Centre de Suivi Ecologique

The Ecosystem Solutions for Sustainable Adaptation (SEDAD)

LOCAL CLIMATE ADAPTATION PLAN OF NIUMI NATIONAL PARK 2023-2028

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Summary

Gambia is highly vulnerable to climate change due to its geographic location and climatic variability. In the Niumi National Park, these changes manifest through various hazards, the most significant of which are strong winds, coastal erosion, rising temperatures (heatwaves), and intra-seasonal drought. The resources (natural, physical, human, financial, and social) on which local stakeholders rely to sustain their livelihoods are all impacted by these hazards. Among these, the most affected are biodiversity, water resources, forest resources (mangrove and terrestrial forests), and agricultural land, which consequently affects the incomes of populations dependent on the exploitation of these resources. The consequences and impacts of climate change on stakeholders and their assets are mostly negative. They include the destruction of marine and coastal habitats, increased soil and water salinity, fishing accidents and equipment loss, reduced agricultural production, degradation of vegetation cover, depletion of water resources and forest species, loss of arable land, and a rise in chronic diseases.

In response to these manifestations and constraints, local stakeholders have developed numerous adaptation strategies to enhance their resilience. These strategies partly rely on strengthening natural barriers (reforestation of mangroves and terrestrial plants), building dikes or embankments using makeshift materials, developing alternative activities to diversify income sources (such as trade, gardening, and the exploitation of non-timber forest products), and initiating sustainable resource management practices. Implementing additional strategies that can complement existing ones is crucial.

However, these efforts should be accompanied by measures such as meteorological monitoring, the establishment of an early warning system, the use of climate-adapted seeds, the adoption of sustainable and climate-resilient agricultural practices, as well as awareness-raising and training for local stakeholders and populations.

The participatory analysis of vulnerability to climatic hazards and their impacts on the Park's resources made it possible to develop an effective and coherent local adaptation plan to respond to the challenges linked to climate change. Its objective is to provide the Park with a reference document for adaptation planning. Its implementation planned over 10 years will help strengthen the resilience of ecosystems and communities to climate change and mitigate its impacts.

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I. Introduction

Context and Justification of the SEDAD Project

The Cégep de la Gaspésie et des Îles (CGI) is a post-secondary educational institution located in eastern Quebec, Canada. Since 1988, The Cégep has led international cooperation projects in several countries, including Senegal, Morocco, Tunisia, the Republic of Guinea, The Gambia, Mauritania, Brazil, Haiti, and Guinea-Bissau. In West Africa, CGI is currently implementing community intervention projects aimed at sustainably improving the economic, social, and environmental development of communities, the living, working, and health conditions of their inhabitants, and the resilience of vulnerable populations to climate change.

The Sustainable Ecosystem-Based Adaptation Solutions Project (SEDAD), executed by the Cégep de la Gaspésie et des Îles, provides an integrated response to the challenges of climate change adaptation for the populations of The Gambia, Senegal, and Mauritania while promoting the maintenance and restoration of biodiversity in the intervention areas. To achieve this, the project will focus on two main areas: (1) implementing nature-based solutions (NBS) for climate change adaptation in areas where climate vulnerability is recognized, and (2) establishing inclusive and participatory management of biodiversity and natural resources by all stakeholders, including vulnerable groups.

The project aims to: (1) enhance knowledge, including indigenous and women's knowledge, to develop and implement NBS that conserve and restore biodiversity; (2) improve scientific knowledge among researchers on developing and implementing NBS in the context of climate change adaptation and the inclusion of vulnerable groups; (3) increase access for women, youth, and men to livelihoods and technical skills relevant to climate adaptation and biodiversity conservation; (4) strengthen the capacities and awareness of women and indigenous people to ensure their leadership in inclusive participatory governance bodies related to the sustainable management of biodiversity and natural resources; (5) enhance the capacities and awareness of local actors and civil society to promote inclusive participatory governance in the sustainable management of biodiversity and natural resources; and (6) improve sub-regional exchanges on

policies, approaches, and tools for sustainable biodiversity and natural resource management through participatory and inclusive mechanisms.

A collaboration agreement has been signed between The Cégep de la Gaspésie et des Îles and the Centre de Suivi Ecologique (CSE) to support the project's implementation and contribute to achieving its results. This progress report focuses on the analysis of climate change vulnerability in Niumi.

Objective and structure of the document

Objective

The objective of this report is to analyze the risks and vulnerabilities related to climate change affecting marine and coastal ecosystems, resources, communities, and sectors of activity dependent on Niumi. Additionally, it aims to identify and evaluate the adaptation strategies adopted by local communities. More specifically, the report seeks to:

- Identify the most important resources and ecosystems, as well as the most recurrent climatic and non-climatic hazards affecting the Park;
- Analyze the consequences and impacts of climatic hazards on resources/ecosystems, marine and coastal biodiversity, and local communities;
- Identify and analyze current endogenous adaptation strategies (measures); and
- Assess the vulnerability of the park to climate change.

Structure of the document

The document is structured into two parts: the first part, dedicated to the presentation of the Park, describes its geographical location, biophysical characteristics, and the socio-economic features of the Park's territory. The second part addresses the issue of climate change in terms of its impacts on and vulnerabilities of the Park's ecosystems. It also presents the results of the vulnerability assessment and the adaptive capacity of the Marine Protected Area (MPA) in response to the adverse effects of climate change.

- **Methodological Approach**

The analytical approach of the assessment is based on the definition of climate change vulnerability by the Intergovernmental Panel on Climate Change (IPCC) in 2007 (Figure 1), according to which vulnerability is a function of exposure, sensitivity, and adaptive capacity.

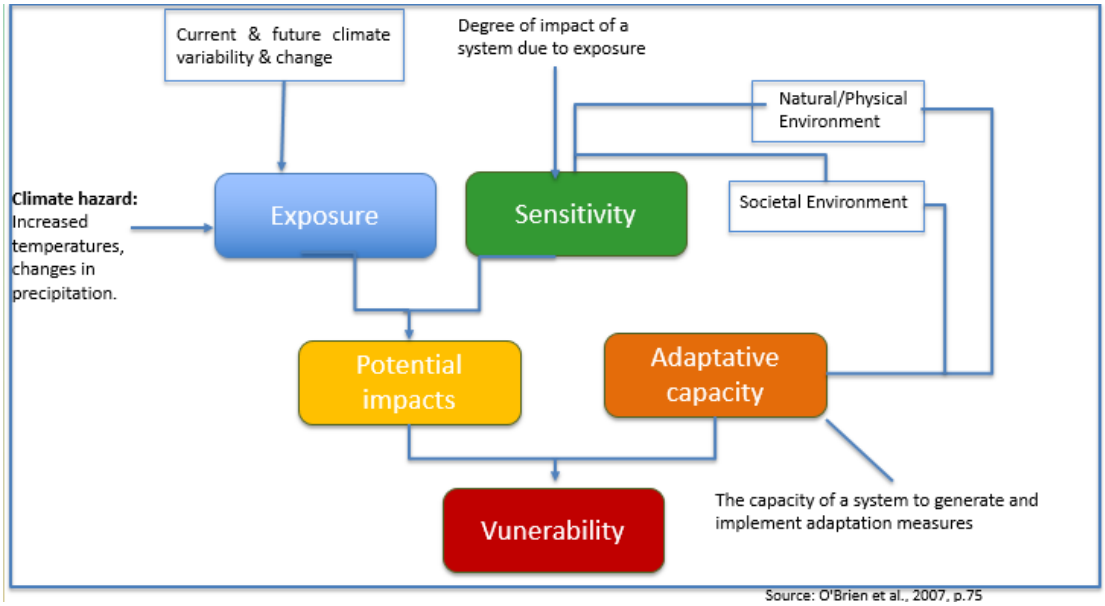

Figure 1 : Vulnerability and its Components According to the IPCC AR4 (IPCC, 2007)

The methodology used in this study combines a qualitative and participatory approach. It was conducted in three stages**:**

i) **Information and Planning Meeting with the Project Field Team:**

This meeting with the project implementation partners in The Gambia served to introduce the project, clarify the CSE methodology, and gather feedback on the proposed approach. It also provided an overview of the site, the hazards, and the impacts faced by the surrounding villages.

i) **Information and Planning Meeting with the Project Field Team**

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ii) **Litterature review** :

The literature review helped establish an assessment of the existing knowledge on past and future climate trends, impacts, climate scenarios, vulnerability, and adaptation strategies within the MPA (Marine Protected Area). Several sources were utilized to achieve this: the Niumi National Park Management Plan, documents on the Niumi Biosphere Reserve, and scientific articles. Additionally, consultations of websites belonging to various national and international organizations working on issues related to biodiversity conservation, fisheries, and climate change further enriched this pre-diagnostic. Sectoral policy documents were also reviewed to gain insights into current policies and ongoing initiatives. These documents and resources provided a deeper understanding of the environmental and socio-economic dynamics of the region, helping to identify gaps and research needs to improve the climate resilience of the MPA.

iii) Data Collection:

Quantitative data : Data were collected using tools such as the Vulnerability and Capacity Assessment (VACA), Community-based Risk Screening Tool – Adaptation and Livelihoods (CRiSTAL), and Participatory Risk Component Analysis (PRCA) from the Climate Change Adaptation Planning and Monitoring & Evaluation Toolkit (TOP-SECAC). This data collection took place during a participatory workshop held in May 2024 in Niumi, which brought together representatives from the various villages within the Park, members of the Park Management Committee, as well as technical services operating in the study area. The data collected enabled the characterization of ecosystems and available resources, and the analysis of the vulnerability and adaptive capacity of communities and the Park's resources/ecosystems to climate change.

Photo 1: Focus group with various stakeholders

- ***Qualitative Data***: Quantitative data on climatic, meteorological, and hydrodynamic conditions, as well as extreme events, were collected from the databases of national institutions such as the National Environment Agency (NEA), the National Disaster Management Authority (NDMA), the Department of Parks and Wildlife, etc. The Kerewan climatological station was used for the validation of climate data. The data collected include rainfall, temperature (maximum and minimum), and wind direction and speed for the period from 1981 to 2022. The data used for the analysis of the current climate comes from the Global Telecommunication System (GTS) database, centralized by the U.S. National Oceanic and Atmospheric Administration (NOAA). These data are subjected to rigorous quality controls.

iv) Data processing and analysis

Once the data were collected and processed, a thorough analysis was conducted to extract key information and identify significant trends. Qualitative and quantitative analysis techniques were applied to interpret the results, which were then used to produce the preliminary diagnostic report.

II. Presentation of Niumi Park

2.1. Location

The Niumi National Park (NNP) forms the southern part of the vast ecological complex that stretches from the Saloum Delta to the mouth of the Gambia River (Figure 1). Established in 1986 (Touron-Gardic et al., 2021), the park occupies the coastal strip north of the Gambia River. It is bordered to the south by Barra, Essau, Mayamba, Medina Kanuma, and Kanuma; to the east by the villages of Dunyo Joyo, Lewna, Nbangkama, and Mbollet Bah (DPWM, 2023); to the north by the village of Bakindik and the Saloum Delta National Park in Senegal. To the west lies the Atlantic Ocean (RAMSAR, 2019).

