

THE VULNERABILITY OF COMMUNITIES AROUND THE MARINE PROTECTED AREAS OF BAMBOUNG, CAYAR AND JOAL-FADIOUTH IN SENEGAL: PLACES OF ADAPTATION TO CLIMATE CHANGE

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ABSTRACT

Climate change accelerates the vulnerability of resources that are of great importance to the lives of communities in many parts of the world. This study aims to analyze the vulnerability and adaptation to climate change of local populations in and around marine protected areas (MPAs) in Senegal. The methodology is based on Participatory Rural Appraisal (PRA) and the CRISTAL tool used to assess the vulnerability of communities and adaptation strategies. The Climate Information Portal (CIP) has been used to make projections of rainfall and temperature; allowing projections to be 'downscaled' to local areas. The results show that the riparian communities of three MPAs (Bamboung, Joal-Fadiouth and Cayar) are facing climate and non-climate vulnerabilities. Strategies for current and potential adaptation options have been identified to overcome the various hazards and these are outlined. Strategies are designed to contribute to the sustainable improvement of the living conditions of communities around the MPAs.

KEYWORDS: climate change, adaptation, marine protected areas, Bamboung, Joal-Fadiouth, Cayar, Senegal

BACKGROUND

It is becoming increasingly clear that the social aspects and ecology of protected areas are not totally independent and that simultaneously protected areas today are increasingly expected to deliver social and economic benefits in addition to conserving biodiversity (Dudley and Stolton, 2008). Achieving these dual aims is however far from easy; the impacts of climate change will make this an even more challenging goal for many protected areas.

Fisheries contribute 30 per cent of Senegal's exports and nearly 600,000 jobs are directly or indirectly created by fisheries and related activities. Approximately 80 per cent of the catch in Senegal (about 400,000 t / year) is from the local artisanal fisheries. Much of the country's population derives its income from fisheries. However, in recent years the fishery resources have decreased drastically. This is seen particularly in demersals species, which have high commercial value. The increase of foreign demand has, for example, contributed to the

collapse of the *Epinephelus aeneus* group on a large scale (Thiao et al., 2012).

This paper focuses on three of five Marine Protected Areas (MPAs) in Senegal, Bamboung, Cayar and Joal-Fadiouth. They were created by the Decree N° 2004-1408 in November 2004, aim to address the declines in fish stocks and cover a total surface area of 82,500 ha. The populations of all three MPAs (38,632 in Joal-Fadiouth, 15,772 in the 14 villages around Bamboung and 22,000 in Cayar in 2009) are vulnerable to climatic and non-climatic events. The consequences of climate change manifest themselves in the degradation of the quality of life, reduced natural resources, and a decrease in revenues. Implementation of adaptation strategies is therefore a necessity for any prospect of local sustainable development.

There are few studies on MPAs in Senegal, and almost none of the studies addresses their vulnerability to climate change and the influence of this vulnerability on



Local fisherman, Cayar village, Senegal © Hartmut Jungius / WWF-Canon

the livelihoods of surrounding communities. This does not facilitate the consideration of local concerns in climate change adaptation projects. This paper is one of the first to look at the issues of development, biodiversity conservation and the vulnerability of communities to climate change in the coastal area of Senegal where fishing is vital for the local economy and sustenance.

INTRODUCTION

Conventions on biodiversity, desertification and climate change are major steps in the governance of the global environment; and are closely linked to many development goals (OCDE, 2005). Populations of non-Annex 1 countries of the United Nations Framework Convention on Climate Change (UNFCCC), which are predominantly developing countries, are already subject to numerous obstacles to sustainable growth including poverty, disease and lack of economic development. The impacts of climate change make them even more vulnerable. Parties to the convention are invited to protect the climate system for present and future generations (Article 3) and to take full account of the specific needs and circumstances of developing country Parties, especially those that are particularly vulnerable to the adverse effects climate change (Article 4).

The conclusions of the Intergovernmental Panel on Climate Change (IPCC, 2007) show that during the 20th century temperatures in Africa rose at a rate of about 0.05°C each decade. An increase in temperature of about 0.1°C per decade is expected for the next two decades. The projected impacts of climate change in West Africa include periods of increased heat and more frequent heavy precipitation, an increase of drought and of arid and semi-arid areas, and exacerbated water stress in some countries. In Senegal the average annual temperature has increased by 0.9°C since 1960 and southern regions saw a significant decrease in rainfall, of 10-15 mm per decade, during the rainy seasons between 1960 and 2006 (the lack of data on daily rainfall does not allow assessment of changes in rainfall intensity) (UNDP / Oxford, 2008). The anticipated rise in sea level is expected to affect low-lying coastal areas with large populations (UNDP, 2008) as well as coastal wetlands, including salt marshes and mangroves, especially when these coastal areas are subject to constraints or they lack sediment (IPCC WGII, 2007). Dennis et al. (1995) compared four scenarios of sea level rise (rises of 0.2, 0.5, 1 and 2 m by 2100) before 2100. On the Senegalese coast the results projected the amount of surface area that could be lost, populations and economic value at risk and the cost of protection. The projections were that between 55 and 86 km² of beach will disappear, due to increased coastal erosion phenomena.

