Centre de Suivi Ecologique

Cégep de la Gaspésie et des Îles

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GROUPE COLLEGIA FORMATION CONTINUE

The Ecosystem Solutions for Sustainable Adaptation (SEDAD)

LOCAL CLIMATE ADAPTATION PLAN OF JUKADU NATIONAL PARK 2023-2028

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Summary

The Gambia is highly vulnerable to climate change due to its geographical location and climatic variability. In Jokadu Park, this vulnerability is manifested through a range of hazards, the most significant of which are storms, coastal erosion/flooding, and rainfall variability.

The resources (natural, physical, human, financial, and social) on which stakeholders rely for their livelihoods are all affected by these hazards. The most impacted resources include fishery resources, forest resources (mangroves and terrestrial forests), water resources, and agricultural land, which consequently affect the income of the populations that depend on these resources. The consequences and impacts of climate change on stakeholders and their assets are mostly negative. These impacts include accidents, destruction of marine and coastal habitats, reduction of water resources and forest and fishery species, loss of fishing equipment and infrastructure, decline in crop yields, destruction of beaches, etc.

In response to these manifestations and constraints, stakeholders have developed numerous adaptation strategies to enhance their resilience. These strategies partially rely on constructing basic structures and makeshift dikes to curb or limit wave action and protect habitats and agricultural areas, developing alternative activities to diversify income sources, restoring biodiversity (reforestation of mangroves and terrestrial species), and seasonal migration to seek additional income.

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

1.1. 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 Jukadu Park.

1.2. 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 Jukadu Park. 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.

1.3.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.

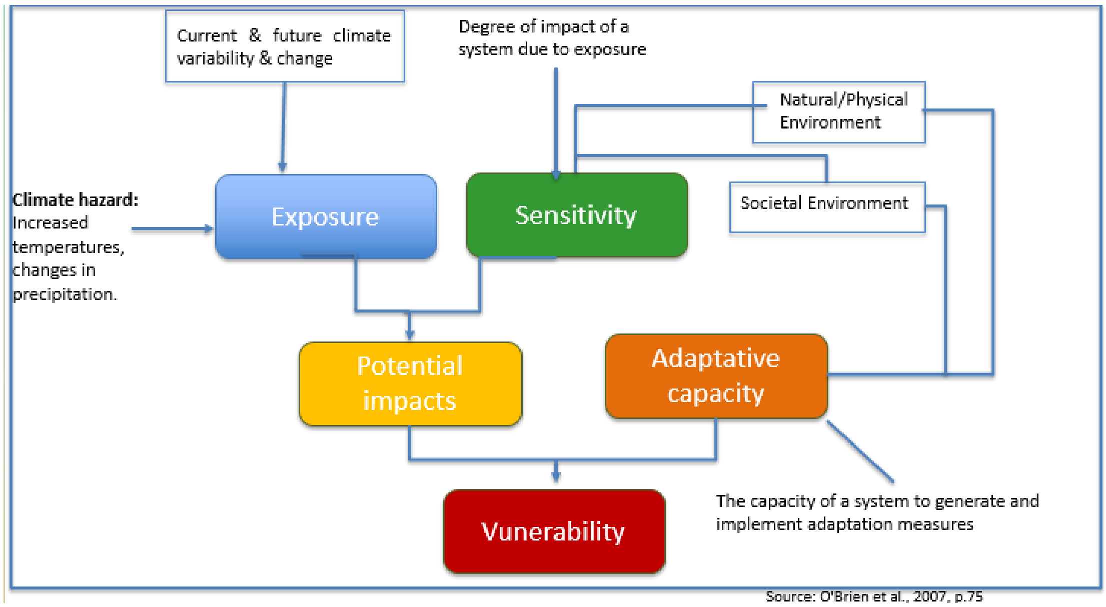


Figure 1 : Vulnerability and its Components According to the IPCC AR4 (IPCC, 2007)

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.

ii) **Document Review:**

The document review aimed to establish a baseline of knowledge on past and future climate trends, impacts, climate scenarios, vulnerability, and adaptation strategies in the Marine Protected Area

(MPA). Key documents, such as the Jokadu National Park Management Plan, materials on the Niumi Biosphere Reserve, and scientific articles, were examined. The documentation on Jokadu National Park is somewhat limited due to its recent establishment in 2019. Additionally, the review involved consulting websites from various national and international organizations working on issues related to biodiversity conservation, fisheries, and climate change, which contributed to this preliminary assessment.

iii) Data Collection:

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

Photo 1: Focus group with various stakeholders

- ***Quantitative 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 Jukadu Park

2.1. Location

Jokadu National Park (JNP) is an estuarine wetland area with a wooded intertidal zone, primarily composed of mangroves. This complex is a newly protected area, established in 2019. It covers an area of 19,293 hectares, mainly across three administrative districts: Upper Niumi, Jokadu, and Lower Baddibu. The natural reserve is located to the south along the Gambia River. To the west, it extends near the border with the Upper Niumi district up to the North Bank Road, which marks its northern boundary. The northern limit is situated south of the villages of Memmeh, Tambana, Karantaba, and the larger village of Kerewan, in the east site, the Bao Bolong Wetland Reserve borders the park (DPWM, 2023).

The park is surrounded by twenty-one villages: Jurunku, Chilla, Nyonfelleh, Malick Nana, Kasewa, Kaba Koto, Tambana, Chamen Sosseh, Memmeh, Kuntair, Karantaba, Bakang, Dasilami, Kerewan, Kinteh Kunda, Gunjur, Saba, Banni, Munyagen, Darufodayba, Suwareh Kunda, and

Jammeh Kunda. The Jokadu complex is an estuary with an intertidal forested wetland zone composed mainly of mangrove forests (60%), waterways (20%), mudflats (15%), and marshes (5%) (JNPMP, 2023).

Its functions and services include, among others: coastal stabilization, serving as a nursery area for fish and marine mammals, providing a resting area for migratory bird species, supporting river transport, agriculture, and recreation.

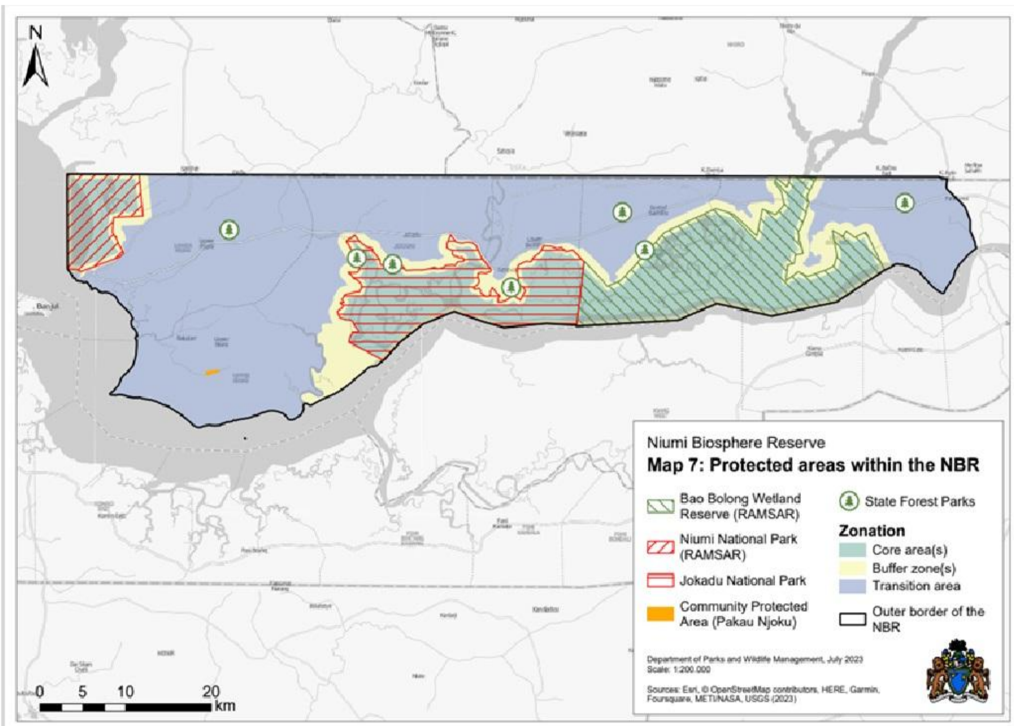


Figure 2 : Location of Jokadu Park

2.2.Biophysical Characteristics

2.2.1. Relief and Soil Types

The landscape of Jokadu National Park extends from agricultural lands in the north to mangroves in the south. The soil characteristics change accordingly: clayey in wetland areas, sandy-loam, and sandy further inland. Rice paddies and agricultural lands are found on the most fertile soils. Millet and peanuts are generally cultivated on the higher ridges of the farmland, while rice occupies the depressions flooded during the rainy season. There are vast areas of bare land within the park, where salt deposits are also found (JNPMP, 2023).

