

Project Proposals on COASTAL EROSION

ASSESSMENT OF THE VULNERABILITY OF SUB-SAHARAN COASTAL ZONES TO THE DIFFERENT IMPACTS OF CLIMATE CHANGE (INCLUDED SEA LEVEL RISE)

1. Identifiers

Project Number: COS3

Project Title: Assessment of the vulnerability of sub-Saharan coastal zones to the different impacts of climate change (included sea level rise)

Tentative requesting Côte d'Ivoire, The Gambia, Ghana, Kenya, Mauritius, Mozambique, Nigeria, Senegal, Seychelles, Tanzania

Countries:

Requesting National Organizations:

Cote d'Ivoire : Ministère de l'Enseignement Supérieur et de la Recherche Scientifique
The Gambia: National Environmental Agency (NEA)
Ghana: Ministry of Environment & Science
Kenya : Kenya Marine and Fisheries Research Institute (KMFRI)
Mauritius: Ministry of Environment
Mozambique : Ministry of Coordination and Environmental Affairs
Nigeria: Federal Ministry of Environment
Senegal : Ministère de la Jeunesse, de l'Environnement et de l'Hygiène Publique
Seychelles : Ministry of Environment
Tanzania : Vice President's Office, Department of Environment

Executing Agencies:

Cote d'Ivoire: Centre de Recherches Océanographiques
The Gambia: National Environmental Agency (NEA), Coastal and Marine Environment Working Group
Ghana: Ghana Surveys Department, Hydrological Services Department, Environmental Protection Agency
Kenya : Kenya Marine and Fisheries Research Institute (KMFRI)
Mauritius: Ministry of Environment, Meteorological Services and the Mauritius Oceanographic Institute
Mozambique : Ministry of Coordination and Environmental Affairs
Nigeria : Federal Ministry of Environment, Ministry of Agriculture, Nigerian Institute for Oceanography and Marine Research (NIOMR)
Senegal : Direction de l'Environnement et des Etablissements Classés
Seychelles : Climate Centre
Tanzania : National Environment Management Council

Required National Partners:

Cote d'Ivoire: Port Autonome d'Abidjan, Centre Ivoirien Anti Pollution, Université de Cocody
The Gambia: Department of State for Finance & Economic Affairs, Chamber of Commerce

Ghana: Researchers in Universities and Research Institutions
Kenya: Ministry of Environment and Natural Resources, National Environment Management Authority, Meteorological Department Kenya Wildlife Service, Coastal Development Authority

Mauritius: Ministry of Fisheries, Mauritius Oceanography Institute, Ministry of Housing and Lands, Ministry of Economic Development, FS & CA, AHRIM, NGOs

Mozambique: National Institute of Meteorology, Eduardo Mondlane University, National Directorate of Water, Ministry of Public Works and Housing

Nigeria : Nigerian Institute for Oceanography and Marine Research (NIOMR), OPTDS (Oil Industry), Niger Delta Development Authority (NDDA), Center for Climate Change

Sénégal : Département de Géologie et LPA de l'Université Cheikh Anta Diop, Equipe Vulnérabilité des zones côtières, Direction des Phares et Balises (PAD)

Seychelles: Ministry of Land Use & Habitats and others

Tanzania Ministry of Natural Resources and Tourism

Priority Issue Addressed: 20. Sea level change; 12-13 Modification/loss of ecosystems; 1: Modification of stream flows

Regional Scope: Sub-Saharan African coastal countries

Project Location: Coastal zones of all the requesting countries
The Gambia: Allahein River to Cape Point, Banjul Island
Kenya: Ghazi village
Mozambique: Southern Mozambique (Limpopo and Incomati river basin), Zambezi river basin and Pungo river basin.
Tanzania : Dar es Salaam and Zanzibar
Other countries: all their coastline

Project Duration: 5 years

Working Group of the African Process Coastal Erosion

2. Summary:

The main objective of this project is to carry out a more in depth assessment of the vulnerability of sub-Saharan coastal zones to the different impacts of climate change in a more integrated approach. The project will not only address the impacts of sea level rise through the determination of historical trends in sea level rise but also the mapping of vulnerable areas based on existing V&A studies. This will be completed by vulnerability analyses including the impacts of other parameters of climate change (temperature, precipitations) on the salinisation of waters, on ecosystems and socio-economic sectors as well as on identification and evaluation of adaptation options.

Specific objectives will be:

- o Measurement of historical sea level rise;
- o Identify vulnerable coastal zones areas and/or sectors to climate change;
- o Characterize this vulnerability and;
- o Identify and select adaptation options with a regional context.

Expected results are:

1. Data on historical sea level rise;
2. Maps of vulnerable coastal zones by countries and at a regional level;
3. Documentation on the different types of expected impacts;
4. Database on potential adaptation options;
5. Adaptation strategies.

These results will constitute databases at national and sub-regional level that could be used by the country to prepare their next national communication to the UNFCCC, but also to develop their national adaptation strategy to the impacts of climate change in the coastal zones considered. In this sense, it is considered that the project will not only benefit from the project on coastal erosion protection that could help to define adaptation options but also feed into the project on coastal zone management by allowing the countries to integrate the effects of climate change in the design of their integrated coastal zone management plans.

At a regional level, the results could allow a better understanding of the vulnerability of the African coastal zones. They could also been used to develop adaptation strategies as part of national sustainable development plans. In the NEPAD context these adaptation strategies could help to better design some infrastructures that are considered under this strategy.

The main beneficiaries will be the governmental institutions that could integrate the adaptation strategies in their national policies for a sustainable development but also could take in consideration coastal zones at risk in their urban development, infrastructures and other kind of development activities envisaged in the near future. The results could also, as previously mentioned, be considered for the preparation of the second national communication to the UNFCCC. Private companies could equally be interested in the location of vulnerable coastal areas in order to invest in a more sustainable way. The scientific community could benefit from these results, particularly the IPCC which is seeking for more information on the consequences of global warming on the African continent. Bilateral and multilateral agencies will certainly consider the information issued specially in their consideration of the most urgent needs of the countries.