The major environmental problems facing the Senegalese coast are more or less directly related to climatic parameters, the most important being floods, coastal erosion, salinization of soil and water, degradation of mangroves and changes in fish resources (MEPN, 2006). A common observation is the need to better link climate issues to local development issues through the management of ecosystems for the most vulnerable populations – human and wildlife (ENDA, 2009). In Senegal, fishing is of vital importance to the people not only in economic terms but also for employment and food security (PRCM, 2003).

The landmark Stern report argues that adaptation is the only possible response to the impacts that will occur in the coming decades before mitigation measures take effect (Stern, 2006). National adaptation programmes of action (NAPAs) address priorities for adaptation under the UNFCCC; however implementation requires resources that are not always available. In addition, these strategies are sometime inadequate when people are faced with a variety of pressing needs. People living around MPAs for example are constrained in the exploitation of natural resources important for their livelihoods and thus need alternative livelihood strategies.

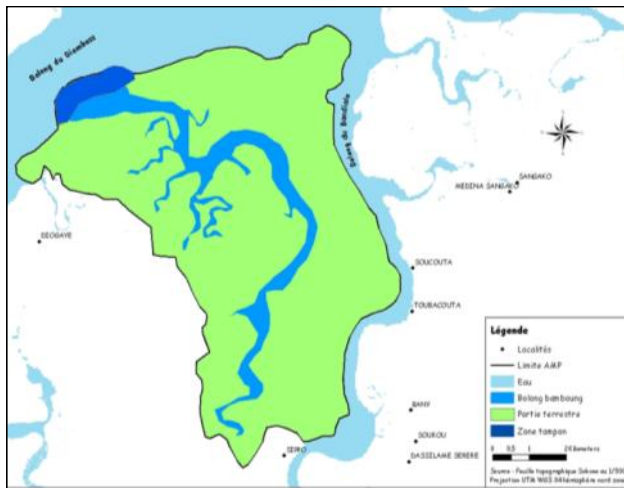
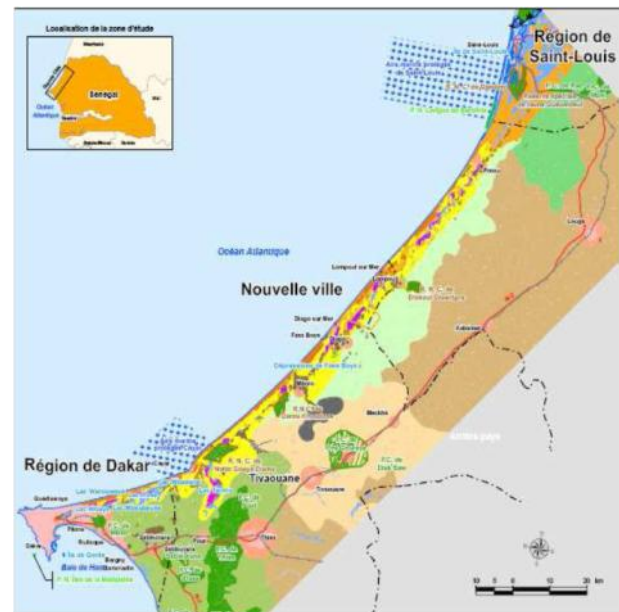


Figure 1 and 2: Map of the MPA of Bamboung (above) and Cayar MPA (right)

The five MPAs (St. Louis, Cayar, Joal-Fadiouth, Bamboung and Abene) that have been established in Senegal are an important step towards the establishment of a representative network of MPAs. They aim to promote sustainable management of fishing areas by protecting nursery and breeding areas. Despite these aims, however, research has revealed the difficult living conditions of people around MPAs – for example the challenges faced by communities in the vicinity of the Bamboung MPA – may be related to its mode of management (Drame, 2008). As the impacts of climate change have become apparent it is increasingly clear that the current management of MPAs is not facilitating the development of socio-economic, cultural and environmental activities to mitigate impacts. The study reported here thus aimed to better understand the vulnerability of communities to climate change in the coastal area of Senegal and highlight on-going and new strategies to be incorporated in the management of the MPAs to help communities mitigate and adapt to climate change.

STUDY SITE: BAMBOUNG, JOAL-FADIOUTH AND CAYAR

Bamboung MPA is in the western part of central Senegal, in the region of Fatick in the district of Toubacouta; it has an area of 70 km². The MPA is divided into a central marine area, a buffer zone and an area of land. The central area consists essentially of the Bamboung bolong (small river) and its tributaries (Figure 1). With a length of 15 km (from the confluence with the Diomboss River to the mudflats of Kole forest), its width varies from 50 to 500 metres and its depth varies from 0 to 15 meters. A buffer zone is located at the confluence of the bolong, at



the confluence of the Diomboss and Bamboung. Fishing is prohibited in the MPA. Twenty -three new species of fish have been recorded between 2003 and 2007 according the results of a survey conducted by the Institute of Research for Development (IRD) (IRD, 2007).