Located at coordinates 13˚31'N, 16˚31'W, the park covers an area of approximately 7,758 hectares, of which 4,940 hectares are terrestrial and 2,818 hectares are marine (DPWM, 2023). The park serves as the natural southern extension of the Saloum Delta National Park and Biosphere Reserve (GMES & Africa, 2020). In December 2008, the Saloum Delta National Park (SDNP) and NNP were declared Africa's first transboundary RAMSAR site (RAMPAO, 2010).

In its eastern part, the park includes a portion of lagoon and creeks ("bolongs") with mudflats and mangrove areas. In its central area, there is a coastal forest zone and a long stretch of beach, while its western section consists of a marine area. Several inhabited zones are adjacent to the park (Touron-Gardic et al., 2021). The park also includes the crescent-shaped island of Jinack Kajata. The island features an 11-kilometer-long beach that borders the park to the west, facing the Atlantic Ocean.

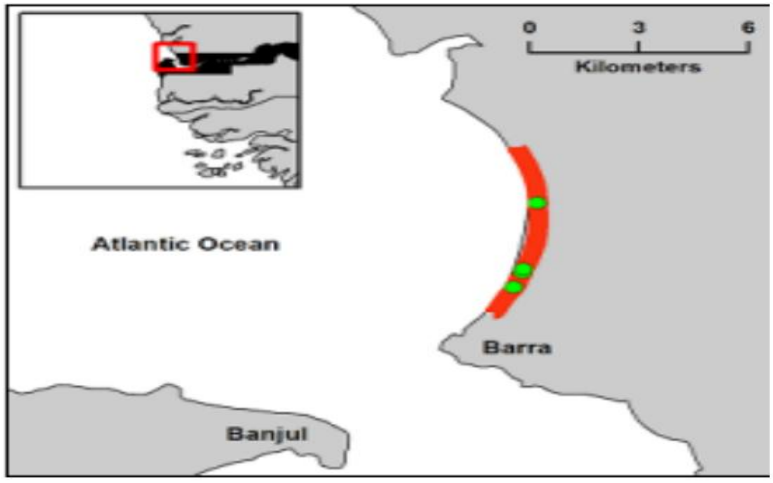

Figure 2: Location of Niumi

2.2. Biophysical Characteristics

2.2.1. Relief and Soil Types

A detailed soil study was conducted in the vicinity of Kajata and Niji on Jinack Island as part of the rice field rehabilitation program. The study area was limited to two major physiographic units: elevated sand dune complexes and the low-lying floodplain. The sand dune complexes are composed of relatively young, coarse-textured soils that are underdeveloped and poor in nutrients and available water (NNPMP, 2020). These soils are unsuitable for most crops, except for coconut. The low-lying floodplain is sodium salt-laden, although the soils are moderately drained and contain appreciable amounts of nutrients (Ramsar, 2019).

Ferric acrisols (ACf) are frequently found in the upland plains. These are highly acidic soils with a clay-enriched subsoil and low nutrient retention capacity. Alluvial and colluvial soils dominate the lowlands. Along the coast and the Gambia River, humic Gleysols (GLu) have developed over large areas. The fluvio-marine sequences are generally gray to black depending on their organic matter content (DPWM, 2023).

2.2.2. Water resources

The wetland complex is primarily coastal in nature, with seasonal variations in the hydrological regime of the inland areas. Traversed by creeks ("bolongs"), it also includes temporarily flooded lagoons, marshes, and mudflats (RAMPAO, 2010). The Niumi National Park is crossed by two main creek systems : the Mansarinko bolong and the Niji bolong. The Mansarinko bolong is the primary water body in the park (DPWM, 2023). This bolong splits north of Mbamkam to form the Ker Jatta and Duniajoes bolongs. The Niji bolong connects to the ocean immediately north of Barra and joins the Mansarinko bolong at the Senegalese border, thus forming Jinack Island (NMNPMP, 2011).

These bolongs in the park are subject to the daily rhythm of the tides, which have a maximum amplitude of 2 meters during the equinoctial spring tides. During the rainy season, from May/June to October/November, the salinity of the bolongs decreases (NMNPMP, 2011). The low-lying areas of Jinack Island and the mainland are flooded during the rains, creating generally linear ponds and seasonal marshes in the salt marshes and Tamarix (*Tamarix senegalensis*) thickets. The groundwater table on Jinack Island fluctuates between 3 and 5 meters depending on the season (NNPMP, 2020).

2.2.3. Vegetation and Wildlife

- **Flora**

The mangrove forest dominates (600 ha) the Niumi National Park and is found along the Mansarinko, Barra, and Niji bolongs as well as along the coastline. The northeast tip of Jinack Island and the Mbankam spit host large stands of this type of forest, which is supported by shrub forest and barren salt flats (Ramsar, 2019). There are five woody species in the mangrove belt, namely: *Rhizophora harisonii*, *Laguncularia racemosa*, *Avicennia nitida*, *Conocarpus erectus*, and *Rhizophora mangle* (NMNPMP, 2011).

The dry forest and savannah are located on an elevated laterite plateau around the Masarinko Bolong (DPWM, 2023). The vegetation consists primarily of open wooded savannah adjacent to the coast, dominated by tree species such as the baobab (*Adansonia digitata*), bembé (*Lannea acida*), African plum (*Neocarya macrophylla*), African locust bean (*Parkia biglobosa*), and West African copal (*Daniellia oliveri*), along with shrubs such as *Acacia albida*, red spike-thorn (*Maytenus senegalensis*), Senegal prickly ash (*Zanthoxylum zanthoxyloides*), *Combretum nigricans*, and sicklebush (*Dichrostachys glomerata*) (Svensson & Bearder, 2013).

- **Fauna**

A great diversity of animal species is associated with the various wetland habitats of the Niumi National Park. The park serves as a nursery for many fish species, which come there for breeding and growth (Touron-Gardic et al., 2021). Fish from at least 13 families have been recorded in the park. More than 70 species of fish reproduce or feed in the mangroves. The most abundant species are *Tilapia* spp. and mullets (*Mugil* spp.), although the fry and juveniles of the giant African threadfin (*Polydactylus quadrifilis*), shads, African red snapper, grunt (*Pomadasys jubelini*), *Ethmalosa fimbriata*, and *Gerres melanopterus* are also present in large numbers (NNPMP, 2020).

The current bird species list for the park includes approximately 300 species from 63 families (Ramsar, 1997 in NNPMP, 2020). The Atlantic coast is home to a large number of roseate terns (*Sterna dougallii*) and several breeding pairs of white-fronted plovers (*Charadrius marginatus*), which are locally declining. The creeks, salt marshes, and rice fields generally host few waterbirds, but black-tailed godwits (*Limosa limosa*) can sometimes be found in the thousands.

The region's fauna also includes the West African manatee (*Trichechus senegalensis*) and the Atlantic humpback dolphin (*Sousa teuszii*). Large mammals such as the bushbuck (*Tragelaphus scriptus*), common warthog (*Phacochoerus africanus*), spotted hyena (*Crocuta crocuta*), and leopard (*Panthera pardus*) are present but not in great numbers. Primates are still well-established, especially the green monkey (*Cercopithecus sabaeus*), patas monkey (*C. patas*), and Senegal galago (*Galago senegalensis*), while Guinea baboons (*Papio papio*) and Temminck's red colobus monkeys (*Piliocolobus badius temmincki*) are also present, but much less numerous. The park is home to endangered species such as the green turtle (*Chelonia mydas*) and the Cape clawless otter (*Anonyx capensis*) (NNPMP, 2020).

2.3. Socio-economic Characteristics

2.3.1. Demography

Eleven surrounding villages rely on the park (Touron-Gardic et al., 2021; DPWM, 2023). The seven villages within Niumi National Park alone host a total population of 4,665 people: Jinak Kajata, Jinak Niji, Mayamba, Bakindik-Koto, Mbangkama, Kanuma, and Medina Kanuma (Touron-Gardic et al., 2021). Only three communities are located entirely within the park boundaries: Bakindik-Koto, Jinack Niji, and Jinack Kajata (GMES & Africa, 2020).

2.3.2. Socio economics activities

The communities surrounding and within Niumi National Park mainly consist of artisans, subsistence farmers, and fishers who depend on natural resources for their livelihoods. The park's wetlands are crucial to these subsistence economies, supporting rice cultivation during the wet season, vegetable gardening during the dry season, livestock grazing, fishing, and the collection of seafood (NMNPMP, 2011). The primary agricultural activity in the wetland area is rice farming, which is practiced throughout the park. Current farming methods are largely extensive, with crop rotation taking place on an annual basis (RAMSAR, 2019).

Despite the abundance of fish in the bolongs and coastal waters, fishing within Niumi National Park remains mostly subsistence-based. A few individuals from each village participate part-time in gillnet fishing and fish trapping during the receding waters. The catch is sold at the nearby "Bara Fish Market" or through the "Fishing Project." The distribution of the catch is roughly 30% for personal consumption and 70% for the domestic market (Touron-Gardic et al., 2021).

Niumi National Park contributes approximately 5% to Gambia's artisanal production (Touron-Gardic et al., 2021). The wetlands also provide various materials, including mangrove poles for roofing and grasses for thatching and fence construction. To promote the sustainability of forest resources, only ripe fruits are harvested, and no branches are cut during the process. Dead trees and branches are collected for timber, while oysters are harvested only during the dry season, which is their non-breeding period.

The park also provides cultural, aesthetic, and religious resources. Medicinal plants such as *Guirea senegalensis*, *Combretum* spp., *Nauclea latifolia*, and *Sanfito* are widely used. Each community has a designated area for meditation and prayer, which is kept relatively untouched and inaccessible to the public. Traditional or sacred sites are preserved by custom (NNPMP, 2020).

The development of ecotourism and environmentally sustainable projects offers a way for local communities to benefit from the park. However, despite its geographical position and natural beauty, the park struggles to emerge as a significant tourist destination. The lack of tourist activities and infrastructure often leads visitors to choose the nearby Saloum Delta, which is more developed and accessible. As a result, economic benefits remain modest, limited to small-scale hotel revenues and boat tours (Touron-Gardic et al., 2021).

Part II: Assessment of Climate Change Vulnerability: Climate Risk Analysis and Identification of Adaptation Strategies

III. Climate Trends in the Marine Protected Area

Temperature and precipitation are the two primary factors used to characterize a climate. Their variations over time lead to changes in the natural environment as a whole: rising sea levels, increased frequency of droughts and heatwaves, and a rise in flooding events. Therefore, it is crucial not only to model their future trends but also to observe the already measurable patterns. The data used in this analysis is sourced from NASA/POWER platform (https://power.larc.nasa.gov/).

3.1. Actual trends

3.1.1. Temperature

The analysis of average annual temperatures shows that they have increased by 1.0°C since 1981. Since the 1980s, observations indicate that minimum temperatures in Barra have steadily risen at a rate of 0.4 to 0.67°C per decade (Government of The Gambia, 2007). From 1998 to 2022, minimum temperatures have generally continued to rise. Additionally, heatwaves have become more intense, longer-lasting, and more frequent in the 21st century (Barbier et al., 2018).

