VULNERABILITY ASSESSMENT OF CENTRAL COASTAL SENEGAL (SALOUM) AND THE GAMBIA MARINE COAST AND ESTUARY TO CLIMATE CHANGE INDUCED EFFECTS

Consolidated Report

GAMBIA- SENEGAL SUSTAINABLE FISHERIES PROJECT

(USAID/BA NAFAA)

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Abbreviations

CBD	Convention on Biological Diversity
CIA	Central Intelligence Agency
CMS	Convention on Migratory Species,
CSE	Centre de Suivi Ecologique
DoFish	Department of Fisheries
DPWM	Department Of Parks and Wildlife Management
EEZ	Exclusive Economic Zone
ETP	Evapotranspiration
FAO	United Nations Organization for Food and Agriculture
GIS	Geographic Information System
ICAM II	Integrated Coastal and marine Biodiversity management Project
IPCC	Intergovernmental Panel on Climate Change
IUCN	International Union for the Conservation of nature
NAPA	National Adaptation Program of Action
NASCOM	National Association for Sole Fisheries Co-Management Committee
NGO	Non-Governmental Organization
PA	Protected Area
PRA	Participatory Rapid Appraisal
SUCCESS	USAID/URI Cooperative Agreement on Sustainable Coastal Communities and Ecosystems
UNFCCC	Convention on Climate Change
URI	University of Rhode Island
USAID	U.S. Agency for International Development
WAFCET	West Africa Cetacean program
WAMER	Western Africa Marine Eco-Region
WRI	World Resources Institute
WWF	World Wide Fund for nature

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Executive Summary

The Saloum and Gambia rivers are at the northern side of the Western Africa Coastal Rivers landscape and are well interconnected. The area covers 300,000 ha and is very densely populated with more than 1,500,000 inhabitants. The mangrove ecosystem which covered 168,000 ha in the early 1960s (100,000 ha for the Saloum and 68,000 ha for The Gambia estuary) was reduced to less than 100,000 ha in 1980s because of persistent reduced precipitation. The upwelling process provides nutrients for fish and marine species in this large continental shelf. It is estimated that the marine and estuary of the sub-region shelters 600 species of fish, 26 species of cetaceans, 6 species of Turtles and more than 200 species of birds. The Gambia coastal zone and Saloum Delta Biosphere reserve are classified by international conservation NGOs intervening in West Africa as a region of Regional importance for marine conservation. The Tanbi Wetlands National Park in The Gambia is a RAMSAR site.

Significant degradation of landscapes with its consequence on communities' livelihoods as well as on coastal and marine ecosystems is occurring in this zone since the early 1960s. Climate change (sea level rise, coastal erosion, mangrove loss, soil salinization), among other causes, is a major driver of these changes. Coastal and marine zones such as The Gambia and Saloum estuaries and coastal areas are among the most vulnerable. Policies, programs and projects must mainstream climate change considerations into development agendas and actions. The Governments of The Gambia and Senegal in their NAPAs and USAID in its Climate Change and Development Strategy (2012) have recognized this urgent need.

The Gambia-Senegal Sustainable Fisheries Project (USAID/BaNafaa) has carried-out this Climate Change Vulnerability Assessment for the purpose of identifying vulnerability "hotspots" and priority Climate Change Adaptation measures that might be addressed within the scope of the USAID/BaNafaa Project. It initiates a climate change adaptation process to support sustainable fisheries development in these contiguous coastal zones of bi-lateral and regional importance.

Objective: To assess the vulnerability of central coastal Senegal (Saloum) and The Gambia marine and estuarine ecosystems and fisheries communities to climate change.

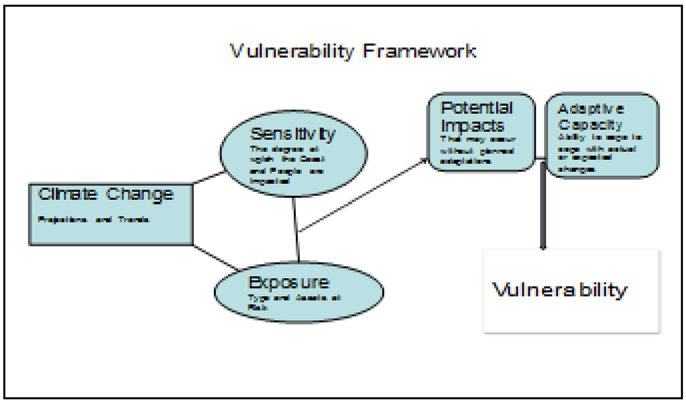

Figure 1: Adapting to Coastal Climate Change. A Guidebook for Development Planners (USAID, 2009)

Vulnerability is a function of exposure, sensitivity and the adaptive capacity of the natural and social system. The assessment was based on the above framework. In collaboration with a multidisciplinary team of consultants, the following components were explored, capitalizing on the significant body of work already done and supplementing with limited new field work and data collection:

- Baseline GIS data and mapping to show several sea level rise inundation scenarios
- Local community socio-economic vulnerability assessment
- Ecological vulnerability assessments including Mangrove habitat and fisheries

Key Findings:

In the scenario of a 2m inundation level by 2100, 52% of the Saloum Delta area will be inundated and the City of Banjul, the village of Albreda and 90% of the mangrove in The Gambia Estuary will be inundated. Islands will vanish, as well as more than 2/3 of human settlement living on islands in the Saloum Delta.

Reduced precipitation (35% drop) and less regularity of rainfall (1 year in 5 flooding) will result in salt intrusion, less exposure of the mangrove ecosystems to fresh water, less organic matter discharge to the ocean and subsequently increased mangrove die-back, disturbed fish biological processes (food chain and reproductive state) and loss of rice fields.

The whole coastline open to the ocean is exposed to coastal erosion. The sandy nature of the beaches make the coastal zone very sensitive to increasing intensity of wind and waves. However, sensitivity differs from site to site. Coast lines in the form of a bay or that are rectilinear are more sensitive than the ones that are convex. The area from The Gambian State House to Kololi stream, the bay shapes of Tanji area and the long rectilinear coast of Palmarin are very sensitive to coastal erosion.

Livelihoods in the study area are heavily dependent on fisheries, agriculture and other ecosystem-based activities, including tourism. Value added and alternative livelihoods are limited for the most climate change vulnerable communities.

Stakeholder Workshop:

Vulnerability Assessment results were shared, discussed and used to identify Climate Change Adaptation priorities in a bi-lateral (Gambia-Senegal) workshop attended by 55 participants. The Gambian Minister of Fisheries, Water Resources and National Assembly Matters and The Minister of Forestry and Environment spent an entire half day at the workshop participating in the discussion. In addition to journalists from print, radio and television, USAID/BaNafaa staff, WWF staff, consultants and USAID/COMFISH staff, 11 Gambian and 7 Senegalese institutions were represented.

The following sites are considered by participants as climate change vulnerability hotspots of bi-lateral importance, with the top 3 prioritized for USAID/BaNafaa interventions:

Banjul/Tanbi Wetland
Dionewar/Djifer
Bettenty
Bijol Island/Iles Aux Oiseaux
Djinack

Participants identified the following priority socio-economic activities for mainstreaming of climate change adaptation measures, with the top 3 recommended for USAID/BaNafaa focus:

Fishing, Shellfishing, Processing
Agriculture
Tourism
Forestry
Settlement

In the context of the above priorities, the workshop recommended that the USAID/BaNafaa Project address the following priority adaptation measures in identified hotspots and at various levels of governance both nationally and bi-laterally.

1. Coastal Wetland Protection and Restoration
2. Development of Alternative Livelihood Activities for Sustainable Resource Use
3. Targeted Awareness Raising Campaign (crosscutting)
4. Protection of Coastal Zone against Waves and Erosion (the limited resources of the USAID/BaNafaa project are not likely to be at a scale sufficient to address this issue adequately, so it was retained as a secondary area of intervention only where it is appropriate on a small scale within the scope of the project (i.e., dune stabilization at a community level with natural planting) or supporting policy level initiatives).

Introduction

The coastal area from central Senegal to Sierra Leone is called Land of Rivers. A flat landscape covered by a mesh of mangrove swamps discharging upland rainfall water to the ocean and nurturing large continental shelves with organic matter characterize this zone of confluence of the canary and gulf of guinea currents. The Saloum and Gambia rivers are at the northern side of this Western Africa landscape and are well interconnected, densely populated and very rich in biodiversity, including migratory marine species in particular. The Saloum and Gambia estuaries and coastal areas are subject to natural and anthropogenic changes.

In recent decades major changes have been noticed. Changes include coastal erosion, mangrove die back, shift of islands, salinization of soil and loss of rice fields, frequent flooding and drought, loss of marine habitats, and extinction or drastic decline of fish stocks. In fact, significant degradation of landscapes with its consequence on communities' livelihoods as well as on coastal and marine ecosystems has been occurring since the early 1960s and has been worsening in recent years. Some of the changes are not localized, but noticed in many parts of the globe.

Communities are attempting to cope with these changes and their effects. Understanding of both direct and indirect causes and appropriate policies and programs to address them are needed. Climate change, among other factors, is a major driver of these changes. Climate change is an alteration in the state of the climate that can be identified by changes in the mean and/or the variability of its properties and that persists for an extended period, typically decades or longer (IPCC, 2012). Climate change induces sea level rise, changes of the sea's physical parameters, and changes in precipitation and salt intrusion in the water table with their ecological, economic and social effects. Climate change may be due to natural internal processes or external forces, or to persistent anthropogenic changes in the composition of the atmosphere or in land use. According to the IPCC, climate change will continue to cause impact worldwide. Coastal and marine zones such as The Gambia and Saloum estuaries and coastal areas are among the most vulnerable.