Cayar (Kayar) MPA includes the maritime dependencies of the commune and the marine depression of Cayar; it covers 171 km² (Figure 2). There are no zones strictly prohibiting fishing operations however at certain periods of the year fisheries are subject to a temporary closure to promote reproduction, increase species and allow regeneration of resources.

Joal-Fadiouth MPA includes the maritime dependencies of the commune, small rivers and mangroves; it covers 174 km² (Figure 3). It is part of a new generation of protected areas in Senegal where the concept of community co-management of resources is applied. The zoning was participatory and was defined as the core area, a multipurpose zone and a mangrove area. Fishing is completely banned from core area which extends over 4.5 km from the coast to the sea. This area covers fish spawning and nursery areas, the habitat of manatees and areas important for sea turtle nesting. The multipurpose zone extends from the edge of the core area (4.5 km from the coast) to 8 km from the sea. In this part of the MPA, sustainable fishing is allowed using equipment that abides by legal standards. The mangrove and bolong area are places where conservation and development activities are practiced. This area includes seeding zones for molluscs (*Anadara senilis*) and oyster farming areas. Ecotourism is authorized within the mangrove area if natural resources are not extracted.

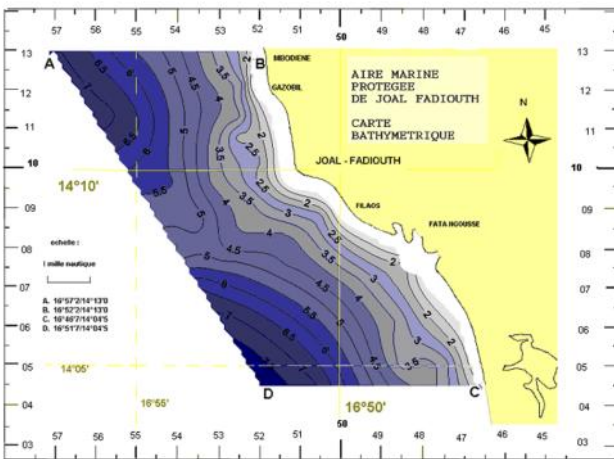


Figure 3: Bathymetry of Joal-Fadiouth MPA (Source: WWF WAMER, 2006)

SOCIAL ORGANIZATION

The Bamboung area belongs to the Saloum Delta, one of the most populated regions of Senegal. Population growth in the region was higher than the national average between 1904 and 1958, i.e. 2.2 per cent compared to 1.3 per cent. This could be explained by the attractiveness of the region due to favourable growing conditions for groundnut production during this period (Sarr, 2005). Traditional social organization is characterized by the presence of family households subject to the authority of the head of the compound, generally the elder.

In Joal-Fadiouth, the Fadiouth inhabitants are 99 per cent Serere ethnic group while in Joal the population is heterogeneous with Wolof, the Serer and other ethnic groups from the sub-region (Mali, Burkina Faso, etc.). The society is matrilineal. Several traditional authorities in Joal-Fadiouth exercise various governance functions.

The population of Cayar was just under 17,000 in 2005. It is spread over nine districts of which five official district form the former core of Cayar. The original population of Cayar is Lebu (an ethnic group), but as fishing activity developed there was an intermingling of populations. The main ethnic groups are essentially the Wolof (80 per cent) and Fulani (10 per cent). There is also small presence of Serere and Diola ethnic groups. The society is patrilineal supported by a caste system strongly influenced by the Muslim religion.

An increase in the population of all these areas has led to pressures on the resource base as the need to satisfy local consumption and markets needs to generate increased income. In addition a drought between 1970 and 2000 led many farmers to turn to fishing, which contributed to the acceleration of overfishing and conflicts between

Table 1: The three main risks identified in each site

Study area	Identified risks
Joal-Fadiouth	1- Coastal erosion 2- Flooding 3- Strong winds
Cayar	1- Strong winds 2- Rainfall variability 3- Sea level rise
Bamboung	1- High temperature 2- Drought 3- Strong winds

indigenous and non-native fishermen. Fishermen have had to go far from their traditional fishing grounds due to scarcity of fish. Fish processing, which was done only by fishermen’s wives, is now carried out by a variety of national and sub-regional operators; who increasingly employ men. This disrupts the social organization and division of labour between men and women.

METHODOLOGY

The study aimed to contribute to a better understanding of the types of vulnerabilities that people face around MPAs in Senegal. It analysed the forms of local adaptation and limitations on adaptive strategies so that appropriate measures can be taken to improve the livelihoods of local populations.

The approach is both qualitative and quantitative. Participatory Rural Appraisal (PRA) was used to develop the profile of a focus group through the use of semi structured interviews. PRA tools were complemented by the Community-based Risk Screening Tool – Adaptation and Livelihoods (CRiSTAL) (IISD, 2012) to assess the vulnerability of communities and identify adaptation strategies. In addition to qualitative techniques, quantitative techniques were used through the Climate Information Portal (CIP) (cip.csag.uct.ac.za) to make projections of rainfall and temperature. This approach allowed researchers to downscale data from climate data sources and analyze future climate in the three MPAs studied.