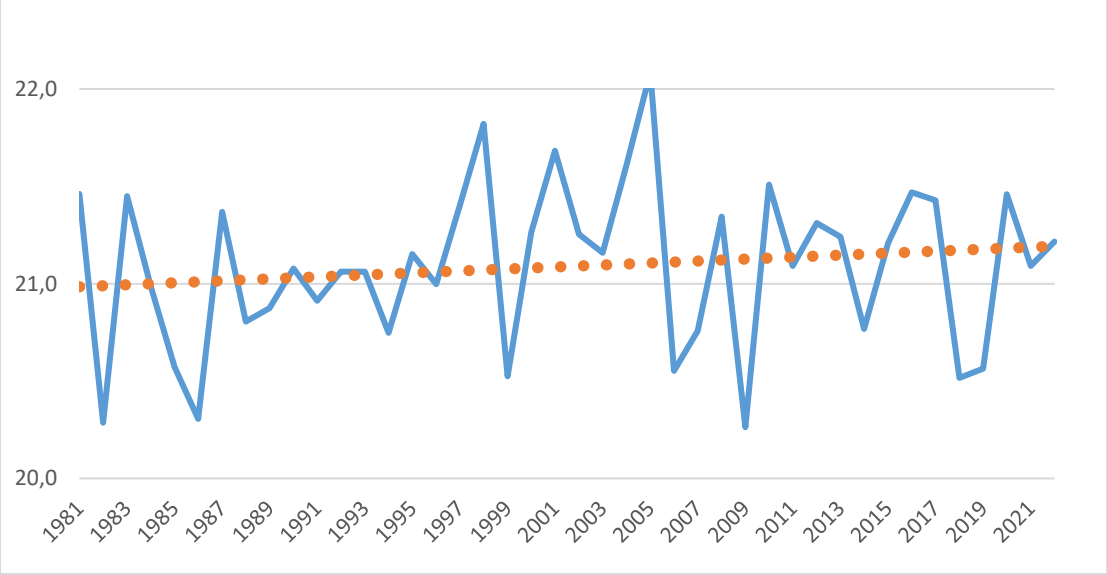

Figure 3: Changes in Maximum Temperatures from 1981 to 2022

This temperature variation is also observed in the oceans, with an increase of 0.4°C. The years 1983, 1998, 2001, and 2014 recorded the highest maximum temperatures. On the other hand, 2010 registered the lowest maximum temperature, at 30.1°C. Regarding ocean temperatures, 2005 remains the warmest year with 23.2°C, while 2018 recorded the lowest temperature in the series, at 21.7°C.

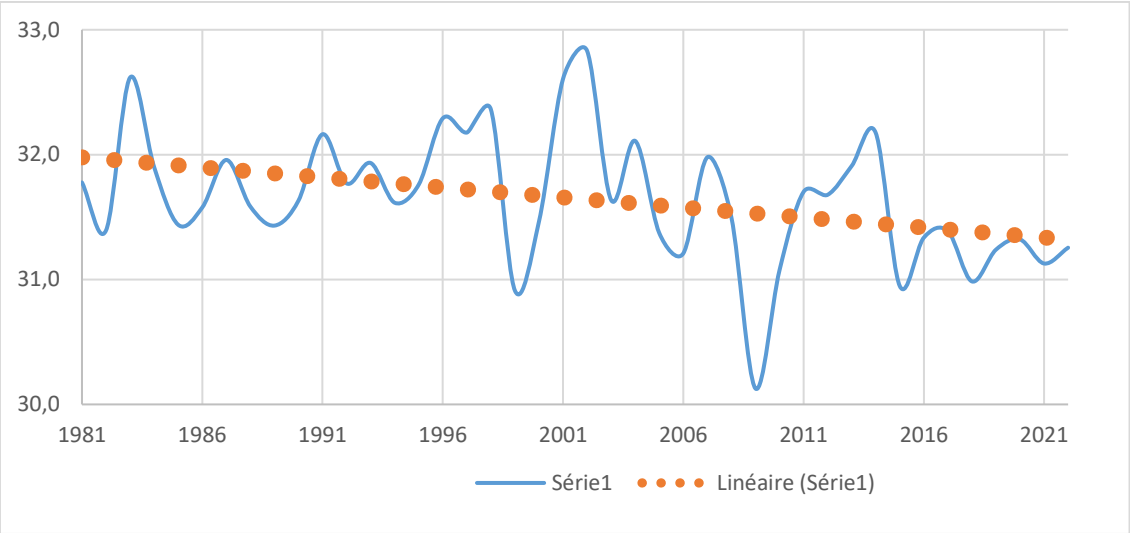

Figure 4: Changes in Minimum Temperatures from 1981 to 2022

3.1.2. Rainfall

Rainfall at the Barra station ranges between the isohyets of 900 and 1000mm. Linear trends indicate inter-annual variability at this station during the study period, with more noticeable fluctuations on a five-year scale.

- From 1981 to 1983, rainfall was generally below the series average of 764.50 mm;
- From 1985 to 1989, observations showed an excess phase compared to the average;
- From 1990 to 2004, 14 years were below average, and one year (1999) exceeded the average with more than 900 mm of rain. The year 2002 was particularly deficient, with a total of 311.13 mm;
- From 2005 to 2022, there was an alternation of surplus and deficit years, with surplus years predominating (9 years);
- In 2020, the Barra station recorded 1,402.71 mm of rainfall, making it the most surplus year of the study period.

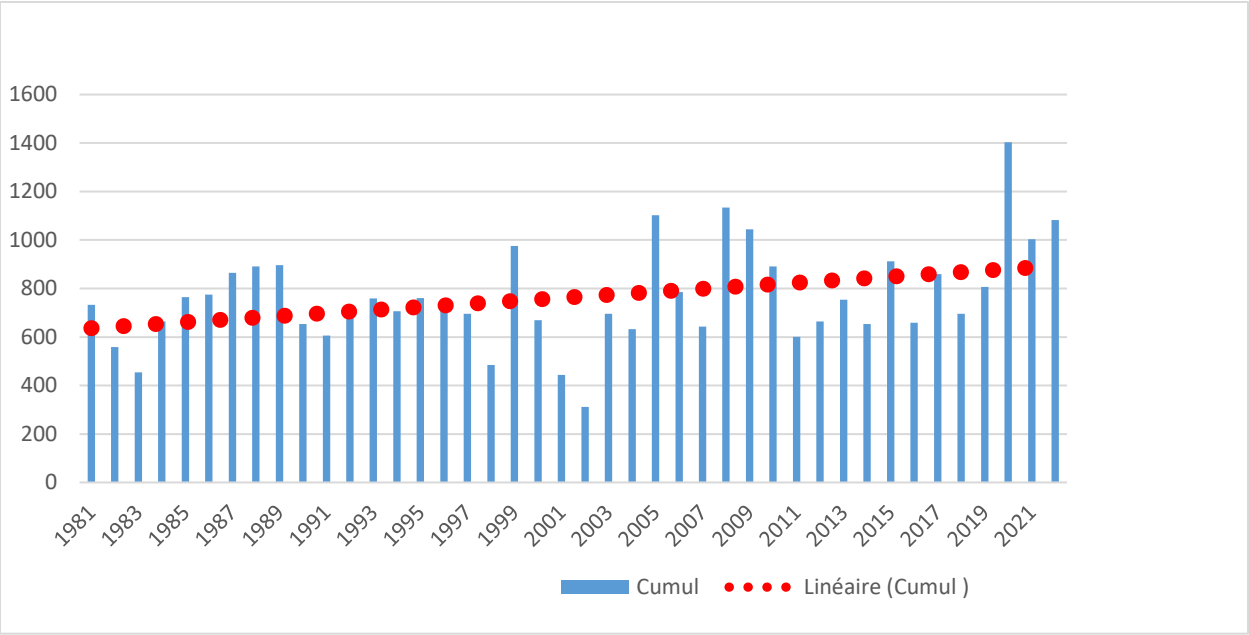

Figure 5: Evolution of Rainfall from 1981 to 2022

The evolution of rainfall in Barra is characterized by inter-annual variability, reflected in alternating dry and wet periods.

3.2.3. Winds

Winds predominantly blow in two directions. From November to April, they are northerly to north-easterly, dominated by marine trade winds or the Harmattan. From May to October, the winds shift to westerly and south-westerly directions, driven by the monsoon. Average wind speeds range from 2 to 2.5 m/s in Banjul, and from 2 to 3.5 m/s in Essau and Kerewan.

3.2.4. Future Climate trend

In the future, projections indicate rising temperatures and a general decline in rainfall. This temperature increase is expected to be more pronounced in the inland eastern region compared to the western coastal areas. Average temperatures are projected to rise by 2.16°C in the east and 1.72°C in the west. Maximum temperatures are forecasted to increase by 2.12°C in the east and 1.69°C in the west, while minimum temperatures are expected to vary between 2.18°C in the east and 1.79°C in the west.

Figure 5 shows the variation in average monthly temperatures over the year for three periods: past (1959-1978), recent (2000-2019), and future (2041-2060). The present period (2000-2019) is

compared with two 20-year periods, each 40 years apart. It is noteworthy that temperature fluctuations are much lower in the west than in the east due to the moderating influence of the ocean. Heatwaves occur between April and May in the east, and in October in the west. For every month of the year, a nearly constant rise in temperatures is observed, with an accelerating trend indicating faster warming. Minimum temperatures consistently occur between January and December. The analysis suggests that higher temperatures should be expected across all seasons of the year.