3. Costs and Financing (Million US \$)¹

International & bilateral sources:

Required financing by potential source	:	US\$ 7.3 million
Subtotal international financing	:	

Co-financing:

Governments in cash & kind	:	US\$170,603
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¹ This budget is preliminary and has not undergone a full consultation process with the respective countries. Therefore, does not indicate the actual financial commitment that would be provided by participating countries once the project proposal and its components are finalised.

Total Project Cost: Subtotal Co-financing : : approx. US\$8 million

4. Government Endorsement(s)

Cote d'Ivoire : Ministère de l'Environnement et du Cadre de Vie
The Gambia:

Ghana: Ministry of Environment & Science

Kenya: Kenya Marine and Fisheries Research Institute (KMFRI) (Ministry of Agriculture and Rural Development), Ministry of Environment and Natural Resources.

Mauritius:

Mozambique: Ministry of Coordination and Environmental Affairs

Nigeria: Federal Ministry of Environment

Sénégal: Ministère de la Jeunesse, de l'Environnement et de l'Hygiène publique

Seychelles: Mr Lousteau-Lalane, Principal Secretary, Ministry of Environment

Tanzania: Minister of State in Vice President's Office, Department of Environment

5. Government Focal Point(s)

Cote d'Ivoire : Département Environnement du Centre de Recherches Océanographiques

The Gambia:

Ghana: Ministry of Works and Housing

Kenya : : Director, Kenya Marine and Fisheries Research Institute (KMFRI)

Mauritius: Ministry of Environment

Mozambique : Telma Manjate, National Directorate of Environmental Management

Nigeria : Larry Awosika, Nigerian Institute for Oceanography and Marine Research (NIOMR)

Senegal : Mme Fatimata Dia-Toure, Direction de l'Environnement et des Etablissements Classés, Ministère de la Jeunesse, de l'Environnement et des Etablissements Classés

Seychelles : Mr Rolph Payet, Director General, Policy planning, Ministry of Environment

Tanzania : Institute of Marine Sciences

6. African Process Working Group Focal Point(s)

Dr Isabelle NIANG-DIOP, University Cheikh Anta Diop of Dakar, Senegal. Regional coordinator of the Working Group on coastal erosion

Dr Alphonse DUBI, University of Dar es Salaam, Tanzania

Dr Delphine MALLERET-KING, Private consultant, Kenya

PROJECT DESCRIPTION

1. Background & Justification:

According to the World Resources (UNDP/UNEP/WB/WRI, 2000), sub-Saharan Africa has a total coastal length of 63,124 km with important ecosystems like beaches, mangroves, coral reefs and sea grass that not only have a rich biodiversity but also constitute important resources upon which the society and the economy are based. In the coastal area, defined as the zone comprised between the mean sea level and a distance of 100 km inside, the population represents between 3 and 91% of the total population of sub-Saharan Africa. For the requesting countries, this population represents between 7.6 and 90.8% of their total population. Based on slightly different definition of the coastal zone (within 60 km from the coastline), the World Bank indicated that in 1994, about 86.3 million people lived in this area between Mauritania and Somalia and it was expected that this number will dramatically increase in the next decade with an intense urbanization of the coast (Hatzilios *et al.*, 1996). The same document predicted that by 2025, the coastal zone between Accra and the Niger delta will be a continuous chain of cities with a total population of 50 million. Important economic activities like fisheries, tourism, agriculture as well as crucial infrastructures (roads, harbours) and cities are located in the coastal zones of sub-Saharan Africa. It is recognized that the Sub-Saharan African coastal zone is already subject to environmental degradation, destructive practices or unsustainable use of resources that weaken the ecosystems, deteriorate the quality of life and endanger the economic activities in the coastal zone. Climate change and in particular sea level rise will add pressures on the coastal zones leading mainly to a deterioration of the space, ecosystems, infrastructures and economic activities and may also exacerbate the scale of the current pressures. This would threaten the livelihood and development options of the coastal areas and of the countries.

1. **Climate Change: a major threat for the coastal zones in Sub-Saharan Africa**

Since the beginning of the first studies on the impacts of climate change in Africa, it appeared clearly that climate change will have huge consequences on the coastal zones, specially on small islands (Ibe and Awosika, 1991; Saha, 1991; Alusa and Ogallo, 1992; Hoozemans *et al.*, 1993; Ibe and Ojo, 1994; Smith *et al.*, 1996). This is first due to their morphology – mainly low lying coasts with numerous estuaries and deltas but also small islands, the presence of important ecosystems (mangroves, coral reefs) that are highly sensitive to climate parameters and then to the high concentration of population and economic activities along these littorals based on a high dependency of the national economies on the natural resources (beaches, halieutic resources, oil, sand, ...). Among all the expected climatic modifications, sea level rise is the most certain change and most of the studies have been restricted to an analysis of the consequences of sea level rise in the coastal zones. Under this respect small islands are considered particularly vulnerable due to the limited space they have to relocate populations and activities. The main biophysical impacts of sea level rise, as defined by the second IPCC assessment, are mainly: increased coastal erosion, more extensive coastal inundation, higher storm surge flooding, salinisation of surface and ground waters, loss of wetlands (Bijlsma *et al.*, 1996). Ibe and Ojo (1994) also indicated that other components of climate change could induce dramatic changes in water resources, energy resources – through inundation of oil-producing deltaic zones (Nigeria for example) and modifications in dams inducing changes in hydropower production - and oceanic circulation, particularly upwellings, but also exacerbate drought- and desertification. The main coastal ecosystems at risk are mangroves and coral reefs (McLean *et al.*, 2001). Mangroves are strictly dependent on the sea level variations and also on the rainfall and salinity so it is expected that they will migrate or die if lateral shifting is not possible or if salinity is too high. However, other factors like the topography of the area but also the rate of sedimentation will be of importance in the response of mangroves to sea level rise (Bijlsma *et al.*, 1996). Coral reefs are highly susceptible to oceanic temperatures and could not be able to keep pace with the expected rise in sea surface temperatures. The observation of massive extinction of coral reefs in the Indian coast due to the onset of El Niño is a good indication of the risk linked to climate change. There are also indications that lagoons will be under stress mainly due to the disappearing of the littoral barrier ridge protecting them from the ocean. These

biophysical impacts of climate change could necessitate a relocation of some coastal populations while new and/or aggravated health problems will occur. Furthermore, Alusa and Ogallo (1992), for the Eastern African Region as well as Ibe and Ojo (1994) for the Atlantic African coast, identified the following impacts of climate change on the main economic activities present in the coastal zones:

- o Fisheries will be affected: first through the degradation/loss of such ecosystems like mangroves and coral reefs which act mainly as spawning, breeding and nursing grounds for a number of fish species, second through the changes in sea surface temperature and also in intensity and location of upwellings that will modify the species distribution;

- o Agriculture will be affected – sometimes positively - by changes in CO₂ atmospheric concentration, temperature and rainfall that will modify the geographical distribution of agro-ecological zones in relation with the sensitivity of most of the crops to climatic parameters. In the coastal zones, sea level rise will also induce a salinization of soils, surface and ground waters that will necessary affect agricultural lands. Permanent flooding will mean a loss of agricultural lands in a number of coastal zones;

- o Coastal infrastructures (such as roads and harbours) will be endangered by sea level rise inducing coastal erosion and inundation then inducing transportation difficulties in the region. For the same reasons coastal towns and villages will be threatened and a number of people will have to be displaced ;

- o Tourism, mainly dependent on beaches and coral reefs or mangroves, will be affected by an acceleration of coastal erosion due to sea level rise that will reduce the number of appropriate sites for this activity but also by the modifications in the other coastal ecosystems.

This has been confirmed by the Third Assessment Report of the Intergovernmental Panel on Climate Change that recognized that “Tropical and subtropical coastlines, particularly in areas that are already under stress from human activities, are highly susceptible to global warming impacts.” (McLean *et al.*, 2001)

2. A limited number of vulnerability – adaptation studies

Despite the important consequences that climate change will have on coastal zones of Sub-Saharan Africa, not only on coastal ecosystems but also on their economy and on the society as a whole, very few coastal countries have carried out assessment of their vulnerability to climate change (Niang-Diop, 1998). Up to now, if we consider publications as well as the Initial National Communications to the United Nations Convention on Climate Change, only 13 countries conducted a vulnerability-adaptation assessment (or V&A study) : Senegal, The Gambia, Cote d’Ivoire, Ghana, Benin, Togo, Nigeria, Cameroon, South Africa, Tanzania, Seychelles, Mauritius, Mozambique. Most of these studies considered mainly the impacts of sea level rise on coastal erosion and flooding. It was in 1989, during the first workshop organized on the adaptive responses to sea level rise and other impacts of climate change that African coastal countries presented very preliminary assessments of their vulnerability to climate change (Titus, 1990). South Africa presented first an assessment of the vulnerability of Walvis Bay (Namibia) to three sea-level rise scenarios (0.2, 0.5 and 1 m) in terms of coastal retreat and salt water intrusion (Hughes *et al.*, 1992). For this, they used a coastal vulnerability index to estimate the vulnerability of the southern Cape Coast to a 1 m sea level rise (Hughes and Brundrit, 1992). During the second meeting organized on the vulnerability of coastal zones to sea level rise, Senegal and Nigeria presented the first quantitative results from a study funded by the US Environmental Protection Agency (Awosika *et al.*, 1994; Niang *et al.*, 1994). These V&A studies assessed, for different sea level rise scenarios (0.2, 0.5, 1 and 2 m by 2100), the land that will be lost due to coastal erosion and flooding, the population and economic value at risk as well as the costs of two different protection options (French *et al.*, 1995; Dennis *et al.*, 1995). Meanwhile, Mauritius presented an analysis of land area, houses and infrastructures located between the mean sea level and an altitude of 2 m (Jogoo, 1994). During the World Coast Conference in 1993, a very preliminary assessment of the vulnerability of Seychelles to the impacts of sea level rise was presented emphasizing the critical threat of an increase in intensity of cyclones and storm surges (Chang-Ko, 1995). In 1997, during an International Workshop, first results of a vulnerability of Mozambique coasts to sea level rise were presented showing that 900 km of coasts –characterized by the presence of numerous rivers - are particularly vulnerable to sea level rise and that implementation of integrated coastal zone management is a

matter of urgency (Chemane *et al.*, 1997). The town of Beira was chosen to do a more detailed assessment based on 3 scenarios of sea level rise (0.2, 0.5 and 1 m) which allow to determine the potential coastal retreat. The Gambia did a V&A study using 3 sea-level rise scenarios (0.2, 0.5 and 1 m by 2100) and calculated the areas of land to be lost, the population and economic value at risk but only for the Banjul-Cape St Mary area while adaptation options were only identified qualitatively (Jallow *et al.*, 1996, 1999). Same scenarios were used to assess the vulnerability of a portion of the Côte d'Ivoire coastline - the Abidjan region - to sea level rise and allowed for a quantification of land losses while economic values at risk were only identified as well as potential response and adaptation options (Jallow *et al.*, 1999). Tanzania benefited from the US Country Studies Programme and assessed the vulnerability of its coastal zone using two sea level rise scenarios (0.5 and 1 m). The area of lands susceptible to be lost by inundation and coastal erosion was estimated as well as the economic value of important structures that will be affected and the costs of protection for the Dar es Salaam coastline and for the all coastline (Mwandosya *et al.*, 1998).

Other vulnerability and adaptation assessments have not yet been published but are present either in the Initial National Communications to the UNFCCC or in the form of reports. Ghana in its Initial National Communication to the UNFCCC presented the results of a V&A study on its coastal zone. Results are presented qualitatively but also quantitatively in terms of area of land at risk, population to be displaced, wetlands at risk. Shoreline protection options are estimated in terms of global costs while legal and institutional framework is considered. The Initial National Communication of Seychelles to the UNFCCC (Payet, 1998) indicates that 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. 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.