Site selection was based on geographical criteria and socio-economic activities. The five MPAs were divided into three types of environments (small coastal areas, large coastal areas and estuary/Casamance – an area south of Gambia including the Casamance River). An MPA was chosen in each environment. The MPAs were also representative of variable levels of implementation and regulation. Bamboung (an estuarine area) was the

first functioning MPA in Senegal. Cayar (Kayar) is in the 'large coast environment' and is one of the most diverse and economically important fishing zones in the world. The MPA boundaries are not yet marked out, but the indigenous peoples have a culture of conservation of fishery resources. In Joal-Fadiouth, located in the 'small coast' and a very important breeding area for sea turtles, the indigenous populations were farmers before being fishermen and do not have the same type of conservation approach to fisheries.

Cayar and Joal-Fadiouth are district communes whilst Bamboung is surrounded by fourteen neighbouring villages. In Bamboung, the technique of rational choice was used for the selection of target villages based on the following criteria:

- The involvement of the village in the process of creating the MPA.
- The involvement of the village in the management activities of fisheries resources.
- The location / position of the village in regard to the MPA.
- Presence or not in Bamboung before it was protected.
- The villages selected for the survey around Bamboung were thus Toubacouta Soukouta, Sipo, Diogaye and Nema Bah.

Resource persons from various socio-professional categories operating in fisheries and agriculture were the main targets for the collection of information. The research included documentary research, the collection of field data, data processing and reporting.

CURRENT VULNERABILITY OF COMMUNITIES AROUND MPA

Table 1 summarises the three main vulnerabilities assessed by the communities in the three MPAs studied. These include climate and non-climatic risks that increase vulnerability; all risks have an impact on the communities and resources.

Current climate vulnerability is closely linked to climatic factors and is summarised below.

Wind: Wind determines ocean circulation off the Senegal coast. There are two types of wind circulation: the cold north equatorial current (toward the west) and the hot and salty equatorial counter-current (toward the east). These currents change direction before reaching the continental plateau, resulting in a southerly current with cold and salt water, which prevails from January to

May; and a northerly current, with warm, salty waters from June to October. The transition between the two periods is between November and December, with the onset of coastal upwelling. There exists a variability of speeds and wind directions during the dry season (Roy, 1989, cited by Niang Diop, 1994).

The winds have become more frequent and are accompanied by dust. They cause murky water and strong waves. Winds often prevent the fishermen of Cayar, Joal-Fadiouth and Bamboung from going to sea. The wind also causes damage to property including the destruction of boats, sinking of canoes and can cause damage to fish habitats. Women working in fish processing are impacted as their work depends on the availability of fish. In addition, they must take more stringent hygiene measures when there is a lot of dust; and the dust is also linked with the increased frequency of coughs and other lung ailments.

Coastal erosion: Coastal erosion is a major environmental problem and affects nearly 10 per cent of the Senegalese coast (ANDS, 2011). The rate of decline of the shoreline is between 1.25 to 1.30 m per year according to studies conducted in Senegal's first national communication to the UNFCCC. These rates may seem low at first glance, but they are responsible for habitat and infrastructure destruction mainly in highly urbanized areas such as St. Louis, Rufisque and Joal.

Coastal erosion has the greatest impact in Joal. During the application of the CRiSTAL tool in focus group interviews the population of Joal-Fadiouth spoke of the coastal erosion hazard as having a high-impact on their livelihoods. Major damage was noted to infrastructure and livelihoods through the loss of trees and the displacement of several houses that were not far from the beach. Turtle nests have been washed away and the île des mouettes and several islets have disappeared.

Rising sea level: In Senegal, a 1 m rise in sea level could cause flooding and erosion of more than 6,000 km² of land, most of which are wetlands (Dennis et al., 1995). In general, floods are responsible for more than 95 per cent of land losses, whichever sea level rise scenario is considered. Dennis et al., (1995) showed that for a 1 m rise, buildings with a total market value of at least US\$499-707,000,000 would be at risk. In this scenario, tourist facilities across the country represent 20 to 30 per cent of the total value at risk. It estimated that at least 110,000 to 180,000 people, between 1.4 and 2.3 per cent of the population of Senegal in 1990, would be at risk (Dennis et al., 1995).

