX] with [YY%] allocated towards projects addressing coastal/marine management issues.

Capacity Development Needs to Address Climate Issues in Coastal Zones

Issues:	Currently Available Services:	Services needed for Adaptation:	Capacities Needed for Services:
[Coastal Erosion]	1. 2. 3.	1. 2. 3.	1. 2. 3.
[Salinization of Aquifers]	1. 2. 3.	1. 2. 3.	1. 2. 3.
[Coastal flooding]	1. 2. 3.	1. 2. 3.	1. 2. 3.

DWR Capacity Development Needs

- Settlement of a nation network meteorological stations
- Capacity building on data (real time) acquisition
- Data & Products analysis
- GIS training
- The deployment numerical buoys along Senegalese costal region (costal ocean)
- The use and develop numerical models;
- Implementation of WAM model covering West Africa AND Gulf of Guinea.
- Costal Modelling (200 500 m resolution), Swan MODEL, communication (VPN);
- Modelling High resolution for the Ports with communication

NATIONAL ENVIRONMENT AGENCY (NEA)

Vision: Environmental Quality Standards

Priorities:

1. To make sure that the economic and social development of The Gambia is done in an environmentally sustainable manner.
2. To develop and maintain a National Environmental Planning Framework for the Gambia.
3. To have a Legal recognition of the fundamental right to a sound environment, ensuring the health and well-being of all those living in the Gambia.
4. To educate about the environment, increasing environmental awareness and empowering communities to take action to identify and solve environmental problems.
5. To provide reliable and relevant information for sound environmental management.
6.
To conserve and promote the sound and rational use of natural resources.

Coastal Adaptation Strategy: [N]

Collaborating Organizations:

NATIONAL:

- NEMC
- DWR
- DOSTIE
- DOSH
- DOSJ
- GCCI

INTERNATIONAL:

- UNEP
- AEIN
- UNDP
- WB
- GEF

Phone: +220 422 80 56/ 422 48 67/ 422 48 68/ 422 48 69
Fax: +220 422 97 01
Email: nea@gamtel.gm; info@nea.gm
Web: www.nea.gm; www.nea.gm/aboutus.htm www.accessgambia.com/information/nea.html
Address: 5 Fitzerald Street, PMB 48, BANJUL, THE GAMBIA

Director:
Momodou B. SARR
Email: msarr@gamtel.gm
DIRECTOR: OF TECHNICAL SERVICES NETWORK
Momodou B. CANTEH
Email: mbcantey@nea.gm
DIRECTOR: OF INTER SECTORAL NETWORK:
Ndey Sireng Bakurin
Email: ndeyb@gamtel.gm ; ndeyb@hotmail.com

Ministry: **MINISTER OF FORESTERY AND THE ENVIRONMENT**

Institute Strengths:

Human Resources: The NEA currently has [XX] professional and administrative staff. Of the [YY] professional staff, [ZZ] have PhD, [WW] have a M.Sc/M.Tech and [VV] have a B.Sc/B.Tech

Infrastructure: The NEA has a good power supply. The internet link is ADSL and the connection speed is 1024 Mbps with approximately 15 personal computers connected. There are no laboratories specializing in [Please insert fields researched]. Data collection at sea is done using [research vessels, moored and/or drifting buoys, installed equipment].

Publications: In the last 5 years, [XX] researchers affiliated to The NEA have received [YY] publications related to marine and coastal zone issues. The NEA has provided information concerning [Insert Issue] to [Organization(s)] in preparation for COP-15. [If Applicable]

Financial Resources: The NEA has a total budget of approximately [XX] with [YY%] allocated towards projects addressing coastal/marine management issues.			
Capacity Development Needs to Address Climate Issues in Coastal Zones			
Issues:	**Currently Available Services:**	**Services needed for Adaptation:**	**Capacities Needed for Services:**
[Environmental Information System (EIS)]	1. Maps 2. Aerial photos & images satellites	1. GIS training 2. Data & products analysis 3.	1. Reinforcement of capacity building
[Environmental Education & Communication]	1. Dissemination of Education materials 2.	1. 2. 3.	1. Reinforcement of capacity building
[Coastal & Marine Environment]	1. Maps of coast line erosion 2. 3.	1. 2. 3.	1. Reinforcement of capacity building
[Environmental Impact Assessment	1. Potential impacts of proposed projects 2. 3.	1. 2. 3.	1. Reinforcement of capacity building
Pesticides & Hazardous Chemicals Management	1. Promotes the safe and wise use and handling pesticides and chemicals 2. Guidelines in the handling of pesticides and hazardous chemicals 3 Publish a list of banned and approved chemicals and delegate any public officer to monitor their sale and use		1 Reinforcement of capacity building

NEA Capacity Development Needs

- Settlement of stations network in the country
- Capacity building in the field
- Data & Products analysis
- Environmental variables acquisition
- GIS training

2.1.1.4 Guinea-Bissau

National Synopsis

CCLME MARINE SCIENCE INSTITUTES
NATIONAL ASSESSMENT OF CAPACITIES TO SUPPORT CLIMATE CHANGE ISSUES
(GUINEA BISSAU)

The Guinea Bissau as the others countries in the CCLME adopted a National Action Plan on the basis of United Nations Framework Convention on Climate Change (**UNFCCC**) for adaptation to climate changes (République de la Guinée Bissau, 1999 & 2002).

During the last years, the Guinea-Bissau adopted several instruments of policy and management for the most varied sectors of national development in which are defined as the priorities of national development, with a more direct relationship with the problems of the climate changes (République de la Guinée Bissau, 1999). These priorities are also reinforced by the actions defined within the sub-regional and regional framework. These sectoral policies and comprehensive strategies are:

a) Prospective National Studies in the long run (NLTPS) for a temporal horizon which goes until 2025, and which included all sectors of the economy, with various alternative scenarios of development and integrating the various forms (options) of Governorship.
b) The Document of National strategy of Reduction of the Poverty (DENARP) recently worked out, and which is the base of all the development actions and of strategic partnership for the development of the Guinea-Bissau, with a special attention to the fight against poverty.
c) The National plan of Good governance (**PNG**).
d) Improvement of the access to drinking water,
e) Improvement of knowledge on the potentiality of the non renewable natural resources,
f) Increase in the national capacities in the field of technologies which increase the value of the local resources, and
g) Durable exploitation of the basic resources associated with a judicious protection of the environment.

The relative strategy includes the development of a policy and a national plan for the management of environment (**PNGA**), the management of the reserves and other protected areas like; development and execution of a control program for the biodiversity of the coastal areas (Anonymes, 2005).

Difficulties
Consequently and within sight of the other needs at the national level, the motivation to make it possible for the government to improve its management of the environment is weak. The strategic document against poverty (**DENARP**) considers environmental measurements only in a surface way. For example, with regard to the access to drinking water and cleansing, the DENARP mentions only the reinforcement of the cleansing with Bissau, and of the systems semi-collectives in perish-urban medium (Republic of Bissau Guinea, 1999).

There is a lack of basic information allowing the planning and the management of the environment, such as an agro-ecological zoning, a forest inventory, or the hydrogeology synthesis. Furthermore, many scientific data and results of the studies are dispersed in several departments of the government, research centres, and even on the level of expatriates, or then disappeared at the time of the war. Moreover, culture of data sharing between different institutions is not well developed.

Since the country, currently initiates new options - which one wishes it will be of stability and peace - the weight of the environment with regards to the other priorities; remains weak. This is due to the fact that the interaction between the environment and poverty is not yet well implanted in the spirit of the political decision makers and the culture of the nation. (Bettencourt & Jonard, 2007).

Some adaptative strategies
Identification through studies, seeking out of the most vulnerable zones to the modifications of sedimentary nature; and which constitute a throttling for the ecological processes with ebb tides of the rivers.
Identification of studies through seeking out of the most vulnerable zones to the marine and coastal erosive phenomena; and to integrate problems in a more total context of research solution (sub-regional and international level).

National capacity needs
In order to achieve and execute successfully the National Action for Adaptation Plan, the following needs are expressed:

- permanent system of actualization and exchange of information on the various sectors related to the problems of climate changes ;

- System for data collection and data processing, in terms of human and material resources necessary to meet these needs ;
- capacity development through the formation and recycling of the national technical experts directly related to the problems ;
- Acquisition of technologies for the various sectors of development, likely to minimize the negative impacts of the climate changes ;
- Mechanism of incentive to the public authorities (national and sub-regional) for adoption of policies and respectful technologies to the environment ;
- Creation of a information, education and communication device (**IEC**) in order to support the diffusion of information to a large public mainly the End Users ;
- Early mechanism for alarm and prevention against the risks created by uncertainties of the evolution of climatic parameters
- Creation of a management system of the non biodegradable solid residues, especially in the urban areas.

The main institutes involving in adaptation to climate changes are:

- **CAIA**
- **CEATA**
- **CNDD**
- **DGA**
- **DGE**
- **DGFC**
- **DGRH**
- **FISCAP**
- **GPC**
- **IBAP**
- **INEP**

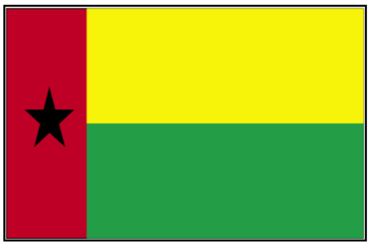
Consulted documents

1. Republic of Bissau Guinea, 1999. Initial national Communication of Guinea Bissau about climate change.
2. République de la Guinée Bissau, 1999. Rapport national sur la mise en œuvre de la convention des Nations Unies sur la lutte contre la désertification.

3. République de la Guinée Bissau, 2002. Rapport national sur la mise en œuvre de la convention des Nations Unies sur la lutte contre la désertification.
4. José de Bettencourt et François Jonard, 2007. Elaboration du Profil Environnemental de Pays – Guinée Bissau, 122 p.
5. Anonymes, 2005. Aires Marines Protégées de la Zone Côtière de la Guinée Bissau

Centro de Estudios Ambientais e Tecnologia Apropriada do Instituto Nacional de Estudios e Pesquisa (CEATA/INEP)

Centre for Environmental Studies and Appropriate Technology (CEATA) of the National Institute of Studies and Research (INEP)



Phone: +245 251 68 67/ 251 6868
Fax: ++245 251 61 25
Email: inep@mail.gtelecom.gw
Web: www.inep-bissau.org
Address: Complexo Escolar 14 Novembro, CP 112 Bissau, Guinea - Bissau

Director:
Mamadu Jao
Email: inep@sol.gtelecom.gw; mama_jao@hotmail.com
Deputy: Rodriguez Daniel

Ministry: MINISTRY OF NATURAL RESOURCES

Vision: Promote the studies and research in the domain of social and natural sciences related with the problems of development of the country and to contribute for the valuation of the local human resources

Priorities:
1. In the accomplishment of basic inquiry and the elaboration of studies, being constituted by a body of permanent national investigators and a net of investigators national and foreign associates

Coastal Adaptation Strategy: [N]

Collaborating Organizations:

- Aliança Internacional para a Consolidação da Paz (Interpeace)
- Arquivo Histórico Nacional de Cabo Verde, Cabo Verde
- Conselho para o Desenvolvimento da Pesquisa em Ciências Sociais em África (CODESRIA), Senegal
- CEA do EHSS de Franca,
- CEA do ISCTE, Portugal,
- CEAA do Colégio do México,
- CEAMO, Cuba,
- CRA Paris I,
- CRDI do Canada,
- CWAS da Universidade de Birmingham de Inglaterra,
- DÜ de Alemanha,
- Embaixada da Alemanha,
- Embaixada dos Estados Unidos,
- Fundação Mário Soares, Portugal
- Institut fondamental d'Afrique noire (IFAN), Senegal
- Instituto de Investigação Científica e Tropical (IICT), Portugal
- International African Institute (IAI),
- SAREC,
- UICN,
- UNIJUI do Brasil,
- Universidade de Bayreuth

Institute Strengths:
Human Resources: [INSTITUTE X] currently has [XX] professional and administrative staff. Of the [YY] professional staff, [ZZ] have PhD, [WW] have a M.Sc/M.Tech and [VV] have a B.Sc/B.Tech

Infrastructure: [INSTITUTE X] has a good power supply. The internet link is ADSL and the connection speed is 1024Mbps with approximately 10 personal computers connected. There is 01 laboratory specializing in [fish biology. Data collection at sea is done using [research vessels, moored and/or drifting buoys, installed equipment].

Publications: In the last 5 years, [XX] researchers affiliated to [INSTITUTE X] have received [YY] publications related to marine and coastal zone issues. [INSTITUTE X] has provided information concerning [Insert Issue] to [Organization(s)] in

preparation for COP-15. [If Applicable] Financial Resources: [INSTITUTE X] has a total budget of approximately [XX] with [YY%] allocated towards projects addressing coastal/marine management issues.			
<u>Capacity Development Needs to Address Climate Issues in Coastal Zones</u>			
Issues:	**Currently Available Services**:	**Services needed for Adaptation:**	**Capacities Needed for Services:**
[Coastal Erosion]	1. 2. 3.	1. 2. 3.	1. 2. 3.
[Salinization of Aquifers]	1. 2. 3.	1. 2. 3.	1. 2. 3.
[Coastal flooding]	1. 2. 3.	1. 2. 3.	1. 2. 3.
[Insert Issue]	1. 2. 3.	1. 2. 3.	1. 2. 3.

The Centro de Estudios Ambientais e Tecnologia Apropriada do Instituto Nacional de Estudios e Pesquisa (CEATA/INEP) Capacity Development Needs still to improve the training and education of students. For this:

- sharing experience and knowledge with partners and other International organisation as IOC/UNESCO, taken in account the environment and climate changes
- capacity building for data acquisition and analyse
- Modelization
- Analyse products

Vision: Research on Biodiversity and Fish resources monitoring

Priorities:

1. Monitor fishing activities
2. Conservation of resources
3. Management of coastal & Ocean resources

Coastal Adaptation Strategy: [N]

Collaborating Organizations:

NATIONAL:

- INEP
- CEATA
- IUCN
- DA
- GPC

INTERNATIONAL:

- IRD
- GIBAO
- PRCM
- IUCN
- WETLANDS

Centro de Investigação Pesqueira Aplicada (CIPA)

Applied Fisheries Research Centre

Phone: +245 21 16 95
Fax:
Email:
Web: www.ird.fr/les-partenariats/nos-principaux-partenaires/cipa
Address: Av. Amilcar Cabral, C.P. 102, Bissau

Director:
Mrs. Virginia PIRES
Email: cruzpires@yahoo.br

Ministry: Ministry of Fisheries and Marine Economy

Institute Strengths:

Human Resources: **CIPA** currently has [XX] professional and administrative staff. Of the [YY] professional staff, [ZZ] have PhD, [WW] have a M.Sc/M.Tech and [VV] have a B.Sc/B.Tech

Infrastructure: **CIPA** has a good power supply. The internet link is ADSL and the connection speed is1024 Mbps with approximately 12 personal computers connected. There is 01 laboratory specializing in fish biology. Data collection at sea is done using [research vessels, moored and/or drifting buoys, installed equipment].

Publications: In the last 5 years, [XX] researchers affiliated to **CIPA** have received [YY] publications related to marine and coastal zone issues. **CIPA** has provided information concerning [Insert Issue] to [Organization(s)] in preparation for COP-15. [If Applicable]

Financial Resources **CIPA** has a total budget of approximately [XX] with [YY%] allocated towards projects addressing coastal/marine management issues.

Capacity Development Needs to Address Climate Issues in Coastal Zones

Issues:	**Currently Available Services:**	**Services needed for Adaptation:**	**Capacities Needed for Services:**
[Coastal Erosion]	1. 2. 3.	1. 2. 3.	1. 2. 3.
[Salinization of Aquifers]	1. 2. 3.	1. 2. 3.	1. 2. 3.
[Coastal flooding]	1. 2. 3.	1. 2. 3.	1. 2. 3.
[Insert Issue]	1. 2. 3.	1. 2. 3.	1. 2. 3.

The Centro de Investigação Pesqueira Aplicada Capacity Development Needs

- Strengthen the capacity of collecting and analyzing data,
- Software acquisition (new technologies on fish biomass evaluation & monitoring)
- Environmental impacts on marine resources & biodiversity
- Implementation of required system and national network (with more implication) for adaptation to climate change

Vision: Protect and Sustainable Use of Natural Resources
Priorities:
1. Identify natural resources
2. Protect resources
3. Add value in Natural Resources

Coastal Adaptation Strategy: [N]
Collaborating Organizations:
NATIONAL/
- MNR
- CEATA/INEP
- GPC
- CIPA

INTERNATIONAL:
- FFEM
- FIBA
- PRCM
- IUCN

Gabinete de Planificaçao Coteira (GPC)

Coastal Planning Cabinet Integrated in Wetlands

Phone: +245 25 51 64
Fax: +245 20 11 68
Email: gpc@mail.telecom.gw
Web: www.republica-da-guine-bissau.org/index.php?id=3
Address: AP 23 1031 Bissau-Codex, Guinée-Bissau

Director:
Herculano, Da Silva Nhaga
Email: hedasyn@yahoo.com

Ministry: Ministry of Energy and Natural Resources (www.republica-da-guine-bissau.org/index.php?id=3)

Institute Strengths:
Human Resources: **GPC** currently has [XX] professional and administrative staff. Of the [YY] professional staff, [ZZ] have PhD, [WW] have a M.Sc/M.Tech and [VV] have a B.Sc/B.Tech

Infrastructure: **GPC** has a good power supply. The internet link is ADSLand the connection speed is 1024Mbps with approximately 09 personal computers connected. There are no laboratories specializing in [Please insert fields researched]. Data collection at sea is done using [research vessels, moored and/or drifting buoys, installed equipment].

Publications: In the last 5 years, [XX] researchers affiliated to **GPC** have received [YY] publications related to marine and coastal zone issues. **GPC** has provided information concerning [Insert Issue] to [Organization(s)] in preparation for COP-15. [If Applicable]

Financial Resources: **GPC** has a total budget of approximately [XX] with [YY%] allocated towards projects addressing coastal/marine management issues.

Capacity Development Needs to Address Climate Issues in Coastal Zones

Issues:	Currently Available Services:	Services needed for Adaptation:	Capacities Needed for Services:
[Coastal Erosion]	1. 2. 3.	1. 2. 3.	1. 2. 3.
[Salinization of Aquifers]	1. 2. 3.	1. 2. 3.	1. 2. 3.
[Coastal flooding]	1. 2. 3.	1. 2. 3.	1. 2. 3.
[Insert Issue]	1. 2. 3.	1. 2. 3.	1. 2. 3.

The Gabinete de Planificaçao Coteira Capacity Development Needs

- Reinforcement of their capacity on coastal erosion and management
- Biodiversity monitoring and conservation (plant & mangrove)
- Network for data acquisition & analyse on climate & environmental variables
- Analyze products

Instituto da Biodiversidade e das Áreas Protegidas, (IBAP)

Institute of Biodiversity and Protected Areas (IBAP) (Integrated in IUCN, Bissau)

Vision: To protect and develop the ecosystems; to ensure the safeguarding of biological diversity and durable the use of the natural resources for the social advancement and economic of the populations.

Priorities:
1. Create AMPs
2. Save & Protect, Dolphin, turtle and forest zones

Coastal Adaptation Strategy: [N]

Collaborating Organizations:
NATIONAL/
- MNR
- CEATA/INEP
- GPC
- CIPA

INTERNATIONAL:
- FFEM
- FIBA
- PRCM
- IUCN
- WCPA

Phone: +245 20 71 06/
Fax: +245 20 71 07
Email: alfredo.simao.dasilva@iucn.org
Web: www.papaco.org/AP_Parc%20guine%20bissau.htm
Address: Rua São Tomé, Casa N° 6A CP 70, Bissau, Guinea-Bissau

Director:
Alfredo Simao Dasilva
Emails:
alfredo.dasilva@iucn.org ; asdasilva@eguitel.com
Admin:
Justini Biai
Email: justino.biai@iucn.org

Ministry: Ministry of Natural Resources

Institute Strengths:
Human Resources: **IBAP** currently has [XX] professional and administrative staff. Of the [YY] professional staff, [ZZ] have PhD, [WW] have a M.Sc/M.Tech and [VV] have a B.Sc/B.Tech

Infrastructure: **IBAP** has a good power supply. The internet link is ADSL and the connection speed is1024 Mbps with approximately 11 personal computers connected. There is 01 laboratory specializing in fish biology. Data collection at sea is done using [research vessels, moored and/or drifting buoys, installed equipment].

Publications: In the last 5 years, [XX] researchers affiliated to [INSTITUTE X] have received [YY] publications related to marine and coastal zone issues. [INSTITUTE X] has provided information concerning [Insert Issue] to [Organization(s)] in preparation for COP-15. [If Applicable]

Financial Resources: **IBAP** has a total budget of approximately [XX] with [YY%] allocated towards projects addressing coastal/marine management issues.

Capacity Development Needs to Address Climate Issues in Coastal Zones

Issues:	Currently Available Services:	Services needed for Adaptation:	Capacities Needed for Services:
[Coastal Erosion]	1. 2. 3.	1. 2. 3.	1. 2. 3.
[Salinization of Aquifers]	1. 2. 3.	1. 2. 3.	1. 2. 3.
[Coastal flooding]	1. 2. 3.	1. 2. 3.	1. 2. 3.

The IBAP Capacity Development Needs

- Reinforce the capacity building on MPAs monitoring
- Data and products analyze
- Environmental variables acquisition
- Reinforce the national and sub regional networks
- Management of MPAs for sustainable exploitation

2.1.1.5 Cape Verde

National Synopsis

CCLME MARINE SCIENCE INSTITUTES NATIONAL ASSESSMENT OF CAPACITIES TO SUPPORT CLIMATE CHANGE ISSUES (CAPE VERDE)

Cape Verde has, since 1999 a National Action Plan for Adaptation (**NAPA**) to climate changes. The agro-climatological analyses show that there exists a reduction in the duration of the wet season, with some frequent episodes of dryness. In Cap Verde, the climate is a factor dominating in the conditioning of activities of the agricultural sector.

Cap Verde is vulnerable to natural phenomena such as the dryness; this led to the deterioration of microclimates and the turning into a desert (République du Cap Vert, 1999). The cyclic periods of dryness alternated with floods are the leading causes of economic losses, environmental degradations and socio-economic problems. The great dryness from 1968 to 1974 highlighted imbalances between the human existence and the ecological conditions, and also it did mark the relevance on the responsibility of a man in the propagation of the phenomenon of the turning into a desert.

The most important problems affecting the coastal areas are directly result of extraction of sand and gravel, that accelerates coastal erosion and the loss of marine habitats which causes the disappearance of some species, and an increased danger in coastal assets of tourism, reduction in the national potentialities in terms of leisure buildings. The advances of more accelerated sea waters stroke of " the interface" between the sea and the ground, leads to an increase of dirtily in the soil and reduction of its capacity of production; with low registers reflected in the agricultural activities developed with the length of the coastal areas.

The fact that Cap Verde is formed by small islands; this makes it a vulnerable country. The coastal areas play a very important role in the process of their development. The greatest agglomerations are concentrated in the coastal areas or close. It is estimated that approximately 80% of the population live in these zones.

Globally, all the coastal area exposed to danger with the changes on the climatic system.

A rise of the mean level of the sea under current conditions makes it vulnerable to danger on most parts of the country (République du Cap Vert, 1999).

Theses changes impacted on:

- Reduction of the vegetative cycle
- Reduction in the availability of water
- Leaching of soil
- Incidences of epidemic diseases

- Higher rate of erosion
- Rise in the sea level
- Seasonal variability
- Occurrences of torrential rains and floods

For adaptation to negatives impacts, several actions were identified through the NAPA:

- Revaluation of the agro-climatic zones and the structure of cultures
- Limit the culture in zones with the greatest potentialities in soils
- Develop and intensify breedings
- Reinforce and maintain activities for soil conservation

The target goals of these actions were:

- Inversion of the process of the turning into a desert
- Recovery of the ecological inheritance by the reconstitution of the vegetable cover and the adoption of measurements for forest recovering and soil conservation;
- Rational exploitation of national resources, in order to contribute to the satisfaction of the basic needs for the population.

National needs

For a country which is starting on industrial development, the Cap Verde needs its own and efficient new environmental technologies and following support and collaboration on:

- Education and emancipation on planning and environmental monitoring for authorities (developers), on management and economy of energy for associations and technicians of rural development and on the environmental protection of the resources for energy.
- Obtaining technical and administrative self-driven capacity-building, of the personnel on methodologies for the realization of auditors environmental and energy, of the managers of the companies of the sector of energy and of the members of the co-operatives, associations of farmers and fishermen, in environmental practices adapted for agriculture and fishing.
-
- The access to data banks on the environment and energy, following the necessary for the identification of data banks on environment and energy relevant for the field of the National Plan of Mitigation, such as for example recording of a given data on wind and solar natural energy of the various zones, and localities of the Cape Verde Islands.
- Institutional support for the technical and structural pegging at the national level.

The national institutes involving in climate changes are:

- **ADAD**
- **DGASP**
- **INDP**
- **INERF**
- **INIDA**
- **INGRH**
- **NGOs**
- **MINISTRIES**

Consulted document

1. République du Cap Vert, 1999. Communication Nationale sur les changements climatiques, 84 p

Vision: Education and Training
Priorities:
1. Training
2. Student Capacity development

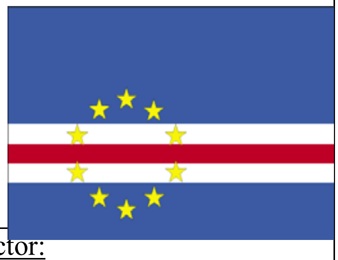
Coastal Adaptation Strategy: [N]

Collaborating Organizations:
- CNI Uni-cv
- DECM
- INGRH
- INMG
- INE
- POGCV
- Uni JPCV
- DFQQ
- IP
- Rede de Académicos, Investigadores e Profissionais
- Network of Academics, Researchers and Professionals

INTERNATIONAL:
- Fao
- UNDP
- Universidade em Rede

Institute Nacional de Descenvovimento das Pesca (INDP)

National Institute for the Development of Fisheries



Phone: +238 232 13 73/ 232 13 74
Fax: +238 232 16 16
Email:
Web: www.indp.cv ; www.ine.cv
Address: C.P. 132, Mindelo, Cape Verde

Director:
Dr. Oscar MELICIO (Chairman)
Email: oscar.melicio@indp.cv ; omelicio@yahoo.com
Deputy:
Dr. Anibal MEDINA
Email: anibal.medina@indp.cv
Admi:
Vito RAMOS
Email: vitomelo10@yahoo.com

Ministry: Ministry of the Education and Valuation of the Human resources (www.minedu.gov.cv)

Institute Strengths:
Human Resources: **INDP** currently has [XX] professional and administrative staff. Of the [YY] professional staff, [ZZ] have PhD, [WW] have a M.Sc/M.Tech and [VV] have a B.Sc/B.Tech

Infrastructure: **INDP** has a good power supply. The internet link is ADSL and the connection speed is 1024Mbps with approximately 09 personal computers connected. There are [YY] laboratories specializing in [Please insert fields researched]. Data collection at sea is done using [research vessels, moored and/or drifting buoys, installed equipment].

Publications: In the last 5 years, [XX] researchers affiliated to [INSTITUTE X] have received [YY] publications related to marine and coastal zone issues. **INDP** has provided information concerning [Insert Issue] to [Organization(s)] in preparation for COP-15. [If Applicable]

Financial Resources: **INDP** has a total budget of approximately [XX] with [YY%] allocated towards projects addressing coastal/marine management issues.

Capacity Development Needs to Address Climate Issues in Coastal Zones

Issues:	**Currently Available Services:**	**Services needed for Adaptation:**	**Capacities Needed for Services:**
[Coastal Erosion]	1. 2. 3.	1. 2. 3.	1. 2. 3.
[Salinization of Aquifers]	1. 2. 3.	1. 2. 3.	1. 2. 3.
[Coastal flooding]	1. 2. 3.	1. 2. 3.	1. 2. 3.

INDP Capacity Development Needs

- More collaboration with International organizations on environmental changes
- Settlement of strong network for data acquisition
- Data & products analyze
- Software on fish statistics & biology
- Biodiversity, Systematic

Vision: Education and Training

Priorities:

1. Education
2. Improve knowledge
3. Research Capacity for students

Coastal Adaptation Strategy: [N]

Collaborating Organizations:

NATIONAL:

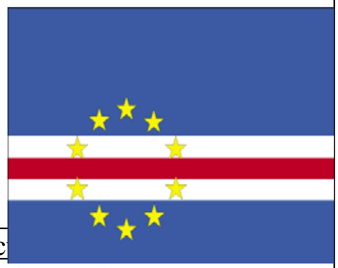
- CNI Uni-cv
- INE
- POGCV
- Uni JPCV
- INDP
- INGRH
- INMG
- DFQQ
- IP
- Rede de Académicos, Investigadores e Profissionais
- Network of Academics, Researchers and Professionals

INTERNATIONAL:

- FAO
- UNDP
- **Universidade em Rede**

[Universidade de Cabo Verde. Departamento de Engenharias e Ciencias do Mar (DECM) ex ISECMAR

University of Cape Verde. Department of Engineering and Sciences of the sea



Phone: +238 232 65 61
Fax: +238 232 65 63
Email: decm@unicv.edu.cv
Web: www.unicv.edu.cv/decm
Address: Campus de Ribeira de Julião
Caixa Postal 163, Midelo - São Vicente

Direc
Antonio Varela
Email: valera@isecmar.cv

Ministry: Ministry of the Education and Valuation of the Human resources (www.minedu.gov.cv)

Institute Strengths: [NO AVAILABLE DATA]

Human Resources: **DECM ex ISECMAR** currently has [XX] professional and administrative staff. Of the [YY] professional staff, [ZZ] have PhD, [WW] have a M.Sc/M.Tech and [VV] have a B.Sc/B.Tech

Infrastructure: **DECM ex ISECMAR** has a good power supply. The internet link is DSL and the connection speed is 1024 Mbps with approximately 05 personal computers connected. There are 01 laboratories specializing in Fish biology. Data collection at sea is done using [research vessels, moored and/or drifting buoys, installed equipment].

Publications: In the last 5 years, [XX] researchers affiliated to [INSTITUTE X] have received [YY] publications related to marine and coastal zone issues. **DECM ex ISECMAR** has provided information concerning [Insert Issue] to [Organization(s)] in preparation for COP-15. [If Applicable]

Financial Resources: **DECM ex ISECMAR** has a total budget of approximately [XX] with [YY%] allocated towards projects addressing coastal/marine management issues.

Capacity Development Needs to Address Climate Issues in Coastal Zones

Issues:	**Currently Available Services:**	**Services needed for Adaptation:**	**Capacities Needed for Services:**
[Coastal Erosion]	1. 2. 3.	1. 2. 3.	1. 2. 3.
[Salinization of Aquifers]	1. 2. 3.	1. 2. 3.	1. 2. 3.
[Coastal flooding]	1.	1.	1.

	2. 3.	2. 3.	2. 3.

DECM Capacity Development Needs

- More collaboration with International organizations on environmental changes
- Settlement of strong network for data acquisition
- Data & products analyze

Vision: Management of the Hydraulic Resources

Priorities:

1. Planning and Management of Hydraulic Resources
2. To define the norms relative techniques to the construction, modification maintenance and exploration of hydraulically workmanships
3. To approve programs and plans for development, preservation and excellent use of the hydraulic resources
4. To authorize restrictions of the use of hydraulic resources in determined areas, as well as in case of danger of exhaustion, degradation or contamination
5. To approve directives of obligator application for all in charge entities of relative specific functions to the water in diverse sectors

Coastal Adaptation Strategy: [N]

Collaborating Organizations:

NATIONAL:

- **INIA; MAA; NIS ; INDP; DECM; INMG**

INTERNATIONAL:

- **INA; SNIRH; IJWRD,**

Instituto Nacional de Gestão dos Recursos Hidricos (INGRH)

National Institute for Water Resource Management

Phone: +238 26139 74 / 261 63 44 / 261 60 00
Fax: +238 26130 47
Email: ingrh@ingrh.gov.cv
Web: www.ingrh.cv
Address: C.P : 567 - Praia - Cabo Verde

Director:
Arrigo Querido
Email: arrigoq@ingrh.gov.cv
Deputy:
Miguel Angelo Moura (Project Manager)
Email: Miguel_moura@yahoo.com ; miguelangelo@ingrh.gov.cv

Ministry: Ministry of Environment, Agriculture and Fisheries

Institute Strengths:

Human Resources: INGRH currently has [XX] professional and administrative staff. Of the [YY] professional staff, [ZZ] have PhD, [WW] have a M.Sc/M.Tech and [VV] have a B.Sc/B.Tech

Infrastructure: INGRH has a good power supply. The internet link is ADSL and the connection speed is 1024Mbps with approximately 07 personal computers connected. There are [YY] laboratories specializing in [Please insert fields researched]. Data collection at sea is done using [research vessels, moored and/or drifting buoys, installed equipment].