It is striking that most of these studies rarely went further than general, qualitative assessments with the exception of the estimation of land areas susceptible to be lost. Moreover, most of the studies only considered the impacts of sea level rise and mainly coastal erosion and flooding while, for example, salinization processes were rarely considered and if so only on a qualitative way. Also, the other climate change parameters that will also influence the status of coastal zones in case of climate change were not taken into account. In these conditions, it must be considered that globally the impacts of climate change in the coastal zones of sub-Saharan Africa were underestimated.

The main objective of this project is then to contribute to a more in depth assessment of the vulnerability of sub-Saharan coastal zones to the different impacts of climate change in a more integrated approach. The project will not only address the impacts of sea level rise through the determination of historical trends in sea level rise but also the mapping of vulnerable areas based on existing V&A studies. This will be completed by vulnerability analyses including the impacts of other parameters of climate change (temperature, rainfall) on the salinisation of waters, on coastal ecosystems and socio-economic sectors as well as on identification and evaluation of adaptation options.

Actually, the Non Annex I countries to the United Nations Framework Convention on Climate Change (UNFCCC) are urged to define adaptation strategies to cope with the impacts of climate change. However, studies have so far been too much qualitative and limited (impacts of sea level rise) to enable a precise idea of all the potential impacts of climate change. The project will therefore allow beneficial countries to have a more global picture of their vulnerability to climate change that will allow them to further prioritize their adaptation options. These could be merged in a strategy that could be integrated in the national development plans. The results of this project could also be integrated in the coastal zone management plans that will take into account future trends and impacts of climate change.

However, in sub-Saharan Africa climate change will take place in a context where the expertise, financial and technical resources are limited. This is why capacity building, technology transfer but also stakeholder

involvement are important components for the success of adaptation of sub-Saharan countries to the impacts of climate change.

2. Objectives & Expected Results:

Objectives

The main objectives of the project are to assess the vulnerability² of coastal States to the impacts of climate change and to ensure the sustainable use of the littoral zone through, in particular, an appropriate adaptation strategy and more integrated coastal zone management plans.

Specific objectives will be:

- o measurement of historical sea level rise;
- o identify vulnerable coastal zones areas and / or sectors to climate change;
- o characterize this vulnerability and;
- o select adaptation options with a regional approach.

Through the course of the project the impacts of climate change in the coastal zones will not be limited only to the impacts of sea level rise. This will allow a better integrated approach for the development of the adaptation strategy.

Expected results

Expected results are:

1. Data on historical sea level rise;
2. Maps of vulnerable coastal zones by countries and at a regional level;
3. Documentation on the different types of expected impacts;
4. Database on potential adaptation options;
5. National adaptation strategies.

These results will constitute databases at national and sub-regional levels that could be used by the countries to prepare their next national communication to the UNFCCC, but also to develop their national adaptation strategy to the impacts of climate change in the coastal zones for inclusion in the national development plans.

Coherence with the national and sub-regional priorities

In the national reports issued from the first phase of this GEF-MSP project on Development and Protection of the Marine and Coastal Environment in sub-Saharan Africa, two countries, Seychelles and Nigeria, identified sea level rise (as one of the consequences of global climate change) as a major environmental issue and as a potential threat to their coastal zones in a context where coastal erosion, flooding, salinisation and degradation of ecosystems are already experienced. As many small island states, Seychelles expressed concern about the potential impacts of climate change, specially those linked with sea level rise, increased extreme events and climate induced changes in the ecosystems. It was considered as an issue for all the hot spots and sensitive areas and was ranked on 2nd position in the national report. Sea level rise is already taken in account by ongoing projects like the East Coast Reclamation project that have elevated the height of reclamation by an additional 70 cm to allow for sea level rise. The report considered also as a priority the development of comprehensive vulnerability assessments in order to develop appropriate strategies of adaptation to climate change. Nigeria is already affected by a strong erosion and regular coastal flooding and noted in its report that “it is expected that with global change and specifically sea level rise, these problems will increase” as the first V&A in Lagos State and Niger delta already indicate. In total, over 18,000 km² or 2 percent of the Nigerian coastal zone and about 3.68 million people are at risk with a one meter sea level rise. The value at risk is estimated at U.S \$18 134 billion also with a one meter sea level rise. In its recommendations, the report suggested “to take in account coastal protection

² Vulnerability is here understood as the combination between impacts and adaptation to climate change.

from flooding and erosion resulting from future sea level rise”. Moreover, Cote d’Ivoire and The Gambia, in their reports, identified the actual sea level rise as one cause of coastal erosion.

Among the 10 countries parties to this project, all the countries which presented their Initial National Communication to the UNFCCC (Senegal, Cote d’Ivoire, Ghana, Seychelles, Mauritius) have considered their coastal zone as a prime sector for the V&A studies.

During the PACSICOM conference, the participants indicated that the building of an African network of tide gauges to monitor sea level rise was one of the priority action and decided to create the GOOS-Africa (Global Ocean Observing System) (IOC, 1999). It is considered that the determination of historical trend of sea level rise from the existing tide gauges could contribute to this priority since sea level rise can better be detected from long term records. Moreover, the PACSICOM Statement indicated that “the expected impacts of climate change, sea-level rise in particular, will exacerbate the present problems and could, *inter alia*, impair future development and use of low-lying areas and coastal zones and cause setbacks in our efforts to achieve sustainable development”. One of the commitments that African governments made during the PACSICOM conference was “to promote concerted efforts, at the regional level, to monitor the impacts caused by climate change and to encourage regional and international co-operation to address the impacts”.

Relevance of expected results

The results of the project on the impacts of climate change and sea level rise on coastal zones could be used at different levels.