Policies, programs and projects must mainstream climate change considerations into development agendas and actions. The Governments of The Gambia and Senegal in their NAPAs and USAID in its Climate Change and Development Strategy (2012) have recognized this urgent need. USAID is supporting governments and coastal stakeholders to address this new paradigm through its West Africa regional program. In this context, The Gambia-Senegal Sustainable Fisheries Project (USAID/Ba Nafaa) has carried-out this Climate Change vulnerability assessment for The Gambia and Saloum estuaries and coastal and marine areas to determine the following;

What are major geographic features of Saloum and Gambia estuaries and coastal zone? What are climatic trends? What is climate change? What are the likely effects? How exposed to climate change effects are The Gambia and Saloum population and ecosystems? What have been natural and human communities' adaptive capacities to reduce the negative impacts? What adaptation measures can be undertaken to manage climate related effects?

This report on The Climate Change Vulnerability Assessment for The Gambia and Saloum estuaries and coastal and marine zones is presented in 5 chapters that summarize the findings of technical reports on the subjects of inundation scenarios, mangroves, fisheries and socio-economic factors. This report also presents the conclusions of the bi-lateral stakeholder workshop where the vulnerability assessment was reviewed and analyzed and where recommendations were made for adaptation measure priorities for the USAID/BaNafaa Project. Chapter 1 defines the objective and the methodology, Chapter 2 compiles a brief description of the study zone's richness. The 3rd Chapter develops physical and climatic features and trends. The 4th chapter assesses vulnerability by exploring the aspects of climate change vulnerability: exposure, sensitivity, potential impacts and adaptive capacity. The last chapter is about priority adaptive measures and the way forward.

1. Objective and Methodology

The Gambia-Senegal Sustainable Fisheries Project (USAID/BaNafaa) has carried-out this Climate Change Vulnerability Assessment for the purpose of identifying vulnerability "hotspots" and priority Climate Change Adaptation measures that might be addressed within the scope of the USAID/BaNafaa Project. It initiates a climate change adaptation process to support sustainable fisheries development in these contiguous coastal zones of bi-lateral and regional importance.

1.1 USAID/Ba Nafaa Project

The **USAID/*Ba Nafaa*** Project is a five-year regional initiative supported by the American people though the U.S. Agency for International Development (USAID)/West Africa Regional Mission. It is implemented through the University of Rhode Island (URI)-USAID Cooperative Agreement on Sustainable Coastal Communities and Ecosystems (SUCCESS). The World Wide Fund, West Africa Marine EcoRegional Program is the regional implementing partner. Project activities are carried out in partnership with The Gambian Department of Fisheries (DoFish) and stakeholders in the fisheries sector in The Gambia and in Senegal. The focus is on sustainable fisheries management including the shared marine and coastal resources between The Gambia and Senegal. Given the importance of climate change impacts for sustainable fisheries management in this region, the USAID/Ba Nafaa Project received additional funding in July 2011 to support a climate change vulnerability assessment to enable stakeholders to integrate vulnerability and adaptation planning into the sustainable fisheries management activities that are the focus of the Project.

1.2 Objective

The objective of this study is: to assess the vulnerability of central coastal Senegal (Saloum) and The Gambia marine and estuarine ecosystem and fisheries communities to climate change.

1.3 Approach and Methodology

1.3.1 USAID Guidelines

"Adapting to Climate Variability and Change: A Guidance Manual for Development Planning," (USAID, 2009), is a key reference document used to orient the present assessment. The USAID guidebook proposes a six step vulnerability and adaptation processes shown in Figure 1.

Figure 2: Climate change adaptation steps

The present USAID/BaNafaa study addresses Step 1. It assesses the vulnerability of The Gambia and Saloum estuaries and coastal and marine areas to climate change.

The guidebook defines vulnerability as the degree to which a human or natural system is susceptible to, or unable to cope with, adverse effects of climate change. It considers that Vulnerability is a function of the character, magnitude, and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity. The guidebook provides a framework for the analysis of vulnerability as follows:

VULNERABILITY ASSESSMENT

1. Assess climate change projections
2. Assess exposure to climate change
3. Assess sensitivity to climate change
4. Assess Potential Impacts
5. Assess adaptive capacity

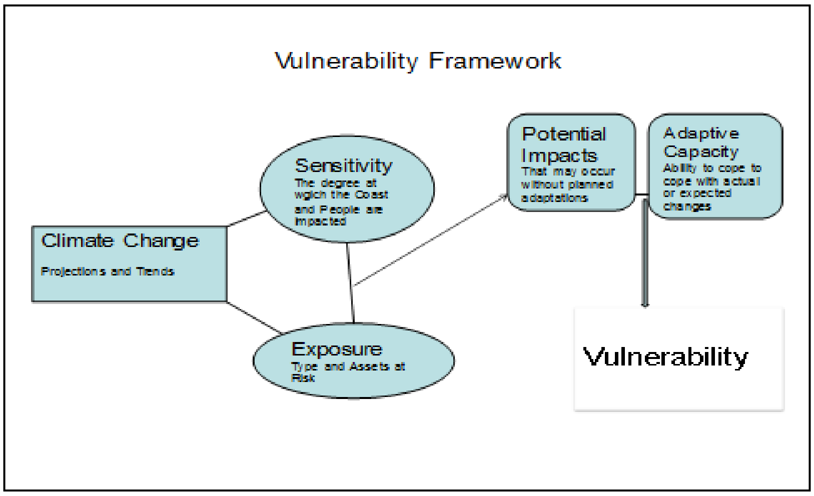

Figure 3: From "Adapting to Coastal Climate Change: A Guidebook for Development Planners (USAID, 2009)"

1.3.2 Multidisciplinary Assessment

The vulnerability assessment of central coastal Senegal (Saloum) and The Gambian estuarine and marine area adopts the above approach in collaboration with a multidisciplinary team of consultants, including experts in marine and wetland ecology and conservation, GIS, Climate Change, fisheries biology, and community development. The following components are explored, capitalizing on the significant body of work already done and supplementing with limited new field work and data collection:

1. Baseline GIS data and mapping. A common GIS database for the ecoregion was developed with data on land cover/land use (from landsat and google earth), settlements, infrastructure, elevation, shoreline erosion rates and seasonal salinity based on existing studies and data. Maps presenting these elements are presented in the consultant report. In addition, several sea level rise inundation scenarios are presented. (CSE, 2012; Niang, 2012)

2. Local community vulnerability assessment. Existing socio-economic studies of the communities in the study area and PRA exercises are synthesized. Field work involving key informant and focus group interviews were conducted in 5 communities/fisheries landing sites to fill information gaps related directly to climate change and coastal community vulnerability (Sall, 2012). Existing PRA exercises include the 2010 oyster community PRA by the USAID/Ba Nafaa project, and PRA's of the Sine Saloum conducted by IUCN and Wula Nafaa projects, among others.

3. Ecological Assessments including the following:

- **Mangrove habitat assessment**. A study of mangrove vulnerability to sea level rise and precipitation change (salinity change) in the study area is conducted to prioritize potential adaptation needs and opportunities. To what extent mangroves are able to retreat to higher ground and what mangrove areas will be lost with sea level rise is explored. DaCosta, 2012)

- **Climate change impacts on fish species**. A study based on existing information and science on the likely effects of climate change on specific fish species in The Gambia and Senegal study area is carried-out. (Darboe, 2012)

After consultants provided their technical proposals, a harmonization meeting was organized to provide a common vision, standardized use of terms and emphasize the multidisciplinary nature of the work. The following general structure for the reports was validated:

Framework of Assessment Reports for Each Area of Expertise:

- Assess potential impacts of climate change projections
- Assess exposure to climate change
- Evaluate sensitivity to climate change
- Evaluate hot-spots and critical sites
- Potential impacts if adaptation measures are not taken
- Status of the adaptive capacities
- Make recommendations on priority sites and adaptation measures

The study started on November 18th 2011 and lasted twice the expected time: 5 months. This report consolidates the outcomes of the multidisciplinary assessment.

2. Context

2.1 Description of the Study Area

Senegal and The Gambia are located within one of the most diverse and economically important fishing zones in the world - the WAMER.

2.1.1 The Study Area

The study area covers central Senegal and The Gambia coasts and estuaries 13° 35’ and 14° 10’ N, 16° 50’ and 17° 00’ W. The coasts and estuaries of the two countries are interconnected through their ground water and marine ecosystems.

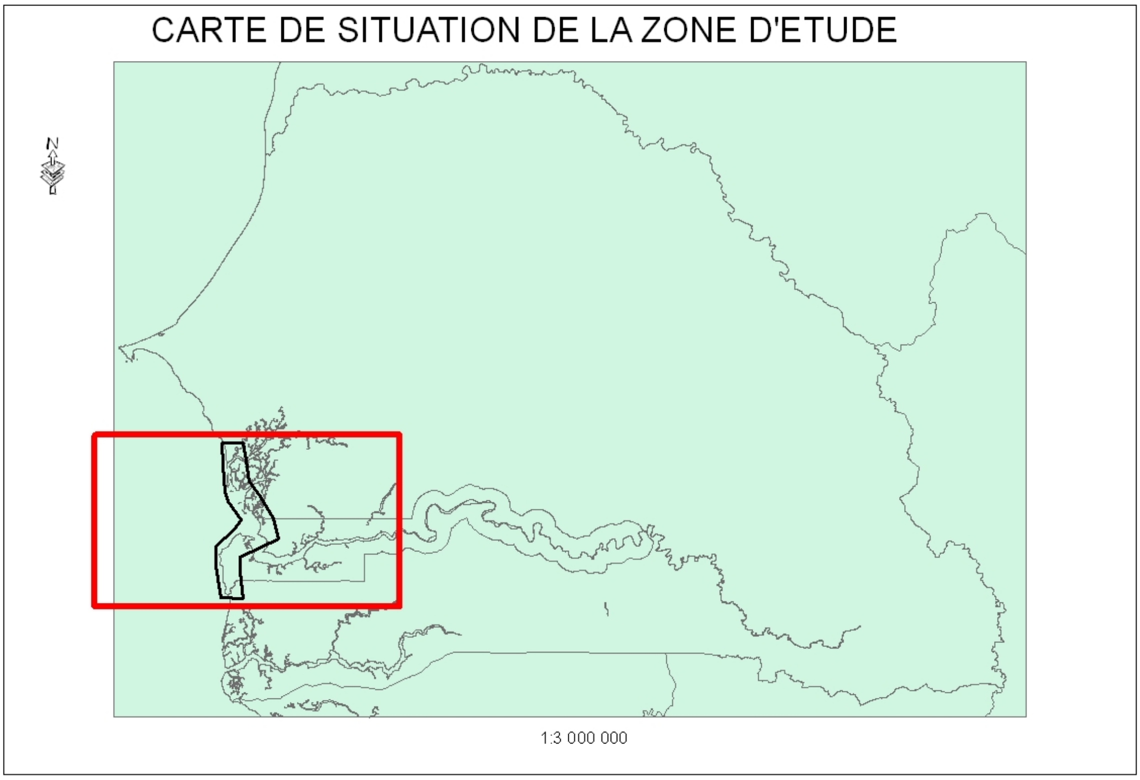

Figure 4: Map of the Study Area

The study area is 300,000 ha. It is very densely populated with more than 1,500,000 inhabitants, among which more than 75% live in The Gambian part of the area. The continental shelf is very large, shallow and rich in algae, seaweeds and phytoplankton.