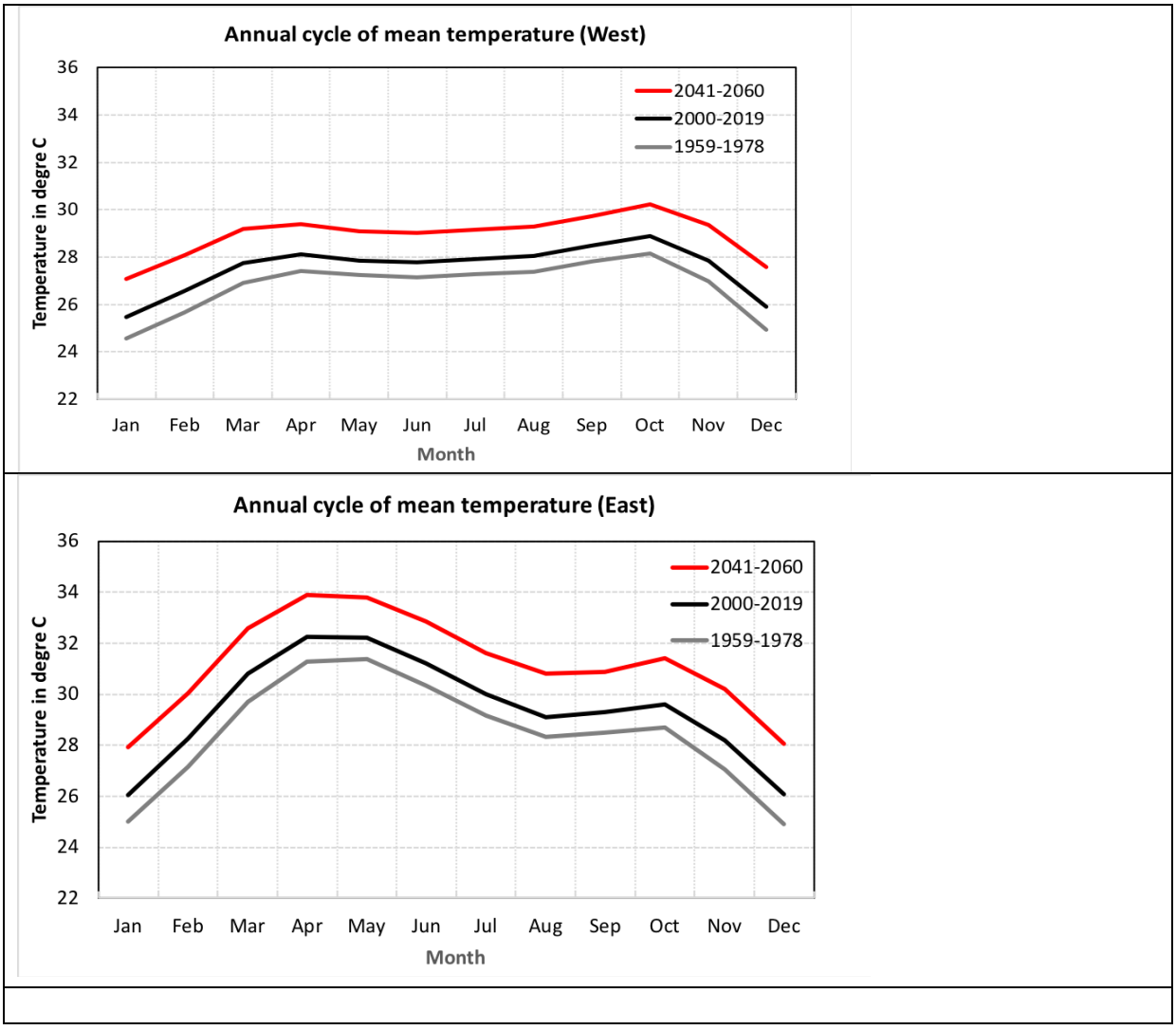

Figure 6: Seasonal variation in temperature in the past (1959-1978), present (2000-2019), and future (2041-2060) for RCP8.5 scenarios in the West (left) and East (right) of The Gambia.

The results presented in Figure 6 should not be interpreted as deterministic and precise climate forecasts for specific geographical locations. Instead, they represent climate projections with

inherent temporal and spatial uncertainties. Each projection (line) reflects a certain probability of future temperature variation. The bold curve represents the mean of all the models (MME).

While the temporal variation in temperature shows some uncertainty, it remains fairly consistent across scenarios: the lowest scenario (RCP2.6) indicates slower temperature increases compared to the intermediate scenario (RCP4.5), followed by the pessimistic scenario (RCP8.5).

For temperature trends, the overall pattern is one of rising temperatures across the entire national territory. This has also been demonstrated by the work of Ly et al., covering the broader West Sahel region.

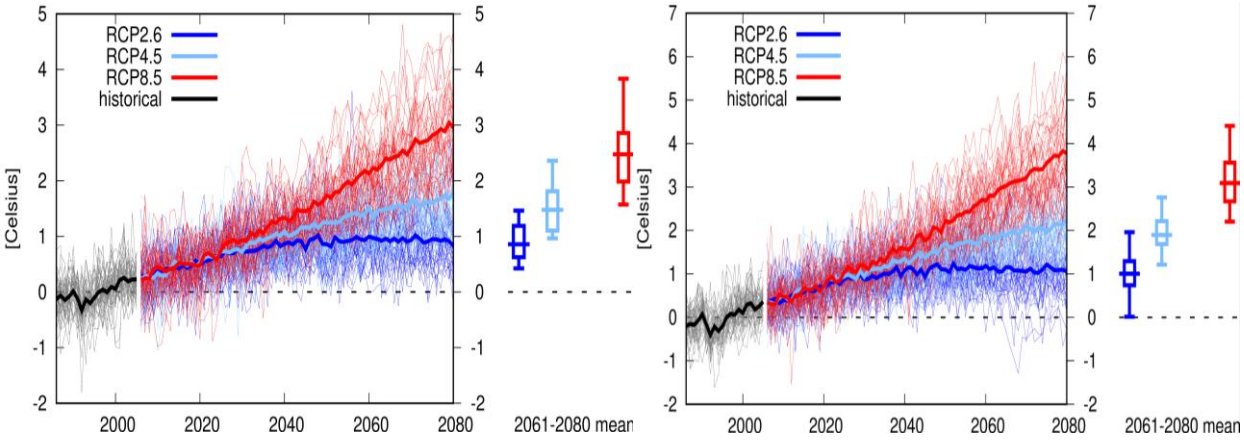

Figure 7: Overall Trends in Annual Average Temperatures According to Three IPCC Scenarios (RCPs 2.6, 4.5, and 8.5) in the Western (left) and Eastern (right) Zones of The Gambia.

We also analyzed several indices derived from rainfall and temperature, as described in the methodology section.

For the temperature index that represents the percentage of days with temperatures exceeding the 90th percentile, a very significant increase is observed (Fig. 7) in the future. The percentage rises from 15% in the past (1981-2010) to 60% in the future (2041-2060) across both zones.

Regarding the number of days where the highest temperature exceeds 25°C, there is also an increase, from 20 days in the past to 150 days per year on average in the future. This result is

notable as it indicates that lower temperatures, which affect certain types of crops, will decrease in the future.

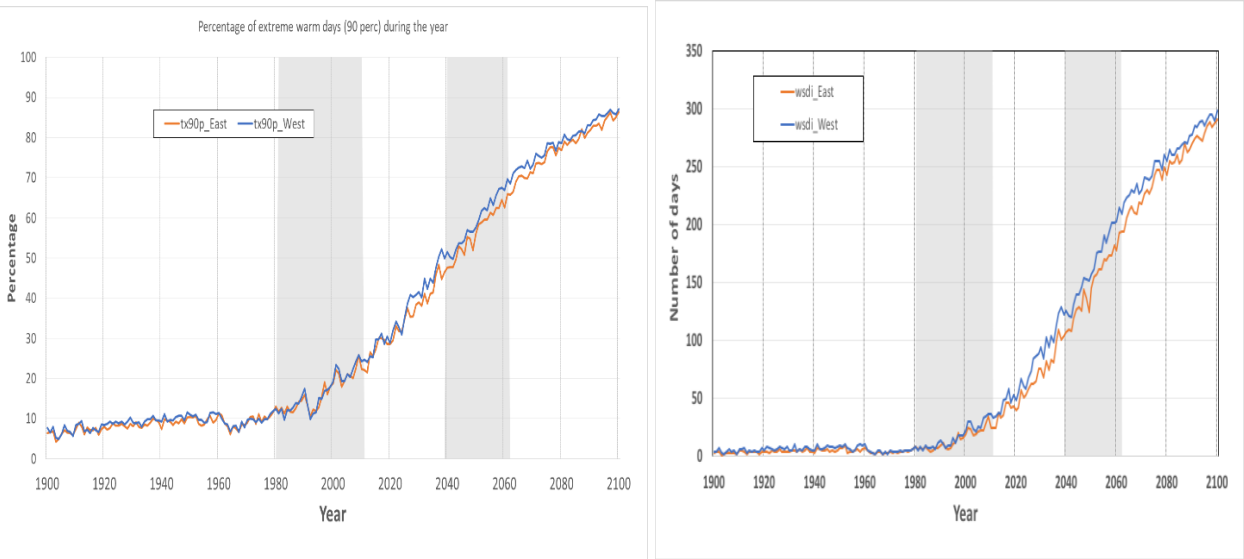

Figure 8: Frequency of hot days (in percentage) exceeding the 90th percentile (top) and the number of hot days exceeding 25°C (bottom) in the Western zone (blue) and Eastern zone (red) of The Gambia, with the reference periods (1981-2010) and future periods (2040-2061) highlighted

Figure 8 shows the temporal variation of several rainfall indices. A slight decrease in annual rainfall totals is observed in the future, accompanied by significant inter-annual variability. The number of rainy days per year is expected to decrease considerably in the future. However, extreme weather events are projected to increase. This may seem paradoxical, but it reflects one of the characteristics of climate change: the occurrence of extreme events. While rainfall will become less frequent, it will be more intense. As a result, even though the annual amount of rainfall decreases, its intensity will significantly increase. In summary, there will be fewer rainy days, but the rain will be much more intense.

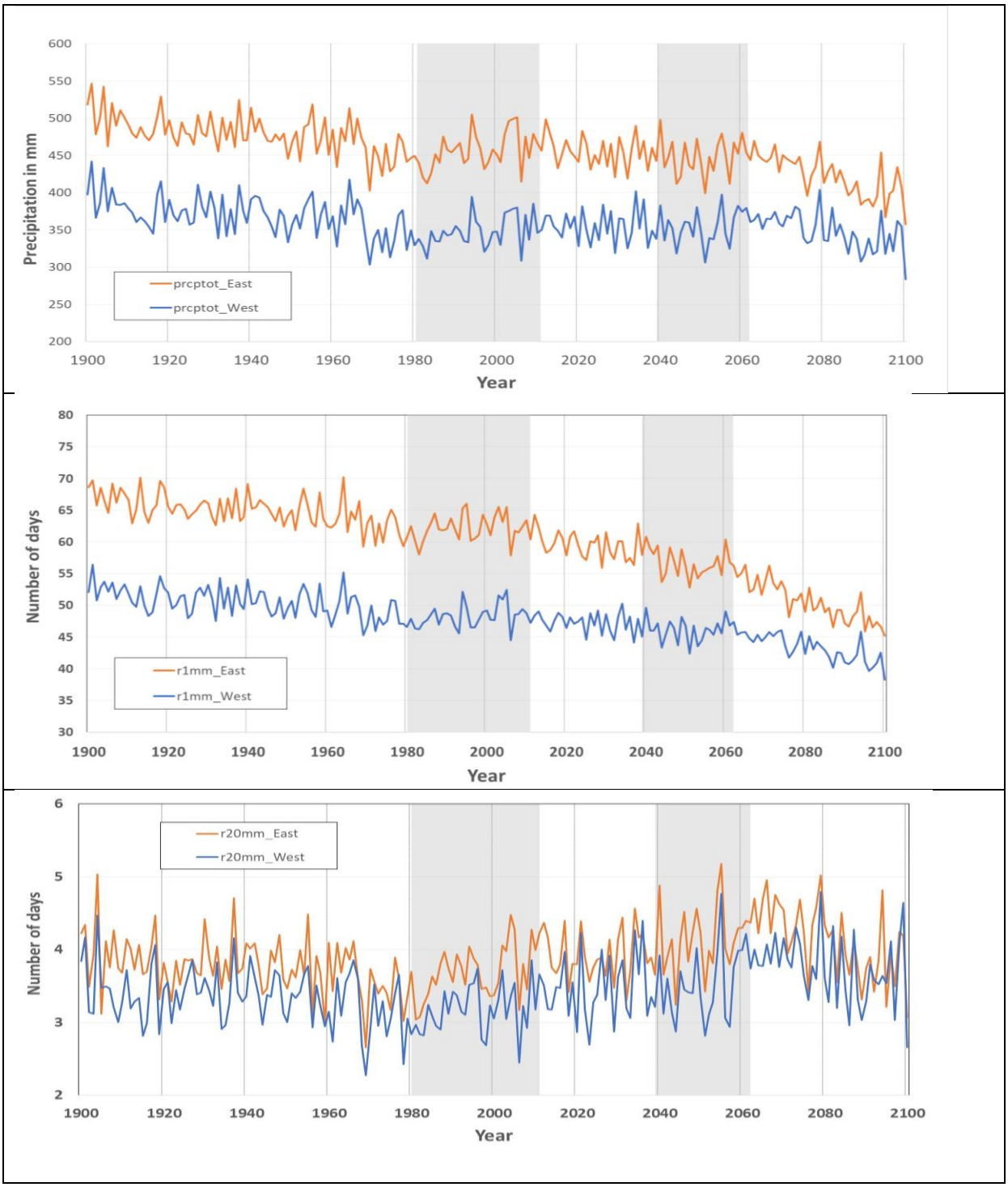

Figure 9: Variation in Annual Rainfall Totals (top), Number of Rainy Days (middle), and Number of Extreme Rainfall Days Over 20 mm (bottom) in the Western Zone (blue) and Eastern Zone (red) of The Gambia, with the reference periods (1981-2010) and future periods (2040-2061) highlighted

To assess the changes due to climate change, we considered a future period (2040-2060) and compared it to a reference period (1981-2010).