Publications: In the last 5 years, [XX] researchers affiliated to [INSTITUTE X] have received [YY] publications related to marine and coastal zone issues. INGRH has provided information concerning [Insert Issue] to [Organization(s)] in preparation for COP-15. [If Applicable]

Financial Resources: INGRH has a total budget of approximately [XX] with [YY%] allocated towards projects addressing coastal/marine management issues.

Capacity Development Needs to Address Climate Issues in Coastal Zones

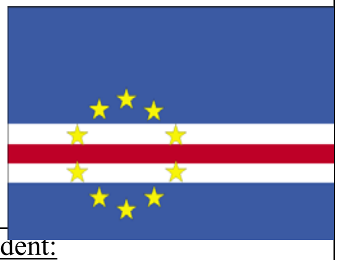
Issues:	Currently Available Services:	Services needed for Adaptation:	Capacities Needed for Services:
[Coastal Erosion]	1. 2. 3.	1. 2. 3.	1. 2. 3.
[Salinization of Aquifers]	1. 2. 3.	1. 2. 3.	1. 2. 3.
[Coastal flooding]	1. 2. 3.	1. 2. 3.	1. 2. 3.

INGRH Capacity Development Needs

- More collaboration with International organizations on environmental changes
- Settlement of strong network for data acquisition
- Data & products analyze
- Water Resource mapping & management

Instituto Nacional de Meteorologicae Geophysica (INMG)

National Meteorological and Geophysics Institute



Vision: Supervise and predict the behaviour of the atmosphere and the ocean surface

Priorities:

1. to maintain the network of weather stations and pulsimeter stations installed on the national territory
2. The acquisition, the treatment, the exploitation and the diffusion of national weather data

Coastal Adaptation Strategy: [N]

1. To monitor coastal & marine data
2. to monitor coastal areas for climate variability change

Collaborating Organizations:

NATIONAL:

- **INIA; MAA; NIS ; INDP; DECM; INMG**

INTERNATIONAL:

- UNDP;

Phone: +238 232 40 21 / 991 48 95
Fax:
Email:
Web: www. Inmg.cv
Address: BP. 567, Praia, Guinea Bissau

President:
Ester Araùjo de Brito
Email:
NAPA Coordinator:
Jose Pimenta Lima
Email:
ACCC Cordinator:
Francisco Correia
Email:
franciscocorreia073@gmail.com

Ministry:

Institute Strengths:

Human Resources: **INMG** currently has [XX] professional and administrative staff. Of the [YY] professional staff, [ZZ] have PhD, [WW] have a M.Sc/M.Tech and [VV] have a B.Sc/B.Tech

Infrastructure: **INMG** has a good power supply. The internet link is ADSL, and the connection speed is 1024 Mbps with approximately 10 personal computers connected. There are01 laboratory specializing in forecasting. Data collection at sea is done using installed equipment and satellite.

Publications: In the last 5 years, [XX] researchers affiliated to **INMG** have received [YY] publications related to marine and coastal zone issues. **INMG** has provided information concerning [Insert Issue] to [Organization(s)] in preparation for COP-15. [If Applicable]

Financial Resources **INMG** has a total budget of approximately [XX] with [YY%] allocated towards projects addressing coastal/marine management issues.

Capacity Development Needs to Address Climate Issues in Coastal Zones

Issues:	**Currently Available Services:**	**Services needed for Adaptation:**	**Capacities Needed for Services:**
[Coastal Erosion]	1. 2. 3.	1. 2. 3.	1. 2. 3.
[Salinization of Aquifers]	1. 2. 3.	1. 2. 3.	1. 2. 3.
[Coastal flooding]	1. 2. 3.	1. 2. 3.	1. 2. 3.

INMG Capacity Development Needs

- To strengthen and improve the role of our National Marine Meteorological Service
- The deployment numerical buoys along national costal region (costal ocean) and drifter buoys the open ocean area for observing different parameters of ocean and atmosphere
- The use and develop numerical models;
- Implementation of WAM model covering West Africa AND Gulf of Guinea.
- Costal Modelling (200 500 m resolution), Swan MODEL, communication (VPN);
- Modelling High resolution for the Ports with communication (Internet in-situ) .
- To analyse the products ;
- Training in the different domains and sectors

2.1.2 Institutes of Sub-Region 2: West Africa – Cote D'Ivoire, Ghana, Togo, Benin and Nigeria (Regional Coordinator: Ayaa K Armah)

The main coastal issues for Region 2 are urban sprawl, coastal erosion caused by natural and anthropogenic factors and high pollution levels. Other issues are sea-level rise, precipitation and floods and depletion of mangrove and fisheries resources. Population estimate in 2005 for the region was 381 million people with average population growth rate of 2.4 %. The total area is 1,348,548 km2 of which 2.9 % consists of water. The total length of the coastline is 1,563 km.

CAPABILITIES OF NATIONAL INSTITUTES IN PROVIDING SUPPORT FOR CLIMATE CHANGE ISSUES PERTAINING TO MARINE & COASTAL ENVIRONMENTS – AN ASSESSMENT OF SOME GCLME COUNTRIES

The marine and coastal issues of climate change constitute major challenges to the coastal nations sharing the Guinea Current Large Marine Ecosystem (GCLME) because of paucity of information, inadequate awareness of their long term impacts as well as inadequate capacity for adaptation.

Generally, key impacts of climate change in the coastal zone of the GCLME are quite similar and include: increased flooding, shoreline retreat, wetland and mangrove habitat loss, salt water intrusion into rivers and groundwater as well as economic losses such as coastal infrastructure (property and crops). The Guinea Current Upwelling, in particular, stands the risk of dislocation and weakening as the earth warms up.

Tide gauge data and beach temperature data can be provided by Cote d'Ivoire, Ghana, Togo, Benin and Nigeria to support climate changes studies and impact assessment.

The following constitute an assessment of how effectively institutes in some of the GCLME countries can provide support in climate change issues. In general, countries of the sub-region have unequal levels of capacity to support climate change issues. One clear thing is that no one single country has all the capacity to deal with the issues related to the phenomenon in the GCLME area.

All the institutions in the GCLME can provide the following additional services/ support towards climate change issues.

- Generate awareness on climatic change issues.
- Establish country or region specific database on climate change issues to assist in global modelling.

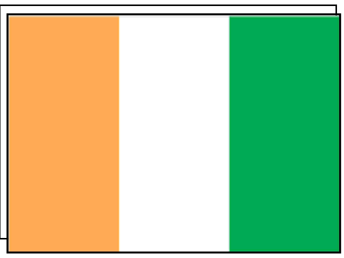
Finally, it is worth emphasizing the need for technology development and deployment to address climate change impacts as a long term strategy in view of the rather poor state of preparedness for adaptation by GCLME countries.

Country	Institute	Climate Change Issue	Institutional support capacity ranking (1=Excellent, 5=Poor)	Remarks
Cote d'Ivoire	Centre de Recherches Océanologiques (CRO)	Flooding/Storm surge	5	Poor capability to predict storm surges and provide data.
		Shoreline retreat	2	Shoreline change estimation and prediction expertise available, however, financial support is required to be effective.
		Wetland & mangrove habitat loss	1	Capacity to estimate vulnerability and adaptation strategies exist.
		Saltwater intrusion into rivers	1	Capacity to provide data on saltwater intrusion exists. Measurements are irregular.
		Salinisation of coastal aquifers	2	Capacity to provide data on saltwater intrusion exists. Measurements are irregular.
Ghana	Department of Oceanography & Fisheries, University of Ghana	Flooding/Storm surge	5	Poor capability to predict storm surges and provide data.
		Shoreline retreat	2	Shoreline change estimation and prediction expertise available, however, financial support is required to provide effective support.
		Wetland & mangrove habitat loss	1	Capacity to estimate vulnerability and adaptation strategies exist.
		Saltwater intrusion into rivers	1	Data on saltwater intrusion exists. Measurements are irregular as climate change is not the objective in many cases.
		Salinisation of coastal aquifers	2	Capacity to provide data on saltwater intrusion exists. Measurements are irregular.
Ghana	Marine Fisheries Research Institute	Flooding/Storm surge	5	Poor capability to predict storm surges and provide data.
		Shoreline retreat	Not applicable	Shoreline change does not form part of mandate of institution.
		Wetland & mangrove habitat loss	Not applicable	Wetland and mangrove issues do not form part of mandate of institution.
		Saltwater intrusion into rivers	Not applicable	Wetland and mangrove issues do not form part of mandate of institution.
		Salinisation of coastal aquifers	Not applicable	This is not part of mandate of institution.
Togo	1. Centre de	Flooding/Storm	5	Poor capability to predict storm surges

	Recherche Agronomique du Littoral. 2. CGILE: Centre de Gestion Intégrée du Littoral et de l'Environnement	surge		and provide data.
		Shoreline retreat	4	Shoreline change estimation and prediction expertise absent. Human capacity needs to be developed as well as adequate provision of funding.
		Wetland & mangrove habitat loss	1	Capacity to estimate vulnerability and adaptation strategies exist.
		Saltwater intrusion into rivers	1	Capacity to provide data on saltwater intrusion exists. Measurements are irregular.
		Salinisation of coastal aquifers	2	Capacity to provide data on saltwater intrusion exists. Measurements are irregular.
Benin	Centre de Recherches Halieutiques et Océanologiques du Bénin (CRHOB)	Flooding/Storm surge		Poor capability to predict storm surges and provide data.
		Shoreline retreat		Shoreline change estimation and prediction expertise available, however, financial support is required to provide effective support.
		Wetland & mangrove habitat loss	1	Capacity to estimate vulnerability and adaptation strategies exist.
		Saltwater intrusion into rivers	1	Capacity to provide data on saltwater intrusion exists. Measurements are irregular.
		Salinisation of coastal aquifers	2	Capacity to provide data on saltwater intrusion exists. Measurements are irregular.
Nigeria	Nigeria Institute of Oceanography & Marine Research	Flooding/Storm surge	3	Average capability to predict storm surges and provide data.
		Shoreline retreat	2	Shoreline change estimation and prediction expertise available, however, financial support is required to provide effective service.
		Wetland & mangrove habitat loss	1	Capacity to estimate vulnerability and adaptation strategies exist.
		Saltwater intrusion into rivers	1	Capacity to provide data on saltwater intrusion exists. Measurements are irregular.
		Salinisation of coastal aquifers	2	Information on salinisation of coastal aquifers exist for sections of the coastline.

2.1.2.1 Cote d'Ivoire

National Synopsis
[TO BE PROVIDED]

Vision: [INSERT BRIEF INSTITUTE VISION] Priorities: 1. Climate variability 2. Aerosol and pollution 3. 4.	**University de Cocody** Cocody University [Department?]	

<table>
<tr>
<td rowspan="2">Coastal Adaptation Strategy: [N]
1.
2.
3.

Collaborating Organizations:
CRO
SODEXAM
ASECNA
IRD</td>
<td>Phone: (225) 07 82 77 52
Fax: (225) 22 44 14 07
Email:
Web: www.univ-cocody.ci
Address: UFR SSMT, LAPA-MF, 22 BP 582 ABIDJAN 22</td>
<td>Director:
[TEA Gokou Celestin]
Email:
Deputy:
[BALOU Bi Toto Jerome]
Email:
Admin:
[KOUASSI Chantal]
Email:</td>
</tr>
<tr>
<td colspan="2">Ministry:
Ministère de l'Enseignement Supérieur et de la Recherche Scientifique
Ministry of Higher Education and Scientific Research</td>
</tr>
</table>

Institute Strengths: [PLEASE MODIFY TEXT AS NEEDED]
Human Resources: [University of Cocody] currently has [800] professional and administrative staff. Of the [] professional staff, [ZZ] have Ph.D, [WW] have a M.Sc/M.Tech and [VV] have a B.Sc/B.Tech.

Infrastructure: [University of Cocody] has a good] power supply. The internet link is [ADSL.] and the connection speed is [512] [in Mbps or Kbps] with [approximately] [100] personal computers connected. There are [1] laboratories specializing in [Climate research]. Data collection at sea is done using [].

Publications: In the last 5 years, [5] researchers affiliated to [University of Cocody] have received [10] publications related to marine and coastal zone issues. [CRO, Abidjan Port Authority] has provided information concerning [SST and tide] to [ODINAFRICA, SHOM)] in preparation for COP-15. [If Applicable]

Financial Resources: [INSTITUTE X] has a total budget of approximately [XX] with [YY%] allocated towards projects addressing coastal/marine management issues.

Capacity Development Needs to Address Climate Issues in Coastal Zones

Issues:	**Currently Available Services:**	**Services needed for Adaptation:**	**Capacities Needed for Services:**
[Coastal Erosion]	1. 2. 3.	1. 2. 3.	1. 2. 3.
[Salinization of Aquifers]	1. 2. 3.	1. 2. 3.	1. 2. 3.
[Coastal flooding]	1. 2. 3.	1. 2. 3.	1. 2. 3.
[Insert Issue]	1. 2. 3.	1. 2. 3.	1. 2. 3.

Capacity Development Needs.

- There is a great need in human capacity building in Physical Oceanography.
- There is coastal erosion along all the coasts of the Gulf of Guinea. Researchers and technicians need training in this field.
- Training in tide analysis and interpretation is required.

- We have no equipment for automatic data collection.
- No pollution data is collected along the coast.
- 5 Automatic meteorological stations are needed.

2.1.2.2 Benin

National Synopsis
[TO BE PROVIDED]

Vision: Contribute to management of living and non living aquatic resources, coastal zone, based on integration of scientific, economic and sociological opinions,] Priorities: 1. Research on physico chemical	**Centre de Recherches Halieutiques et Océanologiques du Bénin (CRHOB)** Benin Fisheries and Oceanographic Research Centre (CRHOB)	

parameters (sea and coastal zone)
2. Research on living and non living resources
3. Research on Coastal erosion
4. Research on Cetacean

Coastal Adaptation Strategy: [Y/N][If Yes, please indicate year adopted and priority actions] **NO,** in progress
1.
2.

Collaborating Organizations:
- National Centre of GIS (CeNaTel); Fisheries Office; Autonom Harbor of Cotonou; University of Abomey-Calavi
- National Direction of Meteorology (DNM)
- ODINAFRICA, GC LME, GOOS, FAO, IRD-PROPAO
- MPO-Canada
-

Phone: 229 21 31 75 86
Fax: 229 21 32 36 71
Email:
Web: http://www.nodc-benin.org
Address: 03 BP 1665 Cotonou Benin

Director:
Roger DJIMAN
Email: rodjiman@yahoo.fr
Deputy:
Zacharie SOHOU
Email: zsohou@yahoo.fr
Admin:
Georges DEGBE
Email: gdegbe@yahoo.fr

Ministre:
Ministère de l'Enseignement Supérieur et de la Recherche Scientifique
Ministry of Higher Teaching and Scientific Research

Institute Strengths: [PLEASE MODIFY TEXT AS NEEDED]
Human Resources: [INSTITUTE 11] currently has [10] professional and administrative staff. Of the [9] professional staff, [2] have Ph.D, [7] have a M.Sc/M.Tech and [2] have a B.Sc/B.Tech.

Infrastructure: [INSTITUTE X] has a [poor, fair, good, very good] power supply. The internet link is [dial-up, ADSL, VSAT, etc.] and the connection speed is [100] [in Mbps or Kbps] with [approximately] [10] personal computers connected. There are [6] laboratories specializing in [Fisheries and Oceanography]. Data collection at sea is done using [research vessels (Nansen Program), moored and/or drifting buoys, installed equipment].

Publications: In the last 5 years, [4] researchers affiliated to [IRD, ODINAFRICA, COI, IMS] have received [20] publications related to marine and coastal zone issues. [IMS] has provided information concerning [Marine and coastal] to [Organization(s)] in preparation for COP-15. [If Applicable]
Financial Resources: [Government, ODINAFRICA, PROPAO] has a total budget of approximately [20000$] with [80%] allocated towards projects addressing coastal/marine management issues.

Capacity Development Needs to Address Climate Issues in Coastal Zones

Issues:	**Currently Available Services:**	**Services needed for Adaptation:**	**Capacities Needed for Services:**
Coastal Erosion	1. Data collect and products 2. Expertise 3. Sensitization	1. SIG, Software for SIG 2. Coastal Sensitivity maps 3. Impact of climate	1. Training course 2. Training course 3. Financial support
Coastal flooding	1. Data collect and products 2. Vulnerability indices 3.	1. SIG, Software for SIG 2. 3.	1. Training course 2. 3.
Freshwater Salinization	1. Data collect and products 2. Expertise 3. Sensitization	1. SIG, Software for SIG 2. SIG, Software for SIG 3.	1. Training course 2. Training course 3. Financial support
[Marine Fisheries]	1. Data collect and products 2. Expertise 3. Sensitization	1. Specialized software 2. Regional exchange 3. Regional exchange	1. Training course 2. Training course 3. Financial support

2.1.2.3 Togo

National Synopsis
[TO BE PROVIDED]

Vision: [INSERT BRIEF INSTITUTE VISION] Priorities: 1. Marine Resources Assessment 2. Development of Fisheries activities 3. 4. Coastal Adaptation Strategy: [Y/N][If	Institut Togolais de Recherche Agronomique Sous Division/ Centre de Recherche Agronomique du Littoral (ITRA/CRAL) Togolese Institute of Agronomic Research / Coastal Zone Agronomic Research Centre (ITRA/CRAL)	

Yes, please indicate year adopted and priority actions] 1. National Adaptation Program Action (NAPA) 2. 3. Collaborating Organizations: [INSERT NATIONAL AND INTERNATIONAL PARTNER ORGANIZATIONS (Acronyms)] FAO	Phone: 00 228 225 30 96 Fax: 00 228 225 15 59 Email: intra@cafe.tg Web: http://www.itranet.tg/itranet.html Address: Ministre: **Ministère de l'Agriculture de l'Elevage et de la Pêche**	Director: AGBOKOUSSE V. Tél : 00 228 225 15 59 Email : not available Deputy: SOMANA Amouzou somanaeric@yahoo.fr Admin: [NAME] Email:

Institute Strengths: [PLEASE MODIFY TEXT AS NEEDED]
Human Resources: [INSTITUTE X] currently has [XX] professional and administrative staff. Of the [YY] professional staff, [ZZ] have PhD, [WW] have a M.Sc/M.Tech and [VV] have a B.Sc/B.Tech

Infrastructure: [CRAL] has a [good] power supply. The internet link is [ADSL] and the connection speed is [XX] [in Mbps or Kbps] with [approximately] 3 personal computers connected.

Publications: No publication available on Marine Science Research

Financial Resources: [CRAL] has a total budget of approximately [8000$] with [15%] allocated towards projects addressing coastal/marine management issues.

Capacity Development Needs to Address Climate Issues in Coastal Zones

Issues:	**Currently Available Services:**	**Services needed for Adaptation:**	**Capacities Needed for Services:**
Coastal Erosion	1. Visual monitoring of coastal zone 2. Visual estimation of coastal erosion 3.	1. Systematically monitoring of coastal zone through satellite data 2. Warning system in coastal zone 3.	1.Instrumentation of coastal zone 2. Tide gauge tools 3.
Coastal flooding	1.Estimation of coastal flooding areas	1.Regional Rain fall Prediction 2.Coastal protection infrastructure 3. Warning system for population	1. Capacity building in numerical weather prediction 2.Tecnical capacity building 3. National and International Experts
Freshwater Salinization	1. Control of water quality 2. Estimation of salt concentration in water 3.	1. Coastal Protection Task Force 2. Control and protection of coastal zone 3.	1. Capacity building 2.International experts 3.
[MORE ISSUE]	1. 2. 3.	1. 2. 3.	Creation of the Institute for Marine Science in Togo

			1. International Experts 2. 3.

[Institute X] **Capacity Development Needs**

[Please insert text of not more than 1 page explaining the capacities that are needed in order for this institute to provide the services needed to adapt to climate issues in coastal zones]

2.1.2.4 Ghana

National Synopsis
[TO BE PROVIDED]

Vision: To achieve sustainable development and management of fisheries resources through marine scientific research. Priorities: 1. To monitor marine environmental parameters	**Marine Fisheries Research Division (MFRD)**	

<table>
<tr>
<td rowspan="2">2. To estimate annual fish production
3. To assess stocks of demersal and pelagic fishery resources
4. To undertake biological studies of important fish species
5. To undertake study and development of fishing gears

Coastal Adaptation Strategy
1. To ensure the natural equilibrium of the habitat by establishment of community based fisheries management committees

Collaborating Organizations:
Department of Oceanography & Fisheries (DOF)
CSIR Water Research Institute (WRI)
Ghana National Committee for IOC (GNC/IOC)
Ocean Data & Information Network for Africa (ODINAFRICA)
Int’l Commission for Conservation of Atlantic Tuna (ICCAT)</td>
<td>Phone: +233 21 931702
Fax: +233 22 203066
Email: mfrd@africaonline.com.gh
Web: www.nodc-ghana.org
Address: P. O. Box BT 62, Tema. Ghana</td>
<td>Director:
Mr. Paul Bannerman
Email: paulbann@hotmail.com
Deputy:
Ms. Hawa Bint Yaqub
Email: bint.hawa@yahoo.co.uk
Admin:
Mrs. Ernestina Hodanu
Email:mfrd@africaonline.com.gh</td>
</tr>
<tr>
<td colspan="2">Ministry:
MINISTRY OF FOOD & AGRICULTURE</td>
</tr>
<tr>
<td colspan="3">Institute Strengths: [PLEASE MODIFY TEXT AS NEEDED]
Human Resources: MFRD currently has 11 professional, 17 technical and 18 administrative staff. Of the 11 professional staff, 0 have PhD, 7 have a M.Sc/M.Tech, 4 have a B.Sc/B.Tech. and 17 technicians

Infrastructure: MFRD has a good power supply. The internet link is ADSL and the connection speed is 512 Kbps with approximately 14 personal computers connected. There are 2 laboratories specializing in marine environmental parameters monitoring and fish
biological studies. Data collection at sea is done using research vessels.

Publications: In the last 5 years, 10 researchers affiliated to MFRD have received 100 publications related to marine and coastal zone issues.

Financial Resources: MFRD has a total budget of approximately US $ 370, 000 with 40% allocated towards projects addressing coastal/marine management issues.</td>
</tr>
</table>

Capacity Development Needs to Address Climate Issues in Coastal Zones

Issues:	**Currently Available Services:**	**Services needed for Adaptation:**	**Capacities Needed for Services:**
Marine Environment Monitoring	1. Sea surface temperature 2. Sea surface salinities 3. Plankton	1. Analyses of satellite imageries 2. Real time satellite data 3. Simulations	1. CPR methods 2. Physical oceanography 3. Chemical oceanography
Conservation of coastal living resources.	1. Stock assessment 2. Biological studies	1. Modeling 2. Reappraisal of assessments methods 3. Land survey methods	1. Ecosystem approach 2. Fisheries socio-economics 3. Human behaviour management.
Sustainable use of coastal marine	1. Public awareness 2. Use of environmentally friendly	1. Mariculture 2. Marine protected areas	1. Mariculture 2. Monitoring &

environment	gears	3. Land survey methods	Surveillance

Capacity Development Needs to Address Climate Issues in Coastal Zones

The coastal zones are highly productive and complex ecosystems that are essential to mankind. With the variety of human activities that occur in coastal zones, these areas face diverse range of pressures. Nevertheless they offer diverse range of possibilities for exploitation. With over concentration of industries in coastal zones, this fragile and sensitive ecosystem is under severe stress.

The climate change issues, principally sea level rise, in coastal zones usually involve modification of habitats and communities with consequent loss of ecosystems. Also, coastal zones are sites of aquaculture facilities, agriculture, ports, harbours, airports, tourism infrastructure, public infrastructure and land waste disposal sites among others. This leads to loss of key protective species such as mangroves and may collapse the entire system and leading to loss of natural protective mechanisms.

Capacity is needed in the area of appropriate legislation and enforcement. Legislation is a powerful tool in controlling undesirable human activities. Rules and regulations are needed to ensure sustainable development of coastal zone. The effects of diverse human activities needs to be thoroughly studied and legislations made to control human activities. This can impact positively on addressing climate issues in coastal zones.

There is the need to provide alternative livelihood to the people living in these coastal zones. The alternative livelihood programme should include alternatives sources of fuel or energy to prevent destruction of the mangroves which are important in defending coastlines against the rising sea.

Public education is necessary to ensure that people understand the consequences of their actions in the coastal zone with its destructive effects on the climate.

The resources in coastal zone need to be sustainably managed by employing Geographical Information System (GIS) to properly demarcate the coastal zone for sustainable development.

Vision: To develop world-class human resources and capabilities to meet national development needs and global challenges through quality teaching, learning, research and knowledge dissemination in marine and fishery science. Priorities:	**Department of Oceanography and Fisheries – University of Ghana**	

1. Training of marine and fisheries scientists 2. Research in marine science and fishery science 3. Coastal management studies 4. Coastal biodiversity studies Coastal Adaptation Strategy: No adaptation strategy has been adopted on climate change impacts such as sea level rise but a coastal environmental sensitivity atlas exists as part of the national oil spill contingency plans produced by the Ghana Environmental Protection Agency. Coastal low-lying areas likely to be affected by oil spills are similar and overlap with areas likely to be affected by rising sea levels Collaborating Organizations: National: EPA, Fisheries Commission, Ghana Meteorological Agency, Water Research Institute, Hydrological Services Division. International: GCLME/IGCC, UBC-Fisheries Centre Canada.	Phone: +233-21-518129 Fax: +233-21-502701 Email: oceano@ug.edu.gh Web: www.ug.edu.gh Address: P. O. Box LG 99 University of Ghana, Legon, Ghana Ministry: Ministry of Education	Director: Dr. F.K.E. Nunoo Email: fkenunoo@ug.edu.gh Admin: Ms. Ruth Ocloo Email: oceano@ug.edu.gh

Institute Strengths:

Human Resources: The Department Oceanography & Fisheries has currently has [13] professional and administrative staff. Of the [11] professional staff, [5] have PhD, [5] have M.Sc/M.Tech and [1] have a B.Sc/B.Tech.

Infrastructure: The Department of Oceanography & Fisheries has a very good power supply. The internet link is VSAT 3, and the connection speed is 54 Mbps with approximately 20 personal computers connected. There are 3 laboratories specializing in marine biodiversity and productivity, coastal processes and satellite oceanography. Data collection at sea is done using vessels of opportunity and coastal installed equipment e.g. tides gauges.

Publications: In the last 5 years, 8 researchers affiliated to the Department of Oceanography & Fisheries have received 80 publications related to marine and coastal zone issues. The Ghana National UNESCO Commission has provided information concerning oil impacts to IOC in preparation for COP-15.

Financial Resources: Approximately 5 % of annual budget is allocated towards projects addressing coastal/marine management issues.

Capacity Development Needs to Address Climate Issues in Coastal Zones

Issues:	**Currently Available Services**:	**Services needed for Adaptation:**	**Capacities Needed for Services:**
Coastal Erosion	1. Shoreline change assessment 2. Shoreline protection with gabions and revetments.	1. None 2. None	1. Training in Coastal and offshore engineering.
Coastal flooding	1. Coastal elevation measurement 2. 3.	1. Early detection of storm surges 2. 3.	1. Training in storm surge prediction and modelling 2. 3.
Freshwater Salinization	1. Groundwater quality assessment 2. 3.	1. None 2. 3.	1. Training in state of the art techniques in groundwater quality assessment

Guinea Current Upwelling	1. Beach temperature measurements 2. 3.	1. Regional scale wind, current and SST monitoring.	1. training in regional wind, currents, SST etc data management.

[Institute X] Capacity Development Needs

[Please insert text of not more than 1 page explaining the capacities that are needed in order for this institute to provide the services needed to adapt to climate issues in coastal zones]

2.1.2.5 Nigeria

National Synopsis

CAPABILITIES OF NATIONAL INSTITUTES IN PROVIDING SUPPORT FOR CLIMATE CHANGE ISSUES PERTAINING TO MARINE & COASTAL ENVIRONMENTS – AN ASSESSMENT OF SOME GCLME COUNTRIES

The marine and coastal issues of climate change constitute major challenges to the coastal nations sharing the Guinea Current Large Marine Ecosystem (GCLME) because of paucity of information, inadequate awareness of their long term impacts as well as inadequate capacity for adaptation.

Generally, key impacts of climate change in the coastal zone of the GCLME are quite similar and include: increased flooding, shoreline retreat, wetland and mangrove habitat loss, salt water intrusion into rivers and groundwater as well as economic losses such as coastal infrastructure (property and crops). The Guinea Current Upwelling, in particular, stands the risk of dislocation and weakening as the earth warms up.

Tide gauge data and beach temperature data can be provided by Cote d'Ivoire, Ghana, Togo, Benin and Nigeria to support climate changes studies and impact assessment.

The following constitute an assessment of how effectively institutes in some of the GCLME countries can provide support in climate change issues. In general, countries of the sub-region have unequal levels of capacity to support climate change issues. One clear thing is that no one single country has all the capacity to deal with the issues related to the phenomenon in the GCLME area.

Nigeria	Nigeria Institute of Oceanography & Marine Research	Flooding/Storm surge	3	Average capability to predict storm surges and provide data.
		Shoreline retreat	2	Shoreline change estimation and prediction expertise available, however, financial support is required to provide effective service.
		Wetland & mangrove habitat loss	1	Capacity to estimate vulnerability and adaptation strategies exist.
		Saltwater intrusion into rivers	1	Capacity to provide data on saltwater intrusion exists. Measurements are irregular.

		Salinisation of coastal aquifers	2	Information on salinisation of coastal aquifers exists for sections of the coastline.

All the institutions in the GCLME can provide the following additional services/ support towards climate change issues.

- Generate awareness on climatic change issues.
- Establish country or region specific database on climate change issues to assist in global modelling.

Finally, it is worth emphasizing the need for technology development and deployment to address climate change impacts, as a long term strategy in view of the rather poor state of preparedness for adaptation by GCLME countries.

[INFORMATION ON NIGERIAN INSTITUTES TO BE PROVIDED]

2.1.3 Institutes of Sub-Region 3: West Africa – Cameroon, Republic of the Congo, Gabon, Angola and Namibia (National Coordinators: Jean Folack (Cameroon), Alain Claver Batchy (Rep. of Congo), Magloir Désiré Mounganga (Gabon)

The main coastal issues for Region 3 are coastal erosion and the depletion of the mangrove ecosystem. This region is the least studied and hardly any information exists. This is not to say that there are no issues but that the documentation of issues is limited. The population estimate in 2005 for the region was 19 million people with an average population growth rate of 2.2 %. The total area is 3,088,517 km2 of which 2.9 % consists of water. The total length of the coastline for the region is 1,324 km. Estimate of capture fisheries for the region in 2006 was 238,238 while that for aquaculture fisheries was only 0.2 % of the capture fisheries. The total mangrove area estimate for 2005 was 408 million km2 while estimate for coral reef areas were not documented as at 2001. The GDP per capita in US$ in 2005 was US$ 9,967. Marine protected areas form 5 % of the total territorial waters.