Table 1: Characteristics of WAMER countries (Earthtrends (WRI), CIA Fact book, 2003)

Country	**Area (km^2)**	**Maritime boundaries and Exclusive Economic Zone (EEZ) (km^2)**	**Length of coastline (km)**	**Population (millions)**	**Population growth rate (%)**	**Value of fishing industry (USD) 1999**
Senegal	Total: 196,190 Land: 192,000 Fresh Water : 490	Territorial sea : 11,495 EEZ : 147,221	718	10.58	2.56	475,120,000
The Gambia	Total: 11,300 Land: 10,000 Fresh Water : 1,300	Territorial sea : 2,329 EEZ : 20,530	80	1.5	3.03	4,400,000

2.1.2 WAMER

The Western Africa Marine Ecoregion (WAMER) extends along nearly 3,200 km of coastline and covers some 1.4 million square kilometers of the east-central Atlantic. Its continental shelves make the West Africa marine zone one of the most biologically diverse and productive marine areas in the world. It has been adopted as one of WWF’s four Global 200 focal marine eco-regions. The WAMER is bounded on the north by the cold water Canary Current, which flows westwards across the Atlantic from Morocco/Mauritania, and on the south by the warm water Guinea Current which flows eastwards along the equator from the Atlantic, reaching the African continent near Guinea and following the coast westwards (WWF, 2005). A network of rivers discharges rainfall waters and inland organic matter into the ocean during 4 to 6 months. The central Senegal and The Gambia marine and coastal zones are within the WAMER eco-region. However, benefits from the above described marine processes and associated biological dynamism are further enhanced in this zone by dense mangrove ecosystems of approximately 60 000 ha in each country.

2.1.3 The Gambia

The Gambia lies within the Sahel region in Central-West Africa and is generally oriented east to west along the lower reaches of the Gambia River between 13º and 14º N latitude.

The coastal zone consists of 70 km open ocean coast and 200 km sheltered coast. The Gambia River and its major tributaries or “bolongs” are dominant economic and ecological features. The Gambia River originates in the Fouta Djallon highlands in Guinea and flows 1100 km through Senegal and though the entire length of The Gambia on its way to the Atlantic Ocean.

Though it is a small Sahelian country, The Gambia is rich in plant and animal species. This impressive diversity is due to a combination of its geographical position and the presence of the Gambia River on which the country is centered. The number of species recorded in The Gambia to date is 3,339 from seventeen taxonomic groups. The Gambia is endowed with 1,005 flowering plants, 125 species of mammals, 627 species of fish, 566 of birds, 784 of insects and 77 of reptiles (Linda and Creg, 2005).

The Republic of The Gambia has ratified UN conservation conventions, including the Convention on Biological Diversity (CBD), the Convention on Migratory Species, the Convention on Wetlands of International Importance (Ramsar Convention), and the Convention on Climate Change (UNFCCC). Since 1977, with the Banjul Declaration, National Policy is enforcing strong conservation programs though the National Biodiversity Act. The government of The Gambia designated a total of seven protected areas covering 51,240 ha or 4.27% of the total surface area. Except The River Gambia National Park, all protected areas are within marine and estuary areas.

2.1.4 Saloum Delta Biosphere Reserve

The Saloum Delta (13° 35’ and 14° 10’ N, 16° 50’ and 17° 00’ W) is located on the coast of Senegal about 100 km south of Dakar. The Saloum Delta covers an area of about 180,000 ha that integrates several types of wetlands (J. Frans and al., 1997). The watershed which hosts the Sine-Saloum estuary covers an area of about 80,000 ha.

The river system is made up of three main tributaries: the Saloum (110 km long) in the north and north-east, the Bandiala (18 km) in the south and south-east and the Diomboss (30 km) between the two. The delta was formed by the confluence of the three rivers flowing south west into the Atlantic. Freshwater inflows are recorded in the rainy season from July to September. Freshwater inflows do not compensate for the intense evaporation. As a result, the salinity is higher than that of the sea water in all three estuaries. It can even reach and exceed 100‰ upstream of the Saloum late in the dry season (Louis Le Reste, 1994). Nevertheless, these tributaries are surrounded by a network of very dense *bolons* bordered by intertidal mudflats that are colonized by mangroves. The Saloum Delta is one of Senegal's most populous regions with 10% of this area inhabited by around 16% of the country’s total population (Maria Conception Villanueva et. al. 2002) As in The Gambia, the Senegal Government has also ratified major international environmental conventions and is implementing a biodiversity policy that combines setting aside areas for protection and adopting strict control for the hunting of wild fauna.

The Saloum Delta and marine area is a biosphere reserve that encompasses three protected areas: The Saloum Delta National Park, the Bamboung Community Reserve and the Palmarin Community Reserve for a total of more 90,000 hectares.

2.2 Biological Importance of The Study Area

Stretching across two countries and two river basins, the marine and coastal fauna in the study area is the same and very rich.

2.2.1 Marine Biodiversity

The river estuaries in the study area attract marine fish species for feeding and spawning and, as a consequence, the estuarine reaches of the rivers in this zone are rich in marine fish species of high economic importance and in crustaceans, mainly shrimp and crab.

The upwelling process provide nutrients for fish and marine species; It is estimated that the marine and estuary of the sub-region shelters 600 species of fish, 26 species of cetaceans, 6 species of Turtles and more than 200 species of birds.

The region is classified by international conservation NGOs intervening in West Africa as a region of regional importance for marine conservation. More than 114 fish species spawn and/or nurse in the Saloum and The Gambia mangrove ecosystem. Mature fish then spread out in the sub-region marine ecosystem. The mangroves and river flows provide organic matter that is the basis of one of the two major food chains for West African marine species.

Considering the marine species in the area of study, it has global importance. According to WAFCET Report (Van Waerebeek et al. 2000; 2003), the area shelters at least 6 to 8 species of cetaceans, including:

- Atlantic humpback dolphin *(Sousa teuszii),*
- Bottlenose dolphin *(Tursiops truncatus),*
- Common dolphin *(Delphinus Delphis),*
- Clymene dolphin *(Stenella clymene),*
- Short-Finned pilot whale *(Globicephala macrorhynchus)*
- Long-beaked common dolphin *(Delphinus capensis)*
- Minke whale *(Balaenoptera acutorostrata)*

The area is a corridor for whales as noted by fishers interviewed in Delta du Saloum in 2011 (ICAM II, 2011).

Marine birds are among the greatest biological asset. More than 200 species are present during surveys in January. Two-thirds of them are migratory birds. An IUCN 2002 study has shown that species coming from 12 Northern European countries and Greenland winter in the area. Moreover, the Saloum Delta Bird Island and Bijol Island are among the most important laridae (royal and Caspian terns and gulls) nesting sites in the world, with more than 60,000 nests each per year.

2.2.2 Mangrove Ecosystem

1. Generality and Functions

In West Africa, mangroves stretch from Mauritania to Nigeria; this continuum covers a current area of about 1,687,200 ha. Mangroves in the study area covered more than 150,000 ha in the early 1960s (100 000 ha for the Saloum and 68 000 ha for The Gambia estuary). This dropped to less than 100,000 ha in the 1980s and recovered to 120,000 ha today (60,000 ha in each country). Compared to East Africa, the West African mangrove ecosystem is less rich in terms of floristic composition: six main species dominate The Gambia mangrove ecosystem:

- *Avicennia germinans,*
- *Conocarpus erectus,*
- *Laguncularia racemosa,*
- *Rhizophora harrisonii,*
- *Rhizophora mangle,*
- *Rhizophora racemosa*.

Mangrove forests and related wetland habitats support a large number of important wildlife species, including the West African manatee (*Trichechus senegalensis*), several dolphin species and numerous migratory bird species, including the Western Reef-egret (*Egretta gularis*), Black-winged Stilt (*Himantopus himantopus*), Black-tailed Godwit (*Limosa limosa*), Grey-headed Gull (*Larus cirrocephalus*), Slender-billed Gull (*Larus genei*), Caspian Tern (*Sterna caspia*), and Royal Tern (*Sterna maxima*) (BirdLife International 2007). Similarly, coastal beaches provide important habitats for sea and waterbird breeding colonies and support marine turtle nesting.