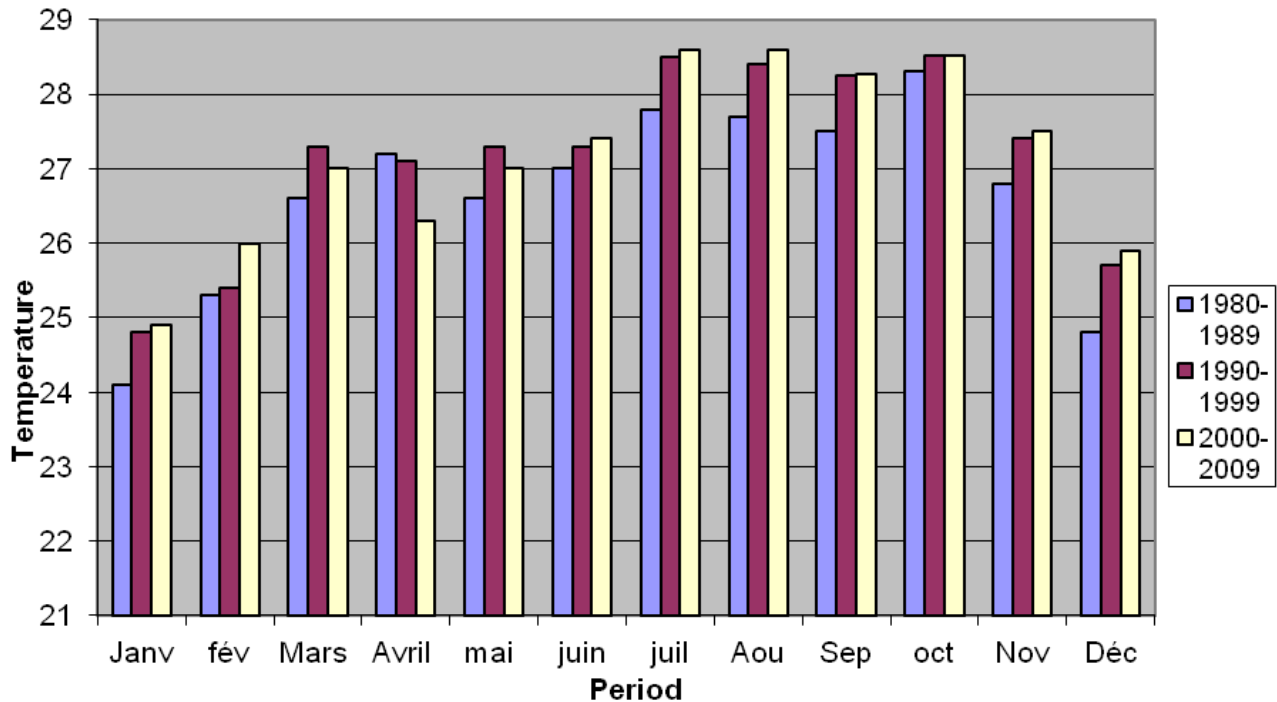


Figure 4: Mbou decadal temperature from 1980-2009

Local populations living near the three MPAs signalled a rise in sea level in the focus group discussions. It was among the three major risks cited in Cayar. Sea level rise causes the displacement of the local population to more distant sites as homes are damaged and demolished and infrastructure such as fishing piers is lost.

High temperature: Marine species are less constrained than terrestrial species by physical barriers of transportation and migration, so their distribution is mainly determined by environmental factors (e.g. temperature, oxygen, light, salinity, etc.) There are many examples of plankton (Beaugrand et al., 2002) and fish species (Brander et al., 2003) which are rapidly extending their range as the environment changes. Because many marine organisms are already living near their upper thermal tolerance limits, increases in temperature can adversely affect the performance and survival (Amara, 2003). Carpenter (1992) speaks of the vulnerability of fisheries to climate change and notes that impacts depend on the nature of climate changes, the type of fishery, fish species and their habitats. Changes in climatic conditions such as air temperature and precipitation affect fisheries by altering the availability or quality of the habitat. Specifically, fish habitat may be affected by changes in water temperature, time and duration of extreme temperature conditions, the size and curve of annual flows, and sea-level rise affecting surface water and the shores of lakes, reservoirs and coastal marine environments.

Decadal average temperatures have increased from 1980 to 2009 at Mbou in the Thiès Region of Senegal (Figure 4). Data from this station was used to represent the situation in Joal-Fadiouth and Cayar as it is the nearest station with complete information for the selected period. In the focus group discussions people gave examples of the different species captured during high and low temperatures. The general observation from the communities in the MPAs is the disappearance of fish species, especially what are called “noble species”. These species have a high market value which previously allowed the fishermen to make good profits.

Drought: Desertification and land degradation in arid, semi-arid and dry sub-humid areas results from various factors including climatic variations and human activities.

Data from the National Weather Service of Senegal helped plot the development of rainfall patterns over a 40 year period. The findings showed drought conditions over three decades followed by a relatively wet period over the last ten years. This trend was the same in all three study areas with only slight variability. Communities reported that drought has an environmental and socio-economic impact. Soils, vegetation, water and livestock were all affected. For example, soil erosion is accelerating, salinization is ongoing, soil is drying out and deteriorating and land abandonment is increasing. There is a decline in

productivity and yields, problems with pests, and some crops, such as rice, are no longer being cultivated. The decline in revenues is a reality.

Rainfall variability: Rainfall amounts show a downward trend from 1970 to 2000. Since 2000, there has been a recovery in rainfall. Water stress strongly impacts fishing, agriculture and gardening.