2.1.3.1 Cameroon

National Synopsis

Les défis principaux de l'adaptation au changement climatique dans les zones côtières au Cameroun

Par Dr Jean Folack[1]

1. Introduction

La zone marine et côtière du Cameroun est le théâtre d'énormes enjeux économiques, sociaux et environnementaux qui, comme ailleurs dans le monde, en font un espace hautement sensible et menacé. Les problématiques environnementales globales de cette zone sont liées potentiellement à la convergence des pollutions pétrolières, industrielles, agro-industrielles, portuaires, urbaines et transfrontalières, à diverses utilisations du domaine maritime notamment l'exploitation et l'exploration des ressources marines, la navigation et transports maritimes, la pêche auxquels il faut ajouter les impacts dus aux changements climatiques. Au Cameroun, les problèmes liés au changement climatique sont pris en compte au plus haut niveau de l'Etat. Ainsi en 2007, le Président Paul Biya parlait de « la sauvegarde de la planète terre menacée par les émissions de gaz à effet de serre, l'Afrique, continent

[1] Dr Jean Folack
Océanologue Chercheur-Maître de Recherche
Directeur du Centre Spécialisé de Recherche sur les Ecosystèmes Marins (CERECOMA)
MINRESI-IRAD Kribi-Cameroun

bien que contribuant très faiblement aux émissions des gaz à effet de serre, se trouve particulièrement affecté par le réchauffement climatique, au point d'être considéré comme l'une des zones les plus vulnérables. Le Cameroun est largement exposé aux modifications inquiétantes des écosystèmes côtiers, du fait de la sédimentation, des inondations et de la montée des eaux salées. L'exploitation et l'utilisation des énergies fossiles, principales source d'émission des gaz à effet de serre ont entrainé le dérèglement du système climatique. Il s'agit donc de concilier les impératifs de développement et l'exigence de stabilisation des conditions climatiques qui appelle à repenser nos modes de production car pour longtemps encore, ceux-ci seront tributaires de l'énergie d'origine fossile

Pour le Cameroun il s'agit de:

- Diminuer progressivement l'utilisation de l'énergie fossile et promouvoir des énergies renouvelables : hydroélectricité, biomasse et énergie solaire dont le Cameroun possède d'énormes potentialités dont l'exploitation harmonieuse et rationnelle peut aider les autres pays africains
- Mettre en place un Plan d'Action National Energie
- Rechercher les financements »

2. Caractéristiques des zones côtières camerounaises

Le Cameroun avec une superficie de 475 412 km^2 s'ouvre sur l'Océan Atlantique sur une côte d'environ 402km de long (Sayer et al.1992). Cette côte s'étend de 2°20' de la frontière avec la Guinée Equatoriale au sud à 4°40' au nord à la frontière avec le Nigeria (Figure1). Sur le plan naturel, cette côte est très diversifiée et comprend la forêt littorale, les mangroves, des plages sableuses alternant avec des plages rocheuses, des baies et plusieurs rivières qui se déversent dans l'océan formant de grands estuaires. Enfin cette côte est dominée par la présence du mont Cameroun qui culmine à 4075m créant un microclimat particulier avec une pluviosité annuelle de 11000 mm à Debundscha située au pied de ce mont. C'est une zone fortement peuplée, de tourisme par excellence, présence de grandes plantations agro-industrielles, riche en biodiversité, activité de pêche et pétrolières intenses. Tous ces atouts vont susciter des convoitises origines de nombreux conflits auxquels s'ajoute une dégradation de l'environnement, liée essentiellement aux actions anthropiques et aux impacts dus aux changements climatiques

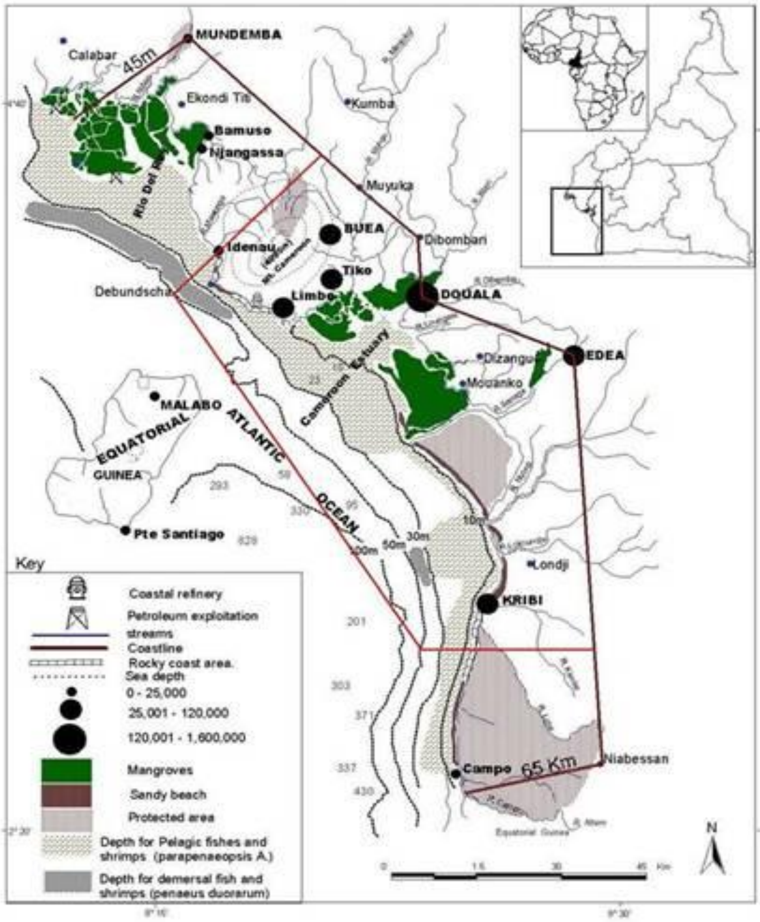


Figure 1. Caractéristiques des zones côtières camerounaises

3. Le Cameroun face aux défis de l'adaptation aux changements climatiques en zone côtière

Le changement climatique selon le Groupe International d'Etude sur le Climat (GIEC) est tout changement de climat dans le temps qu'il soit dû à la variabilité naturelle ou aux activités humaines. La Convention Cadre des Nations Unies sur les Changements Climatiques (CCNUCC) ajoute à cet essai de définition la notion de modification de la composition de l'atmosphère dans son ensemble. Après la Conférence des Nations Unies sur l'Environnement et le Sommet de Rio en 1992, le Cameroun a ratifié en 1994 la CCNUCC. Par cette ratification, le Cameroun s'est engagé avec la communauté internationale à stabiliser les concentrations des Gaz à Effet de Serre (GES) dans l'atmosphère à un niveau qui préviendrait l'interférence dangereuse anthropique avec le système climatique. Ainsi le Cameroun a entrepris :

3.1. Etudes réalisées au Cameroun sur l'analyse de la vulnérabilité des écosystèmes côtiers aux changements climatiques

i) L'inventaire des GES : les trois gaz ainsi identifiés comme principaux responsables de la presque totalité des émissions au Cameroun sont : le CO_2, le CH_4 et le N_2O

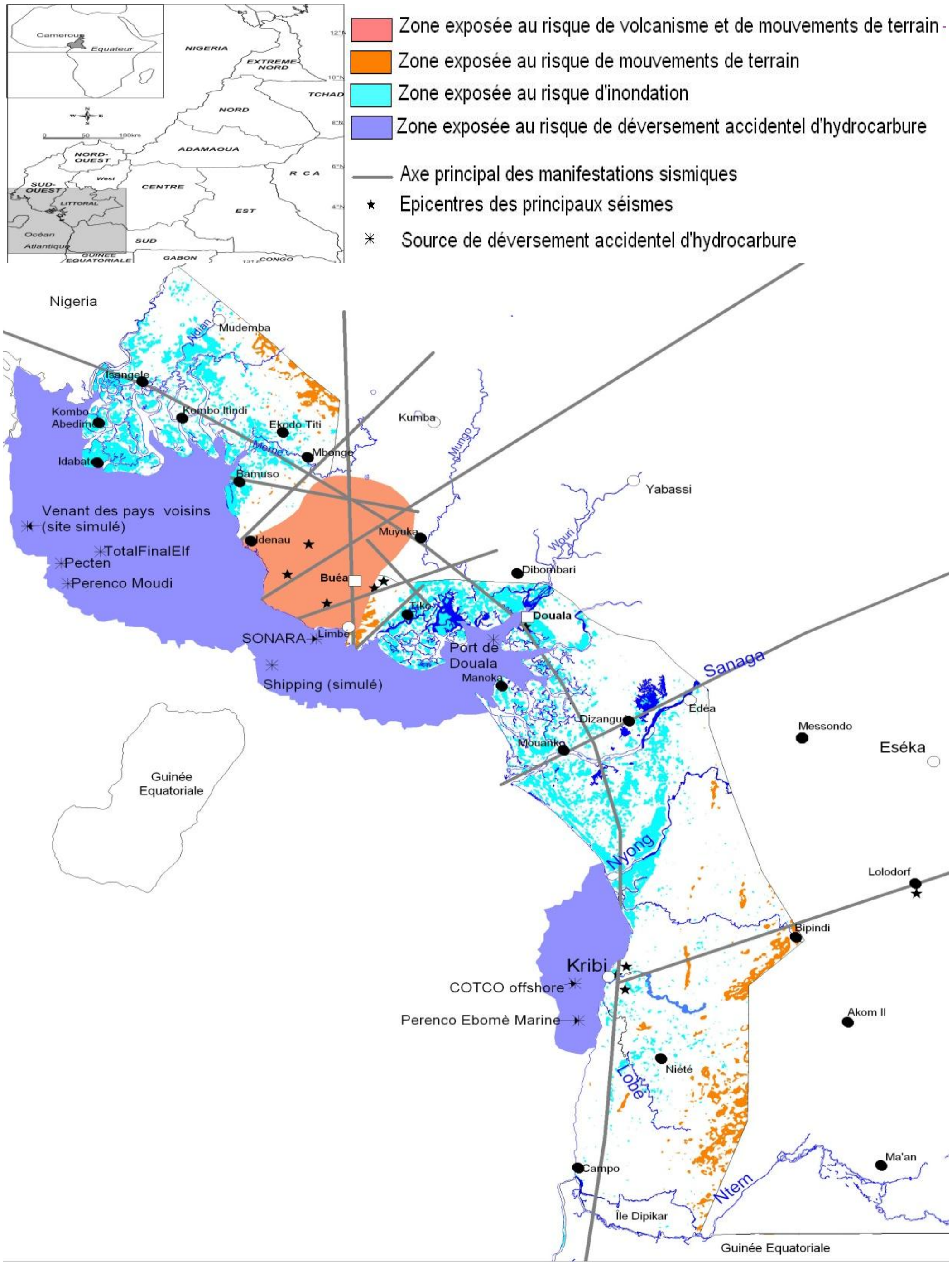
ii) Analyse de la vulnérabilité des zones côtières aux effets adverses des changements climatiques

ii.1. Vulnérabilité sur l'environnement côtier :

- Effets de l'élévation du niveau de la mer et débit des cours d'eau : érosion, inondation, fréquence des crues, remontée des eaux salées (Figure 2)
- Effets biochimiques et de la pollution sur la faune et la flore côtières
- Effets de changement de température sur la répartition des espèces et la biodiversité
- Effets de changements hydrologiques sur la faune et la flore des mangroves
- Effets de variation des précipitations sur l'activité des pêches
- Effets de changements climatiques sur les aspects liés au développement socioéconomique en zone côtière

ii.2. Vulnérabilité sur les infrastructures côtières

Il a été montré qu'au Cameroun dans la région de Douala, l'élévation du niveau de la mer de 50cm en 2050 va entraîner une perte de 1ékm^2 de terres côtières, destruction de 20000 habitations et le déplacement de 294000 personnes et causer des dommages de près de 2,74 milliards de FCFA aux propriétés individuelles



Source : D'après le Plan National de Lutte Contre les Déversements Accidentels d'Hydrocarbures (2004) et l'élaboration du consultant.

Figure : 2 Carte de la typologie des risques naturels et de déversements accidentels d'hydrocarbures dans la zone côtière camerounaise

3.2. Stratégies de réponse du Cameroun face aux changements climatiques en zone côtière

3.2.1. Actions entreprises ayant une contribution sur l'atténuation des impacts des changements climatiques

3.2.1.1. Mise en place des politiques et outils nationaux

- Loi no 90/013 et son décret d'application no 92/223 du 25 mai 1992 sur la protection des plantes
- Loi no 94-01 du 20 janvier 1994 sur les forêts, la faune et la pêche
- La Loi-cadre n° 96/12 du 5 août 1996 relative à la Gestion de l'environnement
- Loi no 98 :005 du 14 avril 1998 sur l'eau
- Loi no 001 du 16 avril 2001 sur le code minier
- Le décret 94/259/PM du 31 mai 1994 portant création de la Commission Nationale Consultative pour l'Environnement et le Développement Durable (CNCEDD) ;
- Le décret N° 1999/780/PM du 11 octobre 1999 modifiant et complétant les dispositions de L'article 3 du décret N° 94/259/PM du 31 mai 1994 portant création de la Commission Nationale Consultative pour l'Environnement et le Développement Durable (CNCEDD) ;
- Le décret N°2001/718/PM du 03 septembre 2001 portant organisation et fonctionnement du comité interministériel de l'environnement ;
- Le Décret N° 2005/0577/PM du 23 février 2005 fixant les modalités de réalisation de l'Etude d'Impact Environnemental ;
- Le décret n°95/466/PM du 20 juillet 1995 fixant les modalités d'application du régime des forêts
- Adoption en 1996 du plan National de Gestion de l'Environnement (PNGE)
- Plan d'Action National de lutte contre la désertification
- Programme Sectoriel Forêt Environnement (PSFE)
- Stratégie Nationale de mise en Œuvre de la CCNUCC
- Document de Stratégie de Réduction de la Pauvreté (DSRP)
- Mise en place d'un Plan d'Action National Energie
- Plan National de Développement des Pêcheries

3.2.1.2. Ratification des conventions internationales liées aux changements climatiques

- Ratification du protocole de Kyoto et de Montréal
- Ratification de la convention sur la diversité biologique
- Ratification de la convention sur les zones humides (RAMSAR)
- Ratification de la convention sur la désertification

3.2.2. Stratégies actuelles d'adaptation aux impacts des changements climatiques en zone côtière au Cameroun

Les zones côtières et leurs infrastructures sont vulnérables aux inondations, et aux remontées d'eaux salées. Des catégories d'options d'adaptation alternatives suivantes sont envisagées:

i) **Retrait** : les impacts peuvent être atténués par la délocalisation des infrastructures et des habitations ; dans ces conditions il faut déterminer une zone de démarcation au-delà de laquelle l'occupation est interdite ; le retrait peut aussi servir comme moyen naturel pour permettre une restauration naturelle, surtout dans les zones de mangrove, le retrait enfin nécessite l'acquisition de terrain pour relocaliser les gens

ii) **Accommodation** : les populations modifient leur mode de vie et leur style d'habitation ; l'élévation des maisons est alors la principale mesure d'accommodation

iii) **Protection :** construction des structures de protection

iv) Adaptations spécifiques à l'activité des pêches

- Réduire le taux de prise en réduisant les quotas
- Augmenter le maillage pour éviter les captures de petits poissons
- Renforcer le contrôle de suivi des prises
- Renforcer le contrôle et les sanctions contre les mauvaises pratiques de pêche
- Développer l'aquaculture par la recherche des technologies aquacoles appropriées

Le défi du Cameroun consistera à définir les responsabilités à élaborer les mécanismes de coordination de communication et de renforcement des capacités pour la gestion des impacts des changements climatiques en zone côtière, notamment :

3.2.3. Besoins de formation en matière des ressources humaines des institutions impliquées dans les problématiques de changements climatiques en zone littorale dans les domaines suivants:

i) Collecte des données et suivi de l'évolution des paramètres du climat : physiciens de l'atmosphère, météorologues, océanographes physiciens

ii) Modélisation des données : mathématiciens, physiciens, climatologues,

iii) Ressources en eau et écoulement des eaux: hydrologues, hydrogéologues, géophysiciens, ingénieurs en assainissement

iv) Problèmes relatifs aux GES : forestiers, bio géochimistes, océanographes, physiologistes végétaux, physiciens énergétiques, sédimentologies, ingénieurs de génie civil, pédologues, chimistes organiciens, ingénieurs énergéticiens

v) Stratégies d'adaptation : experts en sciences sociales et épidémiologistes

3.2.4. Besoins de renforcement institutionnel

i) Coordination et harmonisation des activités des institutions à l'échelle nationale

ii) Promotion au sein des institutions d'une culture de partage de responsabilité

iii) Réseau d'échange efficace entre les institutions nationales

iv) Renforcement des capacités des institutions en matière de technologies performantes : logiciels, ordinateurs adaptés et des équipements de mesures et d'analyse des sols, de suivi hydrologique, de couverture météorologique

4. Aperçu sur quelques institutions nationales

Au Cameroun les recherches en zone côtière et en milieu marin sont réalisées par l'Institut de Recherche Agricole pour le Développement (IRAD) à travers le Centre Spécialisé de Recherche sur les Ecosystèmes Marins (CERECOMA) et la Station Spécialisée de Recherches Halieutiques et Océanographiques de Limbe (SSRHOL). Les autres structures nationales comme l'Institut National de Cartographie (INC), l'Institut de Recherches Géologiques et Minières (IRGM), la Direction Nationale de la Météorologie (DNM) n'ont pas de programmes spécifiques en milieu marin, mais peuvent avoir des activités ponctuelles/projets qui les amènent à travailler en milieu marin. D'autres structures comme le Ministère de l'Elevage, des Pêches et des Industries Animales (MINEPIA) à travers la Direction des Pêches est chargé de la gestion des pêcheries maritimes ; la Société Nationale des Hydrocarbures (SNH) effectue des activités d'exploration et d'exploitation pétrolières en milieu marin. La marine nationale et la marine marchande interviennent dans la sécurité maritime. Pour le moment la DNM n'a pas un programme maritime. Toutes ces institutions n'ont pas de stratégies d'adaptation en milieu côtier. Ce que nous proposons, ce sont des besoins en fonction des domaines de compétence au cas où ces structures interviendraient en zone côtière.

Vision: Contribute toward fight again poverty and food security notably: (i) Implement scientific programme on	**Institut de Récherche Agricole pour le Développement (IRAD)**	

<table>
<tr><td rowspan="3">main issues for the agricultural development of the country based on real needs of users at national and regional levels
(ii) Develop food and industrial technology
(iii) Gather collections on conservation and research
(iv) Promote valorization of research products
(v) Facilitate transfer of research results
(vi) Establish and reinforce partnership with production sectors
(vii) Look for all information which have impact on agricultural development in the country
Priorities:
1. perennial and annual crops
2. Fisheries and animal productions
3. Forest and environment
4. Rural sociology and production systems
Coastal Adaptation Strategy: [Yes][,2005]
1. Management, geomorphology and coast protection
2. Hydrology, environment and ecosystem health
3.marine resources management
Collaborating Organizations:
[FAO, CIRAD, UNIDO, FAO, IOC-UNESCO, ITTA, CORAF,UNEP]</td><td>Institute of Agricultural Research for Development)</td><td></td></tr>
<tr><td>Phone: 237 22 22 33 62
Fax: 237 22 22 33 62
Email:iradpnrva@yahoo.com
Web: www;Irad-cameroon.org
Address: P.O.Box 2123 Yaoundé-Cameroon</td><td>Director:
[Dr Zok Simon]
Email: zoksimon@yahoo.fr
Deputy:
[Dr Njoya Aboubakar]
Email: njoya_aboubakar@yahoo.fr
Admin:Director
[Bame Amos]
Email:</td></tr>
<tr><td colspan="2">Ministry:
[Ministry of Scientific Research and Innovation (MINRESI)</td></tr>
<tr><td colspan="3">Institute Strengths:
Human Resources: [IRAD] currently has [1033] professional and administrative staff. Of the [273] professional staff, [34%] have PhD, [41%] have a M.Sc/M.Tech and [25% have a B.Sc/B.Tech

Infrastructure: [IRAD] has a [good] power supply. The internet link is [, ADSL, VSAT, etc.] and the connection speed is [XX] [in Mbps or 230,5Kbps] with [approximately] [500] personal computers connected. There are [10] laboratories specializing in [biotechnology on animal and vegetal production, rubber, chemical and soil analysis, fish biology, shrimp and fish biotechnology]. Data collection at sea is done using [fiber glass canoe].

Publications: In the last 5 years, [20] researchers affiliated to [IRAD] have received [100] publications related to marine and coastal zone issues. [IRAD] has provided information concerning [coastal zone issues] to [national institutions and some Organization(s) from the UN system such as FAO and UNIDO] in preparation for COP-15. [If Applicable]

Financial Resources: [IRAD] has a total budget of approximately [one billion CFA] with [2, 5%] allocated towards projects addressing coastal/marine management issues.</td></tr>
</table>

Capacity Development Needs to Address Climate Issues in Coastal Zones

Issues:	**Currently Available Services**:	**Services needed for Adaptation:**	**Capacities Needed for Services:**
[Coastal Erosion]	1. Scientific Publications on sediment Dynamics 2. Sensitive map of the littoral 3. Bathymetric maps of estuary zone 4. Map of distribution of sediment faciès 5. Profil of coastline	1. Modelisation of the coastline Dynamics 2. coastal Sediment dynamic and movement of estuaries 3. Monitoring of the coastline 4. Promotion of innovative and cheaper methods for coast protection	1. Cartographer 2. Géomorphologist 3. Géochimist 4. Civil engeneer 5. Sédimentologist 6. Mathematicians 7. Physicians
[Salinizatio n of	1. map of salt water intrusion distribution	1. Monitoring of sea water intrusion in estuaries	1. Hydrologist 2.Cartographer

Aquifers]	2. Data base on fresh water discharges at sea	2. Collection of data on fresh water discharge into the ocean	
[Coastal flooding]	1. map of risk zones 2. Data base on flooding 3. Protection plan for coastal risk zones	1. Identification and inventory of zone prone to flooding 2. Drainage of risk zones 3. Promotion of cheap adaptation techniques	1. Civil engeneer 2. Hydrologist
Land slide	1. Map of risk zones 2. Data base on the types of coastal soils	1. identification des zones à risques 2. Identification de types de sol côtier	1. Soil expert 2. Cartographer
Other hazards such as volcano	1Prediction and timing model for eruption	Monitory of mount Cameroon volcano	1. Geologist 2. Geographer 3. Mathematicians 4. Physicians

Institut National de Cartographie (INC)

National Institute of Cartography (INC)

Vision: **Cartographic and geographic research within the national territory notably:**

1. Mettre à la disposition des décideurs, des politiques et tout autre acteur de développement, des documents cartographiques fiables qui sou tendent les projets ou actions de développement
2. Produire et mettre à la disposition des décideurs, des politique et de tous les autres usagers, les outils fiables d'aide à la décision en vue d'une parfaite maîtrise du développement et une gestion rationnelle et efficace de l'espace national et des ressources (naturelles, humaines et matérielles).

Priorities

-Geodesy and photo topography

- Cartography and Remote sensing

-Geographic Research

-Administration and Finance

Coastal Adaptation Strategy: [N[,2005]

Collaborating Organizations: IRD (France), []

Phone: 237 22222921
Fax: 237 22 23 39 54
Email: inacart@camnet.cm
Web: www.inc.org
Address: 779, Avenue mgr Vogt
P.O.Box 157 Yaounde-Cameroun

Director:
[Paul Moby Etia]
Email: incart@camnet.cm
Deputy:
[]
Email:
Admin:
Email:

Ministry:
[**Ministry of Scientific Research and Innovation (MINRESI**)

Institute Strengths: [PLEASE MODIFY TEXT AS NEEDED]

Human Resources: [INC] currently has [113] professional and administrative staff. Of the [43] professional staff, [6] have PhD, [24] have a M.Sc/M.Tech and [13] have a B.Sc/B.Tech

Infrastructure: [INC] has a [good] power supply. The internet link is [] and the connection speed is [XX] [in Mbps or Kbps] with [approximately] [] personal computers connected. There are [] laboratories specializing in []. Data collection at sea is done using [fiber glass canoe].

Publications: In the last 5 years, [] researchers affiliated to [INC] have received [] publications related to marine and coastal zone issues. [INC] has provided information concerning [] to [] in preparation for COP-15. [If Applicable]

Financial Resources: [INC] has a total budget of approximately [] with [] allocated towards projects addressing coastal/marine management issues.

Capacity Development Needs to Address Climate Issues in Coastal Zones

Issues:	**Currently Available Services:**	**Services needed for Adaptation:**	**Capacities Needed for Services:**
[Coastal Erosion]	1. Sensitive map of the littoral 2. Bathymetric map of estuary zones 3. Profile of coastline	1. Modelisation of the coastline dynamics 2.mapping of coastal risk zones	1. Cartographer 2. Civil engeneer 3. Physicians 4. Mathematicians
[Salinization of Aquifers]	1. Map of distribution of salt intrusion	1. Monitoring of salinity distribution within estuaries	1. Hydrologist 2.Cartographer
[Coastal flooding]	1. Map of risk zones 2.Data base on flooding 3. Plan of protection of risk zones	1. Identification and inventory of zone prone to flooding 2. Improvement of draining Systems in risk zones 3. Promotion of cheap adaptation techniques	1. Civil engeneer 2. Hydrologist
Land slide	1.Carte des zones à risques	1. identification and mapping of	1. Soil expert

		risk zones	2. cartographer
Other hazards such as volcano	1 Prediction and timing model for eruption	1. Monitory of mount Cameroon volcano	1.Geologist 2.Geographer

<table>
<tr>
<td rowspan="3">Vision: Mining and geological research within the national territory notamment: conception et l'exécution des programmes de recherche en vue d'assurer la maîtrise des données géographiques, minières, hydrologiques et énergétique du Cameroun. Dans le cadre de cette mission et dans ses domaines d'activités spécifiques (Géologie, Géophysique, hydrologie et énergie)

Coastal Adaptation Strategy: [N[,2005]

Collaborating Organizations:
[]</td>
<td colspan="2">Institut de Recherches Géologiques et Minières(IRGM)
Institute of Mining and Geological Research (IRGM)
</td>
</tr>
<tr>
<td>Phone: (237) 222-24-30
Fax: (237) 222 24 31
Email: irgm@iccnet.cm
Web: www.irgm.org
Address: B.P. 4110 Nlongkak Yaoundé - Cameroun</td>
<td>Director:
[Dr Joseph Victor Hell]
Email: irgm@iccnet.cm
Deputy:
[]
Email:
Admin:
Email:</td>
</tr>
<tr>
<td colspan="2">Ministry:
[Ministry of Scientific Research and Innovation (MINRESI)</td>
</tr>
</table>

Institute Strengths: [PLEASE MODIFY TEXT AS NEEDED]
Human Resources: [IRGM] currently has [60] professional and administrative staff. Of the [30] professional staff, [6] have PhD, [14] have a M.Sc/M.Tech and the [10] have a B.Sc/B.Tech

Infrastructure: [IRGM] has a [good] power supply. The internet link is [] and the connection speed is [XX] [in Mbps or Kbps] with [approximately] [] personal computers connected. There are [] laboratories specializing in []. Data collection at sea is done using [fiber glass canoe].

Publications: In the last 5 years, [] researchers affiliated to [IRGM] have received [] publications related to marine and coastal zone issues. [IRGM] has provided information concerning [] to [] in preparation for COP-15. [If Applicable]

Financial Resources: [IRGM] has a total budget of approximately [] with [] allocated towards projects addressing coastal/marine management issues.

Capacity Development Needs to Address Climate Issues in Coastal Zones

Issues:	**Currently Available Services:**	**Services needed for Adaptation:**	**Capacities Needed for Services:**
[Coastal Erosion]	1. Map of geological structures of the coastal zone	1. Inventory of geological structures along the littoral 2. study of coastal soils 3. Data collection on currents	1. Cartographer 2. Geomorphologist 3. Sedimentologist 4. Hydrologist
[Salinization of Aquifers]	1. Map of distribution of salt intrusion to estuaries	1. monitoring of salinity distribution within estuaries	1. Hydrologist 2.Cartographer
[Coastal flooding]	1. Map of zones prone to flooding 2. data base on flooding 3. Zoning plan in coastal zone prone to flooding	1. Identification and inventory of zones prone to flooding 2.Improvement of drainage systems in risk zones 3. zoning and topographic study in coastal zones prone to flooding	1. Civil engeneer 2. Hydrologist 3. Cartographer
Land slide	1. Carte des différents types de sols côtiers	1. identification and mapping of coastal soil types	1. Soil expert 2. Cartographer 3. Geologist
Other hazards such as volcano	1.Prediction and timing model for eruption	1.Monitory of mount Cameroon volcano	1. Geologist 2. Geographer

Vision: **meteorological cover of the national territory notably:** élaboration, de la mise en œuvre de la politique du gouvernement en matière de météorologie, notamment: • de la collecte, du traitement et de la diffusion	**Direction de la Météorologie Nationale (DMN)** **National Direction of Meteorology)(DMN)**	

<table>
<tr>
<td rowspan="2">des informations météorologiques ;
• de l'exploitation des données transmises par les réseaux météorologiques aux niveaux national et international ;
• de l'établissement des informations climatologiques ;
• de l'élaboration des prévisions météorologiques ;
• de la diffusion des informations météorologiques ;
• du suivi des relations avec les organismes internationaux et régionaux de météorologie et/ou d'hydrométéorologie ;
• du suivi de la veille météorologique et climatologique ;
• du suivi de la mise en œuvre des conventions et protocoles en matière de météorologie et de l'environnement atmosphérique ;
• du suivi des centres de veille météorologiques des aérodromes, en liaison avec l'Autorité Aéronautique.

Coastal Adaptation Strategy: [N[,2005]

Collaborating Organizations:
[WMO, PNUD, OACI, ACMAD,ASECNA,CAMAC,METEO FRANCE,) and various national ministries]</td>
<td>Phone: 23733431635
Fax: 237 33421635
Email:
Web: www.meteo-cameroon.net
Address: 296 rue Ivy Douala P.O.Box 186 Douala Cameroun</td>
<td>Director:
[SAAH Michel Legrand]
Email: mlsaah@yahoo.com
Deputy:
[KENNE Etienne]
Email:etienne_kenne@yahoo.com
Admin:
Email:</td>
</tr>
<tr>
<td colspan="2">Ministry:
[Ministry of Transport (MINTRANS)</td>
</tr>
</table>

Institute Strengths: [PLEASE MODIFY TEXT AS NEEDED]
Human Resources: [DNM] currently has [100] professional and administrative staff. Of the [30] professional staff, [2] have PhD, [28] have a M.Sc/M.Tech and [have a B.Sc/B.Tech

Infrastructure: [DNM] has a [] power supply. The internet link is [..] and the connection speed is [XX] [in Mbps or Kbps] with [approximately] [] personal computers connected. There are [] laboratories specializing in []. Data collection at sea is done using [fiber glass canoe].

Publications: In the last 5 years, [] researchers affiliated to [DNM] have received [] publications related to marine and coastal zone issues. [DNM] has provided information concerning [] to [] in preparation for COP-15. [If Applicable]

Financial Resources: [DNM] has a total budget of approximately [] with [] allocated towards projects addressing coastal/marine management issues.

Capacity Development Needs to Address Climate Issues in Coastal Zones

Issues:	**Currently Available Services:**	**Services needed for Adaptation:**	**Capacities Needed for Services:**
[Coastal Erosion]	1. Prediction model for extreme events in coastal zone	1. Collection of data on wind speed and direction, air temperature, wave regime, sea surface temperature, rainfall and current	1. Meteorologist 2. Geographer
[Salinization of Aquifers]			
[Coastal flooding]	1.Data base on flooding phenomenon within coastal cities	Collection of data on rainfall and sea level rise	1.Meteorologist 2.Hydrologist
Land slide			
Other hazards such as volcano			

2.1.3.2 Gabon

National Synopsis

Appui technique à l'adaptation en zone côtière au Gabon : état des lieux des capacités

Dans le cadre de la formulation de la Communication Nationale Initiale du Gabon sur les changements climatiques (2005), l'étude de vulnérabilité a dégagé les changements de certains paramètres tels que les températures, la pluviométrie et le niveau de la mer.

Ainsi, les projections du réchauffement global pour les horizons temporels 2050 et 2100, par rapport à la normale climatique 1961-1990, donnent comme résultat une augmentation de la température de l'ordre de 0,5 à 1,3°C et 1,4 à 2,8°C. Ces projections issues des modèles climatiques Maggic et Scengen confirment les résultats du bilan climatique du littoral nord et centre. A cet effet, dans le cadre de l'élaboration de la Seconde Communication Nationale (en cours de finalisation), les mesures de températures et de précipitations enregistrées par la Direction de la Météorologie Nationale, au cours des trente dernières années enregistrent une hausse moyenne de 0,4°C, et les précipitations enregistre une baisse de l'ordre de 36 mm. L'application du modèle de circulation globale à l'échelle du Gabon prévoit pour l'horizon 2050 une augmentation graduelle des précipitations du nord vers le sud, d'environ 2% au nord (Province du Woleu-Ntem), et 8% au sud (Province de la Nyanga).

Par ailleurs on prévoit également une élévation moyenne du niveau de la mer sur les côtes Gabonaises de l'ordre de 18 à 50 cm entre 2050 et 2100.