Coastal ecosystems provide many important resources for the local human population. Mangroves, for example, are integral to the health and functioning of local fisheries. Mangrove leaf litter is a food source for a variety of invertebrates that are in turn consumed by other species in the food chain, including fish. The region's mangroves also act as a "nursery" for the spawning of 114 species of fish (Diouf et al., 1996). Mangroves have important hydrological functions; they may slow or prevent coastal erosion and serve to buffer or mitigate water pollution and flooding. Finally, mangroves are also an important source of fuel and construction wood. The mangroves of The Gambia and the Saloum constitute an important ecosystem for river bank stability, agricultural production and fish spawning. Globally, mangrove forests have high potential for carbon sequestration.

In The Gambia, the mangrove forests are among the most beautiful, especially those of the River Gambia which hosts one of the tallest mangroves in the sub-region (+20m) at a distance of about 100 km upriver (Forestry Department Report, 2009). However, at the level of Bintang bolong, the degradation of the mangrove is estimated to be more than 90%. At the level of the other formations, the degradation can be estimated at 3.3%.

2. Gambia Mangrove

The Gambia mangrove is concentrated along the River Gambia channel and reaches upstream about 200 km (UNEP, 2007) although thin curtains of mangroves border the estuary up to 250 km (Marius, 1984).

Prior to 1980, The Gambia had a total of about 68,000 ha of mangrove forest. It declined to about 56,900 ha by 1983 (Forster), representing a total loss of 11,100 ha. The main area of the mangrove die-back was along the Bintang Bolong area, extending into the Cassamance Region of Senegal. However, this trend is not linear. The loss of significant mangrove area that took place between 1980 and 1990 was followed by a period of strong recovery probably related to a return of rainfall contributing to decreasing salinity in the Gambia basin.

3. Saloum Delta Mangroves

The Saloum mangrove ecosystem is located in the inter-tropical zone, between 12°30’ North and 16°30’ North latitude and 11°30’ West and 17°30’ West longitude, at 150 km south of Dakar and 15 km from Kaolack. Several authors agree that its surface has drastically dropped and is estimated at less than 100, 000 ha. The Saloum mangrove is also divided into three major units along the three bolons in the Saloum Delta:

- In the southern part of the Sine-Saloum, the mangrove is very extensive. It inhabits almost the entire space between the *bolons*. Mangroves are tall (7 to 11 m), particularly along the tidal channels (Barusseau and *al.*, 1986) and particularly in their downstream part. In this area the ***tannes***, bare saline soils, are absent or rare.

- The central portion (the Diomboss banks and area east of Dionewar) is characterized by increased areas occupied by *tannes* and mangrove shorter than that in the south (2 to 8 m). Mangroves in the upstream parts of the *bolons* in this area show a degraded aspect.

- The north of the estuarine complex is occupied by a highly degraded mangrove which ultimately disappears upstream of the Saloum. The mangrove is generally less than 4 m tall (ISRA, 2005).

3. Physical and Climatic Features

3.1 Geology and Geomorphology of the area (ICAM, 2007)

The Saloum and The Gambia estuaries and coastal and marine areas are located in the western part of the sedimentary basin between Senegal and Mauritania. The geology of the various basins is simple. On the surface, the formations of the Continental terminal cover the whole area. These are tertiary period formations, made up of heterometric sand with argillaceous or sandy-argillaceous passes. They are based on a marine oligo-miocen, which consists of argillaceous sandstone, marno-limestone and sand.

At the geo-morphological level, there are four units of relief: (I) the plateau whose maximum altitude seldom exceeds 20 m (2.7 m in Banjul; 2. 3m in the Saloum Delta, 15 m in Kerewan) (Michel 1973); (II) the lowlands and the basins are the meeting point between the high glacis and the shallows. The drainage network makes a gash in this relief unit. (III) The colluvial and alluvial terraces which constitute the drainage network and (IV) the marine zone. Their inundation varies according to their position on the toposequence.

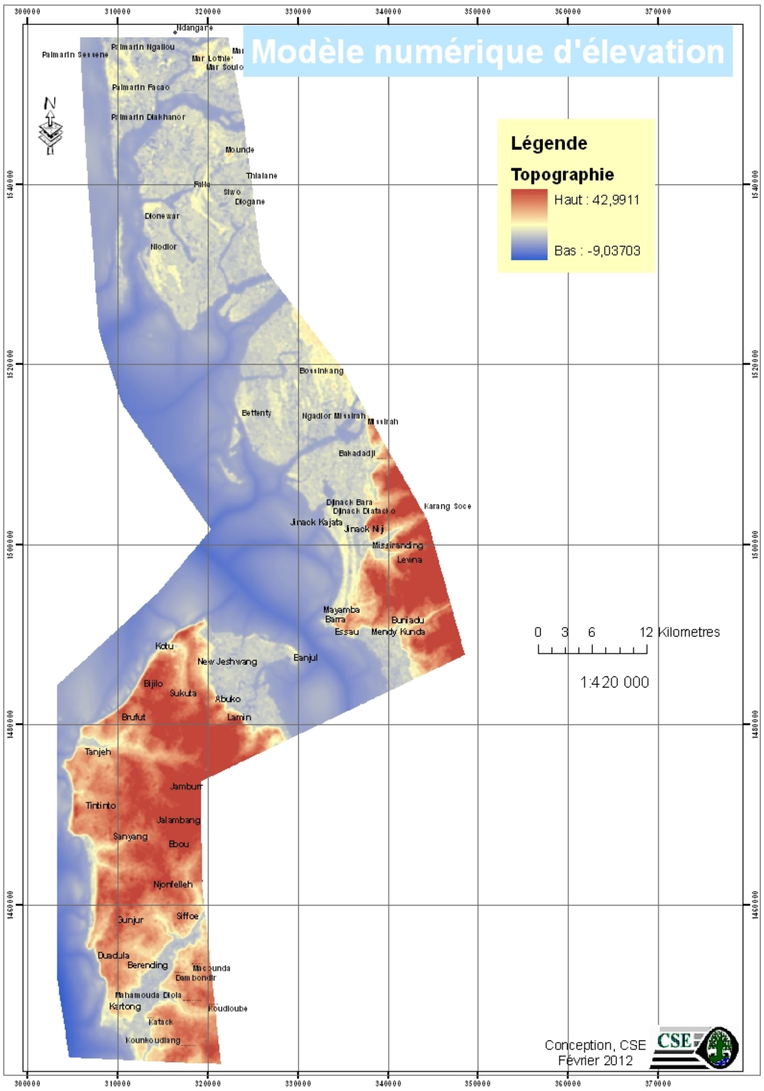

Figure 5: Digital Terrain Model

This topographic map shows (i) the Saloum Delta and The Gambia estuary are two riverine and marine interconnected features that will be impacted by climate change. They are lowland areas. In particular, the Saloum Delta and Banjul city, which are below 2m, are exposed to sea level rise.

There are four types of soil in the area: tropical ferruginous and leached soils on the high lands, residual hillocks and glacis; the ferrallitic soils; hydromorphic soils in the shallows and on the colluvial and alluvial terraces, and the mangrove soils.

Conclusion

The geomorphology shows that the area is flat and very sensitive to any rise of water. Soil is very sensitive to erosion as well.

3.2 Climatology

The climatic analyses are extracted from the ICAM project hydrological study of the area conducted in 2007.

3.2.1 Temperatures

Mean monthly temperatures do not vary significantly. The principal mean monthly maximum (between 39.2 and 35.5° C) is reached in April and the secondary maximum in November. The minima are felt from December to February. The variation amplitudes are 10°C in Banjul and 15°C in Kerewan (ICAM 2007).

3.2.2 Insulation

The average daily insulation in the area is 8 hours. The maximum insulation takes place in April with almost 9 hours and the minimum occurs during the rainy season while cloudiness and relative humidity are at the maximum. The minimum insulation during the rainy season reaches 6.8 hours in August.

3.2.3 Humidity

The monthly change in relative humidity is consistent with the two seasons of the year. It is minimal during the dry season, less than 50% from January to May. From June to November, it exceeds 60%, and goes beyond 80% from August to September.

3.2.4 Winds: direction and speed

There are two major directions when the wind blows. From November to April, it blows from the North to the North-East and is dominated by the sea tradewinds or the Harmattan. From May to October, it blows from the West to the South West and is guided by the monsoon current. The mean velocity varies from 2 to 2.5m/s in Banjul, and from 2 to 3.5 m/s in Kerewan. The highest speeds take place between March and June with the East winds.

3.2.5 Evaporation and evapotranspiration

Atmospheric sampling depends on various factors which are often interdependent: the duration of insulation, temperatures, atmospheric circulation, and the proximity of the coastline. The ETP Penman equation gives results which approximate 1995mm in averages; 1430 mm and 2464 mm annual evaporation for Banjul and Kerewan stations respectively. The evaporation is very high for inland areas and gives way to a negative water balance. This partially accounts for the decrease of ground water and the consequent expansion of the salt wedge.

Table 2: Climatic parameters in Banjul and Kerewan stations

Banjul													
Parameter	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT.**	**NOV.**	**DEC**	**Year**
Min temp. C	18,2	18,8	20,2	20,5	21,7	23,3	24,2	24,2	24	24,6	23	20,2	**21,9**
Max temp. C	32,6	33,2	33,2	31,8	31,3	32,7	31,6	31,5	32,4	34,3	34,4	33,5	**32,7**
Avg. temp. C	25,4	26	26,7	26,2	26,5	28	27,9	27,9	28,2	29,4	28,7	26,8	**27,3**
Winds m/s	2,3	2,3	2,5	2,5	2,4	2,2	2,1	1,8	1,6	1,6	1,6	1,8	**2,1**
Evaporation mm	121,5	118,9	146,2	130,4	129,2	115	115,4	102,7	104,6	113,7	116,9	115,4	**1430,3**
Kerewan													
Parameter	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT.**	**NOV.**	**DEC**	**Year**
Min temp. C	16,5	18	19,2	20,1	22,9	23,8	23,9	23,6	24,7	24,6	20,2	17,5	**21,3**
Max temp. C	34	36,4	38,4	39,2	38,5	35,9	33	32	32,3	34	35,5	34,4	**35,3**
Avg. Temp. C	25,3	27,2	28,8	29,6	30,7	29,9	28,5	27,8	28,5	29,3	27,9	26	**28,3**
Winds m/s	3	3	3,2	3,4	3,5	3,5	2,9	2,7	2,3	2,2	2,2	2,6	**2,9**
Evaporation mm	215,9	217,3	274,6	284,1	274,5	223	179,2	157,8	146,4	144,9	160,7	186,4	**2464,6**

3.2.6 Rainfall Trend

Rainfall is analyzed on a monthly and yearly basis for the stations in Banjul, Kerewan, and Toubacouta. These stations are viewed as very representative of the area.