At a national level, the coastal zones are areas of rich biodiversity but also the basis for crucial economic activities such that attempting to understand potential impacts of climate change and defining adaptation strategies to limit these consequences are critical issues. While a number of efforts are deployed to define and implement Coastal Zone Management Plans and Sustainable Development Strategies, these are still not taking into account climate change. This situation could change with a better knowledge of the vulnerability to climate change that allow to integrate adaptation options in the strategic plans of development for coastal zones. The second IPCC assessment (Bijlsma *et al.*, 1996), reinforced by the third IPCC assessment, recognized that “adaptation options are best addressed when they are incorporated in integrated coastal management and sustainable development plans” (McLean *et al.*, 2001). The results could also be used by the countries for their Initial or Second National Communications to the UNFCCC.

3. Project Components/Activities

Components and activities

Four main components will be undertaken in order to deliver the expected outputs:

1. **Component 1** : Determination of historical sea level rise. According to McLean *et al.* (2001), the information on historical trends of sea level is considered as one important component in the analysis of the impacts of climate change in the coastal zones. However, sub-Saharan Africa is generally lacking tide gauges records long enough to allow for sea level analysis. Only 6 of the participating countries have this kind of tide gauges (Senegal, Cote d’Ivoire, Ghana, South Africa, Kenya and Mauritius). It could thus be possible to determine the historical trend and eventually to detect changes in the trend with these data. If possible, tide gauge data will be compared with satellite data that register the actual variation of the sea level. For the new tide gauge stations, it will be possible to at least retrieve the records for baseline information. These results could help to better define relative sea level rise scenarios for the countries concerned, to assess the reality of sea level rise and eventually to detect sub-regional differences.

- i. Activity 1.1 : identification and collection of all the available data that could allow for the determination of the sea level trend. For each tide gauge, a control of the quality of the data must be ensured, based on collaboration with National Port Authorities and the Permanent Service for Mean Sea Level as well as GLOSS. Depending of the countries, the data could come from the same tide gauge or

from different tide gauges. In the second case, it will be necessary to do a topographic levelling to know the exact altitudinal position of the different gauges;

ii. Activity 1.2 : based on the data, each country will establish the sea level trend for the period considered. An analysis of this trend and variability will be proposed based on the knowledge of the different factors responsible for the changes in sea level (currents, upwellings, subsidence);

iii. Activity 1.3 : synthesis of the data to identify the trends of sea level rise in the sub-Saharan Africa, look for possible sub-regional differences and compare with other sources of data (litterature, satellite data if available).

2. **Component 2:** Delimitation of vulnerable coastal zones to the impacts of climate change. These vulnerable zones could be first defined as those that will be threatened by sea-level rise mainly through coastal erosion and/or coastal flooding. These elements of the coastal vulnerability will be assessed using current methodologies like the Bruun rule (1962, 1988) and the inundation levels defined by the Hoozemans *et al.* (1993) formula. These vulnerable coastal areas will be mapped using the same scale and GIS.

i. Activity 2.1 : definition of the conditions of analysis. The methodologies to be used (Bruun rule, Hoozemans *et al.* formula, satellite images and GIS) as well as the sea level rise scenarios, time horizons and scales to be considered will be agreed upon in order to obtain comparable results. Based on the existing maps and beach profiles, the sites where the analysis will be conducted will be decided (preferably the whole country or specific coastal zones with similar conditions for example deltas, estuaries, coastal wetlands). Existing analyses will be identified and results will be retrieved ;

ii. Activity 2.2 : the identification of areas likely to disappear due to coastal erosion and coastal flooding. For the time horizons chosen, maps of the land areas to be lost will be created and superimposed on land use maps. Using GIS, the areas likely to be lost as well as the different land use present in these zones will be determined. In a second time, the economic valuation of these lands to be lost will be done as well as an estimation of population at risk;

iii. Activity 2.3: based on the results obtained an analysis of the potential impacts will be carried out, taking in account the actual situation (ecosystems, population, economic activities, infrastructures, cultural and historical sites, etc.) but also the different development plans for the vulnerable areas concerned as well as the evolution of some socio-economic parameters (populations, GDP, etc.). A first synthesis will be made at the sub-regional level to assess the degree of vulnerability of the coastal areas thus determined;

3. **Component 3:** Analysis of the vulnerable coastal areas to determine environmental and socio-economic consequences of climate change in all its dimensions, that to say not only sea level rise –in most the V&A studies, that has been the only climate change component that was assessed, despite the fact that it is now recognized that other climate parameters could be of influence [like for example changes in the wave storminess, McLean *et al.* (2002)] - but also changes in other climate parameters like temperature and precipitations. In this part, we shall focus, as appropriate, on coastal ecosystems, processes of salinisation of soils and waters but also on socio-economic impacts. This analysis will be as quantitative as possible and will depend on the existence of climate change scenarios and appropriate models. It will allow to qualify the extent of the impacts of climate change. Particular attention will be devoted to hot spots and sensitive areas determined in the Phase I of the project.

i. Activity 3.1: choice of the systems and sectors to be assessed and definition of scenarios. Based on the national conditions, each country will decide on which systems and/or sectors to work in order to determine other impacts of climate change (changes in salinisation, temperature, precipitations, etc.). It could be coastal ecosystems (coral reefs, mangroves, etc.) (marine ecosystems will be considered by RES3), soils and/or groundwaters as affected by salinization, economic sectors (fisheries, tourism, agriculture, etc.). Existing climate change scenarios (mainly those determined for the first V&A studies and reported in the Initial National Communications to the UNFCCC) will be used and selected using the available information (TAR of IPCC, publications and first results of AIACC) one condition being their compatibility with the sea level rise scenario. Each country will define socio-economic scenarios based on existing national scenarios already used for development planning or on scenarios

defined by international bodies like the World Bank, UNDP, etc. At least the same time horizons as those defined in activity 2.1 will be used;

ii. Activity 3.2: impacts analysis for the systems and sectors chosen. This analysis will be as quantitative as possible. Where available, impact models will be used. The systems and sectors to be analyzed will be to the extent possible considered in an integrated way. The objective here is to integrate changes in other climate parameters in the impact analysis to complement the component 2 that is devoted to sea level rise only. For example, the impacts of increased temperature and decreased precipitation will be assessed for a mangrove ecosystem or for the evolution of the salt water/fresh water interface in the coastal aquifers. If systems are considered, the impacts of changes on economic activities and populations will be also determined ; in case of sectors, the relationship with other sectors will be also analyzed;

iii. Activity 3.3: a synthesis of the results with an objective of integration of the different impacts will be made at national level. It will be completed at the sub-regional level with a view to have more detailed information of the importance of impacts of climate change on the coastal zones. Gaps and limitations will be identified and a tentative comparison with other regional analysis will be done.