Partant de ces considérations, la préoccupation majeure actuelle du pays est d'arriver à prévoir, avec des marges d'incertitude scientifiquement admises, les impacts potentiels des changements climatiques sur les secteurs vitaux du pays et de mettre en place une stratégie d'adaptation pour y faire face. L'urgence commande qu'un accent particulier soit mis sur le secteur littoral en raison de multiples enjeux stratégiques que regorge ce domaine. En effet, les littoraux sont des espaces instables, des milieux fragiles et fortement exposés aux menaces naturelles telles que la submersion marine engendrant des inondations, et l'érosion côtière accentuée par des activités humaines plus ou moins incontrôlées. La forte concentration démographique et économique rend donc la zone côtière gabonaise particulièrement exposée aux effets potentiels des changements climatiques.

Au Gabon, la zone côtière couvre environ 950 km de longueur et comprend trois domaines répartis ainsi : au nord, la zone des estuaires, au centre ouest le complexe du système deltaïque de l'Ogooué, et au sud une côte d'accumulation qui est le domaine des grandes lagunes. L'ensemble du littoral concentre plus de 70% de la population (ce taux atteindrait 85% en 2015 selon le Ministère du Plan) et une part importante des activités économiques aux enjeux stratégiques tels que le développement touristique, l'exploitation pétrolière, minière et halieutique, et l'urbanisation. C'est donc un espace de vie, de production, d'habitat, de relations particulièrement attractives pour les populations côtières, mais aussi pour celles de l'intérieur.

On constate, depuis plusieurs années déjà, que le littoral de la région de Libreville connaît, dans son ensemble, une accentuation de l'érosion. Dans le secteur nord au lieu dit la « Sablière », l'exploitation non-réglementée des sables a déséquilibré les protections naturelles (destruction du cordon littoral). Depuis plus de trois ans maintenant, une rivière est née et s'écoule désormais de manière continue sur ce lieu. L'autre fait aggravant de cette situation est l'augmentation de la capacité érosive des eaux

Marines sur ce secteur, puisque les arbres se déchaussent progressivement. Ce processus d'érosion va évoluer en s'aggravant d'année en année et risque fort de s'accélérer en fonction de l'accélération de l'élévation du niveau de la mer provoqué par le changement climatique global.

Les aménagements d'infrastructure (routes) le long de la côte sont également victimes de l'érosion côtière accélérée, car elles sont situées beaucoup trop près du rivage. Eu égard à l'enjeu stratégique que représente cette voie de communication, sa destruction par l'érosion perturberait considérablement le trafic Nord-Sud et les activités économiques du pays, qui sont concentrées sur la côte.

Le bassin portuaire connaît, quant à lui, des phénomènes d'envasement lié en partie aux aménagements n'ayant pas pris en compte tout le processus hydrodynamique et aux extractions de sable le long du chenal d'accès au port, perturbant la dynamique sédimentaire.

Port-Gentil, deuxième ville du Gabon par le nombre d'habitants (150.000 habitants), et capitale économique du pays, développe une activité industrielle dominée par le raffinage du pétrole, les services au secteur pétrole, et les activités liées au bois. La ville s'apprête à accueillir deux grands projets d'envergure pour la région et le pays : la construction d'un port de pêche, et l'implantation d'une zone franche industrielle dans la Baie du Cap Lopez. Ce dernier projet sera orienté vers les industries pétrolières et parapétrolières.

Sur la base des mesures et des observations de terrain réalisées depuis 1960 au cap Lopez, la mer a gagné près de 230 mètres de large, à la faveur de l'érosion à Port-Gentil. Cela représente près de 4,60 mètres de largeur de terres perdus chaque année, en moyenne. Les récentes mesures de terrain montrent une accentuation du phénomène sur l'ensemble du territoire, avec des pics pouvant dépasser 20 à 30 mètres durant les marées de tempêtes. Les secteurs fortement exposés à cette vulnérabilité sont sans aucun doute ceux où les infrastructures stratégiques (terminal pétrolier, raffinerie, port) sont présentes, à savoir le secteur du cap Lopez et la baie du cap Lopez. A l'horizon 2100, la pointe Iguezè pourrait se transformer en île et serait donc coupée du reste de l'île Mandji. D'autre part, la baie du Prince, la baie de Port-Gentil et la baie de Ndogou présenteront une très forte échancrure entraînant des pertes de terres sur l'île. Au niveau du banc du Prince, la pointe Djolowé et la pointe Chapuis (sites devant abriter le projet d'aménagement de la zone franche) pourraient elles aussi se transformer en île.

Outre les effets directs de l'élévation du niveau marin, soit la destruction potentielle des infrastructures côtières (les sites touristiques, les habitations, les ports et les routes), on relève parmi les impacts du changement climatique l'appauvrissement en eau potable par un accroissement de la salinité sur les terres basses. En effet, les premières conclusions de l'étude de vulnérabilité et adaptation aux changements climatiques dans le cadre de la seconde communication nationale révèlent qu'une partie importante des secteurs autour et dans l'île Mandji, seront affectés par la salinisation des eaux douces. En effet, l'onde des marées se propage déjà bien au-delà de sa zone d'influence actuelle. Cette aire d'influence concerne d'une part la zone de pompage de la station de la Société d'Energie et d'Eau du Gabon (SEEG), située à Mandorové (situé à 28 km au sud de Port-Gentil). D'autre part, cette intrusion saline concerne les zones d'abri (où les eaux saumâtres sont quasi permanentes) telles que les lagunes et les différents chenaux de marées situés dans la baie du cap Lopez. De fait, en saison des pluies, l'intrusion saline est limitée à 5 km de part et d'autre de la station de pompage. En saison sèche par contre, cette intrusion saline déborde et envahit littéralement tous les chenaux de marée situés autour de la station de pompage. Il en est de même pour les zones d'abri, notamment les lagunes et chenaux de marées, où cette intrusion devient de plus en plus longue et durable.

Pour accompagner le processus devant conduire à l'adaptation de ces milieux et infrastructures du littoral face aux changements climatiques, certaines structures et équipements sont nécessaires et utiles à mette en place, à savoir :

- Un observatoire de l'océan et du climat ;
- Des instruments de mesures pour l'acquisition des données de terrain utiles dans les choix en matière d'adaptation, et pour réduire l'érosion côtière ;

- Le renforcement des services de la météorologie nationale qui ne disposent plus d'instruments de mesures des données météorologiques sur tout le territoire ;

Or, ces structures et instruments sont, soit inexistants, soit très sommairement équipés. La première action devrait conduire à développer et rendre opérationnelles ces différentes unités d'observation et de production des données.

Au Gabon, la seule structure qui récolte les données météorologiques, est la Direction de la Météorologie Nationale qui, à ce jour, ne dispose que de cinq stations opérationnelles sur l'ensemble du territoire. Un maillage effectué avec les ingénieurs de la météo a montré qu'il faudrait 78 stations pour couvrir l'ensemble du territoire (39 stations synoptiques et 39 stations automatiques).

En dehors de ce service, il y a lieu de renforcer les laboratoires suivants, qui sont des unités de recherche au sein du Centre National de la Recherche Scientifique. Ce sont:

- Le Centre National des Données et de l'Information Océanographiques (CNDIO). ;
- Le Laboratoire de Gestion des Risques te des Espaces Humides (GREH) ;
- Le laboratoire de Télédétection et des Systèmes d'information géographiques (LARTESIG) ;
- Laboratoire de Recherche sur les Systèmes Portuaires (LARESPO).

Les quatre structures citées ci-dessus ne pourraient travailler en synergie que si elles sont intégrées au sein d'un observatoire (à créer), tel que mentionné plus haut.

Vision: [PLANIFICATION DE LA ZONE COTIERE GABONAISE] Priorities: 1. Observatoire de la zone côtière 2. Programme ARGO sur l'observation des paramètres océaniques 3. dynamique sédimentaire du littoral	**[CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE ET TECHNOLOGIQUE (CENAREST)]** National Centre of Scientific and Technological Research	

<table>
<tr>
<td rowspan="2">gabonais
4. Connaissance et suivi de la qualité des eaux littorales

Coastal Adaptation Strategy: [Y/N][If Yes, please indicate year adopted and priority actions]
1. Réalisation de la seconde communication Nationale sur l'adaptation aux changements climatiques
2. Déploiement des bouées ARGO le long du littoral gabonais
3. déploiement des instruments de mesures sur la dynamique littorale

Collaborating Organizations:
- Commission océanographique Intergouvernementale (COI) de l'UNESCO ;
- Programme de Coopération Internationale ARGO ;
- NOOA ;
- US Navy ;
- IFREMER ;
- Direction Générale du Droit de la Mer (DGDM) ;
- Marine Nationale
- Gabon Port Management (GPM)
- Direction de la Météorologie Nationale (DMN) ;
- Centre National des Données et de l'Information Océanographiques (CNDIO) ;
- Laboratoire de Gestion des Risques et des Espaces Humides (GREH) ;
- Laboratoire de Télédétection et des Systèmes d'Information Géographiques (LARTESIG) ;
- Direction Générale de l'Environnement (DGE) ;
- Direction Générale des Pêches et de l'Aquaculture (DGPA)
- Mairie de Libreville ;
- Mairie de Port-Gentil</td>
<td>Phone: (241) 73 47 86
Fax: (241) 73 25 78
Email: cndiogabon@yahoo.fr
Web:
http://www.cenarest.gabon.org
http://www.nodc-gabon.org
Address: B.P. 10 961 Libreville (Gabon)</td>
<td>Director:
[Pr IDIATA Daniel Franck, Commissaire Général]
Email:
Deputy:
[Dr EKAZAMA Richard, Coordonnateur Scientifique]
Email:
Admin:
[FAURE François Edgard, Chef du département des Sciences Marines]
Email: faured@yahoo.fr</td>
</tr>
<tr>
<td colspan="2">Ministre:
[MINISTERE DE L'EDUCATION NATIONALE, DE L'ENSEIGNEMENT SUPERIEUR, DE LA RECHERCHE SCIENTIFIQUE ET DE L'INNOVATION]</td>
</tr>
<tr>
<td colspan="3">Institute Strengths: [PLEASE MODIFY TEXT AS NEEDED]
Human Resources: [Le Département des Sciences Marines (DESMAR), qui héberge le Centre National des Données et de l'Information Océanographiques, le Programme ARGO et le laboratoire de Gestion des Risques et des Espaces Humides] currently has [17] professional and administrative staff. Of the [17] professional staff, [5] have PhD, [12] have a M.Sc/M.Tech and [0] have a B.Sc/B.Tech

Infrastructure: [Le Département des Sciences Marines (DESMAR)] has a [pauvreté en équipement, lié à l'absence de locaux appropriés, pauvreté en matériel roulants et en embarcation, absence de laboratoires propres à l'institution, amenant la structure à sous traiter avec d'autres laboratoires privés de la place] power supply. The internet link is [équipements individuals de connexion d'environ, de type HSDPA USB MODEM.] and the connection speed is [256 Kbps] with [approximately] [3] personal computers connected. There are [04] laboratories specializing in [Gestion de la vulnérabilité et des Risques littoraux, Gestion des systèmes portuaires, Système d'Information Géographique appliqué à la planification</td>
</tr>
</table>

côtière, Gestion des Données et de l'Information Océanographiques]. Data collection at sea is done using [Grâce au programme ARGO, les chercheurs du département des Sciences Marines ont effectué une mission de déploiement de trois bouées ARGO au large des côtes gabonaises suivant les coordonnées suivantes :

- 00°44.909' N et 08°20.516' E, au large du cap Esterias (69 miles);
- 01°49.611' S et 08°14.767' E, au large d'Omboué (61,5 miles) ;
- 03°46.656' S et 09°19.130' E, au large de Mayumba (82,5 miles).

  En dehors de cette opération, l'institution n'a plus développé une action dans le sens. Le déploiement s'est effectué du 04 au 06 mai 2009, avec la collaboration de la Marine Nationale et La Direction Générale du Droit de la Mer.].

Publications: In the last 5 years, [04] researchers affiliated to [Institut National des Techniques de la Mer (INTEC-MER, Cherbourg-France), institute du Littoral et de l'Environnement (ILE, La Rochelle-France), Institut National des Sciences de Gestion (INSG, Libreville-Gabon)] have received [04] publications related to marine and coastal zone issues. [Le Centre National des Données et de l'Information Océanographiques (CNDIO)] has provided information concerning [la Seconde Communication Nationale du Gabon sur les Changements Climatiques] to [La Direction Générale de l'Environnement, et en ce moment, un chercheur de ce laboratoire collabore avec le PNUD dans le cadre de l'élaboration du projet d'adaptation aux changements climatiques en Afrique. Une autre équipe assure la coordination gabonaise dans le projet de réalisation du Plan d'Action National Adaptation aux changements climatiques] in preparation for COP-15.

Financial Resources: [Les laboratories du Department des Sciences Marines] have a total budget of approximately [22 700 US D] with [20 %] allocated towards projects addressing coastal/marine management issues.

Capacity Development Needs to Address Climate Issues in Coastal Zones

Issues:	**Currently Available Services**:	**Services needed for Adaptation:**	**Capacities Needed for Services:**
Coastal Erosion	1. Programme ARGO - est un observatoire national permet de recueillir des données et informations sur les paramètres océaniques utiles pour la compréhension des changements climatiques. 2. Centre National des Données et de l'Information Océanographiques (CNDIO) - qui permet de stocker, traiter et diffuser les données et informations océanographiques) 3. Laboratoire de Gestion des Risques et des Espaces Humides (GREH) - qui oriente les décideurs et fournit des données, informations et études sur l'évaluation des risques littoraux tels que l'érosion côtière, les inondations dans les villes littorales.	1. Laboratoire de Gestion des Risques et des Espaces Humides (GREH) Programme Erosion Côtière. 2. Centre National des Données et de l'Information Océanographiques (CNDIO) 3. Programme ARGO	1. Laboratoire de Gestion des Risques et des Espaces Humides (GREH) : Operational equipment (especially instruments for measuring erosion) 2. CNDIO: Equipment and financial resources to upgrade infrastructure 3. Programme ARGO : technical maintenance and upgrading to floats and CNDIO
Salinization of Aquifers	1. Centre National Anti-pollution 2. Direction des Etudes et laboratoires 3. Laboratoire GEOGUIDE (structure privée qualifiée dans l'analyse des eaux)	1. Centre National Anti-pollution 2. Direction des Etudes et laboratoires 3. Laboratoire GEOGUIDE (structure privée qualifiée dans l'analyse des eaux)	1. Centre National Anti-pollution 2. Direction des Etudes et laboratories 3. Laboratoire GEOGUIDE (structure privée qualifiée dans l'analyse des eaux)
Coastal flooding	1. Laboratoire de Gestion des Risques et des Espaces Humides	1. Laboratoire de Gestion des Risques et des Espaces Humides	1. Laboratoire de Gestion des Risques et

	(GREH) 2. 3.	(GREH) 2. 3.	des Espaces Humides (GREH) 2. 3.

[Nécessité de création au Gabon de l'Institut National de Recherche sur l'Océan et la Climat (INROC)]

Capacity Development Needs

1. Laboratoire de Gestion des Risques et des Espaces Humides (GREH) : Le Programme de recherche sur l'érosion Côtière, créé en janvier 2009, est chargé d'orienter les décideurs et opérateurs économiques sur les risques littoraux en rapport avec ce problème dont les conséquences sont de plus en plus catastrophiques sur les infrastructures situées sur les côtes du Gabon. Pour augmenter les capacités opérationnelles de cette structure de façon à mieux accompagner les décisions en matière de gestion de l'érosion côtière, l'équipement du GREH devrait être renforcé, notamment à travers le programme Erosion côtière, qui manque d'outils performant utiles pour prévenir les conséquences néfastes de cette problématique sur les infrastructures menacées. Dans ce cas de figure, les instruments de mesures directes tels que les marégraphes, les houlographes, embarcations avec sondeurs, seraient d'une grande utilité pour que ce laboratoire puisse mieux servir les décideurs dans les choix en matière de planification de la zone côtière gabonaise.

2. Programme Argo : Ce programme est développé avec l'ensemble des administrations nationales et opérateurs économiques locaux utilisateurs des données marines. Il devrait lui aussi être renforcé, dans la mesure où les bouées gérées par ce programme doivent être renouvelées tous les cinq ans. De plus, une des trois bouées déployées au large des côtes en avril 2009, ne transmet toujours pas des données. Le centre de réception à Libreville n'a pas non plus bénéficié de financement de la part de l'Etat gabonais. La mise en œuvre effective de ce centre permettrait de renforcer les laboratoires déjà créés pour offrir aux décideurs les données les plus fiables pour gérer l'érosion côtière dans notre pays.

3. Centre National des Données et de l'Information Océanographiques (CNDIO) : La donnée étant un véritable instrument de planification, pour le rendre plus opérationnel, il serait nécessaire de renforcer cette structure en l'équipant d'outils plus performant pour la compilation, le stockage, le

traitement et le diffusion des données sur l'évolution du littoral et du trait de côte.

Les quatre laboratoires ci-dessous devraient constituer les structures à même d'aider à conduire la stratégie nationale en matière d'adaptation aux changements climatiques dans la zone côtière:

- Le Centre National des Données et de l'Information Océanographiques (CNDIO) ;
- Le Laboratoire de Gestion des Risques te des Espaces Humides (GREH) ;
- Le laboratoire de Télédétection et des Systèmes d'information géographiques (LARTESIG) ;
- Laboratoire de Recherche sur les Systèmes Portuaires (LARESPO).

Ils ont déjà l'avantage de développer des thématiques en rapport avec les problématiques telles que :

- la vulnérabilité des littoraux gabonais face aux changements globaux ;
- l'érosion côtière et ses conséquences sur l'environnement et les infrastructures des littoraux ;
- la gestion des systèmes portuaires face aux changements globaux ;
- l'observatoire du littoral à travers le programme ARGO (réseau d'observation des paramètres océaniques),
- la cartographique des risques littoraux et des zones humides (enjeux humains et environnementaux) ;

Mais la stratégie de développement de ces thématiques, en lien avec les laboratoires sus mentionnés, ne serai avéré que si l'ensemble de ces unités sont regroupées au sein d'une structure plus grande, de type Institut National de Recherche sur l'Océan et la Climat.

Les besoins sont de trois ordres :

- Acquisition d'un local d'une capacité plus importante avec au moins quinze pièces et deux salles d'analyses ;
- Acquisition d'instruments de mesures et d'équipements de terrain (embarcations équipées d'outils de mesures des paramètres océaniques,
- Renforcement des capacités humaines à travers des formations diplômâtes et des formations continues

2.1.3.3 Republic of the Congo

National Synopsis

Les principaux défis d'adaptation au changement climatique dans la zone côtière congolaise

Alain Claver BATCHY
Géomorphologue/océanographe
Consultant Ministère délégué chargé de la Marine Marchande
BP: 4808
Tél: 00242 521 38 80/ 921 38 80
batchyalain@yahoo.fr

Introduction

Le Congo dispose d'une façade maritime de 170 km situé au cœur du golfe de Guinée, une côte basse et rectiligne en grande partie sablonneuse et composée par de nombreux écosystèmes lagunaire et lacustres qui sont alimentées par des fleuves et des rivières. Ces environnements riches ressources biologiques et minérales se trouvent menacer de plus en plus par les changements des conditions ambiantes intervenues ces dernières décennies.

Ainsi, Motivée par le souci de provoquer chez les différents acteurs et la population riveraine une réelle prise de conscience quant aux effets des changements climatiques sur le littoral congolais, une équipe des experts nationaux pluridisciplinaires a mené des études dans le but de développer les capacités adaptatives des communautés riveraines aux impacts de ce phénomène.

Ce programme, qui a bénéficié de l'appui du FEM/GEF a été piloté par le PNUD et le Ministère de l'environnement, abouti à l'élaboration des états de lieux des impacts sur les changements climatiques et les mesures d'adaptation pour réduire ces effets.

L'Université Marien Ngouabi, la Délégation Générale de la Recherche Scientifique et Technique (DGRST), l'Institut de Recherche pour le

Développement (IRD) Centre de Pointe Noire, les services publics et administratifs et les ONG de la région côtière ont été mis à contribution afin de fournir les données à l'analyse environnementale de la vulnérabilité du littoral congolaise face aux effets de changement climatique.

Les experts ont réussi, à l'issu d'une série de rencontres tenues à l'échelle nationale, à identifier plusieurs aspects considérés comme étant les plus vulnérables au niveau de la zone côtière à savoir la pêche et les ressources halieutiques, les mangroves, les estuaires et lagunes et le paysage littoral et maritime, l'élévation du niveau de l'océan.

Le projet a contribué également à l'établissement de cartes thématiques de vulnérabilité, à l'émergence d'une prise de conscience chez le grand public et les décideurs quant à la nécessité de s'adapter aux changements climatiques et à un renforcement des capacités des acteurs locaux en la matière.

A ce jour, la mise en place d'une nouvelle législation nationale sur les zones côtières pour la protection des écosystèmes et sections de côtes vulnérables et l'élaboration d'un plan d'action en matière de gestion intégrée du littoral s'imposent aujourd'hui plus que jamais.

La zone côtière congolaise présente une faune et une flore riche en nombre d'espèces. Elle est soumise à des pressions nombreuses auxquelles s'ajoutent les conséquences du changement climatique. Les impacts de ce phénomène sont une menace pour le milieu marin, en particulier pour les écosystèmes, et qui entraînent des répercussions considérables sur l'économie et l'environnement.

Compte tenu des évolutions climatiques et de l'accroissement des populations côtières et de l'industrie en zone côtière, l'adaptation des zones littorales sera un enjeu majeur.

Les effets induits à la vulnérabilité des écosystèmes marin et côtier se résume par un accroissement de la température, élévation du niveau de la mer (inondation, accroissement de l'énergie des vagues, érosion des côtes, pénétration de l'eau salée dans les aquifères), effets
sur les écosystèmes, modification du débit des fleuves, effets socio-économiques, impacts sur l'aquaculture et la pêche.)

1. **les défis principaux de l'adaptation au changement climatique dans les zones côtières congolaise**

Stratégies et mesures d'adaptation au niveau de la zone côtière congolaise

Les travaux effectués par le groupe pluridisciplinaire national face aux impacts des changements climatiques sur la zone côtière congolaise ont permis de conclure sur les stratégies de régulation hydrotechnique envisageables en guise de réponses qui se résume comme suit :

- L'étude et l'apport concret de suppléments de sable sur le rivage et la plage ;
- L'étude et la répartition des digues en guise de protection des zones côtières là où cela s'avère nécessaire ;
- L'évaluation et l'étude de coût pour le déplacement et le relogement des populations menacées sur le littoral (les plateaux ayant des altitudes supérieures à 15 mètres) ;
- Le déplacement de certains sites historiques et ouvrages publics ;
- Le désensablement du Port ;
- La planification du développement urbain.

Au-delà, des approches envisagées par le groupe technique national, on distingue d'autres actions qui pourront être déployées au plan national et au plan international, régional ou sous régional bien que les expériences conduites hors frontière font l'objet de coopérations internationales, régionales ou sous régionales.

Sur le plan national, des mesures juridiques, institutionnelles et réglementaires doivent d'être prises pour faciliter la mise en places des politiques et stratégies de gestion adéquates du littoral;

Dans la pratique, la zone côtière Congolaise apparaît bien placée **pour organiser la concertation avec les nombreux acteurs concernés par l'aménagement de l'espace en particulier pour intégrer les mesures d'adaptation au changement climatique**;

Cette concertation devrait aboutir **à la Gestion Intégrée des Zones Côtières (GIZC),** une stratégie qui a montré ces preuves dans plusieurs régions du monde est particulièrement appropriée pour parvenir à concilier développement économique et adaptation au changement climatique d'autant plus que les zones côtières seront particulièrement exposées aux risques liés au changement climatique.

Cette approche permettrait **de bien planifier les plans de gestion des sections de côtes vulnérables et les écosystèmes fragiles** afin de faire des évaluations conséquentes et de **donner des réponses ou mesures correctives adaptées aux anomalies constatées.**

Les aménagements et ouvrages qui seront issus **de la démarche GIZC devraient faire l'objet de projets innovants** qui pourront s'appuyer sur l'expérience en génie côtier et en environnement marin.

La sensibilisation des populations, la pédagogie, paraissent essentielles à l'acceptation des mesures d'adaptation au changement climatique et donc à la réussite des programmes qui seront menés.

Les mouvements associatifs (ONG) peuvent y contribuer, s'ils sont mobilisés et soutenus, en particulier par les décideurs. En effet, cette notion du changement climatique est complexe et actuellement mal comprise au sein des communautés riveraines. Les réflexions scientifiques et historiques sont importantes dans le cadre de cette pédagogie. Des outils pédagogiques sont à construire pour faciliter les campagnes d'information. Les associations pourraient être utilement associées aux différents projets car il s'agit de procéder à une approche participative.

au plan international, régional et sous régional, faciliter la coopération avec les organismes spécialisés pour un **renforcement des capacités soutenue et le transfert de technologies**. La coopération sous régional est un processus d'intégration et d'harmonisation de procédures et des programmes de recherche.

2. **les services nécessaires pour fournir l'appui scientifique et technique pour faire face à ces défis.**

La Direction Générale de la Recherche Scientifique et Technique (DGRST) contrôle les programmes de recherche qui sont menés dans diverses institutions relevant de l'université et des centres de recherche. Dans la zone littorale (département du Kouilou et Pointe Noire), l'IRD (ORSTOM) avait beaucoup travaillé sur les sujets d'environnement marin et côtier, le Centre de Recherche Forestier du Littoral (CRFL) conduit un programme sur les écosystèmes forestiers du littoral et d'éducation environnementale.

L'état de la recherche au Congo en général est en baisse dans beaucoup de secteurs et sur l'environnement marin et côtier en particulier, le niveau de la recherche stagne sur des références dépassées. Il faut donc des mesures de relance des institutions et des ressources humaines qui n'ont plus les outils nécessaires en matière de recherche et de valorisation des résultats.

En dépit d'absence d'institut National en science marine, la République du Congo en partenariat avec **l'Institut de Recherche pour le Développement** (IRD) est dotée d'un laboratoire d'océanographie physique et biologique à Pointe Noire au centre de l'IRD ex ORSTOM qui malheureusement n'est plus opérationnel. Actuellement après la régionalisation des activités le l'IRD, le centre a été rétrocédé à la l'Etat congolais sous la couverture de la Délégation Général de la Recherche Scientifique et Technique (DGRST) où les activités sont timides et presque inexistantes.

Le Laboratoire d'océanographique du centre de Pointe Noire héberge et exécute le projet de l'**ODINAFRICA** issu du programme l'**IODE** et celui de la Commission Intérimaire du Courant de Guinée (CI CG).

Il travaille en partenariat avec certains programmes de l'Université Marine Ngouabi notamment **les facultés de sciences exactes et de sciences humaines** qui dispose des groupes de travail pluridisciplinaire en son sein, l'exemple du **Centre de Recherche des Tropiques Humides (CRTH)** qui mène des études sur la mousson africaine et d'autres programmes liés au changement climatique.

Le département ministériel en charge des questions maritimes, dispose à Pointe Noire une **Direction Générale de la Marine Marchande**, institution qui centralise toutes les questions Maritimes du pays.

Le Port Autonome de Pointe Noire bien n'ayant pas la vocation scientifique dispose des compétences dans le milieu en particulier sur le génie maritime et l'aménagement côtier dispose également un service d'hydrographie qui collecte les données issues du récent marégraphe.

L'Agence National de l'Aviation Civile (ANAC) institution de collecte des données météorologiques a mis en place une station côtière (CAMAN) dans le Port Autonome de Pointe Noire afin d'enregistrer les paramètres météo-maritimes in situ.

Enfin, le ministère en charge de l'environnement et celui de la recherche scientifique et l'innovation technique à travers sa Délégation Générale de la Recherche Scientifique te technique coordonnent certains programmes de recherche financés par les organismes internationaux.

Le ministère de la recherche scientifique et de l'innovation technique,

3. **les capacités disponibles actuellement au niveau national, et celles à développer en priorité, pour fournir cet appui scientifique**

Le Congo possède des capacités humaines, scientifiques et techniques, qui ne bénéficient pas de conditions de travail favorables et des équipements adéquats au développement de la recherche et en particulier de la recherche marine. Ces compétences sont disséminées et dispersées dans les administratifs publiques et dans le secteur privé et très peu font la recherche scientifique marine.

Diverses ressources humaines universitaires peuvent être identifiées notamment en :

- Océanographie physique et biologique, limnologie côtière,
- Cartographie thématique,
- Géologie et minéralogie,
- Climatologie,
- Paléo-océanographie, nivellement et travaux géodésiques,
- Hydrologie,
- Hydrochimie,

- Bacteriologies,
- Physique - chimie et stérilisation,
- Pédologie,
- Paléo-climatologie,
- Géotechnique,
- Sédimentologie,
- Géomorphologie,

Les compétences à développer en priorité au Congo pour le secteur maritimes

Selon que les missions sont au quotidien centrées vers les questions maritime et océanographique nous pouvons en priorité retenir les structures comme :

Centre IRD Pointe Noire, laboratoire d'Océanographie physique et biologique /Unité ODINAFRICA+ Unité CI CG, à réhabiliter

Université Marine Ngouabi, Département Physique Fac des Sciences et département de Géographie, Fac de Lettre et sciences Humaines,

Centre d'assistance météorologique aux activités maritimes et connexes (CAMAM) de l'ANAC,

Service Hydrographique du Port Autonome de Pointe Noire,

Direction Général de la Marine Marchande,

4. **Des organisations dont la mission inclut, ou incluera prochainement, l'appui scientifique et technique à l'adaptation en zone côtière,**

L'université Marien Ngouabi / Département de Géographie et département de Physique,

Le laboratoire d'océanographie centre IRD/DGRST Pointe Noire / Projet ODINAFRICA + CI CG,

Centre d'assistance météorologique aux activités maritimes et connexes (CAMAM) de l'ANAC,

Service Hydrographique du Port Autonome de Pointe Noire,

Direction Général de la Marine Marchande,

5. **Des organisations dont la mission inclut l'étude des océans pour mieux prévoir le climat (par exemple, la Météorologie nationale).**

Le laboratoire d'océanographie centre IRD/DGRST Pointe Noire / Projet ODINAFRICA + CI CG,

L'université Marien Ngouabi / Département de Géographie et département de Physique,

Centre d'assistance météorologique aux activités maritimes et connexes (CAMAM) de l'ANAC,

Service Hydrographique du Port Autonome de Pointe Noire,

Direction Général de la Marine Marchande,

Le Ministère délégué chargé de la Marine Marchande,

Le Ministère de l'Environnement,

Le ministère de la Recherche scientifique,

Le ministère de l'Enseignement supérieur,

INDICATION SUR CERTAINS FAITS ET OPTION D'ADAPTATION

Objectif général : Adaptation au changement climatique et approche gestion durable des zones côtières.

❖ **Objectifs Spécifiques :**

1 **Déclin des ressources**

- **Restauration et gestion rationnelle des ressources aquatiques ;**
- **Conservation des espèces menacées et en danger ;**
- **Conservation de la biodiversité.**

2 **Erosion**

- **Protection de côte ;**
- **Restauration des habitats dégradés ;**
- **Reconstitution des zones de frayères ;**
- **Restauration des forêts dégradées.**

3 Pollution

- **Amélioration de la qualité des eaux.**

4 Gouvernance

- **Amélioration des capacités institutionnelles en matière d écosystèmes marins et côtiers.**
-

5 Pénétration de l'eau salée dans les aquifères

- **Réalisation des études sur les pane aquifères, développement d'un programme de recherche en la matière.**

Vision: [INSERT BRIEF INSTITUTE VISION] Priorities: 1. Relance des activités du laboratoire d'océanographie physique et biologique centre IRD ex ORSTOM Pointe Noire 2. Elaboration de la politique nation de	**DELEGATION GENERALE DE LA RECHERCHE SCIENTIFIQUE ET TECHNIQUE (DGRST)** General Delegation of Technical and Scientific Research (DGRST)	

gestion des écosystèmes côtier et marin
3. élaboration d'un programme de collecte des données de l'environnement marin et côtier
4. Suivi et élaboration des programmes d'études écosystème menacés de dégradation

Coastal Adaptation Strategy: [N][If Yes, please indicate year adopted and priority actions]
1. No
2.
3.