We observe a consistent increase in temperatures throughout the year. The warming will occur more rapidly in the future than what has been observed in the past. The eastern part of The Gambia will experience a more significant decrease in rainfall and a sharper increase in temperatures compared to the western part. Rainfall will become less frequent, with a decrease in annual totals, but the intensity of rainfall events will be much greater.

4. Vulnerability Assessment of Natural Ecosystems and Adjacent Communities of the MPA

The vulnerability assessment framework used in this study follows the Fourth Assessment Report (AR4) of the Intergovernmental Panel on Climate Change (IPCC). According to this framework, the vulnerability of the Marine Protected Area (MPA) to climate change depends on a range of factors, including site sensitivity (i.e., the magnitude of the effect resulting from a certain level of exposure to climate change), the level of exposure (of species, habitats, or ecosystems to significant climate variations), and adaptive capacity (Otero et al., 2013). Therefore, vulnerability is specific to each location, species, or community and depends on its ecological and socio-economic characteristics.

This chapter will identify the primary hazards and assess their impacts on resources (habitats, ecosystems, and species), economic activities, and the communities within the Niumi MPA.

4.1. Vulnerability Analysis of the Natural Ecosystems of the MPA

4.1.1. *Components of the Park*

The park is predominantly covered by various vegetation formations, including terrestrial forests (savannas, woodlands, gallery forests, etc.) and intertidal forests primarily made up of mangroves. These forests host extraordinary biodiversity and serve essential environmental, social, economic,

and cultural functions. Beyond their ecological value, they support the subsistence livelihoods of communities living in and around the park, making them highly valued by local populations.

Mangrove forests are mainly located along the *bolongs* (creeks) and are dominated by monotypic stands of *Rhizophora mangle*. In total, five species of mangroves are present (*Rhizophora harissionii*, *Laguncularia racemosa*, *Avicennia nitida*, and *Conocarpus erectus*), providing habitats for a diverse range of wildlife. More than 70 species of fish breed or feed within these mangroves. The marshes and mudflats are home to over 200 species of birds, crustaceans, and plankton. The bird diversity is particularly remarkable, with 293 species from 63 families recorded in Niumi National Park (NNP, 2019).

On the terrestrial side, dominant forest species include *Parkia biglobosa*, *Daniellia oliveri*, and *Pterocarpus erinaceus*, along with shrub species such as *Combretum nigricans*, *Dichrostachys glomerata*, *Guiera senegalensis*, and *Ziziphus mauritiana*. Rainfall, identified as the second most important factor, is critical for maintaining ecosystem health, as well as supporting key subsistence activities like agriculture, fishing, and forestry.

Marine resource diversity (ranked third in importance) sustains fishing activities, while the variety of habitats and species contributes to the park's uniqueness and justifies its status as a protected area. Agricultural lands, ranked fourth among the most important natural resources, are vital because agriculture employs the majority of the local population. The main sources of income come from subsistence activities like fishing, agriculture, and forestry, with additional support from remittances sent by relatives to help families meet basic needs.

Table 1 : Ranking of the Most Important Resources by Category

Grade	Natural resources	Physical resources	Human resources	Financial resources	Social resources
1st	Forest (mangrove, savanna, woodland forest…)	Homes/ Social equipments	Local fishing knowledge and skills	Income from farming activities	Site management community (SMC)
2nd	Rainwater	Fishing equipment	Local farming knowledge and skills	Income from fishing activities	Community-based organization (CBO)

3rd	Marine resources	Fishing infrastructure	Local forest knowledge and skills	Income from forest activities	Village development committee (VDC)
4th	Agriculture land (rice field land, upland)	Lodge/Parc infrastructure	Presence of extension service	Remittence	Non-governmental organization (NGO)

By engaging in subsistence activities such as fishing, forest product exploitation, and agriculture, the communities have developed skills and techniques that are valuable in the practice of these activities. These traditional knowledge systems, combined with the support services provided by the state, represent the most important human resources for the communities living in and around the park. The preservation and sustainable management of the park's resources are primarily ensured by the Sie Management Community (SMC). Village-based committees, such as Community-Based Organizations (CBOs) and Village Development Committees (VDCs), support the SMC in implementing conservation actions and strategies. They assist park managers in the monitoring and protection of resources, particularly those under threat. A number of NGOs also play a role in supporting conservation efforts, providing both technical and financial assistance.

4.1.2. *Climate Hazards and Their Impacts*

Various hazards, such as storms, coastal erosion, rainfall variability, rising temperatures, drought, and floods, impact the park and pose significant threats to its natural environments and resources. Among these hazards, strong winds are identified as having the most negative impacts on the park's resources, followed by coastal erosion and rising temperatures (Table 2).

Table 2 : list of the most influential hazards in the Niumi National Park

Hazards	level of influence 0 to 3	Comments
Coastal erosion	1,1	Influence moyenne
Heatwave	0,9	Influence moyenne
Wind storm	1,9	Influence moyenne

Source: Focus group discussions with communities in the Park's buffer zone

Natural resources and financial resources derived from dependent activities are the most affected by the hazards, with respective impact scores of 2.4 and 2.3 (Table 3).

Table 3 : Level of influence of hazards on natural resources and dependent activities in Niumi National Park

Resources category	Level of influence	Comments
Natural resources	2,1	Strong influence
Financial resources	2,3	Strong influence
Human resources	0,6	Minimal influence
Social resources	1,8	Moderate influence
Physical resources	1,7	Moderate influence

Source: Focus group discussions with communities in the Park's buffer zone

The natural habitats of the park and the resources it supports are particularly vulnerable to the effects of strong winds and rising temperatures. Strong winds, often accompanied by tropical storms, are most prevalent during the rainy season, bringing heavy rainfall along the coast and inland. These storms threaten natural resources, economic activities, coastal communities, and infrastructure, leading to coastal flooding. This issue is especially severe in areas like Barra and nearby regions, as well as other communities along The Gambia's Atlantic coastline. The frequency and intensity of marine flooding have increased significantly in recent years, a trend closely linked to climate change.

Coastal erosion is another major challenge for Niumi Park, with significant shoreline retreat observed in several sections. The erosion rate is estimated at 1 to 2 meters per year, worsening during the rainy season when storms cause marine flooding, substantial sand loss on beaches, and damage to human infrastructure. Rising temperatures further exacerbate these issues, posing a significant threat to natural resources and local communities. Although the full extent of the impact is difficult to quantify, it is clear that increasing temperatures directly affect biodiversity and reduce the availability of water and forest resources.

Beyond climatic hazards, Niumi Park faces additional environmental pressures, including bushfires, plastic pollution, and widespread deforestation, particularly in areas such as Essau, Mayemba, Bakindik Kota, and Mbankan.

4.1.3. The Impacts of Climate Change on Marine-Coastal Ecosystems and Biodiversity in the Park

Climate change has significant impacts on marine and coastal ecosystems and their biodiversity. In these areas, the effects include rising sea levels, increasing sea surface temperatures, ocean acidification, and more frequent strong swells and high winds. In The Gambia, projections predict sea level rise of 0.13 meters by 2025, 0.35 meters by 2050, 0.72 meters by 2075, and 1.23 meters by 2100 (Brown et al., 2011). These climate phenomena, combined with human pressures, have harmful effects on marine and coastal biodiversity, ecosystems, and the coastal communities of The Gambia.

In Niumi Park, climate hazards lead to various negative consequences that impact the park's ecosystems.

Table 4 : Summary of the consequences and impacts of climatic hazards according to the populations

Hazards	Impacts and consequences
Windstorm	Habitat destruction; Destroy tree; destruction of fishing equipment; flooding; loss of life; Water erosion; Stopped of fishing activities; decrease of crop yield; shifting of fish stock; Low income;
Coastal erosion	Loss of land; deforestation; loss of natural habitats and species; salt intrusion; Homed and road destruction;
Heatwave	Shifting of fish resources and birds species; Increase of water salinity; impact on rainfall; loss of life; decrease of crop yield; Decrease Poultry and livestock; Heath reduction; decline in forest production

Source: Focus group discussions with communities in the Park's buffer zone

- **Destruction of marine and coastal habitats**

Rising sea levels and climate change have increased the frequency and intensity of storms in coastal areas. These effects, combined with tidal and wave action, cause significant damage to natural

areas and coastal ecosystems. Beyond the physical destruction of trees, storms often lead to flooding, depositing large quantities of sediment. This sediment buildup smothers mangroves and alters the soil's physico-chemical properties, hindering the germination and growth of young plants. In Niumi Park, mangroves are a critical ecosystem that provides essential habitats for fish, crustaceans, birds, and other wildlife.

Accelerated coastal erosion results in beach loss, diminishing crucial resting and breeding areas for many species. The Gambia estuary is home to rare brackish water species, such as the Nile crocodile, dwarf crocodile, West African manatee, clawless otters, and sea turtles that nest on its beaches. The areas most affected by coastal erosion include Djinack, Barra, Essau, and Mbankan. The degradation of these natural habitats has serious consequences for the park's biodiversity, which is steadily declining. Rising temperatures also affect biodiversity, as many species are highly sensitive to temperature fluctuations. For example, pelagic fish in the park rely on surface water layers, and water temperature plays a crucial role in their distribution and survival. As temperatures rise, these species tend to migrate to deeper waters in search of more favorable conditions. Furthermore, thermal stress can impair fish growth and alter their distribution within the ecosystem.

- **Salinity increase**

This issue is particularly acute on islands and in coastal communities such as Jinack, Essau, Bansan, Mbankan, Kanouma, Bakindick Kota, and Mayamba, where salinization affects both water sources and soil. The rise in salinity impacts aquifers, reducing the availability of fresh water for local populations and limiting the development of economic activities. Agricultural lands, especially rice paddies, are increasingly affected, making farming difficult or even unfeasible in some areas.

Marine species sensitive to salinity fluctuations experience stress, which compromises their growth, reproduction, and survival. Mangroves, which are also highly sensitive to changes in salinity, are similarly affected.