4. Component 4: Identification and evaluation of adaptation measures that could help to minimize the negative impacts of climate change while considering potential opportunities. This part could benefit from the project on coastal erosion control (COS1) during which coastal protection measures will be developed and monitored but also where exchange of experiences at the continental level will also take place. On the other side, this component could be an input to the project on integrated coastal zone management (COS2) through the integration of the climate change component in the management plans.

i. Activity 4.1 : Considering the different impacts climate change could have in the countries, a first step will consist in the identification of potential adaptation options. As feasible, these options must come from existing adaptation options coastal populations or States develop in case of similar situations either at a national or sub-regional level. Other options will consist in options available on the international market;

ii. Activity 4.2 : Evaluation of adaptation options. Each option will be evaluated in terms of costs, feasibility (technical and human resources available), constraints (cultural, legal, institutional, etc.) and impacts (what consequences these options will have on the environment, society and economy). A matrix of evaluation will be produced based on a multi-criteria analysis. Some recommendations will be made;

iii. Activity 4.3 : Definition of an adaptation strategy: a prioritization process taking in account the matrix of evaluation and the objectives of the country will allow to define an adaptation strategy that will include the priority adaptation options. Meantime, each country will screen how this strategy could fit into the national development plans. The legal, institutional, technical and financial consequences of this strategy will be assessed.

A synthesis of all the project will be done at a national level. Then, all the results obtained in the different countries will be synthesized to obtain a global overview of the vulnerability of the coastal zones to the impacts of climate change as well as of the adaptation strategies. The coherence of the proposals will be screened. The methodologies used and the results will be presented in documents aimed to disseminate the information to the different stakeholders and decision makers.

Duration of the project

A general time frame of 5 years will be appropriate for this project, each country performing at least 2 of the components, depending on the state they are in the assessment of the vulnerability of their coastal zone to climate change.

Organisational matters

It is considered that this project will be run by a sub-regional committee that will be linked with national implementing committees. The main interest of such a set up will be to ensure an exchange of experiences in this domain. On another side, it is known that the coastal zones are closely linked at a regional level either by littoral currents, migration of species and/or transfer of sediments but also through exchange of

goods and people (fishermen for example), so that it is quite unrealistic to think that the adoption and implementation of adaptation strategies in one country will not affect the neighbouring countries. Moreover, the main impacts of climate change that coastal countries will face are globally the same and will intervene in comparable socio-economic situations. Thus the benefits that countries could gain from a sub-regional approach will not only concern the problem analysis but also the exchange of experience and knowledge on adaptation strategies.

Measurement of the implementation of the project

Each participating country must generate a work plan comprising the main milestones (reports, workshops, publications). The role of the sub-regional committee will be to ensure that the work plan will be fulfilled by each country.

The main indicators that could be used will be:

- o The periodic reports: intermediary and annual reports must be prepared by each national committee that will be examined by the sub-regional committee;
- o Workshops and meetings: depending on the work plan, different workshop must be organized at a country level to ensure a two way process between the national committee and the different stakeholders;
- o Publications and other documents: it is expected that the national and sub-regional committees will edit different documents to ensure the dissemination of the results obtained;
- o The most important indicator will be the adoption of adaptation strategy at country level and its inclusion in the national development policy even though the last must be considered as a process that perhaps will go beyond the limits of the project.

4. Project Preparation

Before the beginning of the project, it will be necessary to conduct two main tasks:

1. an inventory of existing V&A studies in the countries with the main aims to define the data that are available, the complementary studies that could be conducted and precise how the country will be involved in the project (specific activities, etc.);
2. identify the potential members of the national and sub-regional committees based on experience and field of expertise. Set up of these committees.

These activities are considered to take place before the beginning of the project and considered as preparatory phase.

5. Linkages to Other National or International Activities

The project will either benefit or feed sub-regional and international programmes that are actually developed for the marine and coastal zones in Africa.

The project is rooted in the process of revitalization of the Abidjan and Nairobi Conventions. These Conventions have been established at a time when climate change was not a recognized issue as it is now. What is identified as a threat in the Conventions is coastal erosion (art. 10 of the Abidjan Convention; PNUE, 1981). In the 5th meeting of the contracting parties to the Abidjan Convention, a two-years work plan was adopted which comprises a long term monitoring of coastal areas as one action under the component “coastal erosion and shore line changes” (UNEP, 2000). During its Third Conference of Parties, the countries signatories of the Nairobi Convention indicated the great concern they had on coastal erosion and shoreline changes. They defined in their working plan a component named “shoreline changes” that consider two priority activities strongly linked with this project: a) the need for long term monitoring of shorelines changes and b) a risk assessment of vulnerable areas. The proposed project will usefully complement the activities Parties to the Abidjan and Nairobi Conventions have engaged under their biennial programmes.

The World Wildlife Fund, in its Eastern African Marine Ecoregion Action Programme (WWF, 2002³), recognizes that climate change constitutes a threat to the different habitats of the region and considers that the coral bleaching observed in 1998 in the Indian Ocean as well as large scale deaths of fish and other marine species observed in 2002 may be associated with climate change.

The Gulf of Guinea Large Marine Ecosystem (GOG-LME) project identified the need for contingency plans for human-induced and natural including potential effects of climate change even if the project is much more oriented towards pollution.