2.2.2. Water Resources

The most important rivers that flow through the Jokadu National Park are the Kerewan, Koular (Mini Minimum bolong), Memmeh, Tabirereh, and Tambana. These areas also benefit from a good water supply. Additionally, the presence of the Sami bolong located next to the park is noteworthy (DPWM, 2023). Several small streams contribute to the formation of around twenty densely vegetated islands and islets covered by mangroves.

2.2.3. Vegetation and Wildelife

- **Flora**

Jokadu National Park is home to the most pristine mangrove stand in the country. The mangrove forest dominates the bolongs within the park, particularly the Surunkku Bolong, Tambana Bolong, and Mini Minimum Bolong (DPWM, 2023). Five mangrove species are recorded here: *Rhizophora mangle*, *Rhizophora harisonii*, *Laguncularia racemosa*, *Conocarpus erectus,* and *Avicennia nitida*. This ecosystem provides essential services to fish as a breeding and nursery ground (NAWEC, 2022). *Rhizophora* species are particularly abundant in this area, and the height of the trees can exceed 15 meters. Shrub forests are found in areas where tidal flooding is limited, and salinity levels are high, often behind the fringe forest (JNPMP, 2023).

Other plant species found here include *Schoenoplectus spp.*, sea purslane (*Sesuvium portulacastrum*) thriving in coastal environments, grass (*Paspalum vaginatum*), cattail (*Typha australis*), reed (*Phragmites australis*), *Pterocarpus erinaceus*, *Terminalia avicenoides, Terminalia macroptera, Nauclea latifolia, Combretum glutinosum, Combretum micrantum, Cassia siberiana*, *Detarium senegalensis, Strophanthus sarmentosus, Lophira lanceolata,* and *Sclerocarya birrea* (also used for livestock feeding).

However, increasing poverty poses a significant threat, pushing local community members to overexploit natural resources for both subsistence and commercial purposes. This overexploitation includes, among other things, tree cutting, juvenile fish harvesting, and mangrove logging. Furthermore, land degradation in the main agricultural area near the park leads to reduced food production and growing food insecurity.

Additionally, climate change-related issues, such as saltwater intrusion, rice field flooding, and erratic rainfall, pose significant challenges for habitats and species diversity. Consequently, the widespread proliferation of invasive species is also a major problem.

- **Fauna**

The Jokadu region is distinguished by its rich fauna, including a notable diversity of mammals, birds, reptiles, and amphibians (NAWEC, 2022). In terms of mammals, species such as the bushbuck (*Tragelaphus scriptus*), common warthog (*Phacochoerus africanus*), and spotted hyena (*Crocuta crocuta*) are present, though their numbers are relatively low. Primates are still well-represented, particularly the green monkeys (*Cercopithecus sabaeus*), patas monkeys (*Erythrocebus patas*), Senegal bushbabies (*Galago senegalensis*), Guinea baboons (*Papio papio*), and western red colobus monkeys (*Piliocolobus badius temmincki*) (JNPMP, 2023). The African manatee (*Trichechus senegalensis*), African clawless otter (*Aonyx capensis*), and leopard (*Panthera pardus*) are also observed in the area (JNPMP, 2023).

The current list of bird species in Jokadu National Park includes about 200 species from 63 families (DPWM, 2023). During the dry season, there is an increase in oystercatchers (*Haematopus ostralegus*) among gull and tern populations, particularly the lesser black-backed gull (*Larus fuscus*). Numerous species of herons and egrets feed on stranded fish during water recessions. Concerning fish, at least eight families are recorded in the park (JNPMP, 2023). The most abundant species are *Tilapia spp.*, followed closely by mullets (*Mugil spp.*). The juveniles of African giant threadfins (*Polydactylus quadrifolius*), shads, red snappers, grunters (*Sumpat*), and *Ethmalosa fimbriata* are also present in large numbers. For reptiles, Nile crocodiles (*Crocodylus niloticus*) and Nile monitors (*Varanus niloticus*) are commonly found, with large specimens regularly founded.

2.3. Socio-economic Characteristics

Jokadu National Park (JNP) offers a wide range of aesthetic, economic, cultural, and religious resources. The communities surrounding the park are mostly composed of farmers and fishers, relying heavily on natural resources for their livelihoods (JNPMP, 2023). The wetlands within the park play a critical role in sustaining local economies by providing resources for rice cultivation during the rainy season, vegetable gardening in the dry season, grazing for livestock, salt harvesting, fishing, and shellfish farming.

2.3.1. Agriculture

Agriculture is a central pillar of the economy in the areas surrounding Jukadu Park, engaging a large portion of the active population. The local communities cultivate various crops, such as millet, cassava, watermelon, rice, and peanuts. Among these, peanuts, cassava, and watermelon are the main cash crops, although other crops like millet are also sold based on farmers' preferences. However, rice-growing areas face challenges such as saltwater intrusion. Besides food crops, farmers also engage in arboriculture, particularly cashew planting. Vegetable gardening is mainly practiced by women during the dry season. The harvested produce is primarily sold locally or through intermediaries, generating modest income, while the remainder is consumed by households, thus enhancing nutritional intake. The Department of Parks and Wildlife Management has established five support programs for female farmers, also promoting climate-smart agricultural practices (JNPMP, 2023).

2.3.2. Exploitation of Forest Products

Jukadu Park has significant forest resources, including extensive mangrove stands along the waterways and species such as Detarium senegalensis, the African baobab (*Adansonia digitata*), winter thorn (*Acacia albida*), and Saba senegalensis, among others. The exploitation of forest products generates substantial income for the communities living around the park. Various materials are also harvested from the wetland environment, such as mangrove poles for roofing and grasses for thatching and fencing.

2.3.3. Fishing

Fishing activities in Jokadu National Park are primarily at the subsistence level within the National Park (DPWM, 2023). Some villagers near the bolongs (tidal creeks) engage in part-time gillnet fishing, and fish traps are also used in the bolongs at the end of the rainy season when the waters recede. The catches are typically consumed at home or exchanged within the village for other goods or services. However, this situation has changed due to population pressure and other factors, leading to the commercialization of fishing despite its illegality. Additionally, cross-border pressure has encouraged illegal fishing practices aimed at quickly obtaining abundant catches at the expense of the local population.

2.3.4. Livestock grazing

The park supports a large population of sheep, cattle, and goats that graze in its various areas. Although the impact of livestock on regeneration and pastures is not always obvious, grazing and trampling clearly damage young plants. It is therefore crucial to determine an appropriate grazing density for each ecological zone of the park and regulate grazing to ensure sustainability. Additionally, creating permanent cattle paths and watering points would be essential.

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 main factors that characterize a climate. Their variations over time lead to changes in the natural environment as a whole, such as sea-level rise, increased frequency of droughts and heatwaves, and more frequent flooding. Therefore, it is crucial to model their evolution and to observe the already measurable trends. The data used in this analysis are sourced from the NASA/POWER platform (https://power.larc.nasa.gov/).

3.1. Temperature

Analysis of the average annual temperatures shows that they have increased by 1.0°C since 1981. Observations since 1981 indicate that the minimum temperatures in Barra have steadily risen at a rate of 0.4 to 0.67°C per decade. From 1998 to 2022, minimum temperatures have generally experienced an upward trend.

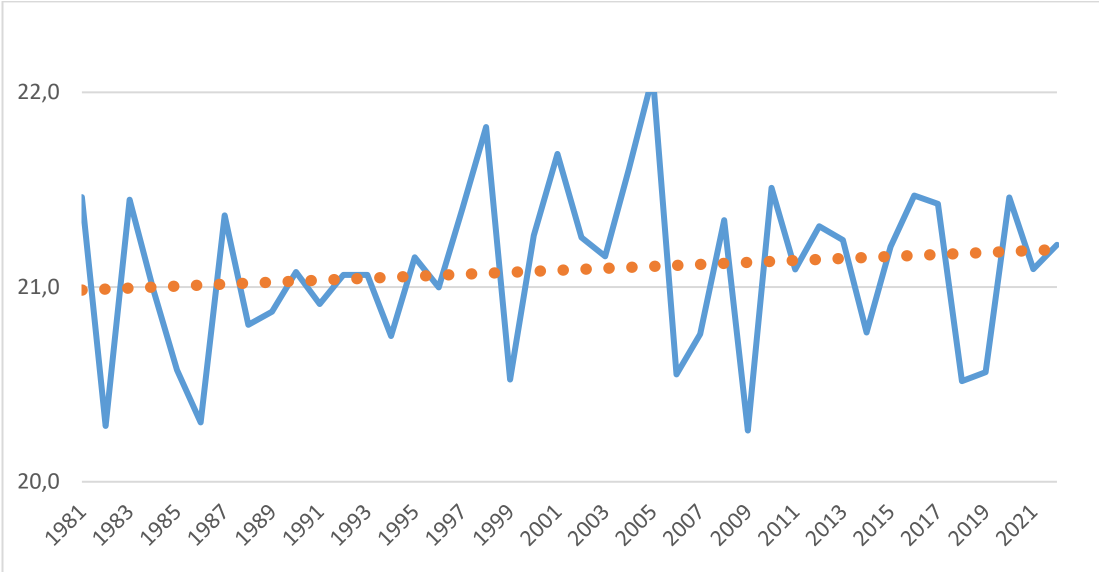


Figure 3: Changes in Maximum Temperatures from 1981 to 2022

This temperature variation is also observed in the oceans (0.4°C). Regarding maximum temperatures, the years 1983, 1998, 2001, and 2014 were the hottest. The year 2010 recorded the lowest maximum temperature (30.1°C). As for ocean temperatures, 2005 remains the warmest year with a temperature of 23.2°C, while 2018 recorded the lowest temperature in the series (21.7°C).