Collaborating Organizations: [le secteur privé petrolier et les institutions publiques (Acronyms)]

Phone: (242) 81 06 07
Fax: (242) 81 01 90
Email: dgrst@yahoo.fr
Web:
Address:
13, Av. du Général de Gaulle, Rond Point du Centre Culturel Français BP. 2499
Brazzaville Congo

Director:
[Pr. A. ITOUA-NGAPORO, Délégué Général]
Email:
Deputy:
[NAME]
Email:
Admin:
[NAME]
Email:

Ministry:
MINISTERE DE lA RECHERCHE SCIENTIFIQUE ET DE l'INNOVATION TECHNIQUE

Institute Strengths: [PLEASE MODIFY TEXT AS NEEDED]
Human Resources: [INSTITUTE X] currently has [XX] professional and administrative staff. Of the [YY] professional staff, [ZZ] have PhD, [WW] have a M.Sc/M.Tech and [VV] have a B.Sc/B.Tech

Infrastructure: [INSTITUTE X] has a [poor, fair, good, very good] power supply. The internet link is [dial-up, ADSL, VSAT, etc.] and the connection speed is [XX] [in Mbps or Kbps] with [approximately] [XX] personal computers connected. There are [YY] laboratories specializing in [Please insert fields researched]. Data collection at sea is done using [research vessels, moored and/or drifting buoys, installed equipment].

Publications: In the last 5 years, [XX] researchers affiliated to [INSTITUTE X] have received [YY] publications related to marine and coastal zone issues. [INSTITUTE X] has provided information concerning [Insert Issue] to [Organization(s)] in preparation for COP-15. [If Applicable]

Financial Resources: [INSTITUTE X] has a total budget of approximately [XX] with [YY%] allocated towards projects addressing coastal/marine management issues.

Capacity Development Needs to Address Climate Issues in Coastal Zones

Issues:	**Currently Available Services:**	**Services needed for Adaptation:**	**Capacities Needed for Services:**
Coastal Erosion	Etude de suivi de l'évolution du trait de côte	-Etude et collecte des données des paramètres hydrodynamiques, climatiques, et socio économiques, d'images Spot etc...	Formation des Océanographes, climatologues, cartographes etc.
	Etude et inventaire des mesures de protection d'adaptation (approche passive et défensive)	Etude géotechnique du littoral et identification des models physiques, mathématiques et numériques	Génie civil maritime, gémorphologue
	Mise en place et Elaboration de la stratégie nationale de gestion intégrée des zones côtières GIZC	Etude mise en place d'une législation en matière de gestion et aménagement du littoral.	Géographes, océanographes, cartographes
Salinization of aquifers	Etude et analyses des nappes aquifères	Etude et détermination de la fluctuation du niveau des nappes translittorales	hydrologue
	Etude hydrobiogéochimie	Etude et collecte de données dans les zones à forte intrusion salines.	Hydrologue, géochimie avec pour capacité de détermination de la concentration de sel dans les zones humides côtières
Coastal flooding	Etudes des variations inter	Etude des variations des	Climatologue,

	saisonnières des pluies	paramètres climatiques	océanographe
	Etudes des paramètres océaniques	Etude hydroclimat	Climatologue, océanographe
	Etude de l'élévation du niveau de l'océan	Etude hydrodymanique	Climatologue, océanographe
Coastal Resources	Ressources de la biodiversité	Amélioration de la gestion, la protection et l'utilisation durable des ressources halieutiques et des mangroves	Océanographe Biologiste,
	Etudes des pêcheries	Evolution des stocks	biologiste

DGRST Capacity Development Needs

COMMENTAIRE SUR LE TABLEAU (SVP ma langue de travail est en français)

Institut : Toutes les recherches sur le domaine maritime et océanographique étaient autrefois conduites par l'Institut de Recherche pour le Développement IRD ex ORSTOM (Institut Français qui travaillait en partenariat avec la Délégation Générale de la Recherche Scientifique et Technique DGRST. **Cette institution ne fonctionne plus depuis 4ans.**

Ainsi, aucune politique est mise en place dans le cadre de la recherche scientifique marine, ni stratégie ni priorité. Les activités réalisées depuis ces dernières années sont pilotées par l'initiative des ministères entre autre le ministère délégué chargé de la marine la marchande, le ministère de l'environnement etc. Ces activités sont ponctuelles.

Aucune étude scientifique n'a été réalisée depuis les 5 dernières années dans le domaine maritime.

Quelques rares compétences actives sont recensées dans le domaine et encore disponibles, malgré l'existence nombreuse d'autres profils au sein de l'université.

Les infrastructures adaptées à la recherche scientifique marine sont obsolètes, désuètes et presque inexistantes

La publication des études sur l' état de lieu sur l'environnement marin et côtier par le PNUD et le Ministère de l'environnement et une étude sur la gestion du domaine public maritime, par le ministère Délegué chargé de la marine Marchande restent les seules d'actualité sur la zone côtière congolaise.

Les ressources financières sont inexistantes autrefois, le laboratoire fonctionnait avec les crédits des URD de l'IRD de Brest.

2.1.3.4 Angola

National Synopsis
[TO BE PROVIDED]

[INFORMATION ON ANGOLAN INSTITUTES IS BEING SOUGHT]

2.1.3.5 Namibia

National Synopsis
[TO BE PROVIDED]

[INFORMATION ON NAMIBIAN INSTITUTES IS BEING SOUGHT]

2.1.4 Institutes of Sub-Region 4: East Africa and Western Indian Ocean Islands – Kenya, Tanzania, Mozambique, Mauritius and Seychelles (Regional Coordinator: Harrison Onganda

The main coastal issues for Region 4 are coastal erosion caused by natural and anthropogenic factors, coastal flooding, decline in fisheries resources and high pollution levels. More specific threats in the region include destructive fishing practices, over fishing, and large-scale tourism development projects (ACOPS, 2002a). In Kenya and Mozambique, beach accretion has taken place, such that beach hotels have lost their beach frontage. Further north, due to the nature of the river-sediment being deposited (brown sand and silt) the aesthetic value of the beach along the Malindi Bay in Kenya has been lost making it less attractive to the development of tourism (ACOPS, 2002a). Destructive fishing practices are transboundary in nature (often involving fishers from other countries) and hard to contain. Other issues are drought, coastal populations and bleaching of coral reefs. In the whole of the Eastern Africa Indian Ocean waters, shrimp trawlers have caused widespread disturbance to the seagrass beds. Extinctions of turtle population and loss of nesting areas has been reported in Maziwe Island in Tanzania (ACOPS, 2002a). Similarly the Dugong population has suffered serious decline of 50 % in Mozambique and almost 99 % in Kenya and Tanzania (ACOPS, 2002a).

2.1.4.1 Kenya

National Synopsis

HOW EFFECTIVELY NATIONAL INSTITUTES IN KENYA CAN SUPPORT CLIMATE CHANGE ISSUES

From various reviews including the Intergovernmental Panel on Climate Change (IPCC) resources the critiical areas that have been considered in the assessment of impacts, adaptation and vulnerability to climate change include:

- <u>Fresh water resources and their management</u>: - The impacts of climate change on freshwater systems and their management are mainly due to the observed and projected increases in temperature, sea level and precipitation variability.

- Ecosystems, their properties and goods: - During the course of this century the resilience of many ecosystems (their ability to adapt naturally) is likely to be exceeded by an unprecedented combination of change in climate, associated disturbances (e.g., flooding, drought, wildfire, insects, ocean acidification) and in other global change drivers (especially land-use change, pollution and over-exploitation of resources), if greenhouse gas emissions and other changes continue at or above current rates.

- Food, fibre and forest products: - In mid- to high-latitude regions, moderate warming benefits crop and pasture yields, but even slight warming decreases yields in seasonally dry and low-latitude regions.

- Industry, settlement and society: - Climate-change vulnerabilities of industry, settlement and society are mainly related to extreme weather events rather than to gradual climate change.

As far as the coastal and marine environment is concerned the above issues are equally quite pertinent and require effective interventions to reduce or eliminate the predicted impacts. The functions of Kenyan institutions required to render support in these include research, funding and regulations. The Kenya coastline extends some 600 kilometres from the border of Tanzania in the south to the border of Somalia in the north. Among its distinctive features are the nearly continuous coast parallel fringing coral reef, the Lamu archipelago, Marine National Parks and Reserves, sandy beaches, Mombasa Creek as well as Wasini and other coral islands.

The Kenyan coast features a diverse marine environment including estuaries, mangroves, seagrass beds and inter-tidal reef platforms and coral reefs, which are vital for the diversity and reproduction of marine organisms. These coastal ecosystems systems are regarded as some of Kenya's most valuable ecosystems; and some are protected by the six marine national parks and reserves. These coastal ecosystems make up the basis for the livelihood of the large coastal population, but do on the other hand face serious threats from the ever increasing human pressure through tourism, industrial pollution, over-fishing, destructive fishing, mangrove logging and other unsustainable use of marine resources.

Research

Capability for research mainly lies in the institutional mandates and human resource. Many institutions are now mandated to conduct research in Kenya

marine environment. These include a number of private and public universities, private research groups and government research agencies.
In previous surveys, it was found that most of the marine science and technology organisations in Kenya still lack sufficient trained skilled personnel. There is a need for a sustained capacity development programme to ensure that a critical mass of personnel is created. The institutions have also been affected by a high-level of staff mobility. Trained and skilled people are able to attract better remuneration in the private sector. In some instances the lack of supporting infrastructure (equipment and funds) to enable them discharges their duties after training has also contributed to departures. This initial survey shows that substantial capacity has already been developed in the biological sciences, which now account for 60 percent of all marine scientists and 73 per cent of all marine scientists with PhD degrees. The physical sciences (physical oceanography, marine meteorology) are the least developed, with less than five percent of the marine scientists. Statistics of publications in marine science from Kenya available also reflect this dominance of the biological sciences. Out of about 200 articles, half are from biological sciences. Chemical sciences and marine pollution numbered about 20 percent of the publications at KMFRI.
Thus further capabilities need to be developed in atmospheric and geological sciences, as well as food production technology.

Regulations

The laws relating to the coastal areas have not been adequately enforced by the relevant authorised institutions, owing to a number of reasons such as poor or weak administrative structures; absence of provisions to specify standards of performance; inadequate deference and inadequate incentives; generally low levels of active and participative awareness among the majority of the population; preference for short term gains at the expense of more sustainable alternatives in policy making and planning; gaps and overlaps in institutional responsibilities making enforcement difficult; and poverty which promotes unsuitable use of resources. Some of the enforcing agencies do not have the necessary resources to adequately enforce regulations and follow-up on complaints and violations.
It is therefore necessary the shortcomings are adequately addressed to assist in tackling climate change issues.

Funding

Out of a few agencies surveyed, there was no indication of that there was any specific allocations towards projects addressing coastal/marine management issues.

[Kenya Marine and Fisheries Research Institute]

[Institute Name translated to English (if applicable)]

Vision:
Be a center of excellence in aquatic research and promotion of sustainable utilization of marine and freshwater resources

Priorities:
1. marine and freshwater fisheries managemement research
2. aquaculture development research
3. aquatic biology including environmental and ecological studies
4. study of marine chemistry and physical oceanography

Coastal Adaptation Strategy: [Y/N][If Yes, please indicate year adopted and priority actions]
1.
2.
3.

Collaborating Organizations:
University of Nairobi, Moi University, Egerton University, Coast Development Authority, Kenya Maritime Authority, Kenya Ports Authority, Kenya Wildlife Service, National Museums of Kenya, World Conservation Society, WWF, CORDIO-EA, UNEP, IOC-UNESCO, UNDP, World Bank, WIOMSA

Phone: 254 (0)20-8021560/1
Fax: 254 (0)20-2353226
Email: director@kmfri.co.ke
Web: www.kmfri.co.ke
Address:
P.O. Box 81651 – 80100,
Mombasa, Kenya

Director:
Dr. Johnson Kazungu
Email: jkazungu@kmfri.co.ke
Deputy:
Dr. Renison Ruwa
Email: kruwa@kmfri.co.ke
Admin:
Mr. Abraham Kagwima
Email: akagwima@kmfri.co.ke

Ministry:
Ministry of Fisheries Development

Institute Strengths: [PLEASE MODIFY TEXT AS NEEDED]
Human Resources: KMFRI marine division currently has 40 professional and administrative staff. Of the 40 professional staff, 9 have PhD, 21 have a M.Sc/M.Tech and 10 have a B.Sc/B.Tech

Infrastructure: KMFRI has a very good power supply. The internet link is dedicated microwave connection and the connection speed is 512/1024 Kbps with approximately 40 personal computers connected. There are 7 laboratories specializing in nutrients, natural products, food technology, heavy metal pollution, primary/secondary production, aquaculture seed/feed production and chemical oceanography... Data collection at sea is done using hired research vessels, rubber boats, and satellite oceanography

Financial Resources: [INSTITUTE X] has a total budget of approximately [XX] with [YY%] allocated towards projects addressing coastal/marine management issues.

Capacity Development Needs to Address Climate Issues in Coastal Zones

Issues:	**Currently Available Services:**	**Services needed for Adaptation:**	**Capacities Needed for Services:**
[Coastal Erosion]	1. Shoreline classification 2. 3.	1. monitoring by beach profiling 2.shoreline management plan based on sediment cells 3. shoreline protection structures 4. Enforcement of regulations	1. training on modern survey techniques 2. development of appropriate management plans 3. research/technology transfer on groins, walls and soft techniques 4. Institutional staff

			capacity building
[Salinization of Aquifers]	1. 2. 3.	1. Salinity instrusion studies 2. 3.	1. training on appropriate study methods and models 2. 3.
[Coastal flooding]	1. sea level data 2. 3.	1. inundation maps 2. early warning systems for lower river flood plains 3. sea wall construction	1. hydrographic models 2. empowerment of local authorities to operate early warning 3. funding for seawall construction
[Sustainable resource use]	1. Fish Catch assement surveys in key landing stations 2. Mangrove reforestation 3.	1. Fish larvae and egg survey 2. Fish stock assessment 3. marine bioprospecting for unique bioactive compounds 4. alternative timber for coastal communities	1. Light vessels and deep sea going vessels 2. Planktonic sampling gears 3. Fisheries models 4. natural products laboratory 5. agroforestry projects
Management of key ecosystems		1. Coral reef monitoring program 2. Coral reef fisheries management plan 3. Mitigation of coral bleaching	
Marine hazards and disaster		1. monitoring of harmful algal blooms 2. coastal sensitivity maps 3. ocean acidification	Staff capacity building on appropriate methods
Marine pollution	1. measurement of organic/inorganic pollutants 2. measurement of river sediment inputs	Isotopic studies on various marine processes including paleoclimate	Development of a radio-isotope laboratory and training of personnel

KMFRI Capacity Development Needs

Personnel

KMFRI requires staff capacity building both in numbers and areas of specialisation in line with the summary given in the above table. In order to develop a critical mass able to handle the broad range of issues covered above there is need to double the number of scientists from 40 to 80 and then source for various scholarships to train in competent laboratories. Such an effort should have a sustainable plan to take care of staff attrition and job transfers.

The Institute must also have a plan to counter competition from the private sector. Trained and skilled persons attract better remuneration in the private sector.

Presently majority of scientists are from biological sciences. From the existing numbers physical sciences including physical oceanography, geology and bio-geo physics is the least developed. There is need for financing further studies for various disciplines based on the needs above.

In addition there is need to strengthen training of technical support staff who man the vital equipment and data capture to acquire necessary academic and specialised skills

Infrastructure and Equipment

Equipment and facilities for physical oceanography research are minimal, with KMFRI having only one current meter, two pressure gauges and two tide gauges installed at Mombasa and Lamu. Atomic Absorption Spectrophotometers and Gas Liquid Chromatographs are presently not functional. The Institute presently has two rubber dingies without board engines and so only near shore surveys can be carried out.

Equipping and certification of various laboratory units in the institute may contribute to the capacity for adaptation.

Information exchange

Due to limited government funding, the communication facilities tend to lag behind further compromising the ability to manage scientific data as well as exchange of scientific and bibliographic information. The Internet connection has improved over time and is expected to remain so due to the landing of the marine fibre optic cable.

Presently the Institute is hosting a number of databases fully on-line including the Nairobi Convention clearinghouse system. There is however the need to continue investing in competent personnel and good computing and terminal equipment in the Institute.

Vision: [To facilitate sustainable management of the fisheries resources and fishery products in the Kenya for Socio-economic Development] Priorities: 1. Frame survey design and implementation	**[Fisheries Department (FiD)]** [Institute Name translated to English (if applicable)]	

<table>
<tr>
<td rowspan="2">2. BMU and community participation in management
3. Catch/effort sampling data collection
4. Species stock assessment

Coastal Adaptation Strategy: [Y/N][If Yes, please indicate year adopted and priority actions]
1.
2.
3.

Collaborating Organizations:
KMFRI, WWF, CRCP, WCS, ReCoMaP, KWS, Moi University, Central Bureau of Statistics, CORDIO-EA, Africa Union, FAO, UNEP, UNDP</td>
<td>Phone: 254 020 3742320
Fax:
Email:
Web:
Address:
Ministry of Fisheries Development
P.O. Box 58187 – 00200, Nairobi</td>
<td>Director:
[Mr. Dodfrey Vincent Mono]
Email: monorgv@gmail.com
Deputy:
[NAME]
Email:
Admin:
[NAME]
Email:</td>
</tr>
<tr>
<td colspan="2">Ministry:
[Ministry of Fisheries Development]</td>
</tr>
<tr>
<td colspan="3">Institute Strengths: [PLEASE MODIFY TEXT AS NEEDED]
Human Resources: [FiD coast region] currently has [30] professional and administrative staff. Of the [30] professional staff, [none] have PhD, [6 have a M.Sc/M.Tech and [18] have a B.Sc/B.Tech

Infrastructure: [FiD coast region] has a [very good] power supply. The internet link is [ADSL] and the connection speed is [128] [in Kbps] with [approximately] [10] personal computers connected... Data collection at sea is done using [observers in commercial ships, ship log returns and beach enumerators].

The Department provides management reports including frame survey, fish exports, and fisheries statistics which are then submitted to the Central Bureau of Statistics. Country summaries are submitted to FAO statistical division.

Financial Resources: [INSTITUTE X] has a total budget of approximately [XX] with [YY%] allocated towards projects addressing coastal/marine management issues.</td>
</tr>
</table>

Capacity Development Needs to Address Climate Issues in Coastal Zones

Issues:	**Currently Available Services:**	**Services needed for Adaptation:**	**Capacities Needed for Services:**
[Sustainable resource use]	1. 2. 3.	1. Fish stock assessment 2.Gear/vessel research 3. Strengthening fisheries statistics and data management	1. Regular sampling of deep/shallow water using (trawls, line, traps, ecosounders) 2. More research on selective gears 3. strengthening sampling programs, data processing and archival
[]	1. 2. 3.	1. 2. 3.	1. 2. 3.

Fisheries Department

Capacity Development Needs

The management of fisheries relies on monitoring, control and surveillance both to determine effectiveness of management decisions as well as to enforce regulations. The investment in MCS includes vessels, appropriate gears, trained staff and communication facilities. The Vessel Monitoring System presently under experiment requires more resources in terms of equipment and personnel.

It has been observed that there is so far only a limited uptake of monitoring/research findings for specific management decision-making, although a number of important findings do exist in recent years. The decrease in sizes of catches of reef fishes emphasizes the need to develop a coherent management strategy for these fisheries/fishing grounds based on research findings. It is necessary to influence the Department to implement an ecosystem approach to management of these fisheries to avoid an incremental effect of climate change.

Elements of the data currently collected are of limited value for application in stock assessments and so the status of many resources remains unknown. Presently the catch data aggregated by Swahili nomenclature are of relatively limited value for more detailed assessments. This is because the nomenclature can include many species/genera or even entire families under one name. The department should therefore be strengthened to collect more relevant statistics with which to monitor fish stocks. As well, increased time frequencies of trawl surveys will be necessary to assist in calculating reliable indicators such as MSY for both deep water fishing and shallow water prawns.

Vision: [To conserve, protect and manage national parks and reserves and promote tourism and conservation]

Priorities:

1. Formulate policies regarding the conservation, management and utilisation of all types of fauna and flora (excluding domestic animals);
2. Manage National Parks and Reserves;
3. Provide wildlife conservation, education and extension services
4. Conduct research and disseminate information
5. Administer and coordinate international protocols, conventions and treaties regarding wildlife in all its aspects.

Coastal Adaptation Strategy: [Y/N][If Yes, please indicate year adopted and priority actions]

1.
2.
3.

Collaborating Organizations:
[KMFRI, CDA, IUCN, WWF, UNEP, USAID, NMK, KFS (Acronyms)]

[Kenya Wildlife Service (KWS)]

[Institute Name translated to English (if applicable)]

Phone:
Fax:
Email:
Web: www.kws.org
Address:
KWS Complex, Lang'ata Road
P.O. Box 40241-00100, Nairobi

Director:
[Mr. Julius Kipng'etich]
Email:
Deputy:
[NAME]
Email:
Admin:
[NAME]
Email:

Ministry:
[Ministry for Forestry and Wildlife]

Institute Strengths: [PLEASE MODIFY TEXT AS NEEDED]

Human Resources: [INSTITUTE X] currently has [XX] professional and administrative staff. Of the [YY] professional staff, [ZZ] have PhD, [WW] have a M.Sc/M.Tech and [VV] have a B.Sc/B.Tech

Infrastructure: [KWS coastal head office] has a [very good] power supply. The internet link is [ADSL, and the connection speed is [256] [Kbps] with [approximately] [10] personal computers connected. Data collection at sea is done using [scuba diving and field observations]. Other data include marine park entry numbers and record of violations

There are five scientists working in marine sciences related fields including Biology/Biological Oceanography, Marine Ecology, Fisheries and Biodiversity. KWS has done collaborative research with KMFRI on Mida Creek biodiversity, pollution assessment in Mombasa and Kisite Mpunguti Marine Parks and an environmental impact study of Makupa Creek Oil Spill. KWS has patrol boats which are used in the marine park and reserves.

Financial Resources: [INSTITUTE X] has a total budget of approximately [XX] with [YY%] allocated towards projects addressing coastal/marine management issues.

Capacity Development Needs to Address Climate Issues in Coastal Zones

Issues:	**Currently Available Services:**	**Services needed for Adaptation:**	**Capacities Needed for Services:**
[Management of key ecosystems]	1. 2. 3.	1. Building resilient reef systems 2. Protecting critical areas (such as turtle sites) 3. Protection of turtle nesting sites threatened by sea level rise	1. resilience studies on local reefs 2. 3.
[Salinization of Aquifers]	1. 2. 3.	1. 2. 3.	1. 2. 3.
[Coastal flooding]	1.	1.	1.

	2. 3.	2. 3.	2. 3.
[Insert Issue]	1. 2. 3.	1. 2. 3.	1. 2. 3.

Capacity Development Needs

The marine protected areas are primarily designed to conserve Kenya's coral reefs which run along most of the coastline and which are important areas of biodiversity. There are four marine national parks – Malindi, Watamu, Kisite and Mombasa. Fauna and flora in these parks are fully protected. There are five marine national reserves – Malindi, Watamu, Mpunguti, Mombasa and Kiunga.

These protected areas can build resilience by controlling other habitat threats such as fishing pressure and illegal extraction of coral reef resources thereby reducing the extinction risks of native species**.** *This may therefore facilitate adaptation to climate change.*

Some of the factors that may impact on the marine ecosystem due to climate change include:

- Loss of nesting and feeding habitats of sea turtles due to sea-level rise which can lead to changes in gender ratios or potentially result in mortality. Conservation plan for refugee of turtles and feeding grounds would then be designed and implemented, including restoration of beach vegetation to provide shady nesting options
- Coral bleaching linked increased ocean temperatures and damage to turtle feeding habitat.
- Changes in ocean currents, with the potential of modifying migration paths and feeding patterns of marine organisms
- Extreme rainfall events, which can increase transfer of sediment to coral reefs

KWS should therefore be assisted to carry out the following activities in mitigation:

- **Assess the current Marine Protected Area (MPA) network** and determine whether it is sufficient to help the system respond to climate change
- **Conduct comprehensive regional reef surveys** to identify reefs that appear to be resistant (those that do not bleach) and resilient (those that bleach but are able to recover) to bleaching events

- **To ensure long-term protection of resistant/resilient reefs** through incorporation in the MPA network or special management relating to fisheries or tourism
- **To identify reefs that are most vulnerable** to coral bleaching and, in particular, the vulnerable reefs upon which fishermen depend for their livelihoods. On these vulnerable reefs they would:
  - Devise adaptation techniques such as reef seeding with more temperature-tolerant corals, reef shading, increasing herbivore abundance, etc.
  - Advocate for stricter regulations, such as the use of only or mainly line fishing rather than nets (which often catch herbivores).
  - Conduct habitat representation analysis to place at least 30 % of each representative habitat under protection (sea grass, mangroves, all types of reef, etc.).
- **Working with fishermen to adopt alternative livelihood methods**,

Vision: To be a global leader in heritage research and management **Priorities:** 1. 2. 3. 4.	**National Museums of Kenya**	

Coastal Adaptation Strategy: **[Y/N][If Yes, please indicate year adopted and priority actions]**
1. None
2.
3.

Key Collaborating Organizations:
KWS; KMFRI; Birdlife International; Nature Kenya; ICIPE; Kenya Forest Service; Universities; RSPB; WWF; FAO; IUCN; CITES; RAMSAR; UNESCO; AFRICOM; Min. of Res, Sc. and Tech; WIOMSA; UNDP

Phone: +254 20 3742131/61
Fax: +254 20 3741424
Email: nmk@museums.or.ke
Web: www.museums.or.ke
Address: P. O. Box 40658

Director:
DR. IDLE FARAH
Email:
Deputy:
DR. MZALENDO KIBUNGUCHI
Email:
Admin:
MR. STEVEN CHECHE
Email:

Ministry:
Ministry of Culture and Heritage

Institute Strengths: [PLEASE MODIFY TEXT AS NEEDED]

Human Resources: National Museums of Kenya currently has [341] professional and administrative staff. Of the professional staff, [32] have PhD, [45] have a M.Sc/M.Tech and [24] have a B.Sc/B.Tech

Infrastructure: National Museums of Kenya has a very good] power supply. The internet link is ADSL and the connection speed is [XX] [in Mbps or Kbps] with approximately 120 personal computers connected. There are [13] laboratories specializing in [Ornithology, Invertebrate Zoology; Ichthyology; Herpetology; Mammalogy; Osteology; Molecular Genetics; Archaeology; Palaeontology; Marine and Wetland studies; Photochemistry; Botanical Sciences; Palynology]. Data collection at sea is done using

Publications: In the last 5 years, [Unascertained] researchers affiliated to National Museums of Kenya have received [several but about 0+] publications related to marine and coastal zone issues. National Museums of Kenya has provided information in various forums concerning trends in coastal bird numbers and marine conservation issues.

Financial Resources: National Museums of Kenya has a total budget of approximately [Ksh ~ 400m] with [not sure) allocated towards projects addressing coastal/marine management issues.

Capacity Development Needs to Address Climate Issues in Coastal Zones

Issues:	**Currently Available Services:**	**Services needed for Adaptation:**	**Capacities Needed for Services:**
[Coastal Biodiversity Erosion]	1. Periodic in-house reports 2. Checklists especially of vertebrates 3. Important bird area maps	1. Establishment of monitoring/surveillance programme 2. Availing of species numbers, composition and distribution trends and maps 3. Access to information such as past, present and future-scenario maps/impressions of coastal erosion incidents to relate to observed species changes 3. Providing the specimen collection as benchmark for comparing/monitoring changes caused by effects of erosion	1. Training of scientists in monitoring including GIS mapping 2. Research funding to asses effect of erosion on species 3. Equipment including for GIS work 4. Scientists attendance if many climate change for a to lean and exchange current ideas on adaptation 5. Subscription to climate change publications

[Salinization of Aquifers]	1. None 2. 3.	1. Establishment of monitoring/surveillance programme 2. Providing the specimen collection as benchmark for comparing/monitoring changes caused by effects of salinization 3.	1.Training of scientists 2. Research funding 3. Equipment for monitoring salinization and its effects
[Management of ecosystems]	1. None 2. 3.	1. 1. Establishment of monitoring/surveillance programme 2. Providing the specimen collection as benchmark for comparing/monitoring changes caused by effects of degradation	1. Research funding to asses effect of erosion on species 2. Equipment including for GIS work 3. Scientists attendance if many climate change for a to lean and exchange current ideas on adaptation 4. Subscription to climate change publications
Inland migration of species	1. Annual reporting on habitat and species trends 2. Checklists especially of vertebrates 3.	1. Maintaining field surveys and monitoring of species compositions 2. Expand existing bird monitoring programme to include marine organisms 3.	1. Wider and more detailed spatial coverage of the existing Important Bird Area (IBA) monitoring 2. Scientists attendance if many climate change for a to lean and exchange current ideas on adaptation 3. An NMK resources centre for adaptation to climate change for coastal ecosystem 5. Subscription to climate change publications

National Museums of Kenya Capacity Development Needs

The National Museums of Kenya marine science component is within the Biodiversity Programme. The Biodiversity Centre was set to pursue the national and regional initiatives on biodiversity conservation. At the national level the centre is developing a research and action programme aimed at developing, gathering, storing, analysing and disseminating information required for the sustainable conservation of biological resources.

The general aim of this department is to gather, store and disseminate information on Kenyan marine life with a view to preserving and protecting the biodiversity. The programme incorporates the element of public education and awareness to let the public know the benefits the sea provides through its products or ecological services and therefore share in the responsibility for conserving marine biodiversity.

Vision: [To be recognised nationally and internationally as the University of choice in nurturing innovation and talent in science, technology and development.] Priorities: 1. Innovation and technology	**[Moi University, , Department of Fisheries and Aquatic Sciences)]** [Institute Name translated to English (if applicable)]	

<table>
<tr>
<td rowspan="2">2. Talent in science
3. Technology
4. Development

Coastal Adaptation Strategy: [Y/N][If Yes, please indicate year adopted and priority actions]
1.
2.
3.

Collaborating Organizations:
[Flemish Interuniversity Council (VLIR)]
[Indiana University]
[Oklahoma State University]
[Kenya Agricultural Information Network (KAINET)]
[Kenya Knowledge Network (KNET)]
[Linköping University, Sweden]</td>
<td>Phone: +254 (0)53 43363 / 43620
Fax: +254 (0)53 43047 / 43171
Email: vcmu@mu.ac.ke
Web: www.mu.ac.ke
Address:
P. O. Box 3900 - 030100
Eldoret
Kenya</td>
<td>Director(VC):
[Prof. Richard K. Mibey]
Email: vcmu@mu.ac.ke
Deputy VC P&D:
[Prof. Samuel Gudu]
Email: dvcpd@mu.ac.ke
Deputy VC R&E:
[Prof. B. E. L. Wishitemi]
Email: dvcre@mu.ac.ke
Admin:
[Dr. J. K. Sang]
Email: cado@mu.ac.ke</td>
</tr>
<tr>
<td colspan="2">Ministry:
Ministry of Education</td>
</tr>
</table>

Institute Strengths: [PLEASE MODIFY TEXT AS NEEDED]
Human Resources: [Moi University, Department of Fisheries and Aquatic Sciences] currently has [XX] professional and administrative staff. Of the [11] professional staff, [5] have PhD, [6] have a M.Sc/M.Tech and [0] have a B.Sc/B.Tech

Infrastructure: [Moi University, Department of Fisheries and Aquatic Sciences] has a [good] power supply. The internet link is [dial-up, ADSL and VSAT] and the connection speed is [8MBPS] with [approximately] [10] personal computers connected. There are [3] laboratories specializing in [aquaculture hatchery production, fisheries biology and water quality assessment]. Data collection at sea is done using [moored and/or drifting buoys, installed equipment].

Publications: In the last 5 years, [Unknown] researchers affiliated to [Moi University, Department of Fisheries and Aquatic Sciences] have received [Unknown] publications related to marine and coastal zone issues. [Moi University, Department of Fisheries and Aquatic Sciences] has provided information concerning [Biodiversity] to [KWS] in preparation for COP-15.

Financial Resources: [Moi University, Department of Fisheries and Aquatic Sciences] has a total budget of approximately [Limited] with [Limited %] allocated towards projects addressing coastal/marine management issues.