The changing dates of the onset of the rains are well recognised by the communities of fishermen and farmers. Periods without rain are becoming longer than in the past. Ponds, groundwater, 'céanes' (small ponds in Wolof) and backwaters are greatly reduced. The rivers are drying up. The lowering of the water table increases well depths. There is less water available for livestock and as a consequence the livestock decreases. The vegetation has suffered a sharp decline. The populations in the three study areas noted that rainfall is not only important for soil and agricultural activities, but is also of great importance for marine and river resources. Normally a good rainy season is also advantageous for fisheries. More species of fish appear when the rainy season is good.

Flood: The west coast of Africa is often battered by storm surge and is currently threatened by erosion, flooding and exceptional weather events. Increased flooding could be of particular concern in the future according to many studies (Awosika et al., 1992; Dennis et al., 1995; Jallow et al., 1996).

Flooding is a major problem for communities and is a major concern in Joal. Several neighbourhoods suffer from flooding and people are often forced to move. Floods cause great disruption and some areas become inaccessible, e.g. the women's fish processing site in Joal, leading to a decline in income during these periods. Overall, the decline in trade during the rainy season and the subsequent reduction in mobility affects all sectors of the economy.

FUTURE VULNERABILITY

The Intergovernmental Panel on Climate Change (IPCC 2007) report notes that by 2020, between 75 and 250 million people are expected to suffer from water stress due to climate change in Africa. The cost of adaptation to climate could amount to 5-10 per cent or more of the GDP in most African countries.

The climate models developed with the CIP make projections of temperature and rainfall for Senegal. Projections for the three MPAs are based on Kaolack



Local fish market, Cayar village, Senegal © Hartmut Jungius / WWF-Canon

(which borders The Gambia) and Thiès stations (60 km east of Dakar), as these weather stations provide the most comprehensive data (available for over forty years). Data of daily temperatures are available. Trends show an increase in temperature and a decrease in rainfall between July and September, with a high variability during the start and the end of the season, i.e. May and October. The projections indicate a shift in the rainy season, which tends to stretch to November, and thus a longer season with lower rain volumes which inevitably leads to dry spells and drought. Thus, the vulnerability of the agriculture sector, which depends on the rainy season, is expected to increase with resulting food insecurity, declining incomes in the agriculture sector and increased poverty. The fishing industry is also not immune from the vulnerabilities that are developing. Farmers who are not making a living from their activity are turning to fishing. This has had an impact on the overexploitation of resources, declining stocks of fishery resources and loss of jobs.



Artisanal pirogue with local fishermen passing Spanish trawler in their fishing grounds, Senegal © Jo Benn / WWF-Canon

CONSEQUENCE OF HAZARDS ON THE LIVELIHOODS OF COMMUNITIES

By affecting different natural resources, climate related risks are causing an array of impacts on the livelihoods of communities.

Overall, the reduction and degradation of resources results in a slowdown in the development of socio-economic activities. The results of the surveys conducted in the three MPAs shows the relatively strong influence of climatic conditions on natural, physical, financial and human resources. Thus, we can conclude that people are very vulnerable to climate risks, and this is exacerbating non-climate vulnerability (e.g. poverty, population growth, overuse of resources, fisheries agreements, abandonment of seasonal fisheries closures and insufficient infrastructure for conservation of fishery products) which are discussed in more detail below.

Poverty and population growth: The population of Joal-Fadiouthin in 2003 was estimated at 17,292 men and 15,699 women giving a total of 32,991 inhabitants. The population growth in Thiès is 2.85 per cent (ANDS, 2010). Thus the population on the basis of this projection rate was 38,632 inhabitants in 2009. The population of the 14 villages around Bamboung in 1988 was 9,775; in

2009 this had risen to 15,772. The Cayar population was 16,148 in 2002 according to the census of that year. Current estimates suggest a population of about 22,000 inhabitants. These figures may be the result of natural increase, but can also be explained by the migration of people both to the capital Dakar and between communities. Cayar, for example, sees seasonal migration of fishermen from other areas from November to June, the most cited migrants are those coming from the district of GuethNdar St. Louis and fishermen from Fass boy and Joal. There are 2,500 to 5,000 migrant fishermen during the fishing period (Drame, 2011). This means about 550 canoes are active during the fishing season against only 300 in the off-season. During focus group discussions with fishermen, young men revealed involvement in illegal migration activities (e.g. using boats to take people to Spain) due to the number of people working in the fisheries and the high cost of fuel. Such activities involve many risks and are thus indicative of the difficult living conditions experienced by many young men in these communities.

The overexploitation of fisheries resources and fisheries agreements: The overexploitation of fisheries resources is a concern for the authorities and for households who are no longer able to eat high quality fish. As a result there is the need to enforce biological

recovery areas, regulations on fishing equipment and the creation of MPAs in order to reduce the unsustainable exploitation of resources.