Annual and inter - annual distribution of rainfall

Like many other countries in the sub-region, The Gambia and Saloum, have been going through a long period of drought over the past few decades. It is radically changing the ecology of the various zones. Analysis of data from Banjul station has shown that the rainfall is characterized by a poor spatial and temporal distribution and a great inter-annual fluctuation, ranging from a maximum of 1978.6 mm in 1893 to a minimum of 353.8 mm in 1972 (ICAM, 2007). This corresponds to a difference of 1624.8 mm and a ratio of 5.6. Breaks in rainfall of more than one week are very frequent. Calculation of the various averages and the graph below clearly illustrate the downward trend of rainfall.

- Average rainfall over the past 121 years between 1886 - 2006: 1072.8 mm
- Averages of 30 year series:

  - 1886 - 1915: 1220.1mm
  - 1916 - 1945: 1160.9 mm
  - 1946 - 1975: 1118.9 mm
  - 1976 - 2005: 796.3 mm

Analysis of the average rainfalls of the above 30-year series between 1886 and 2006 shows a regular decrease of rainfall and a difference of 423.8mm between the (30-year) series of 1886 – 1915, and 1976 – 2005. This accounts for a gap (deficit) of over 35%. It is noteworthy that the average rainfall of the last 30-year series is lower than 858.3mm, which puts current years in the driest period according to hydrologists. This downward trend is also confirmed by the analysis of both the curve of the moving average over 11 years and of the following decennial rainfall average:

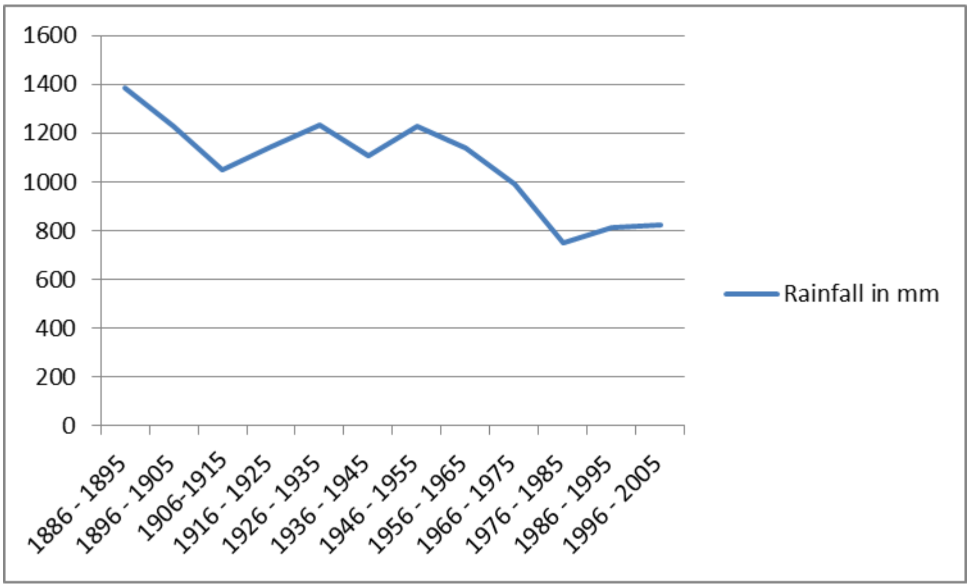

Figure 6: Rainfall in mm

Conclusion

The high intensity of downpours has negative consequences on the environment, at the beginning of the rainy season in particular, because of low vegetative cover and the poor protection of soils. As a result, erosion is intensifying, soils are being stripped, ponds and mangroves are silting-up, natural resources in the area are being degraded (in terms of quality and quantity), and related economic activities are slowing down.

4. Vulnerability Assessment

The chapter above explains clearly that changes are occurring in the climate; a downward trend of rainfall is being recorded since the nineteenth century. The phenomena are not localized, but global and are called climate change. These changes affect, often negatively, natural systems and the livelihoods of coastal communities.

4.1 Climate Change Definition

Climate change is an alteration in the state of the climate that can be identified by changes in the mean and/or the variability of its properties and that persists for an extended period, typically decades or longer (IPCC, 2012). Climate change induces sea level rise, changes of sea physical parameters, and changes in precipitation and salt intrusion in the water table with their ecological, economic and social effects. Climate change may be due to natural internal processes or external forces, or to persistent anthropogenic changes in the composition of the atmosphere or in land use.

There is scientific consensus that increases in greenhouse gases in the atmosphere drive the warming of the air and sea. Even if greenhouse gases were capped today, air and sea temperatures will continue to rise as a result of past emissions—as greenhouse gases in the atmosphere have a lifetime of between 10 and several thousand years.

Warming of the air and sea induces precipitation change, sea level rise, and more extreme weather events (e.g., storms and sea surge). The most significant and immediate consequences of these climate changes for the world's coasts include coastal erosion, flooding, drought, saltwater intrusion, and ecosystem change (USAID, 2009).

4.2 Exposure and Sensitivity to Reduced Precipitation

The climate in the study area presented above shows a consistent declining trend of rainfall for more than a century. The overall decline is 35%. It will likely continue and could result in a similar drop of 35% for the next century. This trend will impact natural systems, with less organic matter load in the marine ecosystem, less fresh water in the areas currently supporting mangroves, higher salinity soils and a deeper water table. Because of the rapid rate of reduced precipitation, the impact on both human and natural systems is high.

The Saloum Delta and River is significantly exposed to reduced rainfall. Since the late nineteen sixties, water flow to the river has dropped. Combined with high evaporation, reduced precipitation has resulted in increasing salinity in the river. It has even become a reverse estuary or ria.

4.2.1 Fish exposure and sensitivity to reduced precipitation

Increased Salinity.
Reduced Precipitation with the accompanying increase in evapotranspiration will render marine ecosystems in the study area vulnerable to salinization, the advance of saline fronts, and the perturbation of fish distribution patterns, among other effects. A marine species that is potentially vulnerable is the pink shrimp (*Penaeus notialis*/duorarum). This crustacean spawns on the continental shelf and early lifecycle stages drift plankonically with the tide into the estuary where they complete metamorphosis within the mangroves. The pre-adults return to feeding grounds based on the salinity gradient. If the salinity gradient is towards inland, the pre-adult migration will be towards inland rather than towards the sea. Any scenario characterized by an extreme decrease in precipitation and intense evaporation driven by high atmospheric temperature will undoubtedly increase upper estuarine salinity, thereby threatening the normal saline gradient of the estuary. Shrimp populations and the fisheries will, then, be directed inland where neither the stock nor the ecosystem services will sustain the fishery, particularly under the current conditions of high demand for foreign exchange.

The mangrove ecosystem is also sensitive to reductions in rainfall, because of its the need for a balance of fresh and salty water. The mangroves that are far from channel's edges are the most exposed to the effects of reduced precipitation.

Reduced surface runoff and nutrient discharge by river inflow.

Annually during the rainy season, The River Gambia and its tributaries converge and empty nutrient-laden water into the estuary. The nutrients serve as one of driving forces for primary production through the process of photosynthesis by phytoplankton. Climate models predict reduced precipitation in the Sahel. This scenario, characterized by elevated temperatures will enhance evaporative losses, resulting in both reduced river discharge volume and surface runoff.

Conclusion

A systematic reduction in annual precipitation and the resultant runoff anomaly will severely impact river regimes. In the Gambia, many freshwater fish species, such as *Gymnachus niloticus, Herterotis niloticus, Clarids and Cichlids,* that provide a significant portion of rural nutrition and economic activity were and still are being affected by the long spell of drought in the 1970's when spawning habitats for these species were desiccated. This resulted in systematic spawning and recruitment failures and reduced populations. In the Gambia estuary and more so in the Saloum Delta systems, the role of freshwater contributed by rain in creating an environment conducive for the ichthyo-fauna cannot be over emphasized. Rainfall is the only source of freshwater and nutrient runoff in the systems.

4.2.2 Agriculture exposure and sensitivity to reduced precipitation

Reduced precipitation and inconsistency of rainfall expose agricultural production to a sharp decline. Shortage of rain and/or a long pause without rain every 10 years will lead to dramatically more fragile food security in the area. The downward trend will likely shift mean rainfall in the study area to less than 700 mm by 2100. In this case, a change in the varieties of food crops cultivated, reduced diversity of varieties cultivated and lower productivity of food crops will most likely occur. Rice fields in particular will be more saline, requiring adapted varieties that current experience shows will probably be less productive than current varieties.

Sensitivity differs from one community to another. Saloum Delta islanders are no longer farmers and are, thus, less exposed to variability of agricultural production, although increasing prices for staple foods will affect them economically. The same is true for increased populations living in cities. Rural farmers are significantly exposed to the phenomena. They are also very sensitive since most of them rely only on rain-fed crops.

4.2.3 Vegetation exposure and sensitivity to reduced precipitation

The downward trend of rainfall over years has lowered the underground water table. This trend will most likely continue. Large trees are exposed and very sensitive to the drop. That is why the savanna forest in the Saloum mainland lost more than 75% of its tall trees between 1980 and 1990 (Dia, 2003). Vegetative canopy will be reduced and will most likely shift to clear savanna or steppe in some cases. Large trees and canopy are habitat for wild animals and reductions will impact wild fauna such as colobus monkeys.