Capacity Development Needs to Address Climate Issues in Coastal Zones

Issues:	**Currently Available Services:**	**Services needed for Adaptation:**	**Capacities Needed for Services:**
[Coastal Erosion]	1. Malindi field station 2. M.Sc & D.Phil Programmes 3.	1. Analytical laboratory 2. M.Sc in Marine Sciences 3.	1. Infrastructure 2. Professional staff 3. Equipment
[Salinization of Aquifers]	1. Malindi field station 2. M.Sc & D.Phil Programmes 3.	1. Analytical laboratory 2. M.Sc in Marine Sciences 3.	1. Infrastructure 2. Professional staff 3. Equipment
[Coastal flooding]	1. Malindi field station 2. M.Sc & D.Phil Programmes 3.	1. Analytical laboratory 2. M.Sc in Marine Sciences 3.	1. Infrastructure 2. Professional staff 3. Equipment
Environmental Human ecology Fish Ecology Marine Ecology	1. Malindi field station 2. M.Sc & D.Phil Programmes 3.	1. Analytical laboratory 2. M.Sc in Marine Sciences 3.	1. Infrastructure 2. Professional staff 3. Equipment

The Department of Fisheries and Aquatic Sciences (Moi University) Capacity Development Needs

Moi University is the only institution in the country offering a wide range of courses that prepare Kenyans for management of aquatic resources. The training recognises the need to advice managers of fisheries resources while recognising the need for an ecosystem approach, and thus recognising the need for factoring in a changing environment.

The development and management of capture and culture fisheries resources demand multi-disciplinary training in order to provide knowledge, skills and technological know how to understand the complex and dynamic systems for sustainable utilization. The Bachelor of Sciences (Fisheries) curriculum focuses on an all round fisheries graduate able to understand and interpret the interacting systems in the sector which may be biological, social, political, administrative or economic in nature to sustainably manage the fisheries resources for the present and future generations

Sustainable development in the fishing industry and conservation of aquatic resources requires relevantly trained manpower. It is for this reason that the Master of Philosophy (M.Phil.) in Fisheries and Aquatic Sciences training programme is directed towards the need for research and advanced analysis of concepts in Fisheries, Aquaculture and Aquatic Resources Management. Graduates of the programme would earn competence in fisheries research and other related issues for careers in scientific research at universities, the public sector and other relevant institutions.

Sustainable development in the fishing industry and conservation of aquatic resources requires relevantly trained manpower. It is for this reason that the Master of Philosophy (M.Phil.) in Fisheries and Aquatic Sciences training programme is directed towards the need for research and advanced analysis of concepts in Fisheries, Aquaculture and Aquatic Resources Management. Graduates of the programme would earn competence in fisheries research and other related issues for careers in scientific research at universities, the public sector and other relevant institutions.

The Doctor of Philosophy (D.Phil) degree programme in Fisheries and Aquatic Sciences is focused on training fisheries managers, researchers and experts to manage fisheries and aquatic resources to increase food security; alleviate poverty among the fisher folk and foster sustainable development.

Strengthening of infrastructure and teaching staff can provide critical personnel in natural resource management in Kenya.

2.1.4.2 Tanzania

National Synopsis

EFFECTIVENESS OF THE NATIONAL INSTITUTES IN TANZANIA ON CLIMATE CHANGE ISSUES

From various reviews including the Intergovernmental Panel on Climate Change (IPCC) resources the crititical areas that have been considered in the assessment of impacts, adaptation and vulnerability to climate change include:

- Fresh water resources and their management: - The impacts of climate change on freshwater systems and their management are mainly due to the observed and projected increases in temperature, sea level and precipitation variability.

- Ecosystems, their properties and goods: - During the course of this century the resilience of many ecosystems (their ability to adapt naturally) is likely to be exceeded by an unprecedented combination of change in climate, associated disturbances (e.g., flooding, drought, wildfire, insects, ocean acidification) and in other global change drivers (especially land-use change, pollution and over-exploitation of resources), if greenhouse gas emissions and other changes continue at or above current rates.

- Food, fibre and forest products: - In mid- to high-latitude regions, moderate warming benefits crop and pasture yields, but even slight warming decrease yields in seasonally dry and low-latitude regions.

– Industry, settlement and society: - Climate-change vulnerabilities of industry, settlement and society are mainly related to extreme weather events rather than to gradual climate change.

As far as the coastal and marine environment is concerned the above issues are equally quite pertinent and require effective interventions to reduce or eliminate the predicted impacts. The functions of Tanzanian institutions required to render support in these include research, funding and regulations.

Tanzania has over 800 km of coastline characterised by a mixture of sandy beaches, rock outcrops, coral reefs and extensive mangrove stands especially around river deltas. The continental shelf is narrow, with the 200m depth contour about 4km offshore, except at the Mafia and Zanzibar Channels where the shelf width reaches up to 60 km.

The coastal plain is relatively narrow, less than 20 km at the Kenya border, and broadening gradually to 150 km in the vicinity of Dar es Salaam. The sediments of the coastal plains are composed of both marine and terrestrial sediments and their ages range from Jurassic through Cretaceous to Tertiary and Quaternary. The rocks of Zanzibar, Pemba and Mafia are composed of calcareous sediments with some marine clays, sandstones and coralline limestone and they range in age from Miocene to Recent.

Rivers including Pangani, Wami Ruvu, Rufiji, Matandu, Mbenkuru, Lukuledi and Ruvuma flow to the Indian Ocean, influencing the coastal environment through creation of productive brackish water environments in estuaries, maintenance of deltas, tidal flats and shorelines, as well as nourishment of mangroves and seagrass beds.

Coastal and marine Institutions

A number of institutions are engaged in training and research. Included here are the public and private universities, private research organisations, Institute of Marine Sciences. There are a number of parastatal organisations granted autonomies to deal with ports and harbours, petroleum exploration, science and technology. A number of NGOs are involved in conservation such as WWF. WIOMSA for instance has taken lead role in development of marine research capacity in the countries of the Western Indian Ocean region.

The government of Tanzania supports the effective operations of these institutions through a number of new and revised legislations as well as policy papers, such as:

- The National Environmental Policy
- The Fisheries Policy
- The National Land Policy
- National Marine Contingency Plan

Human Resources

The review of human resources are based on past surveys of human resources conducted at NEMC, Division of Environment, TAFIRI, Dar es Salaam Maritime Institute, Division of Fisheries, Kunduchi Fisheries Institute, Mbegani Fisheries Development Centre, University of Dar es Salaam, THA, and non-governmental organisation. Also the National Museum, Directorate of Meteorology was surveyed.

The analysis of the data revealed that marine biology and fisheries biology are the predominant fields of specialisation since they account followed by chemical sciences and pollution experts. But the majority of them are not trained up to PhD level. Most of senior administrative positions at the regional and district levels are held by individuals with certificate or ordinary diploma in Fisheries sciences It was also found that training in marine sciences has continued to improve. For instance, at IMS by July, 1995, only one member of staff had a PhD degree however, currently there are several PhDs and a number of staff are in their last year of their PhD program. Overall staffing is far from adequate and more specific areas that require attention include:

- sociology - community consultation and participation and social and cultural issues that are pertinent to coastal communities
- environmental economics - macro-economic policies and their implications on conservation and management of coastal and marine resources, benefit cost analysis of different management options.
- legal expertise - legal framework and its implication on conservation and management of resources.

The other important areas include;

- Remote sensing - interpretation of the remote sensing images and applications of remote sensing as a management tool.
- Geographical Information Systems (GIS) - application of GIS in coastal studies and resources management and planning
- Aquaculture
- Physical Oceanography and Hydrographers

Funding

Out of a few agencies surveyed, there was no indication that there were any specific allocations towards projects addressing coastal/marine management issues.

Vision: [Be an international Centre of Excellence in Research and Development, Training and provision of scientific services in Marine Sciences and Technology for better exploration, exploitation and management of coastal and marine living and non-living resources.]

Priorities:
1. Climate variability, change and impacts
2. Science for integrated coastal area management
3. Remote sensing oceanography
4. Census of marine life
5. Mariculture
6. Modelling, GIS and marine geoinformatics
6. Modelling, and marine geoinformatics

Coastal Adaptation Strategy: [Y/N][If Yes, please indicate year adopted and priority actions]
1.
2.
3.

Collaborating Organizations:
[University of Dar es Salaam; Ministry of Education and Vocational Training; Ministry of Higher Education, Science and Technology, UNEP, Sida-Sarec (Acronyms)]

[Institute Of Marine Sciences]

[Institute Name translated to English (if applicable)]

Phone: +255 24 2230741
Fax: +255 24 2233050
Email: director@ims.udsm.ac.tz
Web: www.ims.udsm.ac.tz
Address:
Mizingani Road
P o Box 668
Zanzibar, TANZANIA

Director:
[Dr. Margareth Kyewalyanga]
Email: director@ims.udsm.ac.tz
Deputy:
[Dr. Ntahondi Nyandwi **]**
Email: nyandwi@ims.udsm.ac.tz
Admin: Ms Edna NYIKA
[NAME]
Email: nyika@ims.udsm.ac.tz

Ministry:
University of Dar es Salaam]

Institute Strengths: [PLEASE MODIFY TEXT AS NEEDED]
Human Resources: [IMS] currently has [23] scientific staff. Of the [23] staff, [16] have PhD, [8] have a M.Sc and [2] have a B.Sc

Infrastructure: [IMS] has a [very good] power supply. The internet link is [VSAT, and the connection speed is [128/256] [Kbps] with [approximately] [60] personal computers connected. There are [YY] laboratories specializing in [Please insert fields researched]. Data collection at sea is done using [research vessels, moored and/or drifting buoys, and tide gauges].

Publications: In the last 5 years, [XX] researchers affiliated to [INSTITUTE X] have received [YY] publications related to marine and coastal zone issues. [INSTITUTE X] has provided information concerning [Insert Issue] to [Organization(s)] in preparation for COP-15. [If Applicable]

Financial Resources: [INSTITUTE X] has a total budget of approximately [XX] with [YY%] allocated towards projects addressing coastal/marine management issues.

Capacity Development Needs to Address Climate Issues in Coastal Zones

Issues:	**Currently Available Services:**	**Services needed for Adaptation:**	**Capacities Needed for Services:**
[Coastal Erosion]	1. Shoreline monitoring at Kunduchi bay 2. 3.	1. monitoring by beach profiling 2.shoreline management plan based on sediment cells 3. shoreline protection structures	1. 2. 3.
[Salinization of Aquifers]	1. 2. 3.	1. 2. 3.	1. 2. 3.
[Coastal flooding]	1.	1. inundation vulnerability	1. hydrographic models

	2. 3.	mapping 2. sea wall construction guidelines 3.	2. empowerment of local authorities to operate early warning 3. funding for seawall construction
[Coastal livelihoods]	1. seaweed farming 2. 3.	1. improved mariculture production facilities 2. 3.	1. infrastructure for field facilities 2. 3.
Marine hazards and disaster		Predictive and simulation models	Training on use of models

Capacity Development Needs

IMS wishes to provide a focal point for networking and coordination of research on marine impacts from climate, climate variability and climate change. In so doing the Institute would wish to integrate a range of issues and create a research and training programmes in areas such as sea level rise, coral bleaching, calcification, acidity, changes in ecosystems and link them to natural marine hazards. This requires a multi-disciplinary approach including:

- Research and provision of training in Coastal Ocean prediction and predictability,
- Support, development and evolution of the coastal ocean observing system
- Use of remote sensing for real-time description of the current state of the sea and long-term climate data
- Study of the spatial-temporal dynamics of biodiversity, distribution and abundance of marine biota. This initiative is supposed to be a fundamental point for conservation and sustainable use of the marine living resources.
- MARICULTURE as means of adaptation to coastal fisheries. The Institute has initiated mariculture research, development and extension education for seaweed, shellfish and finfish. While some of the studies are still at experimental stages, others are at pilot and production stages.

Development of modeling skills, GIS and marine geoinformatics is perceived to provide a better understanding of natural processes that may be linked to climate change including harmful algae blooms, shoreline changes, and distribution of fish. Modeling should enhance the ability to integrate climatic change scenarios into ecosystems. There has been great success of coupling physical and biogeochemical/ecosystem models to bridge the gap between fisheries models and biogeochemical models. Following this observation IMS wishes to initiate courses on modeling to help with education and data management.

IMS would also wish to initiate observation system for tsunamis, coastal erosion, diseases, habitat loss, declines in living resources, harmful algal blooms and mass mortalities of marine mammals and birds. These events often reflect the combined effects of both natural processes and human uses. These should be designed to address the following six goals

- Improve the capacity to detect and predict the effects of global climate change on coastal ecosystems;
- Improve the safety and efficiency of marine operations;
- Control and mitigate the effects of natural hazards more efficiently
- Reduce public health risks;
- Protect and restore healthy ecosystems more effectively; and
- Restore and sustain living marine resources more effectively.

Vision: [carry out research pertinent to the social, cultural, environmental and economic development of Tanzania] Priorities: 1. , 2. 3.	**[Institute of Resource Assessment]** [Institute Name translated to English (if applicable)]	

<table>
<tr>
<td rowspan="2">4.

Coastal Adaptation Strategy: [Y/N][If Yes, please indicate year adopted and priority actions]
1.
2.
3.

Collaborating Organizations:
[Institute of Development Studies, Economic Research Bureau, and Faculty of Science, Faculty of Law, Prospective College of Engineering and Technology and, and the University College of Lands and Architectural Studies- UCLAS)]</td>
<td>Phone: 255-22-2410393
Fax:
Email:
Web:
Address:
P.O Box 35097
Dar es Salaam</td>
<td>Director:
[Professor Raphael B.B. Mwalyosi]
Email: ira@ira.udsm.ac.tz
Deputy:
[Professor Claude G. Mung'ong'o]
Email: claudem@ira.udsm.ac.tz
Admin:
[NAME]
Email:</td>
</tr>
<tr>
<td colspan="2">Ministry:
[University of Dar es Salaam]</td>
</tr>
</table>

Institute Strengths: [PLEASE MODIFY TEXT AS NEEDED]
Human Resources: [IRA] currently has [12] professional and administrative staff. Of the [12] professional staff, [6 have PhD

The Institute has a remote sensing laboratory, which includes a comprehensive collection of air photos dating back from the 1950s, satellite images, and equipment for visual interpretation, image processing and photography.

Infrastructure: [IRA] has a [good, very good] power supply. The internet link is shared by the University of Dar es Salaam and the connection speed is [512] [Kbps] with [approximately] [12] personal computers connected.

The Institute has sufficient computers and printers. The computer facilities offer several services including running a computerised information system in Natural Resources and the Environment; data processing and Geographical Information Systems (GIS) activities; image processing; and database management. A computer has also been installed in the documentation unit and plans are underway to link documentation services with the main University library.

IRA has a documentation unit that organizes and provides reading materials, photocopying, and other documentary services to institute staff, other university staff, graduate and undergraduate students. The unit has a stock of IRA publications dating back to 1967

Financial Resources: [INSTITUTE X] has a total budget of approximately [XX] with [YY%] allocated towards projects addressing coastal/marine management issues.

Capacity Development Needs to Address Climate Issues in Coastal Zones

Issues:	**Currently Available Services:**	**Services needed for Adaptation:**	**Capacities Needed for Services:**
[Natural resource management]	1. Training in various resource management skills 2. Consultancy in resource assessment and use 3.	1. Analytical techniques including resource valuation 2. 3.	1. Higher training 2. 3.
[Information dissemination]	1. Geographic information system 2. 3.	1. Information portal 2. 3.	1. Information server portal 2. Higher training on IT and communications 3.

Institute of Resource Assessment Capacity Development Needs

The Center was established with financial assistance from the World Bank as part of the Forest Resource Management Project of the Tanzania Government. For many years since its establishment, the Institute has accumulated and acted as a repository for data and which those who need it are gradually incorporating into databases for use. The data categories available in include population, meteorology, forestry, various publications and GIS materials and equipment. Thus, IRA is an important source of information for storage, manipulation and supply to other users. Beneficiaries of information stored at IRA are students, the public, University staff, and other national, regional and international institutions.

IRA conducts research of an applied nature and offers consultancy services in the fields of: natural resource and environment; human population and settlement; agricultural systems; distribution of social services particularly health and education; and transportation impact.

IRA continues to build multidisciplinary and interdisciplinary expertise and capacity on various activities including participatory community planning and development, appropriate technology and indigenous knowledge, environmental impact assessment and management, remote sensing and geographic information systems.

Presently IRA is re-establishing with other partners the website for climate change adaptation in Africa named Climate Change Adaptation in Africa-Tanzania, Malawi Agriculture Project which can be viewed at www.ccaa-agrictama.or.tz

Vision: [Training in Nautical engineering and marine engineering; applied fisheries as well as extension service for the fishermen
]

Priorities:

1. Training of middle level technical personnels in fisheries technology
2.
3.
4.

Coastal Adaptation Strategy: [Y/N][If Yes, please indicate year adopted and priority actions]

1.
2.
3.

Collaborating Organizations: [INSERT NATIONAL AND INTERNATIONAL PARTNER ORGANIZATIONS (Acronyms)]

[Mbegani Fisheries Development Centre]

[Institute Name translated to English (if applicable)]

Phone: 255-23-2440038
Fax:
Email: mbeganifdc@twiga.com
Web:
Address:
P.O Box 38
Bagamoyo
Coastal Region

Director:
[NAME]
Email: mbeganifdc@twiga.com
Deputy Principal:
[Mr Yahya Mgawe]
Email: ymgawe@yahoo.com
Admin:
[NAME]
Email:

Ministry:
Livestock Development and Fisheries

Institute Strengths: [PLEASE MODIFY TEXT AS NEEDED]
The Centre has six departments: Finance and Administration, Maintenance, Marine Engineering, Nautical Sciences, Boat Building and Fish Processing. It offers professional training in nautical and marine engineering, applied fishes, as well as providing extension services for fishermen.
and administrative staff. Of the [YY] professional staff, [ZZ] have PhD, [WW] have a M.Sc/M.Tech and [VV] have a B.Sc/B.Tech

Infrastructure: [INSTITUTE X] has a [poor, fair, good, very good] power supply. The internet link is [dial-up, ADSL, VSAT, etc.] and the connection speed is [XX] [in Mbps or Kbps] with [approximately] [XX] personal computers connected. There are [YY] laboratories specializing in [Please insert fields researched]. Data collection at sea is done using [research vessels, moored and/or drifting buoys, installed equipment].

Publications: In the last 5 years, [XX] researchers affiliated to [INSTITUTE X] have received [YY] publications related to marine and coastal zone issues. [INSTITUTE X] has provided information concerning [Insert Issue] to [Organization(s)] in preparation for COP-15. [If Applicable]

Financial Resources: [INSTITUTE X] has a total budget of approximately [XX] with [YY%] allocated towards projects addressing coastal/marine management issues.

Capacity Development Needs to Address Climate Issues in Coastal Zones

Issues:	Currently Available Services:	Services needed for Adaptation:	Capacities Needed for Services:
[Coastal Erosion]	1. 2. 3.	1. 2. 3.	1. 2. 3.
[Salinization of Aquifers]	1. 2. 3.	1. 2. 3.	1. 2. 3.
[Coastal flooding]	1. 2.	1. 2.	1. 2.

	3.	3.	3.
[Insert Issue]	1. 2. 3.	1. 2. 3.	1. 2. 3.

Mbegani Fisheries Development Centre Capacity Development Needs

Mbegani Fisheries Development Centre is one of the institutions in the country offering training relevant to coastal and marine related issues, at middle level ranging from certificate to Certificate to Diploma in fisheries management. The others one is Kunduchi Fisheries Training Institute and Dar es Salaam Maritime Institute.

MFDC established in 1967, offers long-term training in a number of courses including boat building, marine engineering, fish processing, marketing and quality control. In addition, the Centre offers short and tailor-made courses in fisheries and fisheries related sciences. Mbegani participated in stock assessment surveys conducted in the early 1980s off the cost of Tanzania.

Vision: [ensure protection of the environment and sustainable use of resources for enhancing the quality of lives of the people of Tanzania.]

Priorities:

1. Sustainable Coastal Tourism Development
2. Sustainable Mariculture Development and Management
3. Developing and Implementing the National Integrated Coastal Management Strategy
4. Research and Extension Serving Coastal Governance and Management Needs in Tanzania

Coastal Adaptation Strategy: [Y/N][If Yes, please indicate year adopted and priority actions]

1.
2.
3.

Collaborating Organizations:
[DFID; ICUN, GEF; WWF; FAO; WB; USAID; UNDP; UNEP, CARE, as well as Governments of Finland, Norway, Denmark, the Netherlands and Sweden. WWF-EAME, IMS, TAFIRI, University of Dar-es-Salaam, UNEP, USAID-CRC (Acronyms)]

[The National Environment Management Council (NEMC)]

[Institute Name translated to English (if applicable)]

Phone: +255 22 2134603
Fax: 255 22 2111579
Email: nemc@nemctan.org
Web:
Address:
Sokoine Drive,
TANCOT House,
2nd and 3rd Floor,
P.O. Box 63154
Dar es Salaam
Tanzania

Director:
[NAME]
Email:
Deputy:
[NAME]
Email:
Admin:
[NAME]
Email:

Ministry:
[Office of the Vice President]

Institute Strengths: [PLEASE MODIFY TEXT AS NEEDED]
NEMC has approximately 50 qualified technical staffs in various environmental disciplines. It is headed by Director General who is assisted by Directors, Technical and Supporting Staff under the guidance of the Council. The coastal management programs are implemented under the direction of the **Tanzania Coastal Management Project (TCMP).**

Administration of available information technology tools at NEMC including local area network (LAN) of about 80 users, Internet services, NEMC Web site and email services. Proposing and operationalization of information management system of NEMC staff Providing support, including training session to NEMC staff, to ensure beneficial utilization of available IT tools.

Publications: In the last 5 years, [XX] researchers affiliated to [INSTITUTE X] have received [YY] publications related to marine and coastal zone issues. [INSTITUTE X] has provided information concerning [Insert Issue] to [Organization(s)] in preparation for COP-15. [If Applicable]

Financial Resources: [INSTITUTE X] has a total budget of approximately [XX] with [YY%] allocated towards projects addressing coastal/marine management issues.

Capacity Development Needs to Address Climate Issues in Coastal Zones

Issues:	**Currently Available Services:**	**Services needed for Adaptation:**	**Capacities Needed for Services:**
[Mariculture	1. Seaweed farming 2. 3.	1. Monitoring and evaluation 2. Development of markets 3.	1. Community investment schemes and microfinance 2. 3.
[Tourism]	1. Coastal management tourism	1.	1.

	plans 2. 3.	2. 3.	2. 3.
[Critical coastal habitats]	1. 2. 3.	1. Guidelines and code of conduct for natural resource exploitation 2. Good governance, monitoring and evaluation	1. Strengthening community participation on conservation 2. Strengthening monitoring and evaluation 2. 3.
Coastal hazards		Good construction practices along the shorefront	Development of guidelines Impact assessment

The National Environment Management Council Capacity Development Needs

TCMP has focused upon strategies to mitigate the human and environmental costs of coastal hazards before they happen. This spans public education, reducing or eliminating construction in hazardous areas through various regulatory and non-regulatory means and working with the insurance industry to promote good construction practices along the shorefront.

Key ecosystems in the coastal area of Tanzania include estuaries, coastal wetlands, seagrass beds and coral reefs. Large portions of these important elements of coastal ecosystems have degraded over time and the trends continue unabated in many regions of Tanzania. For coastal managers the conservation and rehabilitation of what remains is a top priority.

Mariculture of fish, shellfish, seaweed and other marine products is important mitigation of diminishing sea resources. However unplanned and unregulated operations can lead to the loss and degradation of critical habitats declines in water quality, disease and user conflicts. Farming of sea products including, pond based mariculture, open water mariculture and seaweed production, requires use of appropriate approaches and adequate monitoring and evaluation of the performance and effects on the environment.

Coastal tourism employs thousands of people in Tanzania in recreation, fishing, snorkelling, scuba diving, and other aquatic activities. In the coastal environment the tourists visit beach shorelines, reefs, estuaries, back bays, salt ponds, lagoons, coastal plains, and offshore waters. It will be necessary to develop other sustainable natural resource based enterprises to lessen pressure from climate change.

Some of the projects presently commissioned by NEMC include:

- The conservation status of the coastal marine resources in the vicinity of Dar es Salaam
- Beach erosion in the northern Dar es Salaam area
- Inventory of destructive activities on the aquatic environment
- Inventory of natural resources projects and projects related to environmental conservation
- Inventory of wetlands of Tanzania
- Preparation of marine pollution contingency plan
- Inventory and monitoring of pollution in Dar es Salaam

Vision: A strong centre of excellence in fisheries research and consultancy in the Eastern and Southern Africa.] Priorities: The institute objectives are to carry out	**[TANZANIA FISHERIES RESEARCH INSTITUTE]** [Institute Name translated to English (if applicable)]	

research in the following fields: fisheries statistics and fish stock assessment; Fish biology, taxonomy and fisheries of commercially important fish species; Socio-economic and marketing; Hydrobiology and water pollution; Gear technology and Aquaculture. Coastal Adaptation Strategy: [Y/N][If Yes, please indicate year adopted and priority actions] 1. 2. 3. Collaborating Organizations: Coelacanth project (JAPAN) MACEMP project (World Bank) IFMP project (	Phone: +255 (22) 2650043 Fax: +255 (22) 2650043 Email: tafirihq@yahoo.com Web: Address: P.O Box 9750 Dar es Salaam Ministry: MINISTRY OF LIVESTOCK DEVELOPMENT AND FISHERIES	Director General: [Dr Yohana L. Budeba] Email: yobudeba@yahoo.com Director of Research: [Dr Benjamin P. Ngatunga] Email: bpngatunga@yahoo.co.uk Director of Finance & Administration: [Vacant) Email:

Institute Strengths: [PLEASE MODIFY TEXT AS NEEDED]
Human Resources: TAFIRI] currently has [48] professional and administrative staff. Of the [48] professional staff, [8] have PhD, [28] have a M.Sc/M.Tech and [12] have a B.Sc/B.Tech

Infrastructure: Along the coast there is Institute headquarters (Coelacanth House) located in Kunduchi about 20Km from Dar es Salaam city and the Dar es Salaam centre is located adjacent to the Institutes' Headquarters. The Centre and Headquarters are responsible for activities undertaken in marine waters.

The Institute has a good] power supply. The internet link in the centres is mainly provided by local ISP's] with [certain number of personal computers connected. Data collection at sea and on the lakes is done using institute research vessels or boats.

Publications: In the last 5 years, [XX] researchers affiliated to [INSTITUTE X] have received [YY] publications related to marine and coastal zone issues. [INSTITUTE X] has provided information concerning [Insert Issue] to [Organization(s)] in preparation for COP-15. [If Applicable] For the past twenty years, the institute has carried out several researches resulting into more than four hundred (400) published and unpublished reports.

Financial Resources: [INSTITUTE X] has a total budget of approximately [XX] with [YY%] allocated towards projects addressing coastal/marine management issues.

Capacity Development Needs to Address Climate Issues in Coastal Zones

Issues:	**Currently Available Services:**	**Services needed for Adaptation:**	**Capacities Needed for Services:**
[Mariculture]	1. 2. 3.	1. wet and dry lab research facilities 2. 3.	1. Funding 2. 3.
[Salinization of Aquifers]	1. 2. 3.	1. 2. 3.	1. 2. 3.
[Coastal flooding]	1. 2.	1. 2.	1. 2.

	3.	3.	3.
[Insert Issue] Management of fish stocks	1. Prawn fish stock assessment (along Tanzanian coast 2. Inshore Dermesal fish stock assessment Tanzanian coast 3.	1. hydro acoustic surveys 2. research vessel 3.	1. Funding 2. 3.

Tanzania Fisheries Research Institute Capacity Development Needs

The objectives/mandates of the institute include, among others:
TAFIRI promotes and conduct research in fisheries within and in relation to any part of the territorial waters or in relation to any part of the territory of the United Republic of Tanzania; to assist in the development, improvement and protection of the fishing Industry. This is done by means of enquiries, experiments and research in various aspects of fisheries for the purpose of establishing, improving or developing better methods or techniques of fishing, fish farming or manufacturing using fish products. To carry out investigations on fish disease and their cause so as to develop ways of controlling or preventing the occurrence of particular fish diseases or any category of them.

The Institute is required to establish and operate a system of documentation and dissemination of the findings of enquiries, experiments and research in fisheries which are carried out within the United Republic for use by the Government, public institutions and other persons engaged in the fishing industry in the United Republic; To advise the Government, public Institutions and other persons or bodies of person engaged in the fishing industry in Tanzania on the practical application of the findings of enquiries, experiments and Research carried out by or on behalf of the Institute and in-cooperation with the Government or any persons, within or outside the united Republic to promote or provide facilities for the instruction and instruction training of local personnel for carrying out research in fisheries and for the management of the fishing industry;

The institute also assumes responsibility for the control and management of the business and affairs of any centre, which may be established or vested in the Institute;

2.1.4.3 Mozambique

National Synopsis

EFFECTIVENESS OF THE NATIONAL INSTITUTES IN MOZAMBIQUE ON CLIMATE CHANGE ISSUES

From various reviews including the Intergovernmental Panel on Climate Change (IPCC) resources the crititical areas that have been considered in the assessment of impacts, adaptation and vulnerability to climate change include:

– Fresh water resources and their management: - The impacts of climate change on freshwater systems and their management are mainly due to the observed and projected increases in temperature, sea level and precipitation variability.
– Ecosystems, their properties and goods: - During the course of this century the resilience of many ecosystems (their ability to adapt naturally) is likely to be exceeded by an unprecedented combination of change in climate, associated disturbances (e.g., flooding, drought, wildfire, insects, ocean acidification) and in other global change drivers (especially land-use change, pollution and over-exploitation of resources), if greenhouse gas emissions and other changes continue at or above current rates.
– Food, fibre and forest products: - In mid- to high-latitude regions, moderate warming benefits crop and pasture yields, but even slight warming decreases yields in seasonally dry and low-latitude regions.
– Industry, settlement and society: - Climate-change vulnerabilities of industry, settlement and society are mainly related to extreme weather events rather than to gradual climate change.

As far as the coastal and marine environment is concerned the above issues are equally quite pertinent and require effective interventions to reduce or eliminate the predicted impacts. The functions of Mozambique institutions required to render support in these include research, funding and regulations. Mozambique has an area of 800,000 km and a coastline of about 2770 km long, and a continental shelf area of approximately 68,000 km^2. The coastal belt of Mozambique may be divided into three main geomorphic units which are almost adjacent to one another. These are from north to south; the coral coast; swamp coast and parabolic dune

coast. The coral coast extends for about 770 km from the Ruvuma River in the north to the Primeiro/Segundo Archipelago in the south. The extent of the swamp coast is about 978 km and includes the area between Angoche and Bazaruto Island. Features included within the swamp coast are beaches, swamps, estuaries and two prominent delta, i.e. Zambezi and Save delta. The parabolic dune coast stretches for about 850 km from Bazaruto Island to the border between Mozambique and South Africa. High parabolic dunes and north-oriented capes and barrier lakes are the characteristic features of the parabolic dune coast.

Policies and institutional framework

There are several institutions dealing directly or indirectly with marine issues. These include institutions both at national, provincial and local levels. The province is the lowest authority level for most of the institutions. There is no single institution responsible for all the marine affairs. Co-ordination between institutions has been always an issue of concern within the government and the public in general.

These institutions operate under a number of national policy and development plans under the theme of (i) revitalisation of the economy and (ii) alleviation of the poverty, without degrading the environment.

The government of Mozambique has ratified a number of international conventions which have been used in national environmental legislation, such as the Biological Diversity and the Climate Change Conventions. It is now in the process of the ratification of the Basel and the Bamako Conventions, as well as, the Convention on Desertification and MARPOL 73/78 Convention.

Higher Education Institutions

There are three government higher education institutions, namely: the Eduardo Mondlane University, the Pedagogic University and the International Relation Institute. Also there are several private universities and polytechnics. These universities award Licenciatura degree (a degree equivalent to the British BSc. Honours), in social and natural sciences, and in various fields of engineering. The Eduardo Mondlane University is the only one offering courses on marine sciences. The Pedagogic University offer general biology useful in fisheries sector, among others.

Eduardo Mondlane University also runs a Research Station at Inhaca Island, in Maputo Bay. The station has a small boat for research in shallow water tidal inlets and Maputo Bay, as well as, laboratories for biological/ichthyology research.