- **Deforestation**

Deforestation is a major challenge in Niumi Park. While human activities, such as logging, agricultural expansion, and urbanization, are the primary drivers, natural forces like storms and coastal erosion significantly worsen the loss of forest resources. Rising salinity in water and soil weakens mangrove forests, often uprooted by strong winds. Terrestrial ecosystems, including

savannas and forests, also suffer, leading to the decline or disappearance of certain plant and animal species.

- **Flooding of low land-areas**

Recurrent flooding, caused by storm surges and seasonal rainfall, threatens infrastructure, housing, and agricultural fields, particularly rice paddies, in low-lying coastal areas. These floods have a profound impact on the livelihoods and living conditions of coastal populations.

- **Intensification of water erosion**

During the rainy season, surface runoff accelerates the process of water-induced soil erosion, causing significant sediment displacement. This results in the loss of topsoil, reducing agricultural productivity, and also leads to infrastructural damage to roads, buildings, and drainage system.

4.1.4. Les impacts sur les activités socio-économiques du Parc

- **Impacts on the fishing activities**

The destruction of marine and coastal habitats caused by climate hazards, along with species migration, significantly affects the availability of prized species that local populations depend on for fishing. These habitats are crucial for juvenile species' development, and their loss greatly reduces catch rates and species diversity. Although these impacts remain somewhat limited in the park due to the relatively low fishing effort, the increasing interest in commercial fishing poses a growing threat to the park's biodiversity.

Moreover, during storm periods, fishing activities come to a halt. Fishermen venturing out face risks of accidents or loss of fishing equipment. Fishing gear and infrastructure along the coast are also vulnerable to damage. The interruption of activities and loss of equipment result in significant economic losses for fishermen, compromising their livelihoods and food security.

- **Impacts on agricultural activities**

The combined effects of various climate hazards have severe consequences for agricultural activities. The increasing salinity of soils particularly affects rice paddies, which are subject to saltwater intrusion, leading to the loss of arable land and reduced agricultural yields. Additionally, groundwater contamination by salt limits the potential for vegetable farming, a vital income-generating activity, especially for women. Beyond the physical damage to crops, storms also cause a loss of blossoms, leading to significantly lower expected yields for the season. This reduction in

agricultural production poses a threat to food security and drastically reduces the income generated from these activities. The degradation of vegetation cover also impacts livestock farming, as forage availability can become limited, particularly at the end of the dry season. High temperatures further hinder poultry farming, as chickens are highly sensitive to heat, resulting in increased mortality.

4.1.5. Impacts on Health and Well-Being of Populations

Climate change has a significant and varied impact on human health. Heatwaves can lead to heat-related illnesses, such as heatstroke and hyperthermia, and exacerbate conditions in individuals with chronic diseases, such as cardiovascular and respiratory disorders. Storms and floods can contaminate drinking water sources, increasing the risk of waterborne diseases. Furthermore, the loss of livelihoods leads to reduced income, exacerbating the vulnerability of populations.

The negative effects of climatic hazards are keenly felt by the communities living around the Park, whose livelihoods depend on its resources. At local level, a number of initiatives have been developed to mitigate the impacts (table 6).

4.2. Vulnerability assessment

The AR4 report from the Intergovernmental Panel on Climate Change (IPCC) identifies three key components of ecosystem vulnerability to climate change: sensitivity, exposure, and adaptive capacity. The analysis conducted evaluated both the exposure and sensitivity of key species within the park, as well as the socio-economic components. Additionally, it assessed the available resources in the park that could help mitigate the negative impacts of climate change.

4.2.1. Exposure

Exposure refers to the degree to which a particular asset is likely to be affected by climate change effects. It is determined by a complex combination of geographical, environmental, and socio-economic factors. Among these factors, the type of hazard, the nature of the resource, and its geographic location play a significant role in influencing exposure. In Niumi Park, the identified resources are highly exposed to coastal erosion and rising temperatures (Table 4).

Table 5 : Exposure indice

Hazards	Exposure index	Comments
Coastal erosion	0,7	High exposure
Heatwave	0,7	High exposure
Wind storm	0,5	Modérate exposure

Forests, agricultural lands, marine resources, as well as housing and infrastructure are the most exposed to the different hazards. While overall exposure to strong winds is moderate for most resources, certain assets such as housing, infrastructure, agricultural lands, and terrestrial vegetation show very high levels of exposure.

4.2.2. Sensivity

The sensitivity of the park's key resources, their propensity to be affected by climate hazards was also assessed. This sensitivity largely depends on the specific vulnerability of the species or assets present (their specific physical and biological characteristics) and their built-in adaptation mechanisms that help protect them from climatic stimuli. The sensitivity levels of resources to the three major climate hazards are illustrated in the figure below.

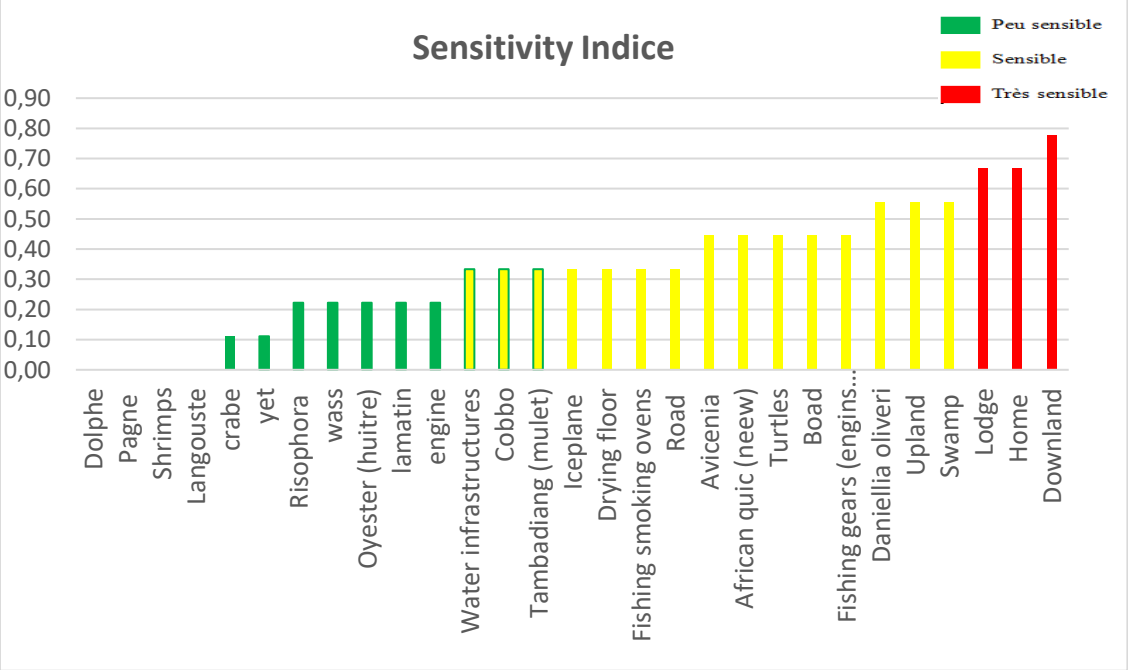

Figure 10: Graphical Representation of Resource Sensitivity Indices

Rice paddies, housing, and tourist infrastructure exhibit high sensitivity to hazards, with sensitivity indices ranging from 0.67 to 0.78. In contrast, species such as crustaceans and mollusks

demonstrate very low, if not negligible, sensitivity due to their inherent ability to protect themselves from the analyzed hazards.

4.2.3. Adaptation Capacity Analysis

The ability of protected areas to adapt to climate change relies on a combination of ecological, technological, social, and political factors. The analysis of the park's adaptive capacity focused on its ability to manage the impacts of climate change by leveraging its key resources. Both park managers and local communities have developed strategies to reduce their vulnerability to climate-related hazards. Figure 11 highlights that technical services, social resources (CBOs, NGOs, SMC), and forest resources play the most significant roles in implementing strategies to mitigate the impacts of these hazards.

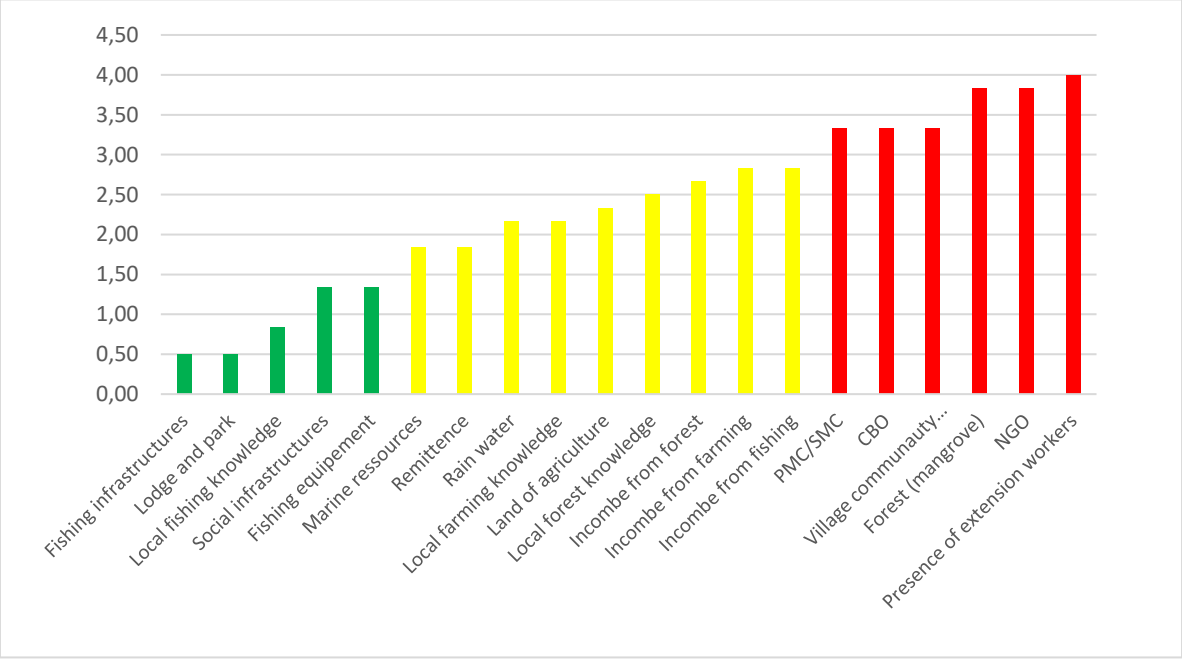

Figure 11: Ranking of the most important resources for the implementation of strategies

4.3. Vulnerability analysis

Vulnerability assessment is an essential step in guiding the planning of adaptation measures in protected areas In the case of Nuimi MPA, several major climate hazards have been identified as threatening coastal ecosystems and the livelihoods of local communities. These are mainly Windstorm, Coastal erosion and Heatwave. These hazards have direct repercussions on the MPA's sensitive ecosystems (wetlands, mangroves, mudflats, banks, etc.), but also on local economic activities, in particular small-scale fishing, the exploitation of non-timber forest products and agriculture. The assessment was based on a method of aggregating sensitivity and adaptability indices to produce a specific vulnerability index for each hazard. The results were interpreted according to the following scale:

- **0 to 0.33 : low vulnerability**
- **0.34 to 0.66: moderate vulnerability**
- **0.67 to 1 : high vulnerability**

Table 6 : index of vulnerability

Hasards	**Index of vulnerability**	**Comments**
Coastal erosion	**0,27**	Low vulnérability
Wind storn	**0,30**	low vulnerability
Heat wave	**0,67**	High vulnérabilité

Source : Données de terrain CSE Mai-juin 2024

In the case of the Nuimi MPA, several major climate hazards have been identified as threatening coastal ecosystems and the livelihoods of local communities. These are mainly Windstorm, Coastal erosion and Heatwave. These hazards have direct repercussions on the MPA's sensitive ecosystems (wetlands, mangroves, mudflats, banks, etc.), but also on local economic activities, in particular small-scale fishing, the exploitation of non-timber forest products and agriculture. The assessment was based on a method of aggregating sensitivity and adaptability indices to produce a specific vulnerability index for each hazard. The results were interpreted according to the following scale:

- **0 to 0.33**: low vulnerability

- **0.34 to 0.66**: moderate vulnerability
- **0.67 to 1:** high vulnerability

- Vulnerability of the MPA to coastal erosion

The MPA has a low vulnerability to coastal erosion, with an index of 0.27. This results in the loss of topsoil, reducing agricultural productivity, and also leads to infrastructural damage to roads, buildings, and drainage systems. This results in the loss of topsoil, reducing agricultural productivity, and also leads to infrastructural damage to roads, buildings, and drainage system.