4.3 Exposure to Sea Level Rise, Sensitivity and Impacts

4.3.1 Scenario

Sea level rise has been observed since 1870. Its more dramatic increase since 1930 is shown in the below graph.

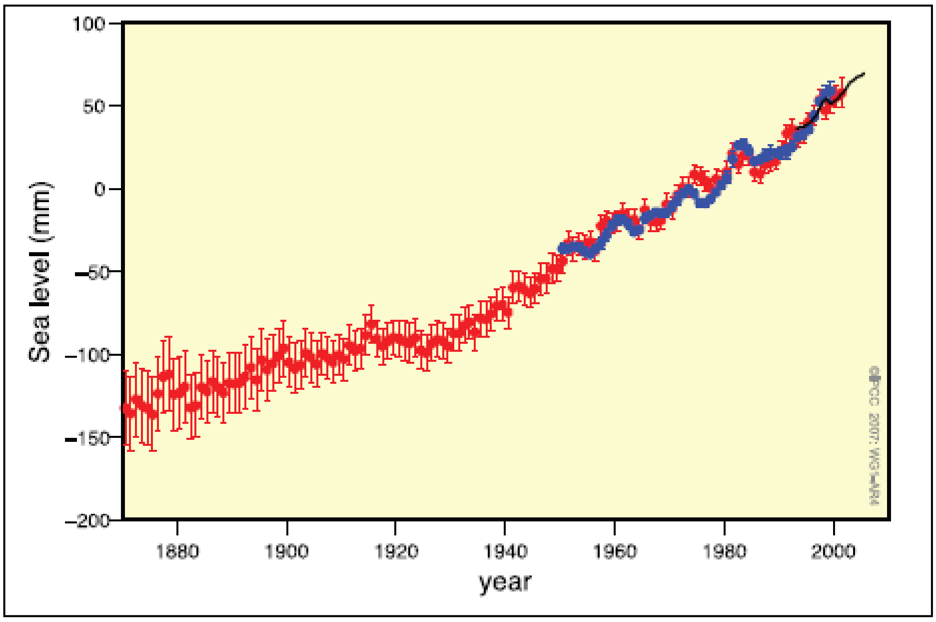

Figure 7: Trend of Mean Sea Level 1970-2003 (IPCC, 2007)

The fourth IPCC report indicates an average global sea level rise between 1990 and 2100 of 18 to 59 cm. However, current observations predict a 1m rise by 2100 (Fletcher, 2009).

For this report the sea-level rise scenarios below will be assumed.

Table 3: Sea-level rise scenarios and inundation level for the area of the Saloum estuary

	2050	**2100**
Sea-level rise		
- **Low hypothesis**	7 cm	20 cm
- **Average hypothesis**	20 cm	49 cm
- **High hypothesis**	39 cm	86 cm
Inundation level		
- **minimum**	1 m	2 m
- **maximum**		6– 8 m

Inundation estimates using the Hoozemans formula (Hoozemans, et. al., 1993) incorporate the mean high water level, mean sea level rise, storm wave height and sea level rise due to a lowering of the atmospheric pressure.

The topography of the area shows that Saloum sites above 10m altitude are rare, while The Gambia coastal zone is higher.

4.3.2 Exposure to a 2m inundation level

For the minimum inundation scenario, by 2100 52% of the Saloum Delta area will be exposed to inundation and 90% of the mangrove will be inundated, as shown by the below map. Islands will be inundated, displacing more than 2/3 of human settlements living on islands, including the town of Foundiougne. In fact, the existence of the Saloum Delta Biosphere Reserve will be threatened. Major roads on the mainland will be disturbed.

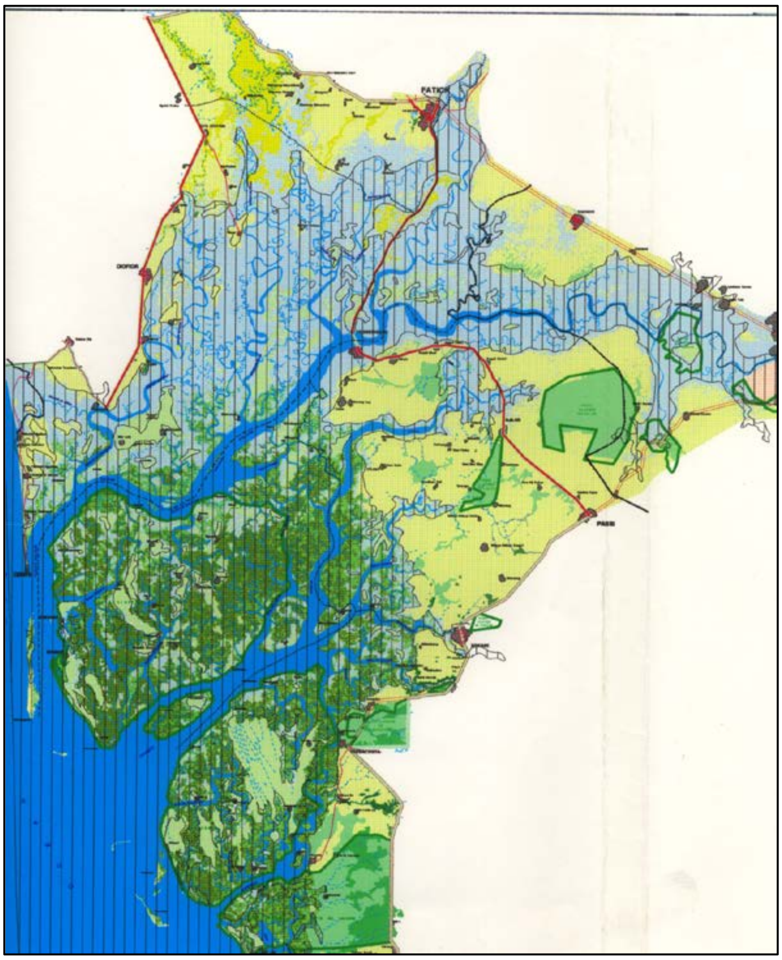

Figure 8: Inundable areas at 2 m inundation level (vertical lines) (Niang-Diop et al., 2005)

For The Gambia, exposure differs according to the area:

- For the North Bank along the Atlantic coast, mangroves, beaches and wetlands are exposed, Mansarinko bolong in particular. Djinak and Barra village are under threat.
- For the coastal area, the 10 m topographic curve is close to the coast, so only fish landing sites and facilities directly on the beach are under threat (Ghana Town, Tanji, Bata Saleh). Kartong is next to the Allahein river and is significantly exposed. Tanji, Tujering, Benifit, Kakima and Allahein river mouths, which are very low, are among the sites exposed to a 2 m inundation

level. Low beaches between Bald Cape and Tanji, between Salifor Point and Bata Saleh, including Osprey Beach are threatened as well.

- The Tanbi Wetland Complex mangrove ecosystem is exposed.
- The North bank of The Gambia River is higher land, but the mangroves and the town of Albreda are exposed.
- The whole of Banjul City is below the 2m level and highly exposed to inundation.

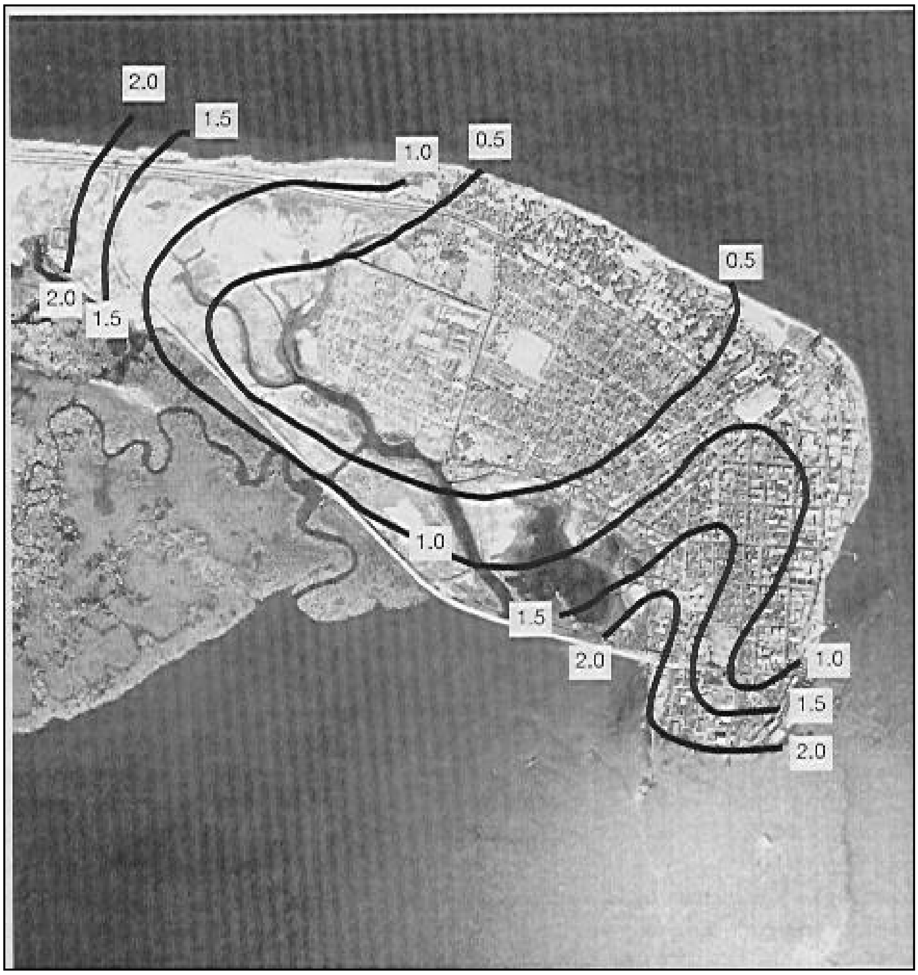

Figure 9: Aerial Photo of Banjul City with level curves (Republic of The Gambia)

4.3.3 Exposure to a 10 m inundation level

The extreme worst case scenario of a 10m inundation level by 2100 was explored to highlight the most comprehensive limits within which the need to plan for exposure to inundation might be relevant. In this case, in the Saloum estuary, 2,911 km2 are exposed to inundation (89% of the study area). The whole delta (2000 km2) and a major part of the mainland (37%) is exposed. Major roads and cities such as Kaolack, Fatick and Foundiougne are also exposed.