Research and Training Institutions

Two institutions stand out in research; the Fisheries Research Institute (IIP) and the Institute for Hydrography (INAHINA). The former undertake research on marine fisheries resources and freshwater fisheries. Some of the research topics carried out so far include: inventory and mapping of the main fisheries resources, the environmental impact on fish resources, and evaluation of the prawn culture potential. Recently, the Institute started surveys in artisanal fisheries. INAHINA offers facilities for research and training on hydrography. The Institute owns a large hydrographic vessel (50m long) “R/V Basaruto” and small boats for surveys in shallow water bays. The large vessel has possibility to operate in shallow water areas. It has a small work station to service electronic equipment and calibration. The vessels are equipped with hydrographic instruments. It needs to be furnished with oceanographic equipment

Human Resources

It is evident from past surveys that there is inadequate skilled personnel and diversity in training specialities. Most of the trained personnel are in the field of Marine Biology. These surveys showed that there is hardly any Physical Oceanographers, Marine Geologist or aquaculturists. The level of expertise is low as shown by the numbers who have obtained higher degrees such as Masters and PhD’s. Even at the University few lecturers have MSc degree. Strengthening the UNESCO Chair in marine sciences would constitute a major foothold for the development of marine science in the country.

Institute for Hydrography and Navigation (INAHINA)

[**Instituto Nacional de Hidrografia e Navegação**] (INAHINA)

Phone: 258 21 430186/8
Fax: 258 21 430185
Email:
Web:
Address: Karl Marx avenue, 153
Maputo

Director:
Augusto Jessenão Bata
Email: augustobata@yahoo.com.br
Deputy:
[NAME]
Email:
Admin:
Cid Cambule
Email: ccambule@yahoo.com.b r

Ministry:
Ministry of Transport and Communications

Vision:
The principal aim is to guarantee safe navigation in the Mozambican waters by providing sea marking assistance, charts, notices to marines and other nautical publications (also to providing support research on existing marine resources.)

Priorities:

1. Sea-level measurements
   - Tidal analysis and Prediction
2. Cartography
   - Seabed bathymetric survey using acoustic approaches
   - Production of navigation charts
3. Help on Navigation
   - Lighthouses, buoys and leading lines for Coast and Port entrance channels
   - Navigations warnings
4. Research in coordination with department of Physics, Eduardo Mondlane University
   - Coastal processes

Coastal Adaptation Strategy: [Y/N][If Yes, please indicate year adopted and priority actions]- N
1.
2.
3.

Collaborating Organizations:
UEM, Department of physics;
IIP(fishery Institute);
INAM (meteorology Institute)

Institute Strengths:
Human Resources: Institute for Hydrography and navigation (INAHINA) currently has 274 professional and administrative staff. Of the [34] professional staff, [0] have PhD, [8] have a M.Sc/M.Tech and [26] have a B.Sc/B.Tech

Infrastructure: INAHINA has a good power supply. The internet link is [ADSL] and the connection speed is [512] [in Kbps] with approximately 80 personal computers connected. There are [1] laboratories specializing in [cartography]. Data collection at sea is done using [research vessels, moored buoys and installed equipment].

Publications: In the last 5 years, [XX] researchers affiliated to [INSTITUTE X] have received [YY] publications related to marine and coastal zone issues. [INSTITUTE X] has provided information concerning [Insert Issue] to [Organization(s)] in preparation for COP-15. [If Applicable]

Financial Resources: [INSTITUTE X] has a total budget of approximately [XX] with [YY%] allocated towards projects addressing coastal/marine management issues.

<u>Capacity Development Needs to Address Climate Issues in Coastal Zones</u>			
Issues:	**Currently Available Services**:	**Services needed for Adaptation:**	**Capacities Needed for Services:**
[Coastal Erosion]	1. tide variations measurements 2. 3.	1. 2. 3.	1. sea level prediction 2. 3.
[Salinization of Aquifers]	1. 2. 3.	1. 2. 3.	1. 2. 3.
[Coastal flooding]	1. 2. 3.	1. 2. 3.	1. 2. 3.
Coastal surveys	1. navigations warnings 2. tide gauges 3.	1. 1 multi-beam echo sounder system 2. 1 wave radar; water level records (pressure gauges) 3.	1. training in using the new technologies 2. 3.

INAHINA Capacity Development Needs

- Capacity to apply GIS and Numerical Models to study shoreline changes (coastal erosion processes)
- GIS skills at senior level
- Capacity for hazard mapping (inundation maps) for tsunami and storm surge
- Capacity to extend Hazard for all the coast of the Country

Vision: [PLEASE MODIFY AS NEEDED]
Working so that the weather forecast is as accurate as possible and that nobody on this earth, however vulnerable, is caught by surprise by the events of weather and climate (translated from website)

Priorities: [PLEASE MODIFY AS NEEDED]
1. Plan, install and maintain meteorological and wind-monitoring stations throughout Mozambique
2. Promote meteorological observations
3. Conduct research in meteorology and climatology
4.

Coastal Adaptation Strategy: [Y/N][If Yes, please indicate year adopted and priority actions]
1.
2.
3.

Collaborating Organizations: [PLEASE…]
Universidade, Eduardo Mondlane, National Water Directorate (DNA), ACRIA, USGS, FEWSNET, INGC, WMO

Instituto Nacional do Meteorologia (INAM)

National Meteorological Institute (INAM)

Phone: +258 21493193
Fax: +258 21491150
Email: mozmet@inam.gov.mz
Web: http://www.inam.gov.mz/
Address: Rua Mukumbura 164, P. O. Box. 256, Maputo, Moçambique

Director:
Filipe Lucio
Email:
Deputy:
[NAME]
Email:
Admin:
[NAME]
Email:

Ministry:
Ministério dos Transportes e Comunicações (Ministry of Transport and Communication)

Institute Strengths: [PLEASE MODIFY TEXT AS NEEDED]
Human Resources: [INSTITUTE X] currently has [XX] professional and administrative staff. Of the [YY] professional staff, [ZZ] have PhD, [WW] have a M.Sc/M.Tech and [VV] have a B.Sc/B.Tech

Infrastructure: [INSTITUTE X] has a [poor, fair, good, very good] power supply. The internet link is [dial-up, ADSL, VSAT, etc.] and the connection speed is [XX] [in Mbps or Kbps] with [approximately] [XX] personal computers connected. There are [YY] laboratories specializing in [Please insert fields researched]. Data collection at sea is done using [research vessels, moored and/or drifting buoys, installed equipment].

Publications: In the last 5 years, [XX] researchers affiliated to [INSTITUTE X] have received [YY] publications related to marine and coastal zone issues. [INSTITUTE X] has provided information concerning [Insert Issue] to [Organization(s)] in preparation for COP-15. [If Applicable]

Financial Resources: [INSTITUTE X] has a total budget of approximately [XX] with [YY%] allocated towards projects addressing coastal/marine management issues.

Capacity Development Needs to Address Climate Issues in Coastal Zones

Issues:	**Currently Available Services:**	**Services needed for Adaptation:**	**Capacities Needed for Services:**
[Adverse weather prediction]	1. Meteorological equipment 2. 3.	1. Increased range and density of equipment listed below 2. 3.	1. Funding and training 2. 3.
[Salinization of Aquifers]	1. 2. 3.	1. 2. 3.	1. 2. 3.

[Coastal flooding]	1. 2. 3.	1. 2. 3.	1. 2. 3.
[Insert Issue]	1. 2. 3.	1. 2. 3.	1. 2. 3.

INAM Capacity Development Needs

Mozambique is particularly subject to natural disasters caused by weather conditions such as drought, floods and tropical cyclones. Such disasters usually have a devastating effect.

Mozambique's meteorological networks were earlier destroyed by different disasters, and this situation has been further worsened by floods over the past years. The INAM requires tools for climate study in each of the different regions, which would allow the Mozambique Government to create an appropriate strategy for the country

The network needed a large number of monitoring stations to be installed, but only limited resources were available. Faced with this situation, it was decided to supply a group of synoptic and agro-meteorological stations, to be complemented by Automatic Weather Observation Systems (AWOS) at the country's main airports, to collect critical meteorological data, and also to buy and install Automatic Weather Stations (AWS) to strategically locate across the country. This project also included supply and installation of weather radar.

The implementation of these new systems has once again enabled the INAM to be capable of predicting and preventing threatening situations, and it also provides support for efficient decision making in order to minimise, as far as possible, the negative consequences of adverse weather phenomena.

The following equipment exists:

- Twelve synoptic stations
- Five agro-meteorological stations
- A Doppler weather radar capability
- Five airport based Automatic Weather
- Observation Systems (AWOS)

- Eight Automatic Weather Stations (AWS) with Meteosat satellite communication with the Control Centre
- A Control Centre for the integration and centralised operation of all the information generated by the weather observation systems

More support is needed in maintenance of the equipment, data management and modelling.

Vision: [responsible for the execution of the environmental policy, co-ordination, evaluation and controlling initiatives, planning and utilisation of the natural resources in the Mozambique]	**Ministerio para Coordenação de Acção Ambiental - Unidade de Gestão Costeira (MICOA)** **Ministry of Coordination of Environmental Affairs - Unit for Coastal Zone Management (MICOA)**	

<table>
<tr>
<td rowspan="2">Priorities:
1. Implementing the National Environmental Management Plan (NEMP) and associated environmental policy and legislation, and
2. Coordinating with other ministries on environmental matters to integrate environmental aspects into their projects, programmes and policies.
Coastal Adaptation Strategy:
[Y/N][If Yes, please indicate year adopted and priority actions]
1.
2.
3.

Collaborating Organizations:
[National Commission for Sustainable Development; UNEP (Acronyms)]</td>
<td>Phone: (258 1) 465843/48/51, (258 1) 466059/465708
Fax:
Email:
Web:
Address:
Av. Acordos de Lusaka 2115
P.O. Box 2020, Maputo, Mozambique</td>
<td>Director:
[Mr Alfredo Victor Massinga
Email:
Deputy:
[NAME]
Email:
Admin:
[NAME]
Email:</td>
</tr>
<tr>
<td colspan="2">Ministry:
[INSERT MINISTRY REPORTED TO]</td>
</tr>
<tr>
<td colspan="3">Institute Strengths: [PLEASE MODIFY TEXT AS NEEDED]
Human Resources: [INSTITUTE X] currently has [XX] professional and administrative staff. Of the [YY] professional staff, [ZZ] have PhD, [WW] have a M.Sc/M.Tech and [VV] have a B.Sc/B.Tech

Infrastructure: [INSTITUTE X] has a [poor, fair, good, very good] power supply. The internet link is [dial-up, ADSL, VSAT, etc.] and the connection speed is [XX] [in Mbps or Kbps] with [approximately] [XX] personal computers connected. There are [YY] laboratories specializing in [Please insert fields researched]. Data collection at sea is done using [research vessels, moored and/or drifting buoys, installed equipment].

Publications: In the last 5 years, [XX] researchers affiliated to [INSTITUTE X] have received [YY] publications related to marine and coastal zone issues. [INSTITUTE X] has provided information concerning [Insert Issue] to [Organization(s)] in preparation for COP-15. [If Applicable]

Financial Resources: [INSTITUTE X] has a total budget of approximately [XX] with [YY%] allocated towards projects addressing coastal/marine management issues.</td>
</tr>
</table>

Capacity Development Needs to Address Climate Issues in Coastal Zones			
Issues:	**Currently Available Services:**	**Services needed for Adaptation:**	**Capacities Needed for Services:**

[Coastal zone management	– Mecufi coastal zone management – Coastal profile of Xai-Xai district – Elaboration of a methodology for physical planning and programme for coastal zone management – The Darwin Frontier Mozambique Quirimba Archipelago marine research programme – National environmental legislation – Management of coastal resources by local communities in Xai-Xai Beach	1. National coastal management policy 2. 3.	1. Policy development 2. Funding for implementation

MICOA Capacity Development Needs

Unit for Coastal Zone Management, which is responsible for all the activities related to coastal area management, including research, planning, programme management and co-ordination has the following tasks:

- formulation of a national programme for integrated coastal zone management.
- establishment of a multi-sectoral task force for integrated coastal zone management.
- establishment of the Coastal Zone Management Centre in Xai-Xai
- publication of a coastal atlas, with GIS capacity established
- identification, implementation and monitoring of pilot projects

In addition an inter-institutional technical committee to deal with coastal zone management has been created. This technical committee is co-ordinated by the Unit, and is comprised of officers (scientists and managers) from many institutions dealing with marine issues.

Presently MICOA coordinates a number of initiatives on coastal resources management such as:

- Mecufi coastal zone management
- Coastal profiling of Xai-Xai district
- Elaboration of a methodology for physical planning and programme for coastal zone management
- The Darwin Frontier Mozambique Quirimba Archipelago marine research programme
- National environmental legislation
- Management of coastal resources by local communities in Xai-Xai Beach

In order to deal with climate change adaptations, the coastal zone management initiatives need to be evaluated and up scaled to national scale. This may require formulation of a coastal management policy and implementation of the same.

Vision: [Undertake research on marine fisheries resources and freshwater fisheries. Some of the research topics carried out so far include: inventory and mapping of the main fisheries resources, the environmental impact on fish resources, and evaluation of the prawn culture potential.	**FISHERY RESEARCH INSTITUTE (IIP)** [**Instituto de Investigação Pesqueira (IIP)**]	

<table>
<tr>
<td rowspan="2">Priorities:
1. shallow and deep water shrimp (penaeidae) and its by-catch
2. estuarine and coastal fisheries
3. line and recreational fishing
4. freshwater fisheries (Kapenta)
5. studies on environmental influence in fisheries
6. river runoff, rainfall influence in shrimp abundance
7. shrimp culture

Coastal Adaptation Strategy: [Y/N][If Yes, please indicate year adopted and priority actions]
1.
2.
3.

Collaborating Organizations:
[Institute of Marine Research, Bergen; Oceanographic Research Institute, Durban; Instituto Portugues de Investigaçao Marítima, Lisbon; University of Wales, Bangor; NORAD; Icelandic development agency (ICEIDA), Eduardo Mondlane University</td>
<td>Phone: (258 1) 492112/490307/490536
Fax:
Email:
Web: www.moziip.org
Address:
Av. Mao Tse-Tung No. 389
P.O. Box 4603, Maputo
Mozambique</td>
<td>Director:
[Eng. Albano Gove]
Email:
Deputy:
[NAME]
Email:
Admin:
[NAME]
Email:</td>
</tr>
<tr>
<td colspan="2">Ministry:
Ministry of Fisheries</td>
</tr>
</table>

Institute Strengths: [PLEASE MODIFY TEXT AS NEEDED]
Human Resources: IIP currently has 28 Scientific staff, 20 technicians and 49 other staff

Infrastructure: IIP] has a good, power supply. The internet link is [dial-up, ADSL, VSAT, etc.] and the connection speed is [XX] [in Mbps or Kbps] with [approximately] [XX] personal computers connected. It has about 5 laboratories where catch landings are collected and analysed and small research programs are conducted.

Field equipment comprises the following oceanographic equipment: Aanderaa current metres and tide gauges, STD - sensor data, STD -ME (broken for repair), anemometer, salinometer (Portsal), Portable echo sounder (Simrad, EY.M.), and several computers (pentium processor). There is a 27 m long vessels for sea sampling which is now decommissioned

Number of books, journals, manuscripts number up to 3500 while periodicals are about 50 subscriptions

Financial Resources: [INSTITUTE X] has a total budget of approximately [XX] with [YY%] allocated towards projects addressing coastal/marine management issues.

Capacity Development Needs to Address Climate Issues in Coastal Zones

Issues:	Currently Available Services:	Services needed for Adaptation:	Capacities Needed for Services:
[Coastal Erosion]	1. 2. 3.	1. 2. 3.	1. 2. 3.

[Salinization of Aquifers]	1. 2. 3.	1. 2. 3.	1. 2. 3.
[Coastal flooding]	1. 2. 3.	1. 2. 3.	1. 2. 3.
[Insert Issue]	1. 2. 3.	1. 2. 3.	1. 2. 3.

IIP Capacity Development Needs

The Institute offers on-job training in three areas, namely, fish stocks and assessment, aquaculture and applied oceanography. It participates actively in the teaching and supervision of students at Eduardo Mondlane University, in the field of oceanography, fisheries biology and aquaculture.

Vision: Promote science studies in the region

Priorities:

- Development of curricula and establishment of courses in Marine Science. The following four degree courses were established: Oceanography, Marine Biology, Chemical Oceanography and Geological Oceanography.
- Establishment of a School for Marine and Coastal Sciences within the university
- Promotion of multidisciplinary and applied research in Marine Sciences
- Establishment of partnership and resource mobilisation

Coastal Adaptation Strategy: [Y/N][If Yes, please indicate year adopted and priority actions]

Collaborating Organizations:
[UEM, IIP, INAHINA, INAM, MICOA UNESCO ; University of Wales, Bangor, School of Ocean Sciences; University of Gothenburg in Sweden; University of Cape Town; University of Aveiro in Lisbon; WIOMSA,

Eduardo Mondlane University – School of Marine and Coastal Sciences (UNESCO Chair in Marine Sciences and Oceanography)

Phone: 258-24-900500/1, 258-82-3152860
Fax: 258-24-900502
Email:
Web:
Address:
School of Marine and Coastal Sciences
Eduardo Mondlane University
P.O.Box 128
Quelimane
Mozambique

Director:
Dr. António Mubango Hoguane
Email: hoguane@yahoo.com.br
Deputy:
[NAME]
Email:
Admin:
[NAME]
Email:

Ministry:
[INSERT MINISTRY REPORTED TO]

Institute Strengths: [PLEASE MODIFY TEXT AS NEEDED]
Human Resources: The chair has one co-ordinator, four research officials, one secretary and one cleaner

For teaching and research there are three computers, one printer and one scanner. Also there is one current-meters, one tide gauge, one CTD Seabirds, one Oceanographic Buoy, one Digital camera, one Video Recorder, books, journals and reprints

Capacity Development Needs to Address Climate Issues in Coastal Zones

Issues:	Currently Available Services:	Services needed for Adaptation:	Capacities Needed for Services:
[Development of marine science]	1. 2. 3.	1. Expansion of marine science courses at the University 2. 3.	1. Increased fellowships 2. 3.
[Coastal zone management]	1. 2. 3.	1. Short skill development on research and monitoring of the marine ecosystems 2. 3.	1. Resource persons 2. Funding from donors and governments 3.
[Coastal flooding]	1. 2. 3.	1. 2. 3.	1. 2. 3.
[Insert Issue]	1. 2. 3.	1. 2. 3.	1. 2. 3.

Eduardo Mondlane University - School of Marine and Coastal Sciences Capacity Development Needs

The UNESCO Chair wishes to focus on the development of applied research and implementation of demo projects on the wise use of natural resources and promotion of sustainable development in coastal area. The technological innovation for ocean observing and use of renewable energy will also constitute top priority.

The immediate activities for which support is needed are as follows:
- Provide a short term training course in Marine Biogeochemistry to lecturers and students of the School of Marine and Coastal Sciences
- Source funds to train the staff of the School of Marine and Coastal Sciences at M.Sc. level abroad
- Develop an oceanographic buoy (continuation). The focus will be on improvement of the existing buoy.
- Develop and construct a mini-tidal power station for education and research

Other development prospects include:
- Publicise its activities and gets more involved with the various stakeholders' activities in the coastal zone at the national level.
- Spearheading the research and monitoring of environmental factors for sustainable management of natural resources, protection of environment and maintenance of biodiversity in coastal and marine environments in the region.

2.1.4.4 Mauritius

National Synopsis

EFFECTIVENESS OF THE NATIONAL INSTITUTES IN MAURITIUS ON CLIMATE CHANGE ISSUES

From various reviews including the Intergovernmental Panel on Climate Change (IPCC) resources the critical areas that have been considered in the assessment of impacts, adaptation and vulnerability to climate change include:

- Fresh water resources and their management: - The impacts of climate change on freshwater systems and their management are mainly due to the observed and projected increases in temperature, sea level and precipitation variability.
- Ecosystems, their properties and goods: - During the course of this century the resilience of many ecosystems (their ability to adapt naturally) is likely to be exceeded by an unprecedented combination of change in climate, associated disturbances (e.g., flooding, drought, wildfire, insects, ocean acidification) and in other global change drivers (especially land-use change, pollution and over-exploitation of resources), if greenhouse gas emissions and other changes continue at or above current rates.
- Food, fibre and forest products: - In mid- to high-latitude regions, moderate warming benefits crop and pasture yields, but even slight warming decreases yields in seasonally dry and low-latitude regions.
- Industry, settlement and society: - Climate-change vulnerabilities of industry, settlement and society are mainly related to extreme weather events rather than to gradual climate change.

As far as the coastal and marine environment is concerned the above issues are equally quite pertinent and require effective interventions to reduce or eliminate the predicted impacts. The functions of Mauritius institutes required to render support in these include: i) research; ii) funding; and iii) regulations.

The state of Mauritius comprises of four major islands of Mauritius, Rodrigues, St. Brandon, and Agalega, as well as many smaller islands. The islands are of volcanic origin. The climate is sub-tropical with a cyclonic season between December and April. In 1978, Mauritius, a signatory member to the Convention on the Law of the Sea, proclaimed its 200 nautical miles Exclusive Economic Zone (EEZ) extending over an area of 1.7 million km.

The island of Mauritius has a coastline of 200 km and is almost completely encircled by 150 km of fringing reefs and enclosing a lagoon of 243 km^2. The oceans, islands, coral reefs, lagoons, and estuaries are closely linked with economic and human activities through direct and indirect exploitation of its living and non-living resources.

Policies and institutional framework

Marine science, planning and monitoring fall under various ministries. The principal institution responsible for planning however is the Ministry of Economic Planning, Information and Telecommunication (MEPIT). Since 1990 when the Ministry of Environment and Quality of Life (MEQL) was created, a number of reorganisations have taken place concerning the individuals and institutions responsible for planning and management of marine matters.

The need for more fish, the banks fishery developed in the 1970s, as well as the delineation of the Exclusive Economic Zone, created incentives for investment in marine science research and development

Ventures were set up for the exploitation of fish on the banks of St Brandon, Agalega, Nazareth and Chagos archipelago. The law was consequently amended to provide for the control of activities in these fishing areas. The Fisheries Act of 1980 makes provision for the protection of rivers, streams, estuaries and lagoons insofar as aquatic organisms are concerned. Destruction of aquatic animal life is punishable by fines and imprisonment. The present legislation is being updated and a new fisheries and marine resources would be in place. A National Oil Spill Contingency Plan has now been finalised.

At present the various organisations concerned with marine science work independently from each other, usually with limited co-operation and linkages and flow of information. There is a need to have a greater co-ordination for the execution of a national programme for marine science which would ensure sharing of responsibilities among the various institutions involved. In particular, increased collaboration involving the Albion Research Centre, the University and the Department of Environment is absolutely necessary for research. The last two organisations would gain by having a base station at the Albion Research Centre and to be able to make use of equipment, boats and the oceanographic facilities of the Centre. This would be particularly desirable for Integrated Coastal Zone Management because of its vital importance to various sectors of the Mauritian economy

Capacity needs

Fisheries research is presently undertaken by the Albion Fisheries Research Center in the Ministry of Agriculture. The Centre (AFRC) was constructed in the period 1981- 1982. In 1995 a Marine Conservation Centre was added on. The objectives of the AFRC are to carry out research and development in fisheries and studies on the marine ecosystems with a view to increasing knowledge on fishery resources within the fishing limits of Mauritius and to provide a basis for their sustainable development and management. Research and development activities are carried out in the main fisheries sub-sectors viz.: coastal, banks and tuna fisheries, marine and freshwater aquaculture and the marine environment.

The Faculty of Science at the University is mainly concerned with teaching in Marine Sciences with some research. The Faculty of Science has a Department of Natural Sciences with an Environmental and Marine Studies Unit. At present no courses on marine science are offered though some modules on the subject are taught in the BSc Biology course.

The Mauritius Oceanography Institute is tasked with monitoring the marine environment around Mauritius, Rodrigues and the Outer Islands. It also provides the Government with advice on management of the living and non-living resources under its jurisdiction, as well as assistance in formulating claims to the UN Commission on the Limits of the Continental Shelf.

The capacity needs of these institutions include adequate staffing and provision of oceanographic research infrastructure.

MAURITIUS OCEANOGRAPHY INSTITUTE (MOI)

Vision: [To contribute towards the advancement of oceanography at the national, regional and international level for the welfare of the people of the Republic of Mauritius.]

Priorities:

1. Monitor the marine environment around Mauritius, Rodrigues and the Outer Islands
2. Provide the Government with advice on management of the living and non-living resources under its jurisdiction
3. Assist the Government of Mauritius in formulating a claim to the UN Commission on the Limits of the Continental Shelf for an extension of the marine jurisdiction of the Republic of Mauritius

Coastal Adaptation Strategy: [Y/N][If Yes, please indicate year adopted and priority actions]

1.
2.
3.

Collaborating Organizations:
[INSERT NATIONAL AND INTERNATIONAL PARTNER ORGANIZATIONS (Acronyms)]

Phone: +230 427 4434
Fax: +230 427 4433
Email:moi@intnet.mu
Address:
France Centre, Victoria Avenue
Quatre-Bornes, Mauritius

Director:
[Dr. **Mitrasen BHIKAJEE**]
Email: bhikajee@moi.intnet.mu
Deputy:
[**Rezah BADAL**]
Email: rezahmb@moi.intnet.mu
Admin:
[NAME]
Email:

Ministry:
[Office of the Prime Minister]

Institute Strengths: [PLEASE MODIFY TEXT AS NEEDED]
Human Resources: [MOI] currently has [20] professional and administrative staff. Of the [20] professional staff, [5] have PhD, [10] have a M.Sc/M.Tech and [5] have a B.Sc/B.Tech

Infrastructure: [INSTITUTE X] has a [poor, fair, good, very good] power supply. The internet link is [dial-up, ADSL, VSAT, etc.] and the connection speed is [XX] [in Mbps or Kbps] with [approximately] [XX] personal computers connected. There are [YY] laboratories specializing in [Please insert fields researched]. Data collection at sea is done using [research vessels, moored and/or drifting buoys, installed equipment].

Publications: In the last 5 years, [XX] researchers affiliated to [INSTITUTE X] have received [YY] publications related to marine and coastal zone issues. [INSTITUTE X] has provided information concerning [Insert Issue] to [Organization(s)] in preparation for COP-15. [If Applicable]

Financial Resources: [INSTITUTE X] has a total budget of approximately [XX] with [YY%] allocated towards projects addressing coastal/marine management issues.

Capacity Development Needs to Address Climate Issues in Coastal Zones

Issues:	**Currently Available Services:**	**Services needed for Adaptation:**	**Capacities Needed for Services:**
[Sedimentology]	1. 2. 3.	1. Quaternary statisgraphy 2. 3.	1. Quaternary laboratory 2. Expert exchange programs 3.

[Sustainable resource use]	1. coral farming 2. 3.	1. Improved farming techniques 2. 3.	1. . Expert exchange programs 2. 3.
[Marine hazard and disaster]	1. Ballast water studies 2. 3.	1. Monitoring of ballast water organisms 2. 3.	1. Analytical laboratory 2. Expert exchange programs 3.
[Management of key ecosystems]	1. Population dynamics studies of corals 2. 3.	1.Genetic studies 2. 3.	1. Genetic laboratory 2. Expert exchange programs 3.

Mauritius Oceanography Institute Capacity Development Needs

MOI has, over a period of time, engaged in a number of projects in research that may contribute immensely to the monitoring of coastal changes including climate-induced ones. Some of the past and on-going undertakings include

- Study of the Quaternary Geomorphology of Mauritius and Rodriguez
- Molecular bar coding of Marine Organisms in the Republic of Mauritius
- Continental Shelf Project
- African Monitoring of the Environment for Sustainable Development
- Oil and Gas Exploration
- Modelling & mapping oceanic processes of South West Indian Ocean: a satellite-based approach
- Bioprospecting Mauritius waters
- Ballast Water
- Bathymetric survey of the shallow lagoons of Mauritius and Rodriguez
- Genetic connectivity and its implications for the design and management of marine protected areas in the East African Ecoregion
- Development of a pilot project for coral farming for tourism, export, education, research and conservation
- Feasibility of Pearl Oyster Culture in Mauritius
- Geo-spatial Information system for Habitat Mapping of South Eastern coast of Mauritius
- Inventory of the Coral Fauna of Mauritius
- Coral Recruitment
- Database of marine organisms of Mauritius

– Evolutionary and population genetics of scleractinian corals

MOI may benefit from expert exchange programs within the Western Indian Ocean region. This can be done in addition to the provision of advanced equipment linked to the project areas enumerated above

Vision: [To provide accurate and timely weather information and meteorological products for the general welfare of the citizens of the Republic] Priorities: 1. Cyclone and other adverse weather warnings	**Mauritius Meteorological Services** [Institute Name translated to English (if applicable)]	

<table>
<tr>
<td rowspan="2">2. Preparation and dissemination of Weather forecast
3. Climatological services
4. Agrometeorology
5. Marine meteorology

Coastal Adaptation Strategy: [Y/N][If Yes, please indicate year adopted and priority actions]
1.
2.
3.

Collaborating Organizations:
[WMO, France Meteo, SADC, UNFCCC, UNEN (Acronyms)]</td>
<td>Phone: (+230) 6861031
Fax: (+230)6861033
Email: meteo@intnet.mu
Web: metservice.intnet.mu
Address:
St Paul Road
Vacoas</td>
<td>Director:
Y. Boodhoo
Email:
Deputy:
[NAME]
Email:
Admin:
[NAME]
Email:</td>
</tr>
<tr>
<td colspan="2">Ministry:
OFFICE OF THE PRIME MINISTER</td>
</tr>
</table>

Institute Strengths: [PLEASE MODIFY TEXT AS NEEDED]
Human Resources: [Meteorological Services] currently has [XX] professional and administrative staff. Of the [YY] professional staff, [ZZ] have PhD, [WW] have a M.Sc/M.Tech and [VV] have a B.Sc/B.Tech

Infrastructure: [INSTITUTE X] has a [poor, fair, good, very good] power supply. The internet link is [ADSL,] and the connection speed is [100/256] [Kbps] with [approximately] [5] personal computers connected. There are laboratories specialising in Weather forecast, Climatological services, Agrometeorology and Marine meteorology

Publications: In the last 5 years, [XX] researchers affiliated to [INSTITUTE X] have received [YY] publications related to marine and coastal zone issues. [INSTITUTE X] has provided information concerning [Insert Issue] to [Organization(s)] in preparation for COP-15. [If Applicable]

Financial Resources: [INSTITUTE X] has a total budget of approximately [XX] with [YY%] allocated towards projects addressing coastal/marine management issues.

Capacity Development Needs to Address Climate Issues in Coastal Zones

Issues:	**Currently Available Services:**	**Services needed for Adaptation:**	**Capacities Needed for Services:**
[Coastal Hazards (storms & cyclones)]	1. Weather alert systems 2. 3.	1. Improved weather alert systems 2.Information dissemination 3.	1. Advanced analytical methods and models 2. Improved communication systems 3.
[Coastal flooding]	1. 2. 3.	1. Flooding risk areas 2. 3.	1. Mapping of potential inundation 2. Early warning systems 3.
[Insert Issue]	1. 2. 3.	1. 2. 3.	1. 2. 3.

Mauritius Meteorological Services Capacity Development Needs

The objectives are fulfilled through the followings:

– Timely acquisition of real time climate and remotely sensed data.

– Development, maintenance and archiving of quality- controlled meteorological data.

- Data processing, including preparation of climatological statistics.
- Maintaining an up- to- date databank.
- Monitoring space-time evolutions of weather and extreme events in the South West Indian Ocean.
- Timely dissemination of adverse weather warnings.
- Understanding and improvement of the modelling of the processes which affect the current and future state of the atmosphere, weather, water resources, physical state of the oceans and climate change.
- Maximizing of the potential of weather, and climate sensitive natural resources including renewable sources of energy, in support of sustainable development and reduce adverse environmental impacts.
- Close collaboration with international, especially WMO, regional partners, other relevant organisations, academia, the media and the private sector.
- Sensitization of the public, government and other sectoral users in understanding weather and climate and its related applications and their use in planning for socio-economic benefits.
- Establishment of on-line systems to stay in touch with all stakeholders.

The strengthening of the weather services including early warning systems, and implementation of climate models may improve the effectiveness of the Meteorological Services in adaptation capacity of Mauritius.

Vision: [To be a driver, catalyst and facilitator for operators in fisheries business]

Priorities:

1. Carry out research and studies on marine living resources (fish stocks, coral reef etc.);
2. Provide support services to stakeholders of the fishing industry
3. Provide advice to policy on exploitation of living marine resources and conservation of marine
4. Focal point for collaborative research and management as regard regional and international fisheries and marine living resources.