At an international level, there is a need to have more information on the observed climate change and particularly on the sea level rise. The analysis of the historical trend of sea level in Africa could be part of the global efforts to better monitor sea level through programmes like the Global Sea Level Observing Systems (GLOSS), the Global Ocean Observing System and its African component (GOOS-Africa). More generally, the project will benefit from and contribute to the ODINAFRICA (Ocean Data and Information Network for Africa) Programme for which the main aims are to develop national oceanographic data centres, networking among scientists and constitution of national and regional databases. They would also satisfy the decisions 14/CP4 and 5/CP5 of the United Nations Framework Convention on Climate Change that recommend a global effort to include Non Annex I countries in the global monitoring systems.

More detailed assessment of the vulnerability of African coastal zones to climate change will also contribute to the efforts of the scientific community present in the Intergovernmental Panel on Climate Change (IPCC) towards a better understanding of the impacts of climate change. It will complement the GEF project AIACC (Assessment of Impacts of and Adaptation to Climate Change in Multiple Regions or Sectors) which already accepted for funding 11 African projects, one being on the impacts of climate change on tourism in Seychelles and Comoros.

6. Regionality & Transboundary Aspects

Climate change and sea level rise will affect indistinctly all the African coastal states. It is considered that due to their coastal morphology (low lying coasts with estuaries, deltas and coastal wetlands ; small islands in the Atlantic and Indian Oceans), the high concentration of population and economic activities along their coasts and also the weakness of their economies, most of the African coastal states will be highly vulnerable to the impacts of climate change. The experience gained in this project could be useful for the other coastal states that are not part of this project.

As indicated previously, the African coastal zones are areas where numerous exchanges (of sediments, species and human beings) are taking place. This transboundary explains the commonality of some present and future environmental problems experienced in the African coastal zones. This is the reason why adaptation strategies must also be considered in a sub-regional context since the adoption of some options by country A could have consequences on the coastal zone of country B.

7. Demonstrative Value & Replicability:

The project will use methodologies that could be applicable in other coastal countries of the sub-region based on the experience developed during this project. One major comment that African countries made in relation to the preparation of their vulnerability and adaptation assessments is that the tools commonly used don't always fit with the constraints that these countries face (lack of data, limited human resources and financial means. It is expected that the combination of tools and expertise applied in the participating countries will constitute a solid basis for a potential "exportation" to neighbouring countries that have the same problems and same context.

The results could be useful for the African negotiators in the UNFCCC process to table concrete examples of the impacts of climate change and sea level rise in the coastal countries with different contexts: from small islands (Seychelles, Mauritius) to major deltas (Nigeria, Ghana, Mozambique) and estuaries (Senegal, The Gambia). The countries involved are also representing different climatic conditions: from semi-arid (Senegal) to humid (Nigeria, Tanzania).

The innovative approach of this project lies not in the methodologies that will be used but on the way by which it will be implemented. The sub-regional approach (although implementation will be at countries levels working within a definite timeframe and using the same methodologies) with a coordinating sub-regional body that will ensure the coherence and transfer of knowledge-experience between the countries is believed to add considerable value.

8. Risks and Sustainability :

Risks

The main risks linked with this project are:

- o Uncertainties linked with the predictions of climate change specially for precipitations and modification of oceanic circulation as well as extreme events;
- o The non definition of adaptation strategies. The experience of V&A studies has shown that too much time and resources are devoted to impacts assessment so that adaptation options are not well identified and prioritized and no strategy is defined. Another cause is the uncertainties linked with the scenarios used;
- o The non integration of adaptation strategy in the national development plans.

To limit the risks identified, the following measures can be considered:

- o Particular emphasis must be put on the “no regret” adaptation options that could be defined as those that could be beneficial whether climate change is taking place or not. In this category are also options relative to elements of climate change that are quite sure (sea level rise, warming,);
- o The work plan must be designed in such a way that enough time is devoted to adaptation (component 4). The same must be true for the allocation of resources;
- o The composition of the national committees must be such that important representatives of the government are members in order to ensure that adaptation strategy could be integrated in the national development plans. Other means will be the workshops and dissemination documents that will be produced by the project;
- o The implication of the public for example through awareness campaigns could also develop the conscienceness in the public of the importance of climate change and its consequences. It will thus be able to influence decision makers.

Sustainability of the project

It will depend on:

- o The integration of adaptation strategies in the development plans that will suppose the budgeting of some activities and thus a long term funding mechanism;
- o The active involvement of the different stakeholders: if the main stakeholders that have been identified are conscious of the threat of climate change and the necessity to implement adaptation strategy, they will be attentive to convince the authorities to effectively implement these strategies;
- o Capacity building gained by the countries could allow a long term consideration of climate change and develop their adaptive capacity. Activities like national and sub-regional workshops would contribute to this through exchange of experience and expertise at these two levels.

9. Stakeholder Participation:

Stakeholders must be considered at different levels:

At a national level, a number of actors need to be considered in all the levels of the project implementation like:

- o Government bodies: they are interested in the results of the study that could be integrated in the national development planning (adaptation strategy) and used in the UNFCCC context either through the National Communications or during the negotiations process. To ensure a good integration of the results all the representatives of the different Ministries must be considered (environment, fisheries, urban management, finances, economy, ...) but also national committees that have been created by the Government to assist in specific fields (Sustainable Development commissions, Climate change committees, etc.);
- o Scientific community: it is supposed that this community will be involved in the national assessments that need multidisciplinary teams. Institutions and researchers that already contributed in such studies will be identified and involved;
- o Decentralized institutions: the local institutions (municipalities, districts, ...) will be involved since vulnerable areas will be certainly confined to some restricted areas where the local governments are pre-eminent. It is impossible to develop an adaptation strategy without the agreement of these kind of decentralized bodies;
- o Coastal users (fishermen, coastal population, tourism operators, ...) at large (individuals and associations) must be part of the process since they are the most exposed and hence impacted by climate change and sea level rise and those whose contribution will be essential in the identification and implementation of adaptation strategy.