Overfishing is a reality in Senegal. Senegalese people are great consumers of fish. Fisheries agreements aim to control access and maintain resources, however the proposed financial compensation is not enough to visibly improve the living conditions of local populations reliant on fisheries. Senegal has had a negotiated agreement with the European Union on fisheries since 1979; an agreement that has been renewed 17 times. But these renewals are not free of difficulties. Parties to the agreement often fail to renew the protocol, and as a consequence most Senegalese people question the value of these agreements and their impact on future livelihoods. In the various focus group discussions with fishermen there was a strong recognition of the large number of nationals involved in fishing but also the increasing role of foreign vessels, which were seen as plundering the resources. Chinese and European boats were most often cited.

IDENTIFICATION OF CURRENT AND POSSIBLE STRATEGIES FOR ADAPTATION TO RISKS

To overcome the risks posed by climate change and improve the lives of local communities living in and around the MPAs a number of current and potential mitigation strategies were discussed. Options can be technological, based on better management of natural resources, or focused on the creation of legal and institutional frameworks. The section below provides an analysis of these strategies according to the risks identified above.

Wind: Windbreaks are used for soil conservation purposes. The practice is to install linear windbreaks, often (living) hedges, composed of woody species, and sometimes herbaceous plants. A windbreak has two parts: a windward (exposed to prevailing winds) and leeward side (UICN, 2011). Windbreaks can become essential components of the production system, for instance by protecting fruit crops from wind damage. Other strategies are based on the need to restore soils affected by the impacts of wind erosion and raising local awareness of hygiene, as windy periods often trigger increased respiratory diseases.

It is necessary to use “all possible means of communication to make weather and climate information accessible to all users” (Anams, 2011). Information provided by the meteorology service in Senegal, often broadcast by community radio stations,

plays an important role in educating fishermen. In Cayar announcements are made via the mosque to inform fishermen of weather conditions. People are also building more solid houses because the winds sweep away insubstantial structures and in particular roofs.

Coastal Erosion: In Joal-Fadiouth adaptation funding is focused on solving the problem of coastal erosion. A dam is being constructed (see below) and the fishing pier in Joal is being protected. Other activities involve the installation of modern ovens to improve the working conditions of female processors at the Kèlkom, which is the most important fish processing site in Joal. Other project activities include:

- Monitoring of nesting turtles.
- Reforestation using casuarina trees, cactus, eucalyptus and *Prosopis* sp outside the MPA and natural regeneration within the MPA.
- Relocation of people and infrastructures, such as fishing piers, away from areas suffering from erosion. This strategy is however insufficient and not sustainable as the cause of the problems is not being addressed. The local population has advocated alternative strategies such as banning the use of the marine sand to help stabilize the shore.

Rise in sea level: To mitigate land salinization, flooding and the destruction of infrastructure an anti-salt dam has been established to fight against salinization. It holds rainwaters and prevents salty waters from invading rice fields. The dam in Joal is being built over a distance of 3,300m with a north bank dam of 1,550m, a south bank dam of 1,800m; it has an average height of 0.60m and width of 3m. It is being built under the supervision of the Centre for Ecological Monitoring, Directorate of Environment and Classified Areas, and is a joint project with other agencies such as the NGO Green Senegal and the Association of Dynamic Women of Joal.

High temperature: To cope with the impact of temperature increases, a number of activities are suggested:

- Development of rainy season ponds to fight against the rapid depletion of temporary streams.
- Reforestation with plant species adapted to each zone and monitoring to reduce losses.
- Improved techniques for drying and salting fish to ensure that products do not rot quickly in the heat.

Activities underway include the creation of workplace shelters to limit exposure to the sun’s heat for the female processors in Joal and Cayar. Also in Cayar growers are



Sorting out fresh-landed fish, Cayar © Olivier Van Bogaert / WWF-Canon

starting to plant more heat tolerant varieties, because they are facing scarcity of food crops such as cauliflower, which are failing due to increased temperatures.

Drought: Drought has led to the degradation of plant cover and to water deficits. Anti- salt dams in Bamboung are helping some people access fresh water and practice gardening. Other useful mitigation strategies include the establishment of mini dams and development of irrigation; sinking wells; more effective harvesting of rainwater; use of local / indigenous knowledge such as 'Bawnane' sessions (a traditional ceremony organized by local people in order to have a good rainy season) at delays in the start of the rainy season or during dry spells; reforestation and protection of plants to reverse the degradation of the vegetation cover; bush fires management including the erection of firewalls; and production of fruit crops more resistant to drought.

Drought also has a negative impact on fisheries, so strategy developments required include good MPA management and stopping the introduction of fishing vessels in areas reserved for artisanal fishing. This latter strategy is beginning to be implemented and in April

2012, the Government of Senegal cancelled 29 fishing authorizations that were granted to foreign trawlers chartered by two Senegalese and Moroccan ship-owners. Other strategies include information and raising awareness on sustainable fishing and fishing techniques such as the prohibition of dormant nets.

Flood: Relocation of populations living in *non-aedificandi* (areas where the local population are not allowed to build because of the topography or geomorphology issue) towards more favourable sites is the most cited strategy by communities.

Rainfall variability: There is a need for research institutions to work with farmers to recommend species that are resilient to changing conditions and allow the farmers to cope with more difficult and unpredictable conditions.