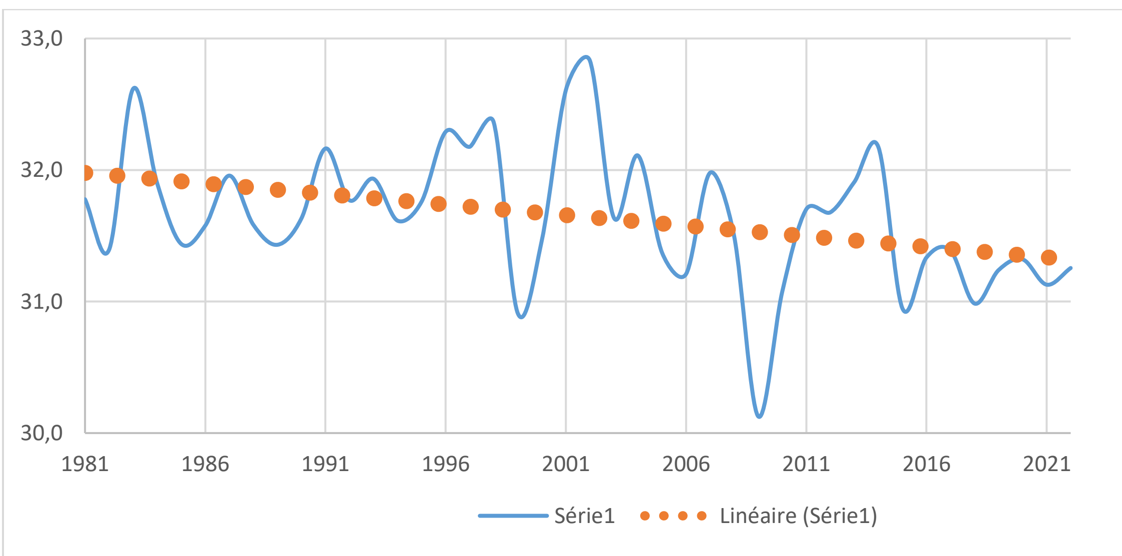


Figure 4: Changes in Minimum Temperatures from 1981 to 2022

3.2. Rainfall

The rainfall at the Barra station is between the isohyets of 900 and 1000 mm. Linear trends indicate inter-annual variability at the Barra station during this period, with this variability being more noticeable on a five-year scale.

- From 1981 to 1983, there was a general rainfall deficit compared to the series average (764.50 mm).
- From 1985 to 1989, observations showed a phase of above-average rainfall.
- From 1990 to 2004, there were 14 years with below-average rainfall and one year with above-average rainfall (1999), which recorded over 900 mm of precipitation. The year 2002 was particularly dry, with a total of 311.13 mm.
- From 2005 to 2022, there was an alternation between years of above-average and below-average rainfall, with a predominance of years with above-average rainfall (9 years).
- It should also be noted that in 2020, the Barra station received 1,402.71 mm of rainfall, making it the year with the highest above-average rainfall.

3.3. Future Climate trend

Projections for the future indicate an overall increase in temperatures and a general decrease in rainfall. The temperature rise is expected to be more pronounced in the inland eastern regions compared to the western areas closer to the sea. Average temperatures are projected to range between 2.16°C in the east and 1.72°C in the west, with maximum temperatures increasing by 2.12°C in the east and 1.69°C in the west. Minimum temperatures are expected to rise by 2.18°C in the east and 1.79°C in the west.

Figure 5 illustrates the variation in average monthly temperatures over three periods: the past (1959-1978), the recent past (2000-2019), and the future (2041-2060). The present period (2000-2019) is compared with two periods of the same length (20 years) that are 40 years apart. It should be noted that the temperature range is much narrower in the west than in the east, due to the moderating influence of the sea. The heatwave season is expected to occur between April and May in the east and in October in the west. Temperature increases are projected for every month of the year, with a nearly constant rise throughout, indicating that warming is accelerating.

Minimum temperatures are expected to occur between January and December. The analysis suggests that higher temperatures will be experienced across all seasons of the year.

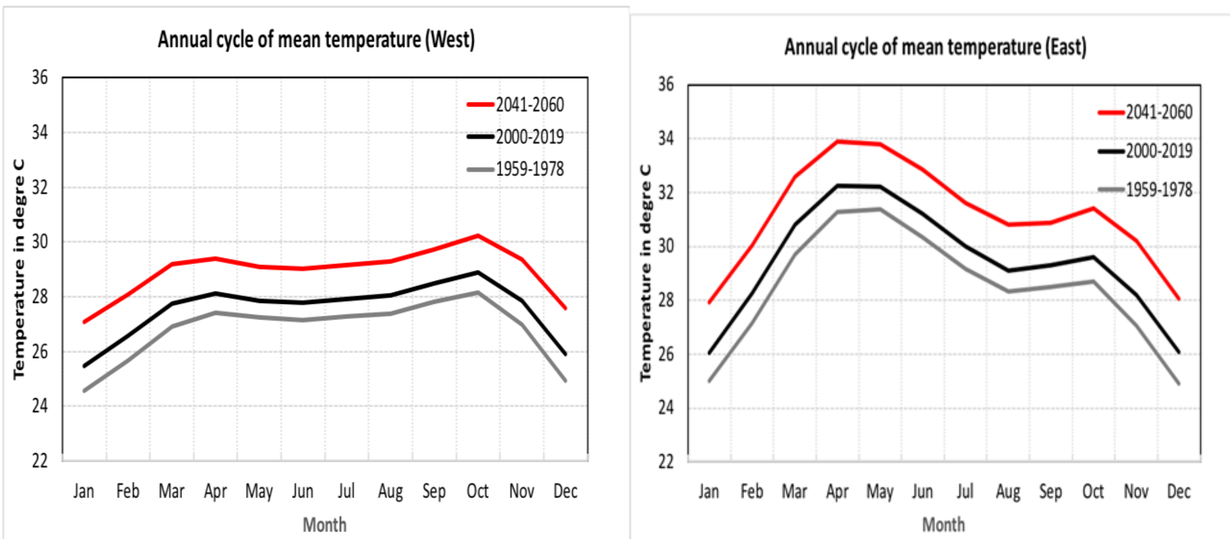


Figure 5 : Seasonal variation in temperature in the past (1959-1978), present (2000-2019), and future (2041-2060) for RCP8.5 scenarios in the West (left) and East (right) of The Gambia.

The results presented in Figure 5 should not be interpreted as precise, deterministic climate forecasts for specific geographic locations; rather, they should be viewed as climate projections with inherent uncertainties in both time and space. Each projection line represents a certain probability of future temperature variation, and the bold curve shows the average of all models (Multi-Model Ensemble, MME).

While the temporal variation in temperature does show some uncertainty, it remains consistent across scenarios: the lowest scenario (RCP2.6) predicts a slower increase, followed by the intermediate scenario (RCP4.5) and the most pessimistic scenario (RCP8.5).

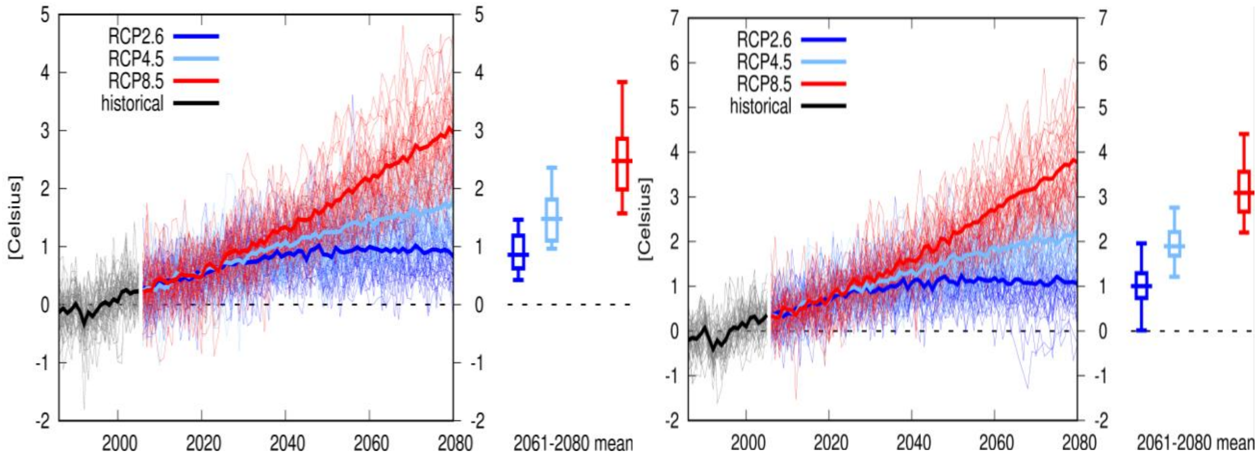


Figure 6: Overall Trends in Annual Average Temperatures According to Three IPCC Scenarios (RCPs 2.6, 4.5, and 8.5) in the Western (left) and Eastern (right) Zones of The Gambia.