For The Gambia, in this scenario the whole city of Banjul is inundated and major tributaries will be overwhelmed by water as well as the town of Albreda. Many roads will not be functional. For instance the Banjul-Kartong road will be inundated when it crosses the Tanji, Benifit, Kakima and Allahein rivers. The Birkama Sibanor Road and the Buniadu Lamin road will also be inundated at their lowest points.

4.3.4 Biodiversity exposure and sensitivity to sea level rise

The above inundation scenarios demonstrate the high exposure of biodiversity assets in the the Saloum Delta and The Gambia estuaries. The mangrove ecosystem protects juvenile fish. Inundation of significant mangrove areas under the minimum 2m inundation level scenario will disturb the reproductive conditions for 114 species of fish and decimate a food chain critical to the eco-region that is based on the productivity of these areas.

The study area is a wintering site for limicoles and paleartic birds. The mudflats are feeding grounds for these wintering birds. The better their feeding conditions during this period, the better their reproductive success in the summer in northern latitudes. More than 90% of mudflats will be lost with mangrove disappearance. Coastal islands of the study area are also nesting sites of international importance for stern and gulls. Bijol Island, Iles aux oiseaux and other secondary sandy islands are under 2m in altitude and will likely be exposed to sea water permanently.

The Saloum and The Gambia estuaries shelter rare brackish water species such as the Nile Crocodile, Dwarf Crocodile, West African Manatee, and clawless otters. The inundation of these sites threatens the habitats of these species.

Marine turtles also nest along beaches in the study area. With gradually sloping beaches up to 2m in altitude reduced in area and exposed to inundation, only abrupt high dunes that are difficult for turtles to climb will remain. Nesting sites will be drastically reduced along The Gambian coast at this flood level. However, green turtles might find more feeding ground with the extension of ocean waters.

4.4 Exposure and Sensitivity to Erosionbays and rectilinear coasts less

The region is already experiencing coastal erosion. The Palmarin and Banjul coastal areas have lost more than 200 meters of land, including loss of infrastructure and human habitation.

The whole coastline open to the ocean is exposed to coastal erosion. The sandy nature of the beaches make coastal zone very sensitive to the intense wind and waves. However, the sensitivity differs from site to site. Bays and rectilinear coastlines are more sensitive than convex coastal areas. The area from The Gambian State house to Kololi stream, the bay shapes of Tanji area and the long rectilinear coast of Palmarin are very sensitive to coastal erosion. The whole area is very sensitive to sea level rise because of the topography.

4.5 Exposure and Sensitivity of Human Activities

Sea level rise results in a progressing salt water tongue in the water table. Lowland rice fields are, thus, exposed to salt intrusion. In recent years, rice yields in the Saloum are down by 90% due to the combination of sea level rise and reduced precipitation. The potential loss of 37% of mainland area to inundation exposure by 2100, will further reduce production and production potential as area for cultivation decreases.

While fisheries landing sites and fish processing facilities are under physical threat from sea level rise, inundation and erosion, major changes in fish stocks are also expected to occur.

This study conducted PRAs in five communities in the study area to understand community members' experience and perception of the exposure and sensitivity of human activities to the effects of climate change. The following tables summarize the results. Based on the scale presented in Table 4, participants scored the level of exposure of livelihoods and income sources to the climate risks identified.

Table 4: Exposure score to climate risks

Scale of magnitude	**Risk sensitivity**
1	Very Low
2	Low
3	Average
4	Strong
5	Very Strong

While all communities surveyed are involved in fishing activities and ranked fishing at highest risk, one of the communities (Djinack) has more diversified activities, including rice cultivation, which they found to be at even higher risk than fishing activities. Strong winds and advanced salinity are considered the phenomena that expose their socio-economic activities to the greatest risk.

Table 5: Exposure of income sources and livelihoods at the Tanji and Albreda sites : data from these sites have been aggregated as they have similar features.

Exposure Units: Income sources and/or livelihoods	**Major climate risks identified by fishermen**				**Exposure Index**	**Ranking**
	Drought	**High heat**	**Strong winds**	**Advanced salinity**		
Fishing (sole, barracuda. etc)	2	3	4	2	11	1st
Shrimp and oyster	1	2	2	4	9	2nd
Fish smoking	1	2	3	1	7	3rd
Impact index	4	7	9	7		

Table 6: Exposure of income sources and livelihoods at the Djinak villages (The Gambia and Senegal)

Exposures Units: Income Sources and livelihoods	**Major climate risks identified**			**Exposure index**	**Rank**
	Advanced salinity	**Drought/rainfall deficit**	**Insects and birds invasion**		
Rice farming	4	4	3	11	1st
Fishing	2	2	1	5	2nd
Exploitation of oysters and clams	3	2	1	6	3rd
Impact index	9	8	5		

Table 7: Exposure of income sources and livelihoods at Djirnda and Dionewar

Sources of income and livelihoods	**Climate Risks**			**Exposure Index**	**Rank**
	Advanced Salinity	**Strong winds**	**Rainfall deficit/drought**		
Fishing	4	4	2	10	1st
Seafood Exploitation	3	2	3	8	2nd
Logging	1	1	2	4	4th
Fish smoking	3	1	1	5	3rd
Apiculture	1	1	1	3	5th
Impact Index	12	9	7		

4.6 Climate change Hotspots

The following sites were identified in the various specialist studies as those where the impact of climate change is potentially the highest:

- 2/3 of human settlement in the Saloum and Banjul
- Bird nesting Islands
- Mudflats or migratory birds feeding sites
- Cemeteries, schools, hospitals and religious sites
- High value infrastructure
- Albreda historical site
- Mangrove ecosystems

4.7 Adaptive Capacity

Adaptive capacity refers to the ability of natural systems and society to change in a way that makes it better equipped to manage the potential impacts of climate change. Climate change trends have been occurring for over a century. Natural and human systems have developed adaptive capacity to the changes.

4.7.1 Adaptive capacity to sea level rise

The current mangrove ecosystem did not exist when communities were first settling in the Saloum. The mangrove ecosystem developed progressively while water bodies were rising during the 19th and 20th centuries. The natural ecosystem adapted as conditions changed and will continue to adapt as sea levels continue to rise and as reduced rainfall increases salinity in these areas.

In general, in The Gambia, to cope with sea level rise, settlements are located on higher sandy sites far from the coast and lowlands. For this reason villages along the estuary and on the coast, except Banjul and Albreda are not at high risk to sea level rise.

Communities responded to rising water by moving and displacing. All coastal villages in Toubacouta in Niumi and Niombato are displaced islanders. During the 1970's, Ngadior village moved from an island to Missirah village. Djirnda province is a community from the same village resettling progressively. The main village relocated to a higher place on the island early in the 20th century.

4.7.2 Adaptive capacity to reduced rainfall

The key adaptive strategy related to recurrent drought in the study area has been changing economic activities and/or emigrating. The population was generally both fishers during dry season and farmers in the rainy season. The 1970's and 1980's droughts led many to stop farming. Alternative activities such as bee-keeping, tourism, and commerce have since increased. However, communities, together with governments and NGOs in the study area in both Senegal and The Gambia, are building dams to protect rice fields from increasing salinization.

Mangrove ecosystems have been under high stress during low rainfall years, but mangroves in The Gambia River tributaries have recovered rapidly in many areas. Fast recovery has been noticed as natural adaptation to severe drought. However, sites highly destroyed without natural seedlings (propagules) can be supported by mangrove planting. Many initiatives of this kind have been conducted throughout the sub-region. At least 300 ha have been replanted in Saloum and The Gambia estuaries since early 2000. Strong regulation on mangrove uses, such as a ban on any mangrove cutting in the Saloum Delta, also supports protection of the species.

Oyster harvesting communities have adapted to climate and non-climate related changes by increasing fishing and collection effort as shown in the below graphs (MoFWR-NAM Cockle and Oyster Co-Management Plan, 2012).