DISCUSSION

The threat of overfishing combined with the impacts of climate change have resulted in increased regulation of the fisheries sector in Senegal through the establishment



Bringing fresh-landed fish from the beach into trucks, Cayar © Olivier Van Bogaert / WWF-Canon

of MPAs and fisheries agreements. These measures are necessary in order to ensure sustainable fisheries resources into the future.

However the development of MPAs can also increase the vulnerability of local communities. Many actors such as beach seine fishermen (fishing using a seine or dragnet deployed from the shore), the 'Kilieur' (fishermen using drag nets for fishing shrimps), and sellers of sea turtles have been affected by the designation of the Fadiouth-Joal MPA. The conversion to MPA management is not easy and cases of poaching are noted in Joal. In Bamboung female processors saw a decrease in their income as those household bordering the MPA could no longer collect oysters. In Cayar there are conflicts between indigenous and non-indigenous populations over the management of resources.

The research reported above however confirms the additional vulnerability of fisheries and local communities to climatic factors (drought, high winds, high temperatures, rising sea levels and coastal erosion). There is clearly therefore an opportunity for MPA managers to further develop common solutions which

link climate vulnerabilities and local livelihoods. For climate vulnerabilities it is especially urgent that coping strategies are implemented. Responses to non-climate vulnerabilities cannot be the sole responsibility of the MPA manager; and need policy input at the highest level as well as a range of involvement from other sectors of society.

Local populations have a level of awareness of the degradation of marine and coastal resources; indicating their close relationship with and reliance on natural resources. They must be involved in the management of the resources of their area. The co-management approach to MPA governance is perhaps the best way to ensure sustainability and conservation. In particular the co-management of MPAs can improve sustainable management of fisheries resources.

Finally, the existence of a project to adapt to climate change in Joal-Fadiouth shows that in some places MPAs need to be accompanied by specific plans to reduce the vulnerability of communities especially as the MPA approach entails prohibitions of exploitation of some resources.

CONCLUSION

Fishing is a very important activity in the socio-economic lives of many communities around the world. However, fishing is not immune to the problems of climate change noted in other sectors; and the phenomena of desertification, drought and loss of biodiversity are not only characteristics of terrestrial systems. Moreover climate change has intensified in recent years leaving many communities in catastrophic situations. In Senegal discussions with local people show that they are becoming increasingly aware of the need to cope with the impacts of climate change. The effects of coastal erosion, rainfall variability and high temperatures are having adverse effects on activities and community life. Coping strategies to overcome various types of vulnerabilities often require financial and technical resources. Knowledge of future vulnerability should allow a better planning of selected adaptation options.

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Traditional fish market, Dakar, Senegal © Seamus Murphy / WWF-Canon

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RESUMEN

El cambio climático acelera la vulnerabilidad de los recursos que son de gran importancia para la vida de las comunidades en muchas partes del mundo. Este estudio pretende analizar la vulnerabilidad de las poblaciones locales y su capacidad de adaptación al cambio climático en y alrededor de las áreas marinas protegidas (AMP) en Senegal. La metodología se basa en la Evaluación Rural Participativa (PRA) y la herramienta CRISTAL que se utiliza para evaluar la vulnerabilidad de las comunidades y las estrategias de adaptación. Se ha utilizado el portal sobre el cambio climático (CIP) para hacer proyecciones sobre precipitaciones y temperatura, lo que permite hacer proyecciones a escala local. Los resultados muestran que las comunidades ribereñas de tres áreas marinas protegidas (Bamboung, Joal-Fadiouth y Cayar) se enfrentan a vulnerabilidades climáticas y de otra naturaleza. Se ha identificado estrategias sobre opciones de adaptación actuales y potenciales para superar las diversas amenazas. Las estrategias están diseñadas para contribuir a la mejora sostenible de las condiciones de vida de las comunidades alrededor de las áreas marinas protegidas.

RÉSUMÉ

Les changements climatiques contribuent à l'accélération de la vulnérabilité des ressources qui sont d'une grande importance pour l'existence de nombreuses communautés dans le monde. Cette étude se propose d'analyser la vulnérabilité et l'adaptation aux changements climatiques des populations locales habitant dans et autour des aires marines protégées du Sénégal. La méthodologie utilisée est basée sur l'évaluation rurale participative et l'outil CRISTAL a permis d'évaluer la vulnérabilité des communautés et les stratégies d'adaptation. Le Portail d'information sur le climat a permis de faire des projections de pluviométrie et de température. Les prévisions ont ainsi pu être faites à échelle réduite pour les zones locales. Les résultats obtenus à travers cette méthodologie montrent que les communautés riveraines des trois aires marines protégées (Bamboung, Joal-Fadiouth et Cayar) font face à des vulnérabilités climatiques et non climatiques. Des stratégies d'adaptation actuelles et possibles ont été décelées pour venir à bout des différents aléas, qui sont présentés. Les stratégies sont destinées à contribuer à l'amélioration notable des conditions de vie des communautés autour des aires marines protégées.