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 when the temperature exceeds the 90th percentile, there is a significant increase projected for the future (Fig. 7). This percentage rises from 15% in the past (1981-2010) to 60% in the future (2041-2060) across both zones. As for the number of days when the maximum temperature exceeds 25°C, there is an increase from 20 days in the past to 150 days in the future, on average, per year. This finding is important because it suggests that low temperatures, which currently affect certain types of crops, are expected to decrease in the future.

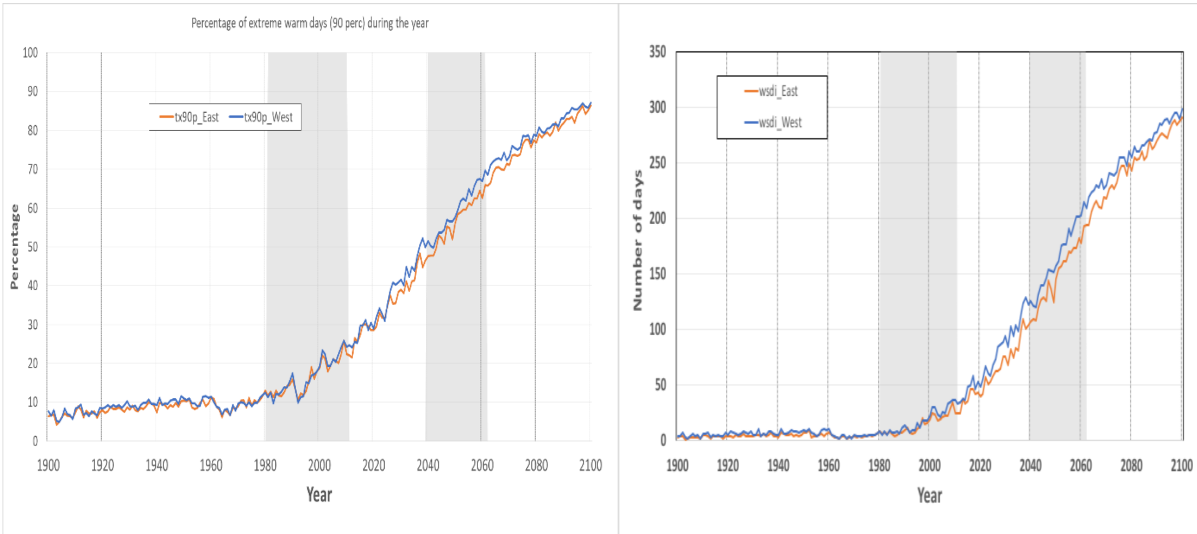
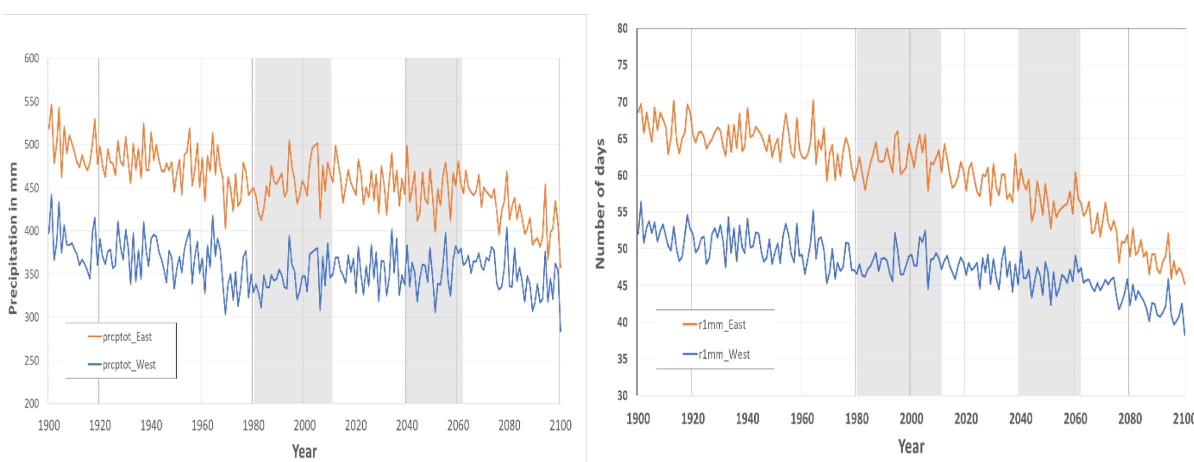


Figure 7: Frequency of hot days (in percentage) exceeding the 90th percentile (top) and the number of hot days exceeding 25°C (bottom) in the Western zone (blue) and Eastern zone (red) of The Gambia, with the reference periods (1981-2010) and future periods (2040-2061) highlighted (shaded in gray).

Figure7 shows the variation over time of several rainfall indices. A slight decrease in annual rainfall totals is projected for the future, but with greater inter-annual variability. The number of rainy days per year is expected to decrease significantly in the future, while extreme weather events are projected to increase. This may seem paradoxical but reflects one of the aspects of climate change: the increased occurrence of extreme events. Although rainfall will become less frequent, it will occur with greater intensity. Even if the total amount of rain decreases over the year, its intensity will become stronger. Thus, we can expect less frequent but much more intense rainfall.



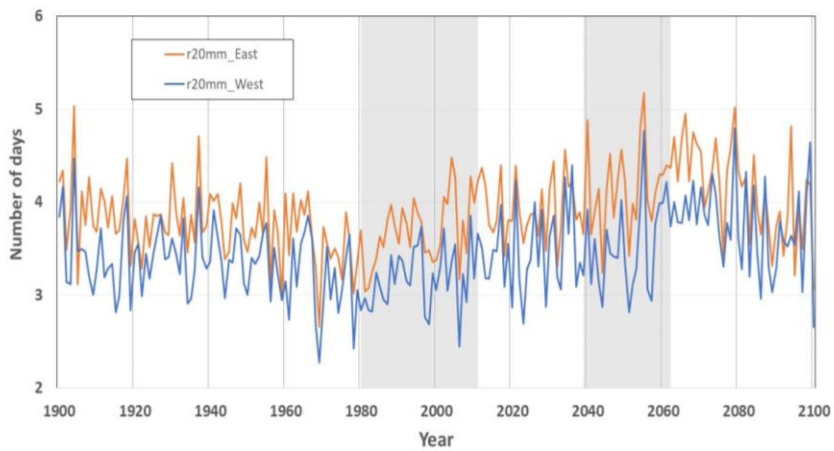


Figure 8: Variation in Annual Rainfall Totals (top), Number of Rainy Days (middle), and Number of Extreme Rainfall Days Over 20 mm (bottom) in the Western Zone (blue) and Eastern Zone (red) of The Gambia, with the reference periods (1981-2010) and future periods (2040-2061) highlighted.

To characterize the changes caused by climate change, we considered a future period (2040-2060) and compared it to a reference period (1981-2010). It should be noted that there is a consistent temperature increase throughout all months of the year. The rate of warming will be faster in the future than it has been in the past. The eastern part of The Gambia will experience a greater reduction in rainfall and a more pronounced rise in temperatures compared to the western part. Rainfall will become less frequent, with a decrease in annual totals but higher intensities.

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

. The vulnerability analysis framework adopted in this study is based on the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC AR4). According to this framework, the vulnerability of the Marine Protected Area (MPA) to climate change will depend on a set of factors, including the sensitivity of the site (i.e., the extent of the effect resulting from a certain level of exposure to climate change), the level of exposure (of a species, habitat, or ecosystem to significant climate variations), and its adaptive capacity (Otero, et al., 2013). Thus, vulnerability is location-specific and will depend on the ecological and socio-economic characteristics of a particular species or community.

This chapter will focus on identifying the nature and scale of the predominant hazards and examining their effects on resources (habitats, ecosystems, and species), economic activities, and the communities' dependent on the Jokadu MPA.