Coastal Adaptation Strategy: [Y/N][If Yes, please indicate year adopted and priority actions]
1.
2.
3.

Collaborating Organizations: [SADC, MPA, NODC, COI, IOTC, SWIOFP, FAO)]

ALBION FISHERIES RESEARCH CENTRE

[Institute Name translated to English (if applicable)]

Phone: +(230) 238 4100, 238 4829
Fax: +(230) 2384184
Email: fisheries@mail.gov.mu
Web: http://www.gov.mu/portal/sites/moasite/fisheries
Address:
Albion, Petite Rivière
MAURITIUS

Director:
[**Mr S SOONDRON**]
Email: ssoondron@mail.gov.mu
Deputy:
[NAME]
Email:
Admin:
[NAME]
Email:

Ministry:
Ministry of Agro Industry & Fisheries (Fisheries Division

Institute Strengths: [PLEASE MODIFY TEXT AS NEEDED]

Human Resources: The Albion Fisheries Research Centre has one substation; La Ferme Fish Farm which, has a total pond rearing area of 4 ha for freshwater aquaculture development. The Centre has a staff strength of some 64 officers in the scientific and technical grade supported by the administrative staff and manual workers

Publications: In the last 5 years, [XX] researchers affiliated to [INSTITUTE X] have received [YY] publications related to marine and coastal zone issues. [INSTITUTE X] has provided information concerning [Insert Issue] to [Organization(s)] in preparation for COP-15. [If Applicable]

Financial Resources: [INSTITUTE X] has a total budget of approximately [XX] with [YY%] allocated towards projects addressing coastal/marine management issues.

Capacity Development Needs to Address Climate Issues in Coastal Zones

Issues:	**Currently Available Services**:	**Services needed for Adaptation:**	**Capacities Needed for Services:**
[Resource , management]	1. 2. 3.	1. Fish stock assessment 2. 3.	1. partnering for ship-based surveys

[Management of ecosystems]	1. 2. 3.	1. Ecological surveys 2. 3.	1. Equipping analytical laboratories 2. 3.
[Coastal hazards]	1. 2. 3.	1. Survey of potential toxic fishes and harmful algae 2. 3.	1. Equipping of analytical laboratories 2. 3.

AFRC Capacity Development Needs

The main activities that are carried out by the Centre which require support can be summarized as such:

- Monitoring of existing fishing activities (including fishing vessels) and fish stock assessment (artisanal, banks and tuna) in order to evolve management measures for their sustainable development.
- Surveys and charting for new or untapped resources or fishing grounds, development of appropriate fishing techniques and provision of advice on exploitation and management of these resources.
- Training of fishermen to enable them to acquire knowledge in fishing techniques, boat handling, engine maintenance, radio communication, survival and safety at sea.
- Collaborative research/studies with regional, international organisation (e.g. the Indian Ocean Tuna Commission (IOTC) for the management of tuna stocks in the Indian Ocean, the Indian Ocean Commission (COI) in fisheries and marine ecosystem monitoring studies and other foreign institutions).
- Development and improvement of aquaculture production techniques. Seed production of marine shrimps and sea breams are being improved for stock enhancement. Red tilapia and sea bream fingerlings are produced for distribution to fish farmers.
- Ecological surveys to monitor and collect base line data on coral reefs and water quality with a view to conservation of aquatic biodiversity and the marine environment.
- Setting up and management of marine protected areas. Two marine parks have been proclaimed at Balaclava and Blue Bay/Le Chaland.
- Enhancement of fish stocks and rehabilitation of ecosystems e.g. release of juveniles and mangroves propagation in the lagoon.

- Production of thematic digital maps of the coastal zone of Mauritius and Rodrigues. These maps will provide information on distribution of coastal marine resources and help in integrated zone management.
- Studies on potentially toxic fishes and harmful algae.
- Monitoring of import and export of fish and fishery products and ensuring quality assurance of imported fish and fish products.

Vision: [To make government services available round-the-clock to better serve the citizens in the digital age] Priorities: – Assist Ministries and Departments	CENTRAL INFORMATION BUREAU [	

<table>
<tr>
<td rowspan="2">to improve effectiveness and efficiency of government services
– Use ICT as an enabler for reviewing processes and streamlining procedures
– Promote rationalisation and sharing of information across the civil service.
– Empower officers with skills to enable them embrace ICT as an effective tool for supporting their day-to day work.
– Propagate the ICT culture within the Civil Service.
Coastal Adaptation Strategy: [Y/N][If Yes, please indicate year adopted and priority actions]
1.
2.
3.

Collaborating Organizations:
[CISD, NCB, ICTA (Acronyms)]</td>
<td>Phone: +230 201 2445
Fax: +230 211 0064
Email: cib@mail.gov.mu
Web:
http://www.gov.mu/portal/site/cib/menuit
Address:
2nd Floor, Belmont House
Intendance Street,
Port Louis</td>
<td>Director:
[Robin Unuth]
Email:
Deputy:
[Ballram Lollbeharree]
Email:
Admin:
[NAME]
Email:</td>
</tr>
<tr>
<td colspan="2">Ministry:
[Ministry of Information Technology & Telecommunications]</td>
</tr>
<tr>
<td colspan="3">Institute Strengths: [PLEASE MODIFY TEXT AS NEEDED]
Human Resources: The CIB team comprises mostly ICT technical staff supported by administrative personnel. There are 12 project managers and 1 system analyst.

Financial Resources: [INSTITUTE X] has a total budget of approximately [XX] with [YY%] allocated towards projects addressing coastal/marine management issues.</td>
</tr>
</table>

Capacity Development Needs to Address Climate Issues in Coastal Zones

Issues:	**Currently Available Services:**	**Services needed for Adaptation:**	**Capacities Needed for Services:**
[Information & communication technology]	1. Consultancy 2.Project management 3.ICT training	1. Improvement on staff skills 2. Improvement on infrastructure 3.	1.Training of personnel 2. Equipment purchase 3.
[Salinization of Aquifers]	1. 2. 3.	1. 2. 3.	1. 2. 3.
[Coastal flooding]	1. 2. 3.	1. 2. 3.	1. 2. 3.
[Insert Issue]	1. 2. 3.	1. 2. 3.	1. 2. 3.

CIB Capacity Development Needs

The Central Informatics Bureau (CIB), created in 1989, is a unit of the Ministry of Information Technology and Telecommunications whose main functions are to plan and coordinate computerisation within the Civil Service.

CIB has been offering the following services and which can be improved on to strengthen their service delivery:

- Consultancy Services: Assist Ministries and Departments in identifying opportunities for improving their respective services through ICT.
- Project Management: Manage ICT projects with the collaboration of end-users
- ICT Procurement: Assist the Civil Service in ICT-related procurement by drawing specifications and evaluating project proposals
- Standards and Quality Assurance: Specify standards, quality assurance schemes and procedures for project implementation
- System support: Ensure, with the help of the Central Information Systems Division (CISD), on-going support for operational systems
- Post Implementation Audit: Post-Implementation evaluation and enhancements of existing information systems
- Training: Plan and monitor training programmes for all categories of officers in the Civil Service

MINISTRY OF ENVIRONMENT AND NDU

[Institute Name translated to English (if applicable)]

Vision: [Mauritius reaches environmental sustainability and we have a clean and healthy environment that Mauritian are proud of]

Priorities:
1. Identification and demarcation of environmentally sensitive areas in Mauritius and Rodriguez
2. Development of an integrated coastal zone management (iczm) framework
3.
4.

Coastal Adaptation Strategy: [Y/N][If Yes, please indicate year adopted and priority actions]
1.
2.
3.

Collaborating Organizations:
UNEP

Phone: +(230) 203 6200 - 6210

Fax: +(230) 211 9524; +(230) 212 8324
Email: menv@mail.gov.mu
Web:
http://www.gov.mu/portal/site/menvsite
Address:
Ken Lee Tower, Cnr Barracks & St Georges Streets,
Port-Louis.

DIRECTOR:
[Mrs. Sin **Lan NG YUN WING EBALUCK**]
Email: dirdoe@mail.gov.mu

Deputy:
[Mr. Oomaduth **JADOO**]
Email: ojadoo@mail.gov.mu
Admin:
[NAME]
Email:

Ministry:
[INSERT MINISTRY REPORTED TO]

Institute Strengths: [PLEASE MODIFY TEXT AS NEEDED]
Human Resources: [The Department of Environment in the Ministry has 10 Divisional Environmental officers who are graduate level in education, and other specialized trainings.

Capacity Development Needs to Address Climate Issues in Coastal Zones

Issues:	**Currently Available Services:**	**Services needed for Adaptation:**	**Capacities Needed for Services:**
[Coastal Management]	1. 2. 3.	1. Sensitivity mapping of the environment 2. Development of ICZM framework 3.	1. Expert advice 2. Capacity development 3.
[Salinization of Aquifers]	1. 2. 3.	1. 2. 3.	1. 2. 3.
[Coastal flooding]	1. 2. 3.	1. 2. 3.	1. 2. 3.
[Insert Issue]	1. 2. 3.	1. 2. 3.	1. 2. 3.

Ministry of Environment Capacity Development Needs

In order to fulfill the national mandate, the ministry has initiated activities in the following areas:

- Review of ambient and emission of air standards as well as Fuel standards for vehicles.
- Training of enforcement officers and dissemination of information
- Involving local authorities to assume more important role in pollution control, environmental management and development control
- Controlling the smoke emissions from vehicles through opacity testing.
- Move towards helping industries in shifting towards more fuel efficient and sustainable patterns of production, and changing consumer behaviours
- Formulation of a green procurement policy for government to provide the framework for use of green products and recycling
- Stronger collaboration with the academic and research community to answer new research questions about the state of our environment.
- Establishing an Environmental Information System through which the ministry will publish sustainable development indicators
- Publication of an environment action plan for Mauritius
- Partnerships with media and NGOs
- Tree planting campaigns
- Award scheme to recognize outstanding individuals, organizations and companies that are role models of environmental protection.
- Strengthen the integration of environment as a cross-cutting issue in government development efforts.
- Adhering to the international code of conduct through relevant conventions and protocols.
- Implementation of the management of Persistent organic pollutants (POPs) under the Stockholm Convention.

Since most of the activities are coordination in nature, the Ministry needs a bigger budget both to employ more qualified personnel as well document production processes including meetings and conferences.

2.1.4.5 Seychelles

National Synopsis

EFFECTIVENESS OF THE NATIONAL INSTITUTES IN SEYCHELLES ON CLIMATE CHANGE ISSUES

From various reviews including the Intergovernmental Panel on Climate Change (IPCC) resources the critical areas that have been considered in the assessment of impacts, adaptation and vulnerability to climate change include:

- Fresh water resources and their management: - The impacts of climate change on freshwater systems and their management are mainly due to the observed and projected increases in temperature, sea level and precipitation variability.
- Ecosystems, their properties and goods: - During the course of this century the resilience of many ecosystems (their ability to adapt naturally) is likely to be exceeded by an unprecedented combination of change in climate, associated disturbances (e.g., flooding, drought, wildfire, insects, ocean acidification) and in other global change drivers (especially land-use change, pollution and over-exploitation of resources), if greenhouse gas emissions and other changes continue at or above current rates.
- Food, fibre and forest products: - In mid- to high-latitude regions, moderate warming benefits crop and pasture yields, but even slight warming decreases yields in seasonally dry and low-latitude regions.
- Industry, settlement and society: - Climate-change vulnerabilities of industry, settlement and society are mainly related to extreme weather events rather than to gradual climate change.

As far as the coastal and marine environment is concerned the above issues are equally quite pertinent and require effective interventions to reduce or

eliminate the predicted impacts. The functions of Seychelles institutes required to render support in these include research, funding and regulations.
The Republic of Seychelles comprises 115 islands between 4 and 11 south of the equator. Geopolitically part of the African continent, the islands are situated off the Eastern Africa coast. The total land area is 455 square kilometres (45,250 hectares). The climate is humid and tropical with the mean annual rainfall ranging from 1,500 to 2,500 mm. Temperatures range from a minimum of 24o C to a maximum of 30o C.
The granitic Seychelles consists of 41 islands and islets built of pre-Cambrian rock approximately 650 million years old formed from the break-up of Gondwanaland some 130 million years ago by tectonic activity. The islands rise from the Seychelles Bank, a shoal area of about 31,000 square kilometres, with depths ranging up to 60 m. The islands rise to a maximum of 914 m at Morne Seychellois on Mahe. The granitic islands are typically rugged and hilly. The 74 coral islands consist of two types: low sand dunes such as Bird and Denis Islands and elevated reef limestone such as the Aldabra group. The coral islands are low, although sand dunes on some islands may reach as high as 32 m.
The bulk of the population, infrastructure and development is located on the so-called plateau of the main granitic island of Mahe. The plateau, which lies up to two meters above sea level, is a discontinuous elevated terrace that runs along the shore in a narrow band and consists of calcareous reef material. Much of the soils of the granitic islands (excepting Silhouette and North islands) consist of Seychelles Red Earth, a laterite formed from weathered granite.
The marine areas of the granitic islands have been classified as rocky shores or sandy beaches, rippled sand zone, marine grass beds, radial zone, algal ridge, reef edge, and outer slopes. Fringing reefs are found along only a few

parts of the coastline on the granitic islands. On the Mahe East Coast, the longest fringing reef in the granitic islands has been partially destroyed by coastal reclamation.

Policies and Institutional Framework

The Seychelles does not possess an institution solely dedicated to marine science as a discipline or activity. Institutions whose activities concern marine science are few. The Fishing Authority is the only recognisable entity whose mandate covers the marine realm. Nevertheless, it confines itself within the immediate sector of fisheries resources. The majority of the organisations that are involved in marine science are governmental departments.

A clear-cut national policy governing overall marine science is generally lacking in Seychelles. This is surprising since the two main industries, fisheries and tourism are marine-based. The Environmental Management Plan of Seychelles states in its introduction that: “The challenge for the 1990’s is to implement an integrated national plan to manage and protect 115 islands and marine resources spread over 1.3 million sq. km”. The efforts of the Government have in fact been to foster policies which bear directly upon national development. In the National Development Plan (1990-1994), now replaced by the Public Sector Investment Program, under Chapter 24, Science and Technology, it is stated that “the Government has long realised that it is impossible to foster and achieve an integrated and comprehensive development without the utilisation of science and appropriate technology”. Policies that do exist therefore concern marine resources with economic or conservation value.

The Seychelles has signed and ratified several international conventions of relevance to marine science. It is noted here that corresponding national legislation for the implementation of these conventions at a local level is weak, with the exception of the main provisions in the United Nations

Convention on Law of the Sea (as found in the Seychelles Maritime Zones Act).

INSTITUTIONS

There is a wide range of institutions involved in one way or another to the management of marine resources. The functions include fisheries research and regulation, marine protected areas, and marine conservation. Existing human resources involved in marine sciences from the aforementioned institutions have been reviewed in past surveys. It was found that young technical staff often moves from one organisation to another to better their economic prospects. As a result there are many, such as teachers, consultants and other professionals, in various sectors whose skills and qualifications may be of importance and relevance to marine science, but who are not available. There is a lack of human resources in most fields of critical importance to marine sciences.

Training and support of technicians and scientists in key fields such as oceanography and coral reef ecology are necessary. State of ecology and human induced impacts, need to be studied to assist policy makers and the general public.

Marine research priorities in Seychelles should concentrate on coastal physical oceanography, coral reef systems ecology, coastal geology, ichthyology and aquaculture. Integrated Coastal Zone Management should be adopted for the purpose of sustainable development of the islands.

There are also opportunities in involving NGOs, in particular children groups such as Wildlife Clubs of Seychelles for creating a pool of future stakeholders and experts.

Legislation regulating marine science activities such as bioprospecting and the collection of organisms for commercial research purposes, release of organisms (natural or genetically modified,) as well as management of keystone and endangered species and taxa such as corals should be enacted, monitored and enforced.

Vision: [carry out and co-ordinate research and monitoring programmes on environmental and natural resource management issues (e.g. water resources management in land and coastal erosion, sand and granite quarrying).]	**Department of Environment – coast/ocean** [Institute Name translated to English (if applicable)]	

<table>
<tr>
<td rowspan="2">Priorities:
1. coral reefs
2. mangroves
3. marine species conservation
4. coastal management
5. Coastal and marine pollution
6. Beach management program
7. Small island voice

Coastal Adaptation Strategy: [Y/N][If Yes, please indicate year adopted and priority actions]
1.
2.
3.

Collaborating Organizations:
[INSERT NATIONAL AND INTERNATIONAL PARTNER ORGANIZATIONS (Acronyms)]</td>
<td>Phone: + 248 670 443
Fax: + 248 610 637
Email:
Web: www.env.gov.sc
Address:
P.O.Box 445, Victoria,
Mahe, Seychelles.</td>
<td>Director:
[Alain De Comarmond]
Email: a.deco@env.gov.sc
Deputy:
[NAME]
Email:
Admin:
[NAME]
Email:</td>
</tr>
<tr>
<td colspan="2">Ministry:
[Ministry of Foreign Affairs, Planning and Environment.]</td>
</tr>
</table>

Institute Strengths: [PLEASE MODIFY TEXT AS NEEDED]

Human Resources: [Director of Conservation, Conservation Officer, Research Officer, Director, Environmental Assessment
and Pollution Control, Assistant Director Environmental Assessment, Assistant Director Pollution Control, Senior Biochemist, 6 Environmental Inspectors, National Co-ordinator (COI), Technical Advisor (COI), and Socio-Economist (COI).

Infrastructure: [INSTITUTE X] has a [poor, fair, good, very good] power supply. The internet link is [dial-up, ADSL, VSAT, etc.] and the connection speed is [XX] [in Mbps or Kbps] with [approximately] [XX] personal computers connected. There are [YY] laboratories specializing in [Please insert fields researched]. Data collection at sea is done using [research vessels, moored and/or drifting buoys, installed equipment]. 1 mobile laboratory, 1 Environmental Resource Centre (documentation)

Publications: In the last 5 years, [XX] researchers affiliated to [INSTITUTE X] have received [YY] publications related to marine and coastal zone issues. [INSTITUTE X] has provided information concerning [Insert Issue] to [Organization(s)] in preparation for COP-15. [If Applicable]

Financial Resources: [INSTITUTE X] has a total budget of approximately [XX] with [YY%] allocated towards projects addressing coastal/marine management issues.

Capacity Development Needs to Address Climate Issues in Coastal Zones

Issues:	**Currently Available Services:**	**Services needed for Adaptation:**	**Capacities Needed for Services:**
[Coastal Erosion]	1. Beach monitoring 2. 3.	1. Shoreline management plan 2. 3.	1. skills on development of shoreline management guidelines 2. 3.

[Salinization of Aquifers]	1. 2. 3.	1. 2. 3.	1. 2. 3.
[Environmental issues]	1. Public participation 2. 3.	1. 2. 3.	1. 2. 3.
[Insert Issue]	1. 2. 3.	1. 2. 3.	1. 2. 3.

Department of Environment Capacity Development Needs

Mangroves were very abundant in the east coast of Mahe during the eighteenth century. However, at present, there has been a significant reduction in the density of these near offshore mangrove forests, which were close to river mouths and marshlands. Loss of wetlands has been a result of pressures of development, reclamation, drainage, and pollution.

Diversion and resource exploitation is unknown but believed to be excessive. Such destruction of freshwater wetlands has not only reached a critical level but is becoming repetitive.

In order to regularize the developmental activities along and in the wetlands, mapping and classification of the coastal wetlands of the Seychelles has been carried out. In addition the following activities require implementation:

- Establishing national and regional sea level and sea temperature monitoring network;
- Monitoring of coastal circulation and coastal erosion;
- Assessment of organic carbon accumulation in surface coastal sediments;
- Monitoring of benthic communities of coral reef ecosystem;
- Improvement of coastal planning and enforcement;
- Assessment of the impact of tourism
- Disaster preparedness- strategies and measures; hazard analysis; insurance and other sustainable financial mechanisms for construction after disaster losses.
- Assessment of cost effective adaptation options (policy and technical) for sea level rise;
- Economic and legal instruments for the protection of the coastal zone

The following projects are being undertaken:

Beach Monitoring Program

The Unit has started its beach monitoring program to monitor the Seychelles' beaches in terms of their recovery, stability and erosion. The program will primarily be implemented in partnership with hotels located on the chosen beaches to achieve the following.

- To establish a long term monitoring system for the Seychelles' beaches
- To establish a database of beach profile data for the Seychelles, enabling a more effective shoreline/beach management approach

Small Island Voice 2004

Seychelles was chosen as a start up island in the Indian Ocean for a project named Small Island Voice 2004 which will ensure that the voice of civil society in small islands is heard and taken into account such that it becomes an effective catalyst for on-the-ground activities. Views of local communities on development and environmental issues will be taken. The project was officially launched in Seychelles on the 18th March 2002.

Sea level monitoring

The Pointe La Rue tide gauge was installed on 11th January 1993 and located at 04° 40.3S and 055° 31.7E as a GLOSS station. Instrument type is the float/well, Handar 436-A, Encoder 436-B. The gauge was a contribution of the University of Hawaii Sea Level Center in Honolulu, and was installed by personnel from the University of Hawaii. It is now under the responsibility of the Meteorological Office of the Directorate of Civil Aviation. The Survey Division of the Ministry of Land Use and Habitat in 1992 established the benchmark for that particular station.

Vision: To secure a sustainable ocean through research, conservation and management Priorities: 1. 2.	**Seychelles National Parks Authority (SNPA)- includes terrestrial and marine parks** [Institute Name translated to English (if applicable)]	

3. 4. <u>Coastal Adaptation Strategy</u>: NO <u>Collaborating Organizations</u>: Local NGOs, Global Vision International (GVI), Earth watch.	<u>Phone</u>: +248 225114 <u>Fax</u>: +248 224388 <u>Email</u>: info@scmrt-mpa.sc <u>Web</u>: www.scmrt-mpa.sc <u>Address</u>: P.O. Box 1240 Victoria Mahé Seychelles	<u>Director:</u> Mr. Rony Renaud Email: r.renaud@scmrt-mpa.sc <u>Deputy:</u> Mr. Rodney Quatre Email: r.quatre@scmrt-mpa.sc <u>Admin</u>: Ms. Christelle Betsy Email: c.betsy@scmrt-mpa.sc
	<u>Ministry</u>: Ministry of Environment, Natural Resources and Transport (MENRT)	

<u>Institute Strengths</u>: [PLEASE MODIFY TEXT AS NEEDED]
Human Resources: SNPA currently has 20 professional and administrative staff. Of the 20 professional staff, 0 have PhD, 0 have a M.Sc/M.Tech and 7 have a B.Sc/B.Tech

Infrastructure: SNPA has a very good power supply. The internet link is ADSL and the connection speed is [XX] [in Mbps or Kbps] with [approximately] 7 personal computers connected. There is 1 laboratory specializing in wet and dry specimen analysis. Data collection at sea is done using Research boat from SNPA or specialized research vessel from the Fishing Authority.

Publications: In the last 5 years, 5 researchers affiliated to the Marine Research Section have received 15 publications related to marine and coastal zone issues. [INSTITUTE X] has provided information concerning [Insert Issue] to [Organization(s)] in preparation for COP-15. [If Applicable]

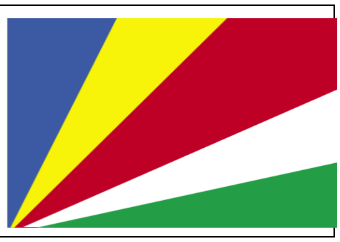
Financial Resources: [INSTITUTE X] has a total budget of approximately SR3million with ~10% allocated towards projects addressing coastal/marine management issues.

<u>Capacity Development Needs to Address Climate Issues in Coastal Zones</u>

Issues:	**Currently Available Services:**	**Services needed for Adaptation:**	**Capacities Needed for Services:**
[Coastal Erosion]	1. 2. Beach profiling data collection every month 3.	1. 2. mitigation measures 3.	1. 2. Equipment 3. Additional and advanced training in such field.
[Salinization of Aquifers]	1. None 2. 3.	1. N/A 2. 3.	1. N/A 2. 3.
[Coastal flooding]	1. management plans 2. task force 3.	1. 2. 3.	1. 2. 3.
[Reef restoration]	1. coral transplant 2. 3.	1. proper guidelines and protocols 2. 3.	1. Training in coral biology and reef management. 2. 3.

[Institute X] Capacity Development Needs

[Please insert text of not more than 1 page explaining the capacities that are needed in order for this institute to provide the services needed to adapt to climate issues in coastal zones]

Vision: [INSERT BRIEF INSTITUTE VISION] Priorities: 1. Conservation of the coralline outer islands of Seychelles 2. Conservation of the Aride Island Nature Reserve in the granitic islands of	**Island Conservation Society (ICS)** [Institute Name translated to English (if applicable)	

<table>
<tr>
<td rowspan="2">Seychelles.
3. Conservation, rehabilitation and educational programmes throughout the islands of Seychelles.

Coastal Adaptation Strategy: [Y/N][If Yes, please indicate year adopted and priority actions]
1.
2.
3.

Collaborating Organizations:
[CHRISTOPHER CADBURY TRUST; AFRICAN BIRD CLUB; INTERNATIONAL SMALL ISLANDS STUDIES ASSOCIATION; ISLANDS DEVELOPMENT COMPANY; MARINE CONSERVATION SOCIETY SEYCHELLES; SHARK RESEARCH INSTITUTE SEYCHELLES; MINISTRY OF ENVIRONMENT; NATURE PROTECTION TRUST OF SEYCHELLES; PLANT CONSERVATION ACTION GROUP; RSWT; SBRC; SIF
(Acronyms)]</td>
<td>Phone: (248) 375354
Fax: (248) 376341
Email:
Web: http://islandconservationsociety.com
Address:
P.O Box 775
Victoria
Seychelles</td>
<td>Director:
Mary Stravens
Email: icsceo@seychelles.sc
Deputy:
[NAME]
Email:
Admin:
[NAME]
Email:</td>
</tr>
<tr>
<td colspan="2">Ministry:
[N/A]</td>
</tr>
</table>

Institute Strengths: [PLEASE MODIFY TEXT AS NEEDED]
Human Resources: [ICS] currently has [XX] professional and administrative staff. Of the [YY] professional staff, [ZZ] have PhD, [WW] have a M.Sc/M.Tech and [VV] have a B.Sc/B.Tech

Infrastructure: [ICS] has a [very good] power supply. The internet link is [microwave wireless] and the connection speed is [128/512] [Kbps] with [approximately] 8] personal computers connected. There are water temperature and ornithology studies on-going].

Publications: In the last 5 years, [XX] researchers affiliated to [INSTITUTE X] have received [YY] publications related to marine and coastal zone issues. [INSTITUTE X] has provided information concerning [Insert Issue] to [Organization(s)] in preparation for COP-15. [If Applicable]

Financial Resources: [INSTITUTE X] has a total budget of approximately [XX] with [YY%] allocated towards projects addressing coastal/marine management issues.

Capacity Development Needs to Address Climate Issues in Coastal Zones

Issues:	**Currently Available Services:**	**Services needed for Adaptation:**	**Capacities Needed for Services:**
[Sustainable resource use]	1. 2. 3.	1. 2. 3.	1. 2. 3.
[Management of key ecosystems]	1. Ecosystem research 2. 3.	1. Coral reef ecosystem studies 2. 3.	1. Research funding 2. 3.

[Shoreline changes]	1. Multi-disciplinary task teams 2. 3.	1. Investigation of shoreline changes 2. 3.	1. Training on shoreline models 2. 3.
[Coastal tourism]	1. Ecotourism 2. 3.	1. Purchase of critical area for direct ownership 2. 3.	1. Funding donations 2. 3.

Island Conservation Society Capacity Development Needs

The society is involved in the preservation, restoration and enhancement of island ecosystems and associated marine environment, the protection of their natural and cultural assets, with particular reference to all the outer islands of Seychelles and the smaller granitic islands. In order to do so a number of programs are being pursude including:

- Conservation programmes based on non-intrusive, non-damaging activities such as ecotourism, through agreements with owners, lease or direct ownership.
- The development of public awareness regarding the biodiversity value of Seychelles islands through publications, lectures, papers and other means.
- The establishment of a multi-disciplinary group of persons with expertise in all aspects of the natural sciences and conservation management, history and cultural heritage of islands.
- The development of local community participation in conservation and other activities which promote sustainable development, gender balance and equitable access to resources.
- Raising and disbursing funds for research and implementation of programmes to further the goal of the Society.
- Information databases to assist those engaged in research concerning the islands of Seychelles.
- International co-operation to exchange experience, expertise and information with other organisations that share similar objectives.
- National and international awareness on the vulnerability and vital importance of islands to the preservation of the planet's biodiversity.

Vision: [ensuring that Seychelles World Heritage sites are well-managed protected areas where conservation, research, education and nature appreciative and protective tourism are sustainably balanced and financially viable.]

Priorities:

1. Overall population models
2. Population studies of fish (including sharks) and marine mammals
3. Turtle satellite tracking
4. Connectivity
5. Lagoon study (already in the pipeline)
6. Seabirds
7. Further turtle studies (ecological)
8. Fish aggregations
9. Sea cucumbers
10. Coral resilience

Coastal Adaptation Strategy: [Y/N][If Yes, please indicate year adopted and priority actions]

1.
2.
3.

Collaborating Organizations:
[UNESCO, Worldfishcenter, FAO, Nature Conservancy, Earth watch(Acronyms)]

Seychelles Island Foundation (SIF)
[Institute Name translated to English (if applicable)]

Phone:+ 248 224030.
Fax: +24825131
Email: sif@seychelles.net
Web: www.sif.sc
Address:
P.O.Box 853, Independence House, Victoria, Mahe, Seychelles.

Director:
[Dr. Frauke Fleischer-Dogley]
Email: sif@seychelles.net
Deputy:
[Mr. Lindsay Chong-Seng]
Email:
Admin:
[NAME]
Email:

Ministry:
[INSERT MINISTRY REPORTED TO]

Institute Strengths: [PLEASE MODIFY TEXT AS NEEDED]

Human Resources: SIF currently has [36] professional and administrative staff. Of the [15] professional staff, [ZZ] have PhD, [WW] have a M.Sc/M.Tech and [VV] have a B.Sc/B.Tech.

Infrastructure: [INSTITUTE X] has a [poor, fair, good, very good] power supply. The internet link is [dial-up, ADSL, VSAT, etc.] and the connection speed is [XX] [in Mbps or Kbps] with [approximately] [XX] personal computers connected. There are [YY] laboratories specializing in [Please insert fields researched]. Data collection at sea is done using [research vessels, moored and/or drifting buoys, installed equipment]. Facilities (Headquarters and Aldabra Research Station) and relevant Equipment and
1 Rapid Response boat, 3 aluminium boats, SCUBA equipment and Compressor, Research Station with labs and photo darkroom, Scientists quarters, Library.

Publications: In the last 5 years, [XX] researchers affiliated to [INSTITUTE X] have received [YY] publications related to marine and coastal zone issues. [INSTITUTE X] has provided information concerning [Insert Issue] to [Organization(s)] in preparation for COP-15. [If Applicable]

Financial Resources: [INSTITUTE X] has a total budget of approximately [XX] with [YY%] allocated towards projects addressing coastal/marine management issues.

Capacity Development Needs to Address Climate Issues in Coastal Zones

Issues:	**Currently Available Services**:	**Services needed for Adaptation:**	**Capacities Needed for Services:**

[Coastal Erosion]	1. 2. 3.	1. 2. 3.	1. 2. 3.
[Salinization of Aquifers]	1. 2. 3.	1. 2. 3.	1. 2. 3.
[Coastal flooding]	1. 2. 3.	1. 2. 3.	1. 2. 3.
[Insert Issue]	1. 2. 3.	1. 2. 3.	1. 2. 3.

SIF Capacity Development Needs

According to the Seychelles Islands Foundation Decree, 1979, the Foundation is responsible for management and conservation of natural life of the group of islands comprising the atoll of Aldabra and any other land in the Seychelles, as well as, initiating research in such natural life.

The unique nature of these islands is recognised from the following features:
– The world’s largest raised coral atoll.
– The world's largest giant tortoise population.
– Some of the world's most spectacular seabird colonies.
– The largest intact coco-de-mer forest and many other endemic trees, plants and animals.
– Unique birds, including the last surviving flightless bird of the Indian Ocean, the Aldabra Rail, and the endangered Seychelles Black Parrot.

The need to conserve these islands will be more pressing when climate change creates adverse conditions. This will result in increased funding to set up conservation studies, clean tourism, and reduction of human induced stresses.