At a regional level, representatives of regional and sub-regional projects and associations will be invited to contribute in the process.

It is agreed that participatory approach is one of the conditions not only for the success of projects intending to solve problems in which populations are implied. It is thus considered that stakeholders will be invited in different meetings organized at all stages of the project. They must be also represented in the national committees that will be charged with the regular follow up of the project. At some stages (identification of potential adaptation options), consultations will be conducted in the different communities and/or stakeholders to ensure a better assessment of opportunities, constraints and status of these options.

10. Project Management & Implementation Arrangements:

Each country participating in the project is to establish a scientific committee that will be charged with the technical study and a national committee that will be responsible for the monitoring of the project as well as the involvement of the different stakeholders. An institution must be designated at the beginning of the study as the focal point receiving all the information relative to the project (reports, maps, etc.).

It is proposed that a sub-regional coordination committee will be established to ensure the coherence and integration of the studies in the different countries (same methodologies used or control of the methodologies), to serve as an advisory body and to synthesize and disseminate the information through web site, publication, brochures, etc. as appropriate. This committee must be hosted by one of the participating country and must provide the technical capacities to execute regional synthesis (maps, reports and publications as well as others materials for stakeholders and decision makers awareness). It is through this sub-regional coordination committee that experience and expertise in the sub-region could be shared and developed. Participation of other regional experts will be welcomed.

The committees will be meeting on regular bases and do intermediate reports that will allow a good monitoring of the project implementation. These reports must serve as a basis for more open meetings involving the different stakeholders to keep them informed of the progress made and collect their suggestions and contributions.

It is suggested that a coordination mechanism be established between the 3 projects working under coastal erosion group as well as with the project RES-3 on “Impacts of global climate change on streamflow and estuaries in sub-Saharan Africa”.

11. Project Financing & Duration:

Table 1. Component & Activity Financing

	External Source of Funds			National Government		Total
	Source 1	Source 2	Source 2	Cash	In-kind	
Component 1	500,000					
Activity 1.1	270,000					
Activity 1.2	80,000					
Activity 1.3	150,000					
Component 2	1,400,000					
Activity 2.1	200,000					
Activity 2.2	850,000					
Activity 2.3	350,000					
Component 3	2,400,000					
Activity 3.1	550,000					
Activity 3.2	1,200,000					
Activity 3.3	650,000					
Component 4	3,000,000					
Activity 4.1	800,000					
Activity 4.2	1,400,000					
Activity 4.3	800,000					
Total	7,300,000					

Note: This budget is preliminary and has not undergone a full consultation process with the respective countries. Therefore, does not indicate the actual financial commitment that would be provided by participating countries once the project proposal and its components are finalised.

Country's contributions in kind: only three countries indicated their possible contribution in kind

Cote d'Ivoire: 0,1 million US\$

Kenya: Contribution of 5 million Kshilling (1 US\$ = 78 KSh) = 64,103 US \$

Nigeria: 6,500 US \$

The project's duration is estimated to be 5 years, not included the time necessary for the project preparation.

12. Funding Information for Investments

13. Monitoring, Evaluation & Dissemination:

Administrative arrangements proposed to manage and monitor the project are described under item 10.

Evaluation of the project could be ensured by two mechanisms:

- o Workshops with all stakeholders at all stages of the project implementation to present preliminary results, have the inputs from the stakeholders and take decisions for the following steps. This will allow stakeholders to be part to the process, to control it from the beginning till the end of the project;
- o Independent evaluation could be decided and organized for each component of the project and for the whole project.

Dissemination of the results of the project is crucial given the objectives of the project. It is proposed to prepare different kinds of documents addressing the different stakeholders, users at large of the results of this project:

- o Publications in international journals to give a wide audience to the results of the project. It is supposed that the results from each country as well as the synthesis could allow for at least one publication each;
- o Brochures will resume the results of the project and will be targeted at the stakeholders and the decision makers. They must be attractive enough to transmit the main results and messages. They will be generated by each country but also at a sub-regional level. In this sense, they could give information to the sub-regional bodies, organizations and to the donors on the work accomplished under the project;
- o A web site with all the results will also permit a wide information on the project;
- o Other means of communication (articles in newspapers, films, etc.) could be used.

ANNEXES

II. Logframe Matrix

Summary	Objectively verifiable indicators	Means of Verification (Monitoring Focus)	Critical Assumptions and Risks
<p>Overall goal of the intervention Definition of the vulnerability of coastal zones to the impacts of climate change and definition of national adaptation strategies</p>	<p>- National adaptation strategies; -Better information of stakeholders - Integration of the strategy in national development plans</p>	<p>Final reports; Publications Data bases Workshop reports and dissemination products Modifications in the strategic plans and other development instruments</p>	<p>Existence of enough human resources Existence of enough data Uncertainties linked to climate change The non collaboration between the different stakeholders The non integration of adaptation strategies in development plans</p>
<p>Project Outputs Op1 : Measurement of the historical sea level rise Op2 : Identification of vulnerable areas and sectors to sea level rise Op3 : Characterisation of the vulnerability of the coastal zones to climate change Op4 : Definition of a national strategy to adapt to climate change</p>	<p>Op1 : Rates of sea level rise for each country Op2 : Maps of inundable and erodable areas identified; potential losses determined Op3 : Identification and evaluation of other impacts of climate change Op4: National adaptation strategy and formal engagement of the national authorities to integrate this strategy in development plans</p>	<p>Op1: Synthesis report of component 1, publications, databases Op2 : Synthesis and workshop reports, publications, maps available Op3: Synthesis and workshop reports, publications, quantification of risks Op4 : Synthesis and workshop reports; integration of adaptation strategies in development plans</p>	<p>Op1: accessibility to data and possibility to identify position of old tide gauges Op2 : existence of remote sensing centers in the countries, human resources available Op3 : availability and adaptability of models and data, enough expertise Op4: will depend on the impacts assessment and the contribution of stakeholders The main risk is the no consideration of adaptation strategies in the development plans</p>

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