4.1. Vulnerability Analysis of the Natural Ecosystems of the MPA

4.1.1. Components of the Park

The natural resources of the Jokadu National Park (JNP) mainly consist of mangrove forests, whose conservation status remains optimal. The MPA is located in an estuarine zone where mangroves cover approximately 60% of the total area. It harbors particularly rich wildlife and flora and represents the most important natural resource of the Park, playing a vital role in the ecological balance and livelihoods of the local population. Furthermore, the terrestrial part of the Park features vegetation formations such as savannas and woodlands, whose exploitation serves as a significant source of income for local communities.

Additionally, the presence of numerous watercourses (Jurunku Bolon, Bang Bolon, Miniminyang Bolon, and Wonkofala Bolon, along with the Gambia River) and proximity to the ocean foster a significant marine biodiversity. The marine resources, which are the second most important resource of the Park (Table 1), consist of various species of fish, mollusks, and crustaceans, supporting mainly subsistence fishing but also commercial purposes.

Water resources (groundwater and rainfall) and agricultural land rank third and fourth in terms of importance. This is because agriculture is the main activity of the localities near the Park.

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…)	Agriculture equipment	Local farming knowledge and skills	Income from farming activities	Site management community (SMC)
2nd	Marine resources	Homes	Local fishing knowledge and skills	Income from fishing activities	Community-based organization (CBO)
3rd	Water resources (aquifer- rainwater)	Fishing equipment	Presence of extension service	Income from forest activities	Non-governmental organization (NGO)
4th	Agriculture land (rice field land, upland)	Roads	Local forest knowledge and skills	Village banking (*Ossoussu, Jacob*)	Doners

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

By engaging in subsistence activities such as fishing, forest product harvesting, and agriculture, the communities have developed skills and techniques that are highly valued in the practice of these activities. These traditional knowledge systems, combined with support from state services, constitute the most important human resources for the communities living around the Park. They enable the populations to ensure their survival and serve as a lever for the sustainable use of natural resources. The primary financial resources of the communities surrounding the Park are derived from these various activities. Agriculture generates the highest income, followed by fishing and forest product harvesting. Additionally, the existence of village banks allows the populations to access funds to meet their needs and finance their activities.

4.1.2. Climate Hazards and Their Impacts

The park is affected by various climate hazards. Among these, strong winds, coastal erosion, marine flooding, and rainfall variability are the most influential. These three hazards have significant impacts (Table 2) on coastal and marine ecosystems, as well as on the services they provide and the communities that depend on them.

This translation incorporates appropriate technical terms such as "traditional knowledge systems," "subsistence activities," and "climate hazards," which are commonly used in environmental and socio-economic studies.

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

Hasards	level of influence 0 from 3	Comments
Windstorm	1,7	moderate influence
Coastal erosion /Flooding	1,6	moderate influence
Précipitation variability	1,6	moderate influence

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

The vulnerability assessment matrix evaluating the degree of influence of climate hazards on natural resources and the economic assets derived from their exploitation (Table 3) reveals significantly high scores in response to climate stressors. Forest resources, including mangroves and terrestrial forests, are the most impacted, with maximum scores (3/3) for all hazards. Marine resources follow closely with an average score of 2.7/3, particularly affected by strong winds and rainfall variability. Water resources and agricultural land each register scores of 2.3/3. Consequently, economic activities reliant on these resources are highly vulnerable to the effects of climate hazards, leading to resource scarcity and the degradation of natural habitats.

Table 3 : Level of Influence of Climate Hazards on Natural Resources and Dependent Activities in Jokadu National Park

Resources \ Hazard	Hazard 1 Windstorm	Hazard 2 Coastal erosion/Flooding	Hazard 3 Precipitation variability	Score 1 (resource)
Natural ressources				
Forest	3	3	3	9
Marine resources	3	2	3	8
Water resources	1	3	3	7
Agriculture land	2	3	2	7
Financial ressources				
Income from farming activities	3	2	3	8
Income from fishing activities	3	3	2	8
Income from Forest activities	3	2	3	8
Village banking	1	0	2	3
Score 2 (per hazard)	19	18	21	

0= no influence; 1= minimal influence; 2= moderate influence; 3= strong influence

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

Moreover, rainfall variability is the hazard that generates the most negative impacts on the Park's resources, closely followed by strong winds, erosion, and coastal flooding. In The Gambia, as in many other regions, climate change is influencing rainfall patterns, resulting in more irregular precipitation from one year to the next, and extreme weather events such as floods or prolonged droughts. Rainfall deficits notably reduce freshwater inputs into estuaries and adjacent coastal areas, thereby affecting the quantity and quality of runoff water flowing into coastal zones and marine ecosystems. This can impact salinity, turbidity, and the availability of nutrients in coastal waters, which in turn affects marine biodiversity.

Strong winds are primarily observed during the rainy season. Tropical storms noted during this period can bring strong winds and heavy rains along the coast and inland, threatening resources, activities, and coastal infrastructure. These storms, resulting from extreme weather events, can also cause coastal flooding that impacts key areas along the coastline. This issue particularly affects coastal regions like Barra and surrounding areas, as well as other communities along The Gambia's Atlantic coast. The frequency and intensity of marine flooding have significantly increased in recent years and are closely tied to climate change. Likewise, coastal habitats are threatened by coastal erosion, with the coastline retreating at a rate of more than one meter per year.

In addition to these hazards, communities in the Park face other environmental issues such as bushfires, plastic pollution, illegal sand mining, and invasive species like Typha.

4.2.Assessment of Climate Change Impacts in the Jokadu Park

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

Due to its geographic location, the Jokadu Park is particularly sensitive to the effects of climate change. Comprising estuarine ecosystems and situated near the Atlantic Ocean, the park is highly vulnerable to the impacts of sea level rise, ocean acidification, and increasing sea surface temperatures (projected to rise by +2 to +4°C by 2100). In The Gambia, projections estimate a sea level rise of 0.13 m by 2025, 0.35 m by 2050, 0.72 m by 2075, and 1.23 m by 2100 (Brown et al., 2011). Additionally, there is an increase in the frequency and intensity of storm events and heavy swells, as well as other marine phenomena and anthropogenic pressures. These factors have detrimental consequences on marine and coastal biodiversity, ecosystems, and the communities established along the coast. In Jokadu Park, these phenomena manifest as follows:

- **Disruption and destruction of marine and coastal habitats**

Marine hazards such as sea level rise and storms cause flooding in low-lying areas, disrupting coastal habitats like mangroves and estuaries that support significant biodiversity and serve as nurseries for many marine species. Flooding also affects animal populations that rely on coastal habitats for food, breeding, or shelter. Additionally, the physical force of storm-driven waves and the accumulation of harmful saltwater contribute to the destruction of coastal habitats, including plant species sensitive to salinity. In Jokadu Park, human pressures, such as illegal logging for construction or fuel, are major factors contributing to the degradation of mangrove stands.

- **Flooding of low-lying areas**

Homes, infrastructure, and rice fields are threatened by recurrent flooding during storms and the rainy season, which negatively impacts the quality of life for populations residing in coastal areas. This phenomen particularly affects the village of Meme and other localities such as Dassilame, Niofela, Diouroukou, and Bakan. Furthermore, the degradation of mangrove forests, which act as protective buffer zones for the inland areas, accelerates coastal erosion.

- **Increased salinization**

The villages of Dassilame, Bakan, Karantaba, Tambana, Niofela, and Diouroukou are particularly affected by the salinization of agricultural land and groundwater. The intrusion of saltwater into aquifers compromises the availability of freshwater for the population and disrupts economic activities (notably agriculture and livestock farming). Agricultural lands, particularly rice fields, are increasingly affected by salinization, making farming difficult or even impossible in some areas.

- **Water erosion (gullying)**

During the rainy season, surface runoff accelerates the process of soil erosion, causing significant sediment movement, loss of fertile land and landscape degradation. Rainwater runoff on steep slopes causes the formation of ravines which gradually deepen and constitute a risk for populations and their activities.

- **Decline in resource availability**

The main hazards observed in the park (storms, marine flooding, decreased rainfall) contribute to the reduction of fish populations and other marine and estuarine species. In addition to habitat degradation, storms disrupt fish migration patterns, pushing them to deeper waters far from the usual coastal fishing areas, which reduces fish catches. Rainfall deficits affect the availability of fish and other marine resources by reducing habitats, decreasing oxygen levels, and increasing water salinity. Indeed, the lowering of water levels leads to a higher concentration of fish in smaller areas, causing increased competition for food and space. Moreover, a reduction in water volume can decrease the concentration of dissolved oxygen, which is critical for the survival of fish and other aquatic organisms.