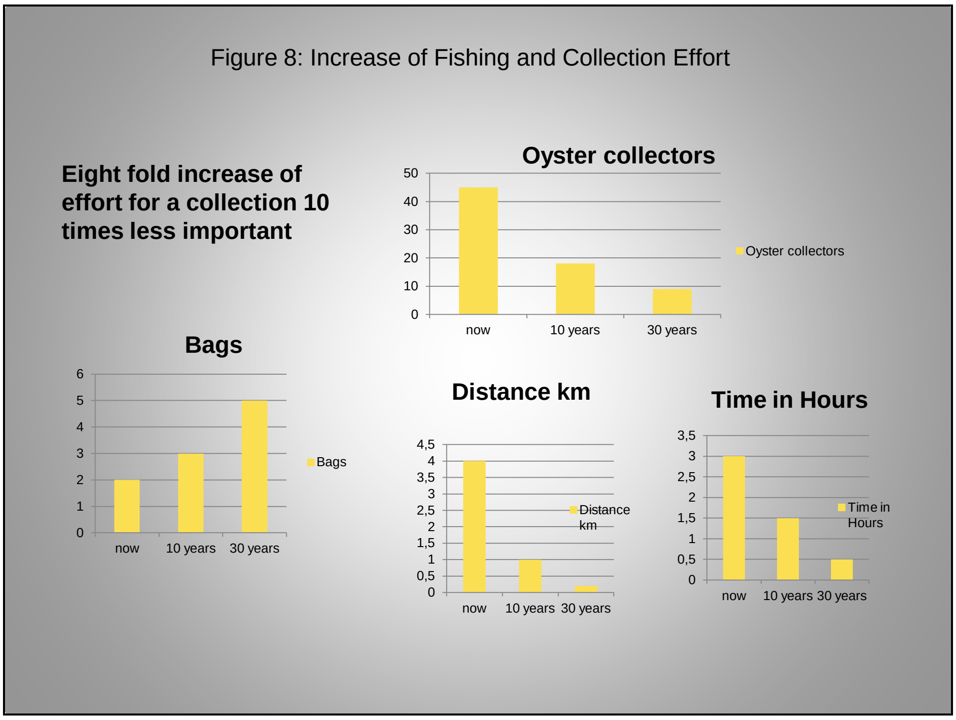

Figure 10: Increase of Fishing and Collection Effort

4.7.3 Adaptive capacity to erosion

Settling far from the beach is one measure that communities have generally adopted in the study area to adapt to beach erosion. Traditional villages are always 200 meters from the sea edge. Initiatives to reduce erosion by planting trees such as *Casuerina* have been successful along the Senegal coast. The Palmarin community has opened more channels on roads that cut estuaries off from the ocean to allow greater flow of ocean water in order to reduce the effects of erosion. Erosion control has also been undertaken with boulders lining areas sensitive to erosion in many places in Senegal and at the Albreda historical site. Beach nourishment has been implemented in Banjul at eroded sites to protect high value assets such as the State House, cemeteries and Hotels.

4.7.4 Adaptive capacity of fish

Changes in the environment are an important driving force of evolution, as recognized by Darwin in his famous quote: “It is not the strongest of the species that survive, it is the one that is the most adaptable to change.” Animals may adapt by altering their behavior, physiology, or morphology. The rate of adaptation to change for animal species can be dependent on many factors, including the range of variation within the species, the character of the life cycle and cognitive ability, among others.

Fish adaptation to increased salinity:

Fish species that can handle a wide range of salinities are termed euryhaline, as opposed to stenohaline (i.e. those that can survive only a narrow range of salinities). Estuarine species fall into the euryhaline classification. Therefore, they are at relatively less risk due to increasing salinity than stenohaline species (Marine and freshwater species). Most pelagic species have a wider salinity range, while most demersal species have narrow tolerance to salinity changes. Under extreme deviation from a species’ range, adaptive mechanisms are often developed, which can include moving out of the unfavorable medium, in the case of shellfish closing of valves/shells, and excretion of excess salts to balance osmotic pressure. Estuarine organisms may become stressed if they cannot cope with salinity changes; newly hatched eggs and reproducing adults are generally more vulnerable to salinity stress than other individuals in a given fish population.

Adaptation to temperature changes:

Fish are classified into eurythermal and stenothermal depending on their range of tolerance to water temperature changes. Most tropical fish species are classified as stenohaline as compared to fish species in temperate regions. When water temperatures reach or approach the upper limit of a particular species’ tolerance limit, in rivers and streams fish concentrate at the point of water inflow. This adaptation is due to the influence of water temperature on oxygen solubility. Dissolved oxygen is inversely related to water temperature and is also highest near moving and turbulent water. Another adaptive strategy of fish to high temperature stress is to concentrate in shaded areas to benefit from reduced light penetration particularly infrared (heat) light. As surface temperatures increase, the majority of fish will adapt by moving deeper and deeper until dissolved oxygen content is tolerable. In estuaries that are relatively homogeneous thermally, like The Gambia estuary, the latter adaptation may not be very significant. These adaptation strategies can stress the fish and increase its vulnerability to fatal circumstances such as predation and fishing.

Fish Adaptation to sea level rise

One of the most significant effects of sea-level rise is intrusion of saline waters. Impacts on fisheries described earlier in this document under increased salinity are applicable. Saline intrusion along The Gambia estuary experienced in the 1970s and 1980s resulted in the displacement of species further up the estuary.

4.7.5 Protected areas as adaptive capacity

The West African sub-region has developed a strong policy of protected areas and marine protected areas to provide refuge to significant biodiversity, contributing to the adaptive capacity of eco-systems to the impacts of climate change. Approximately 10% of the study area is in protected zones. Various Management Plans for PAs and species are being implemented.

Co-management and seasonal closure of fisheries is another measure already taken by governments and fisherfolk to sustainably manage fisheries resources in the context of increasing human and environmental pressure. In the Saloum, each community has chosen channels not to be harvested during the spawning season. In The Gambia, the National Sole Fishery Co-Management Committee and the Department of Fisheries have approved a seasonal closure for all fishing for 1nm out to sea along the entire Atlantic coast. Community fisheries centers participate in this initiative. Processors, fishers and the government of The Gambia hope to manage the sole fishery sustainably enough to obtain an eco-label.

Regular monitoring of species and habitats, recognized as a tool to enable decision-makers to take relevant actions as changes ocurr is being implemented for many species and fisheries. Examples include DPWM ecological surveys in The Gambia, dolphin and marine turtle surveys, Protected Area rapid assessments.

6. Adaptive Measures

The adaptation measures recommended by the specialists who prepared each of the technical reports for the USAID/BaNafaa Climate Change Vulnerability Assessment are summarized as follows:

5.1 Communication Plan On CC Effects

- Develop Awareness campaign on sea level rise scenarios
- Implement community-based disaster risk reduction
- Create a Saloum Climate Change Governance body
- Develop a coastal zone management plan

5.2 Agriculture and Salt intrusion

- Enhance the ongoing desalinization program of low lands and rice fields
- Introduce new crop varieties
- Implement watershed management for small rivers
- Protect water table replenishment sites

5.3 Coastal Wetlands Protection and Restoration

- Monitor and protect bird breeding areas such as Bijol Island, Iles aux Oiseaux
- Monitor wintering birds and Protect their feeding sites
- Identify and protect critical habitats for rare species (manatee, crocodiles and clawless otters)

- Develop local sustainable use of mangroves: non timber uses, restricted planned timber uses, mangrove planting, and monitoring
- Evaluate the impact of human made facilities (roads, hotels, dams and rice fields) on wetland functioning;
- Subsequently, take mitigation measures, establish guidelines and co-manage their application

5.4 Erosion and sea waves impact control

- Assess erosion scenarios, communicate with stakeholders and plan future responses
- Develop Communication plan with communities most likely to be impacted
- Evaluate impact of human made facilities (roads, hotels, dams and rice fields)
- Subsequently, take mitigation and restoration measures
- Develop standard building guidelines and co-manage their application
- Implement Biological protection and hard protection actions
- Set aside dune protected zones and beach natural nourishment ways
- Study sediment dynamics in the area
- Develop an overall settlement and/or resettlement plan

5.5 Sustainable Fisheries

- Develop local codes of conduct for sustainable fishing
- Develop alternative livelihood activities

5.6 Marine Protected Areas

- Expand the MPA system
- Develop a Humpback dolphin management plan
- Develop and implement a Turtle nesting sites protection plan
- Put in place an overall Saloum and The Gambia estuaries and coastal zones Biodiversity Monitoring System

Conclusion and Recommendations

The Gambia coastal zone and Saloum Delta Biosphere reserve is an interconnected hydrological and biological system with 600 species of fish, 26 species of cetaceans, 6 species of Turtles, more than 200 species of birds and 120,000 ha of mangrove ecosystem. The area is classified by international conservation NGOs intervening in West Africa as of regional importance for marine conservation.

Significant degradation of landscapes with its consequence on communities' livelihoods as well as on coastal and marine ecosystems is happening since the early 1960s. Climate change, among otherfactors is a major driver of these changes.

Climate change considered in the study includes sea level rise and associated inundation levels of 2m and 10m by 2100, coastal erosion, reduced and variable precipitation (35% drop and 1 in 5 years of flood), and salt intrusion in the water table, all with their ecological, economic and social effects.

The area is considered to be vulnerable to all of these climate change effects. The Saloum Delta , Banjul City and the mangrove ecosystems are the sites most likely to be impacted significantly, even under the minimum scenario.

Vulnerability Assessment study results and recommendations were shared, discussed and used to identify Climate Change Adaptation priorities in a bi-lateral (Gambia-Senegal) workshop attended by 55 participants. The Gambian Minister of Fisheries, Water Resources and National Assembly Matters and The Minister of Forestry and Environment spent an entire half day at the workshop participating in the discussion. In addition to journalists from print, radio and television, USAID/BaNafaa staff, WWF staff, consultants and USAID/COMFISH staff, 11 Gambian and 7 Senegalese institutions were represented.

Priority Sites

The following sites are considered by participants as climate change vulnerability hotspots of bi-lateral importance, with the top 3 prioritized for USAID/BaNafaa interventions:

Banjul/Tanbi Wetland
Dionewar/Djifer
Bettenty
Bijol Island/Iles Aux Oiseaux
Djinack

Priority socio-economic activities

Participants prioritized the following socio-economic activities for mainstreaming of climate change adaptation measures, with the top 3 recommended for USAID/BaNafaa focus:

Fishing, Shellfishing, Processing
Agriculture
Tourism
Forestry
Settlement

Priority Adaptation Measures

In the context of the above priorities and the human and natural adaptive capacities noted in the study, the workshop recommended that the USAID/BaNafaa Project address the following priority adaptation measures in identified hotspots with local stakeholders and at various levels of governance both nationally and bi-laterally.

1. Coastal Wetland Protection and Restoration
2. Development of Alternative Activities for Sustainable Resource Use
3. Targeted Awareness Raising Campaign (crosscutting)
4. Protection of Coastal Zone against Waves and Erosion (the limited resources of the USAID/BaNafaa project are not likely to be at a scale sufficient to address this issue adequately, so it was retained as a secondary area of intervention only where it is appropriate on a small scale within the scope of the project (i.e., dune stabilization at a community level with natural planting) or supporting policy level initiatives).

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