- Vulnerability of the MPA to windstorms

With an index of 0.30, vulnerability to windstorms is considered low in the Niumi MPA. These extreme events disrupt fishing activities, causing material damage and, in some cases, serious accidents at sea. They also lead to a significant reduction in fishermen's incomes and increase the economic insecurity of coastal households.

- **Vulnerability to rising temperatures**

The vulnerability index for rising temperatures is 0.67. This means that the Nuimi MPA is very vulnerable to rising temperatures. This means that the Nuimi MPA is very vulnerable to rising temperatures. Indeed, the increase in marine temperatures leads to the migration of certain marine species (fish, mammals, etc.), accentuates their scarcity and encourages the salinisation of the soil. These dynamics alter the balance of marine ecosystems and affect biodiversity.

Aggregation of the various indices has produced a composite vulnerability index of 0.42, indicating an overall moderate level of vulnerability of the MPA to climate change. This situation calls for both ecological and socio-economic adaptation measures to strengthen the resilience of the KBK MPA and the communities that depend on it.

4.4. Responses of Populations to Climate Impacts

4.4.1. Current Strategies

The negative effects of climate hazards are acutely felt by communities living around the park, whose livelihoods depend on its resources. At the local level, several initiatives have been developed to mitigate these impacts (Table 6).

Table 7 : Strategies Developed to Address Climate Change

Hazards	Current strategies	Assess the functionality of the current strategies	
		efficiency	sustainability
Windstorm	• Wind breaker • tree planting • Weather information • Use of traditional knowledge • Saving money • Introduce agroforestry practice, compost (organic manure	• Yes • Yes • Yes • Yes/no • Yes • Yes	• Yes • Yes • Yes • Yes/no • No • Yes
Coastal erosion	• Tree planting (mangrove) • Awareness raising • Inforcement of law • Establishment of community forest, • Establishment of wood luck (bois villageois) • Alternative activities • Local defense (tire, sand…) • Local dike	• Yes • Yes • Yes • Yes • Yes • Yes • Yes • Yes • Yes	• Yes • Yes • Yes • Yes • Yes • Yes • Yes • No • No
Heatwave	• Reforestation	• Yes	• Yes

- **Strategies Developed to Address Storms**

Storms often occur suddenly, with destructive effects on resources, communities, and their assets. Responses vary depending on the impacts. Reforestation initiatives are increasingly being launched to strengthen natural barriers (mangroves and terrestrial plants), which act as windbreaks, reducing the strength of storms. These initiatives, led by NGOs and financial partners, are implemented by the Park's Management Committee (SMC) in collaboration with local communities. Fishermen, who are at higher risk during storms, often adopt preventive measures by consulting weather information to avoid being caught at sea. However, there is currently no early warning system in place to provide easy access to such information for the population. Traditional knowledge and practices are also employed to interpret or predict the occurrence of extreme events, such as heavy

swells and storms, helping to prevent fishermen from venturing out to sea during risky periods. Nonetheless, this knowledge can be challenged by climate change, which brings increased unpredictability in extreme events. Additionally, savings accumulated by fishermen help them meet their needs during periods when fishing activities are suspended. Agricultural yield declines are addressed through the adoption of climate-resilient agricultural practices, such as agroforestry or crop rotation.

- **Strategies Developed to Address Coastal Erosion**

Homes and other infrastructure along the shoreline are threatened by coastal erosion. To combat this, dikes or embankments made from local materials (sandbags, rubble, waste, tires, etc.) are installed to protect homes and reduce saltwater intrusion, which affects soil fertility. While these actions can be effective in the short term, they have a limited lifespan and require constant maintenance. Mangrove reforestation helps reinforce the natural barrier they provide. Awareness campaigns are also conducted to educate the population on environmental risks and the importance of preserving the environment, including discouraging harmful practices such as deforestation or beach sand extraction. Administrative and local authorities also promote adherence to laws and regulations to mitigate potential damage. The negative impacts on the agricultural sector drive individuals to invest in alternative activities such as trade, vegetable gardening, and the exploitation of non-timber forest products (*Saba senegalensis*, *Detarium senegalensis*, *Adansonia digitata*, etc.). Sustainable resource management initiatives are also established through local conventions that organize resource use and exploitation, as well as the establishment of village woodlots to reduce excessive tree cutting.

- **Strategies Developed to Address Rising Temperatures**

Apart from reforestation efforts, communities lack adequate strategies to effectively cope with the impacts of rising temperatures.

4.4.2. Optional strategies

During the participatory diagnostic session, the populations proposed optional strategies to enhance community resilience against hazards. The analysis of the implementation of these options considers the available resources as well as the limiting factors and/or constraints that may hinder their realization. Implementing these optional strategies, in addition to the existing ones, would

make a significant contribution to strengthening the resilience of local stakeholders and the Niumi Marine Protected Area.

- **Optional Strategies for Strong Winds**

In response to storms, improving access to weather information is considered an effective and essential measure to enhance the resilience of fishermen and communities in general. Indeed, the development of climate information services remains limited in the Niumi area. Stakeholders emphasized the need to improve the provision and communication of climate information to help communities better anticipate risks. The availability of communication tools and the development of technology are strong assets for operationalizing this measure.

- **Optional Strategies for Coastal Erosion**

The optional strategies identified to address the impacts of coastal erosion are: beach nourishment, hard protective structures, the use of adapted species, and the adoption of agroecological practices such as Assisted Natural Regeneration (ANR).

• Beach nourishment helps restore beaches, preserving both habitats and dependent wildlife, as well as protecting coastal infrastructure and homes. The implementation of this strategy can rely on the availability of materials (sand) and local labor, but high costs and the lack of expertise remain obstacles to its realization.

• The use of seeds and crop varieties that are tolerant to salinity and adapted to local climate conditions can increase agricultural productivity and maintain stable yields despite fluctuating environmental conditions.

• The adoption of Assisted Natural Regeneration (ANR) facilitates ecological restoration by protecting the natural regeneration process from anthropogenic and natural disturbances. This technique, which is low-cost and accessible to communities, allows for the restoration of natural ecosystems and degraded agricultural lands.

- **Optional Strategies for Rising Temperatures**

Communities often find themselves ill-equipped to respond to the increasingly rising temperatures. However, the establishment of heatwave warning systems could allow populations to prepare, take precautionary measures, and adjust their work schedules to avoid exposure during peak heat

periods. Sustainable natural resource management practices can help maintain biodiversity and ecosystem services, thereby increasing ecosystem resilience to external shocks.

V. CLIMATE CHANGE ADAPTATION PLAN FOR NIUMI NATIONAL PARK

The adaptation plan aims to provide a strategic framework to effectively respond to the challenges posed by climate change in the Niumi Park. It describes the directions and actions that will make it possible to anticipate the impacts of climate and coastal risks, preserve biodiversity, and strengthen the resilience of ecosystems and communities in the Niumi National Park. This plan is

based on a participatory and systemic approach, integrating risk assessment, adaptive management and the active participation of communities in the decision-making and action process.

5.1. Vision, objectives and strategic axis

5.1.1. Adaptation plan vision

The vision defines the intervention framework and the direction of actions necessary to strengthen the resilience of the Park in the face of climate change. It underlines the importance of maintaining essential natural habitats and biological diversity while limiting the impacts of climatic and anthropogenic disturbances. It is formulated as follow: « *Niumi national Park : A reference in the preservation of ecosystems and biodiversity, ensuring sustainable use of resource to improve livehood by 2035* ».

The implementation of the action plan will extend over a 10-year horizon, structured in two successive five-year phases. These phases will allow interventions to be adjusted and refined based on progress made and new emerging priorities.

5.1.2. Guiding principle

The Plan was developed taking into account the following principles:

- **Inclusive:** Stakeholders were involved at every stage, from planning to implementation, to ensure a participatory and appropriate approach.
- **Evidence-based:** Decisions are based on sound scientific knowledge, local perceptions and other empirical data to ensure an informed and contextual approach;
- **Preservation of biodiversity**: « biological diversity provides invaluable services and must be conserved for the benefit of current and future generations. Maintaining species, ecosystems and natural processes that support life is essential to guarantee the quality of life of citizens »;
- **Environmental protection**: Environmental protection is a fundamental pillar of sustainable development, which must beintegrated into every stage of development processes to ensure a balance between conservation and progress.

5.1.3. Strategic axis and strategic objectives

To achieve the vision, the actors of the Niumi Park have defined four (04) areas of intervention.

Each of them is associated with one or more specific objectives, as well as priority adaptation actions.