4.2.2. The Impacts of Climate Change on the Terrestrial Ecosystems of the Park

The estuarine zone, bordered by mangrove areas, opens into woodlands and savannas, enhancing the diversity of ecosystems and species in the terrestrial part of the Park. These resources are undergoing severe degradation, intensified by the effects of climate change, which alter environmental conditions such as temperature, precipitation, wind intensity, water availability, and increased salinization. These factors, combined with the overexploitation of natural resources, have a direct impact on the Park's biodiversity. The most exploited tree species (*Pterocarpus erinaceus*, *Terminalia avicennioides, Nauclea latifolia, etc.)* are in sharp decline and some are on the verge of extinction. Additionally, deteriorating climatic conditions are reducing vital water resources (ponds and streams) essential for the survival of wildlife, including the green turtle.

4.2.3. The Impacts on the Socio-economic Activities in the Park

- **Impacts on the Fishing Sector**

The destruction of marine and coastal habitats due to climate-related hazards severely impacts the availability of key species targeted by local fishing communities. These habitats are critical for juvenile species development. Furthermore, storms disrupt fishing activities, exposing fishermen to risks such as accidents and equipment loss. Fishing gear and coastal infrastructure are also highly vulnerable to damage. Significant economic losses due to reduced fish catches lead to financial difficulties and increased food insecurity, particularly since much of the catch is destined for subsistence.

- **Impacts on the Agricultural Sector**

The combined effects of various climate hazards—such as rainfall variability, saline intrusion, and storms—have serious consequences for agricultural activities and their socio-economic returns. Fluctuations in rainfall patterns, leading to droughts or floods, severely affect crop yields. Similarly, delayed or premature rains disrupt agricultural calendars. Strong winds cause physical damage to crops, resulting in flower loss and consequently significant reductions in expected yields for the season. Moreover, increased soil salinization particularly affects rice paddies, which are prone to saline water intrusion, leading to the loss of arable land. Rudimentary anti-salt dikes, erected to prevent saline water incursion, are often destroyed by coastal erosion. Salinization of groundwater limits the potential for horticulture, which is an important income-generating activity, particularly for women. The decline in agricultural production threatens local food security and drastically reduces incomes derived from farming activities.

Table 4 : Summary of the Consequences and Impacts of Climate Hazards

Hazards	**Impacts and consequences**

WINDSTORM	House destruction ; Destroy tree ; Fish stuck ; Low income; Habitat destruction ; Shifting of fish stock, Stopped of fishing activities, food insecurity, accident
FLOODING	Homed destruction; destruction of naturals habitats; gullying; salt intrusion; destruction of digue (ricefield defence)
PRECIPITATION VARIABILITY	Salt intrusion; Decrease of agriculture production; Income decrease; Shortage of food, drop of biodiversity

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

4.3.Vulnerability assessment

The IPCC AR4 identifies three key components of ecosystem vulnerability to climate change: sensitivity, exposure, and adaptive capacity. The analysis conducted assessed the exposure and sensitivity of key species in the Park as well as socio-economic components, while also evaluating the resources available within the Park to mitigate the negative impacts of climate change.

4.3.1. Exposure

Exposure refers to the extent to which an element is likely to be affected by the effects of climate change. It is determined by a complex combination of geographical, environmental, and socio-economic factors. Among these factors, the nature of the hazard, the type of resource, and its geographical location greatly influence exposure. In Jokadu Park, it appears that resources are particularly exposed to strong winds, with an average exposure index of 0.67 (Table 4).

This translation uses technical terms like "rainfall variability," "runoff water," "salinity," "turbidity," "marine biodiversity," "exposure index," and "adaptive capacity," which are commonly employed in climate change assessments and environmental management.

Table 5 : Exposure Indices

Hazards	Exposure index	Comments
Windstorm	0,67	Hight exposure
Coastal erosion/flooding	0,48	Mederate exposure
Précipitation variability	0,43	Mederate exposure

The resources are moderately exposed to coastal erosion, coastal flooding, and rainfall variability. Furthermore, the analysis of the level of exposure of the resources shows that forests, agricultural areas, and dwellings are the most highly exposed, with exposure levels ranging from 75% to 100% across the various hazards.

4.3.2. Sensitivity

The sensitivity of the key resource components of the Park, i.e., their propensity to be affected by climate hazards, has been evaluated. This sensitivity largely depends on the specific vulnerability of the species or elements present (their specific physical and biological characteristics) and their built-in adaptive mechanisms that allow them to protect themselves from the stimulus. The sensitivity levels of the resources to the three major climate hazards are presented in the figure below.

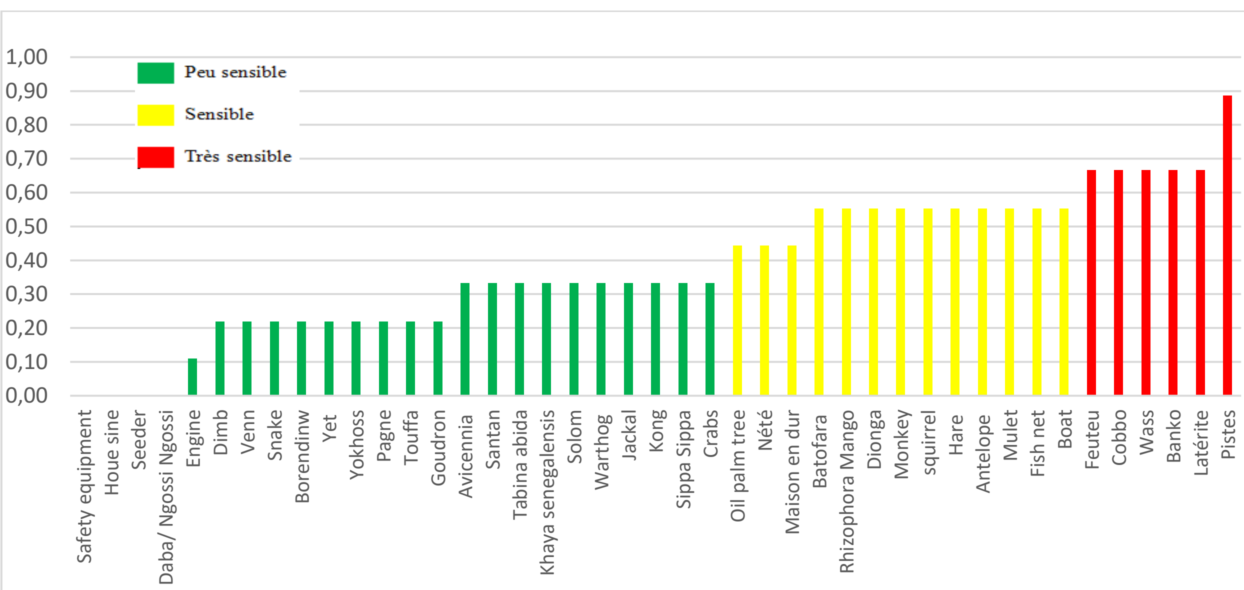


Figure 9: Graphical Representation of Resource Sensitivity Indices

The analysis shows that dirt roads and houses built with straw or Banko are the most sensitive to hazards. Pelagic species (such as wass, cobbo, and feuteu) are also highly sensitive because they live in waters close to the surface.

4.3.3. Adaptation Capacity Analysis

The adaptive capacity of protected areas to cope with climate change is based on ecological, technological, societal, and political factors. The analysis of the Park's adaptation capacity to climate change focused on the adaptive management of its impacts, leveraging the use of the Park's key resources. Both the Park managers and the local populations implement strategies to reduce their vulnerability to climate hazards. Figure 10 shows that social resources, such as financial partners and NGOs involved in the management and conservation of the Park, as well as the Park's management committee (SMC), play a crucial role in implementing strategies to mitigate the impacts of hazards.

Forest resources (mangroves and terrestrial forests) are also vital in the development of responses, as they are used for reforestation, windbreak establishment, and the construction of dikes.

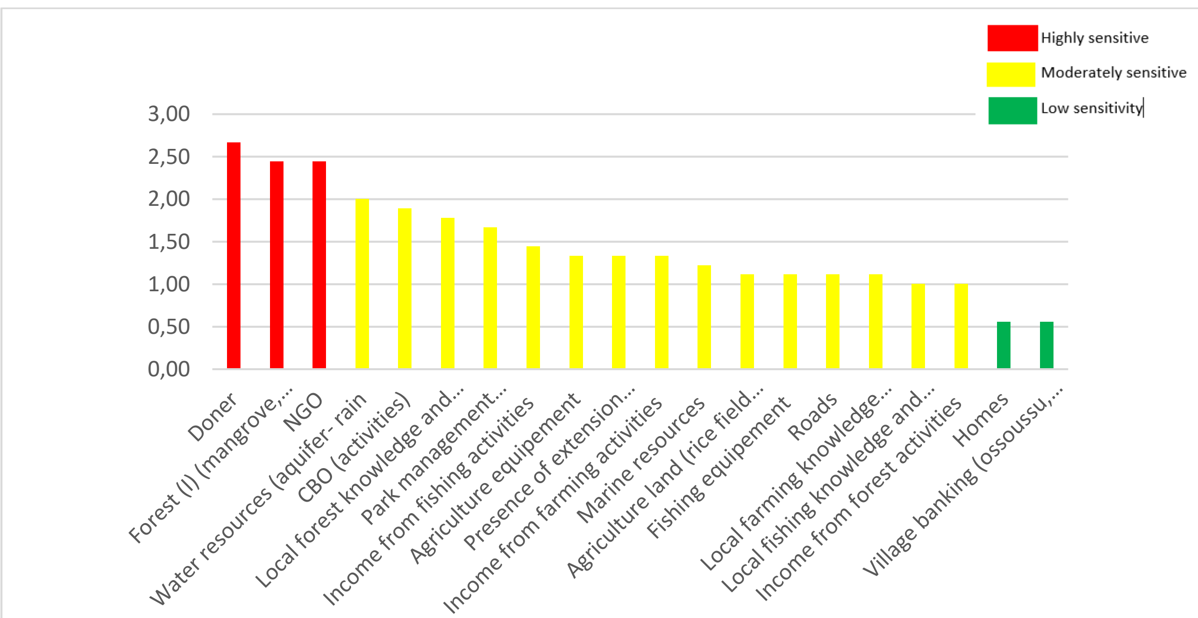


Figure 10: Ranking of the Most Important Resources for the Strategy Implementation

4.3.4. Vulnerability assessment

The vulnerability assessment represents a critical step in guiding the design and implementation of adaptation measures within protected areas such as the Jukado Marine Protected Area (MPA). The main climate-related hazards identified in this area include rainfall variability, rising sea surface temperatures, intense swells and strong winds, and sea-level rise. These phenomena directly impact key ecosystems—namely wetlands, seagrass beds, sandbanks, and mudflats, as well as local communities whose livelihoods are largely dependent on fisheries resources.

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 using the following scale:

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

Tableau : Index of vulnerability

Hazard	Vulnerability Index	Interpretation
windstorm	0,27	Low Vulnerability
Coastal erosion/flooding	0,42	Moderate Vulnerability
Précipitation variability	0,76	High Vulnerability

- **Vulnerability of the MPA to Windstorm**

Windstorms often result in the temporary suspension of community activities, leading to reduced incomes. Over time, they contribute to the destruction of homes and a rise in accidents. The calculated vulnerability index for windstorms is 0.27, which corresponds to low vulnerability.

- **Vulnerability of the MPA to coastal erosion/flooding**

Recurrent flooding, particularly during storms and the rainy season, threatens homes, infrastructure, and rice fields, significantly undermining the quality of life in coastal communities. The vulnerability index for this hazard is 0.42, indicating moderate vulnerability.

- **Vulnerability of the MPA to variability of precipitation**

Rainfall variability leads to saltwater intrusion, soil salinization, declining agricultural productivity, and, ultimately, reduced income for local populations. In Jukado, this hazard exhibits a high vulnerability index of 0.76, denoting high vulnerability.

The aggregation of these individual indices yields a composite vulnerability index of 0.48, suggesting that the overall vulnerability of the Jukado MPA is moderate. However, the pronounced exposure to certain hazards, particularly rainfall variability, highlights the urgent need for targeted adaptation strategies to safeguard ecosystems and livelihoods.

4.4. Population Responses to Climate Impacts

4..4.1. Current Strategies

The communities living around the Park are highly affected by the negative impacts of climate hazards, as their livelihoods depend on natural resources. To cope with these challenges, they implement strategies to mitigate or limit the impacts and strengthen their resilience (see Table 6). Most of these strategies are considered effective, as they significantly reduce negative effects; however, their sustainability remains a concern.

Table 6 : Adaptation Strategies Developed to Address Climate Change

Hazards	**Current strategies**	**Assess the functionality of the current strategies**	
		efficiency	**sustainability**
Windstorm	• Assistance from state authorities to disaster victims (Request management) • Community solidarity • Tree planting • Inforcement of law • Sensitization • Alternative activities	• Yes • Yes • Yes • Yes • Yes	• No • No • Yes • Yes • Yes
Coastal erosion/flooding	• Local diKe • Tree planting	• Yes • Yes	• No • Yes

Precipitation variability	• Alternative activities (garden, salt farming, poultry farming ...) • Trade (Cashew, monkey bread) • Seasonal migration (to Ziguinchor or Guinea for seasonal work) • Local dike	• Yes • Yes • No	• Yes • No • No

- **Strategies Developed in Response to Storms**

Storms, often unpredictable and highly destructive, severely impact resources, communities, and their assets. In the event of a disaster, local populations contact state authorities, who, through dedicated institutions and agencies, provide relief to the affected populations. The damage caused frequently sparks solidarity within communities, with people supporting those most impacted. Additionally, to compensate for the income losses caused by disruptions to economic activities (fishing, agriculture, and forestry), communities develop parallel activities to diversify their income sources. Reforestation efforts (mangroves and terrestrial species) are also initiated by park managers, often supported by NGOs or other donors, to restore ecosystems and reestablish their ecological functions (protection, local climate regulation, among others). Administrative and local authorities monitor and raise awareness among communities about the enforcement of laws and regulations, such as avoiding settlements in high-risk areas (prone to flooding) to reduce potential damage.

- **Strategies Developed in Response to Flooding**

Faced with floods, populations generally implement makeshift structures, such as dikes made with improvised materials (sandbags, rubble, debris, etc.), to limit the impact of waves and protect habitats and communities. agricultural areas. However, these dikes only offer temporary protection because they degrade quickly and require constant maintenance. In addition to the dykes, the restoration of mangroves through replanting, which serves as a natural barrier against erosion, is also underway.

- **Strategies Developed in Response to Climate Variability**

Rainfall irregularity has pronounced effects on community incomes due to their dependence on climatic conditions for subsistence activities. To improve their incomes, populations develop alternative activities that are less dependent on rainfall. They engage in micro-gardening (mainly women), salt extraction, and poultry farming. The commercialization of non-timber forest products (cashew nuts, baobab fruit, honey) also provides them with additional income. Faced with acute problems, some opt for seasonal migration to destinations such as Ziguinchor or even Guinea-Bissau in search of better economic opportunities.

4.4.2. Optional Strategies

During the participatory diagnostic session, local populations proposed optional strategies to strengthen their resilience to climate hazards. The analysis of the implementation of these options takes into account available resources, as well as limiting factors and constraints that may hinder their realization. The identified options are relatively limited and primarily consist of the strict enforcement of laws and regulations to minimize risks and reduce the impacts of hazards, such as adherence to construction standards and the construction of coastal dikes made with durable materials like concrete or riprap. However, the lack of financial resources remains a significant constraint to their implementation, despite clear political will.

These strategies could be reinforced by several additional measures, including:

- **Meteorological monitoring and the establishment of an early warning system**, which would allow communities to anticipate storms and receive timely alerts, enabling them to prepare adequately. Enhanced weather forecasting could also improve the planning, safety, and oversight of agricultural and fishing activities. Additionally, emergency evacuation plans for local populations in the event of marine flooding could save lives and minimize property damage.
- **Zoning and adaptive park management**, which would involve identifying zones within the protected area that are more or less vulnerable to storms and flooding, and adapting regulations and permitted activities according to the vulnerability of each zone.

- **Drought-resistant seeds** by promoting research and development of drought-tolerant crop varieties tailored to local climatic conditions, ensuring stable yields despite fluctuations in rainfall.

- **Adoption of sustainable and climate-resilient agricultural practices**, such as agro ecology, efficient irrigation, and crop diversification, to mitigate the impacts of droughts, floods, or seasonal changes on agricultural productivity.
- **Awareness-raising and capacity-building** initiatives for local populations and stakeholders, aimed at educating them about major climate hazards and the preventive measures they can adopt to reduce both material and human losses. This would also include training farmers and fishers on climate risks and adaptive strategies that could minimize disruptions to their activities and mitigate economic losses.

V. CLIMATE CHANGE ADAPTATION PLAN FOR JOKADU NATIONAL PARK

The adaptation plan aims to provide a strategic framework to effectively respond to the challenges posed by climate change in the Jokadu 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 Jokadu 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: «*By 2035, Jukadu Park will be a model of climate change adaptation, where resilient ecosystems and sustainable resource management safeguard biodiversity and enhance the well-being of local communities for future generations* ».

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 be integrated 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 Jokadu 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.