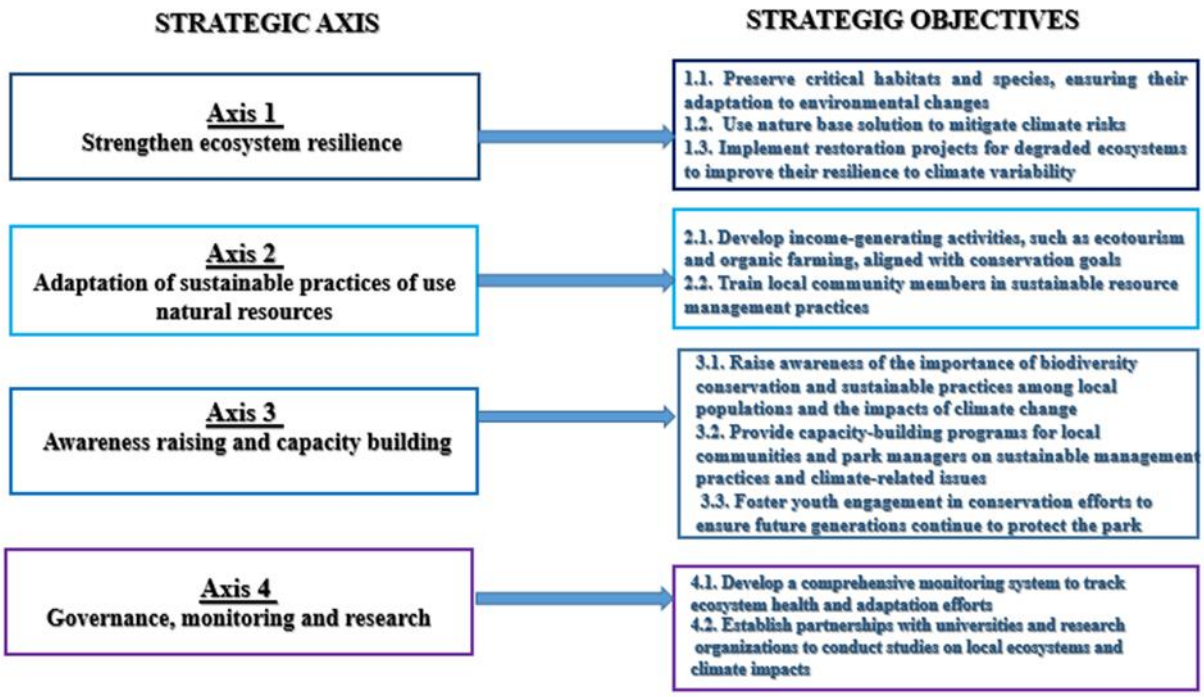

Figure 12: Strategic axis and strategic objectives

Each identified axis brings together concrete and sustainable adaptation measures aligned with the specific objectives set. Due to their number, these activities were prioritized using the MCA (multi-criteria analysis) approach. This method made it possible, within a concerted framework, to select priority adaptation options on the basis of qualitative criteria. The criteria used for this analysis include :

- environmental acceptability
- efficiency
- economic profitability
- emergency
- social acceptability

Each criterion was evaluated on a scale of 0 to 3, without weighting. Strategies considered priority had to achieve a minimum cumulative score of 12.

Table 8 : Prioritization of adaptation options

Hazards	Current strategies	efficiency	Environmental acceptability	Social acceptability	Economy	Emergency	Sum	Status
Windstorm	Tree planting	3	3	3	3	3	15	Priority
	Weather information	3	3	1	3	3	13	Priority
	Use of traditional knowledge	2	3	2	3	2	12	Priority
	Saving money	3	3	2	3	3	14	Priority
	Introduce agroforestry practice, compost (organic manure)	3	3	3	3	3	12	Priority
	Improving access to climate information	3	3	1	3	3	13	Priority
Coastal erosion	Tree planting (mangrove)	3	3	3	3	3	15	Priority
	Awareness raising	2	3	1	3	3	12	Priority
	Enforcement of law	2	3	2	3	2	12	Priority
	Establishment of wood lock (bois villageois)	3	3	2	3	3	14	Priority
	Alternative livelihoods	2	2	2	3	3	12	Priority
	Nature-based solution	3	3	3	3	3	15	Priority
	Suitable species (salt tolerant species)	3	3	2	3	3	14	Priority
Heatwave	Reforestation	3	3	3	3	3	15	Priority

5.2. Roadmap for adaptation to climate change

The selected priority actions are based on the strategic areas identified in the CDN-Biodiversity and the National Climate Change Adaptation Plan. They also draw their basis from the Niumi management plan and the national protected area management strategy.

Table 9 : Action plan for adaptation to climate change in Niumi Park

Strategic axis	Main objective	Specific objectives	activities	Source of funding	Materials and human resources	Years				
						2025	2026	2027	2028	2029
Strengthen ecosystem resilience	**Enhance Ecosystem Resilience to Climate Change**	- Preserve critical habitats and species, ensuring their adaptation to environmental changes - Use nature base solution to mitigate climate risks - Implement restoration projects for degraded ecosystems to improve their resilience to climate variability	Reforest (Mangroves, and other terrestrial plant species)	Government and technical and financial partners	Park, SMC, VDC, CBO, Extension services, NGO					
			Restore beaches (SFN)							
			Submerge artificial reefs							
			Observe biological rest based on scientific knowledge							
			Implement a management plan for each species							
			Promote aquaculture							
			Install anti-salt dikes							
			Regulate conversion to agricultural land or urban areas							
			Soil defense and restoration (rock bunds…)							
Adaptation of sustainable practices of use natural resources	**Support and promote sustainable resource management**	Develop income-generating activities, such as ecotourism and organic farming, aligned with conservation goals	Integrate sustainable agricultural practices (agroecology, assisted natural regeneration, etc.)	Government and technical	Park, SMC, VDC, CBO, Extension services, NGO					
			Develop sustainable tourism projects							
			Develop alternatives activities (market gardening, beekeeping, poultry farming, etc.)							

	that aligns with conservation goals	Train local community members in sustainable resource management practices	promote the processing of local products and support marketing circuits	and financial partners						
			Subsidize/finance sustainable practices							
			Build capacity in local product development and processing techniques							
Awareness raising and capacity building	**Empower communities and stakeholders through education and training for long-term engagement in conservation**	Raise awareness of the importance of biodiversity conservation and sustainable practices among local populations and the impacts of climate change	Organize capacity-building sessions focusing on biodiversity conservation and climate risks	Technical and financial partners	Park, SMC, VDC, CBO, Extension services, NGO					
		Provide capacity-building programs for local communities and park managers on sustainable management practices and climate-related issues	Capacity building on sustainable resource management and climate change	Technical and financial partners	Park SMC, VDC, CBO, Extension services, NGO					
		Foster youth engagement in conservation efforts to ensure future generations continue to protect the park	Educate young people about sustainable management and preservation of naturel resources	Technical and financial partners	Park, Schools					
Governance, monitoring and research	**Establish transparent management that includes community contributions**	- Develop a comprehensive monitoring system to track ecosystem health and adaptation efforts - Establish partnerships with universities and research organizations to conduct studies on local ecosystems and climate impacts	Build the capacity of MPA managers to monitor biodiversity and marine species in the MPA	Government and technical and financial partners	Park, SMC					
			Set up a monitoring system for the MPA's marine and coastal biodiversity							
			Collaborate with research institutions and universities							

5.3. Monitoring and Evaluation of the implementation of the plan

5.3.1 Coordination of plan implementation

The SMC, which includes representatives of the participating villages and the Park manager, will ensure the coordination and implementation of all Plan activities. He will be responsible, among other things, for proposing an annual program of activities, evaluating the costs of activities, ensuring the animation and monitoring of the plan and mobilizing resources for the implementation of actions and producing technical activities evaluation reports.

A manager will be designated within the structure to facilitate the technical management of activities linked to the implementation of the action plan.

5.3.2. Monitoring and evaluation of the plan

Annual monitoring of the execution of plan activities will be carried out on the basis of relevant indicators identified from the adaptation measures. These indicators measure the results obtained from local climate change adaptation plan achievements. achievements. Table 9 XX presents a preliminary list of indicators. This list will be enhanced or modified when the interventions are implemented.

Table 10 : Monitoring indicators – Evaluation

Strategic axis	Main objective	Specific objectives	Activities	Indicators
Strengthen ecosystem resilience	**Enhance Ecosystem Resilience to Climate Change**	- Preserve critical habitats and species, ensuring their adaptation to environmental changes - Use nature base solution to mitigate climate risks - Implement restoration projects for degraded ecosystems to improve their resilience to climate variability	Reforest (Mangroves, and other terrestrial plant species)	Area reforested ; Success rate
			Restore beaches (SFN)	number of infrastructures installed; length of protected coast
			Submerge artificial reefs	Numbers of submerge artificial reefs
			Observe biological rest based on scientific knowledge	number of biological rest periods observed
			Implement a management plan for each species	Number of species monitored
			Promote aquaculture	Number of actors accompanied
			Install anti-salt dikes	Number of dikes installed
			Regulate conversion to agricultural land or urban areas	A regulation is proposed and validated

			Soil defense and restoration (rock bunds…)	Number of rock bunds installed
Adaptation of sustainable practices of use natural resources	**Support and promote sustainable resource management that aligns with conservation goals**	Develop income-generating activities, such as ecotourism and organic farming, aligned with conservation goals Train local community members in sustainable resource management practices	Integrate sustainable agricultural practices (agroecology, assisted natural regeneration, etc.)	Number of actors accompanied
			Develop sustainable tourism projects	Number of actors accompanied
			Develop alternatives activities (market gardening, beekeeping, poultry farming, etc.)	Number of actors accompanied
			Promote the processing of local products and support marketing circuits	Number of actors accompanied
			Subsidize/finance sustainable practices	Number of actors accompanied
			Build capacity in local product development and processing techniques	Number of actors accompanied
Awareness raising and capacity building	**Empower communities and stakeholders through education and training for long-term engagement in conservation**	Raise awareness of the importance of biodiversity conservation and sustainable practices among local populations and the impacts of climate change	Organize capacity-building sessions focusing on biodiversity conservation and climate risks	number of sessions organized/ number of stakeholders trained
		Provide capacity-building programs for local communities and park managers on sustainable management practices and climate-related issues	Capacity building on sustainable resource management and climate change	number of sessions organized/ number of stakeholders trained
		Foster youth engagement in conservation efforts to ensure future generations continue to protect the park	Educate young people about sustainable management and preservation of naturel resources	Number of awareness campaigns organized
Governance, monitoring and research	**Establish transparent management that includes community contributions**	- Develop a comprehensive monitoring system to track ecosystem health and adaptation efforts - Establish partnerships with universities and research organizations to conduct studies on local ecosystems and climate impacts	Build the capacity of MPA managers to monitor biodiversity and marine species in the MPA	Number of sessions organized
			Set up a monitoring system for the MPA's marine and coastal biodiversity	Number of biodiversity indicators monitored
			Collaborate with research institutions and universities	Number of agreements signed

Conclusion

Parks play a crucial role in the conservation and preservation of biodiversity. However, their effectiveness and management are significantly impacted by climate change, with its effects being particularly evident in Niumi National Park. The climate vulnerability analysis highlighted and prioritized the key climate hazards affecting the park, with strong winds, coastal erosion, and rising temperatures identified as the most significant.

These hazards have devastating impacts on the park's natural resources, leading to the destruction of marine and coastal habitats, reduction of vegetation cover, decreased agricultural production, diminished water resources, loss of forest species, and reduced UOHNN availability of arable land. Marine and coastal ecosystems, which are vital for biodiversity and local economic activities, are especially vulnerable to these disruptions.

In response to these challenges, local communities have implemented various adaptation strategies. These include strengthening natural barriers through the reforestation of mangroves and terrestrial plants, constructing makeshift dikes, developing sustainable resource management initiatives, and diversifying income-generating activities. These measures aim not only to mitigate the immediate impacts of climate change but also to enhance the resilience of communities and ecosystems against future disturbances.

It is essential to continue supporting and improving these adaptation strategies while integrating climate concerns into the park's planning and management processes. Increased efforts in research, awareness, and collaboration among stakeholders will be necessary to ensure the long-term sustainability of Niumi National Park's ecosystems and to preserve its rich biodiversity.

The action plan proposed for adaptation to changes mainly aims improving the resilience of ecosystems to climate change, adaptation of sustainable practices of use natural resources, empowering communities and stakeholders through education and training for long-term engagement in conservation and establishing transparent management that includes community contributions. Its implementation planned over ten years will help strengthen the resilience of the ecosystems and resources of Niumi National Park and mitigate the impacts of climate change.

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