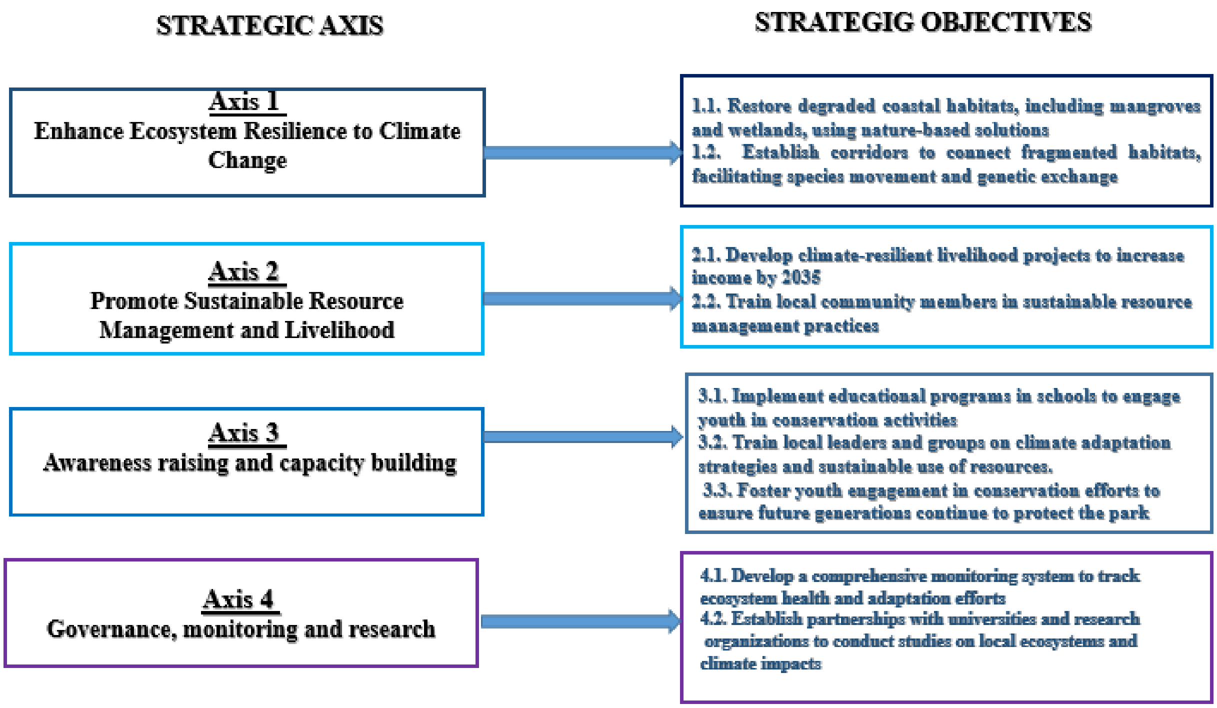


Figure 11: Strategic axis and strategic objectives

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 7: prioritization of adaptation options

Hazards	Strategies	Efficiency	Environmental acceptability	Social acceptability	Economy	Emergency	Sum	Status
Windstorm	Tree planting	3	3	3	3	3	15	Priority
	Enforcement of law	3	3	3	3		12	Priority
	Awareness raising (Sensitization)	3	3	3	3	3	15	Priority
	Alternative activities (garden, salt farming, poultry farming ...)	3	3	3	2	2	13	Priority
Flooding	Tree planting	3	3	3	3	3	15	Priority
Precipitation variability	Alternative activities (garden, salt farming, poultry farming ...)	3	3	3	2	2	13	Priority
	Seasonal migration (to Ziguinchor or Guinea for seasonal work)	3	1	2	3	2	11	Not Priority
	Adoption of sustainable and climate-resilient agricultural practices	3	3			3	9	Not Priority
	Establishment of wood lock (bois villageois)	3	3	2	2	3	13	Priority
	Suitable species (salt tolerant species)	2	2	2	3	3	12	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 Jokadu management plan and the national protected area management strategy.

Table 7 : Action plan for adaptation to climate change in Jokadu Park

Strategic axis	Main objective	Specific objectives	Activities	Source of funding	Materials and human resources	Years				
						2025	2026	2027	2028	2029
Enhance Ecosystem Resilience to Climate Change	**Strengthen the capacity of natural ecosystems to adapt to climate impacts and support biodiversity**	- Restore degraded coastal habitats, including mangroves and wetlands, using nature-based solutions - Establish corridors to connect fragmented habitats, facilitating species movement and genetic exchange	Reforest (Mangroves, and other terrestrial plant species)	Government and technical and financial partners	Park, SMC, VDC, CBO, Extension services, NGO					
			Submerge artificial reefs							
			Observe biological rest based on scientific knowledge							
			Implement a management plan for each species							
			Promote aquaculture							
			Install anti-salt dikes							
			Establish a community wood							
			Soil defense and restoration (rock bunds…)							
Promote Sustainable Resource Management and Livelihood	**sustainable practices that reduce environmental pressure and provide climate-resilient income opportunities**	- Develop climate-resilient livelihood projects to increase income by 2035 - Train local community members in sustainable resource management practices	Integrate sustainable agricultural practices (agroecology, assisted natural regeneration, etc.)	Government and technical and financial partners	Park, SMC, VDC, CBO, Extension services, NGO					
			Develop sustainable tourism projects							
			Develop alternatives activities (market gardening, beekeeping, poultry farming, etc.)							
			promote the processing of local products and support marketing circuits							

			Subsidize/finance sustainable practices							
			Build capacity in local product development and processing techniques							
Awareness raising and capacity building	**Educate communities on the impacts of climate change and empower them to participate in adaptive management**	Implement educational programs in schools to engage youth in conservation activities	Organise awareness-raising activities at school level on the importance of resource conservation.	Technical and financial partners	Park, Schools					
		Train local leaders and groups on climate adaptation strategies and sustainable use of resources.	Organize annual community workshops to train local leaders and groups on climate adaptation strategies and sustainable resource use	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. Table 9 presents a preliminary list of indicators. This list will be enhanced or modified when the interventions are implemented.

Table 8 : Monitoring indicators – Evaluation

Strategic axis	Main objective	Specific objectives	Activities	Indicator
Enhance Ecosystem Resilience to Climate Change	**Strengthen the capacity of natural ecosystems to adapt to climate impacts and support biodiversity**	- Restore degraded coastal habitats, including mangroves and wetlands, using nature-based solutions	Reforest (Mangroves, and other terrestrial plant species)	Area reforested; Success rate
			Submerge artificial reefs	Numbers of submerge artificial reefs
			Observe biological rest based on scientific knowledge	number of biological rest periods observed
		- Establish corridors to connect fragmented habitats, facilitating species movement and genetic exchange	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
			Establish a community wood	Area reforested
			Soil defense and restoration (rock bunds…)	Number of rock bunds installed
Promote Sustainable Resource	**sustainable practices that reduce environmental**	- Develop climate-resilient livelihood projects to increase income by 2035	Integrate sustainable agricultural practices (agroecology, assisted natural regeneration, etc.)	Number of actors accompanied

Management and Livelihood	**pressure and provide climate-resilient income opportunities**	- Train local community members in sustainable resource management practices	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	**Educate communities on the impacts of climate change and empower them to participate in adaptive management**	Implement educational programs in schools to engage youth in conservation activities	Organise awareness-raising activities at school level on the importance of resource conservation.	number of sessions organized/ number of stakeholders trained
		Train local leaders and groups on climate adaptation strategies and sustainable use of resources.	Organize annual community workshops to train local leaders and groups on climate adaptation strategies and sustainable resource use	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

Jokadu Park, like many Marine Protected Areas (MPAs), plays a crucial role in conserving marine biodiversity, protecting aquatic ecosystems, and improving the socio-economic conditions of local communities. However, the growing impacts of climate change threaten the park's effectiveness and management. The climate vulnerability assessment has identified the key hazards affecting the park, including strong winds, coastal erosion, marine inundation, and rainfall variability. These climatic hazards have profound and often detrimental effects on the natural resources that local communities depend on for their livelihoods. The consequences observed include a decline in fish and forest species populations, a significant reduction in agricultural productivity, the destruction of beaches, and damage to fishing infrastructure and equipment.

To mitigate these impacts, local communities are implementing a range of adaptation strategies. These include the construction of makeshift dikes, reforestation efforts, the exploration of new fishing areas, and the diversification of income-generating activities. Although these measures provide short-term relief, they must be complemented by more robust, long-term adaptation strategies to ensure their sustainability.

The proposed optional strategies, though diverse, require reinforcement to maximize their effectiveness. These include establishing a meteorological monitoring and early warning system, adopting climate-resilient agricultural practices, developing and utilizing drought-resistant seed varieties, and enhancing the management of vulnerable areas within the park. Additionally, raising awareness and providing training to local stakeholders on climate risks and preventive measures are essential for minimizing losses and mitigating the impacts of extreme weather events.

In conclusion, while the current adaptation efforts are commendable, it is critical to strengthen these strategies and expand the range of available options to bolster Jokadu Park’s resilience against mounting climate challenges. A comprehensive and proactive approach, combining adaptive management, community engagement, and financial support, is essential for ensuring the long-term sustainability of the park's ecosystems and the well-being of the communities that rely on them.

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 Jokadu Park and mitigate the impacts of climate change.

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