



# Perception of health risk and adaptation to climate change among the populations of *Langue de Barbarie* in Saint-Louis, Senegal

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## Résumé

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Cette recherche vise à identifier les liens existants entre les changements climatiques et les risques sanitaires dans la Langue de Barbarie (Nord du Sénégal). Située sur le littoral, zone d'interface entre mer et terre, la Langue de barbarie se compose d'un cordon de sable et représente un domaine stratégique pour le développement socio-économique de la région. Cependant, elle est exposée à une pression anthropique (urbaine, industrielle, agricole, halieutique et touristique) couplée aux effets du changement climatique qui introduisent de nouveaux risques pour la santé humaine. Des risques qui se matérialisent par une fréquence des vagues de chaleur, une diffusion de maladies tropicales, une prolifération et une dispersion des vecteurs (moustiques et autres insectes) et une augmentation des allergies. Autant de catastrophes qui engendrent des transformations profondes sur le plan sanitaire, social, économique et environnemental.

Il convient de comprendre dans un premier temps la perception des acteurs socio-économiques puis d'identifier les stratégies d'adaptation et les initiatives pertinentes pour éviter et/ou atténuer les effets du climat sur la santé des populations. Nous proposerons enfin des recommandations pour une gestion plus efficace des risques sociosanitaires.

Nous faisons du littoral sénégalais, notamment la Langue de barbarie, notre terrain de recherche et d'application, car cette zone est caractéristique des milieux côtiers exposés aux phénomènes du changement climatique et marquée par une relative pauvreté, une pression accrue sur le littoral et une méconnaissance des risques sanitaires. C'est pourquoi elle constitue un champ expérimental pour notre étude portant sur l'analyse des indicateurs du changement et les risques sanitaires.

**Mots-clés :** santé, changements climatiques, adaptation, Langue de Barbarie.

## Abstract

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This research aims to identify the existing links between climate change and health risks in the Langue de Barbarie (Northern Senegal). Located on the coastline, an interface zone between sea and land, the Langue de Barbarie is composed of a sand bar and represents a strategic area for the socio-economic development of the region. However, it is exposed to anthropic pressure (urban, industrial, agricultural, fishing and tourism) coupled with the effects of climate change that introduce new risks to the health of populations. These risks are materialized by the frequency of heat waves, the spread of tropical diseases, the proliferation and dispersion of vectors (mosquitoes and other insects) and an increase in allergies. These are all disasters that are causing profound transformations in health, social, economic and environmental terms.

First, we need to understand the perception of socio-economic actors, then identify adaptation strategies and relevant initiatives to avoid and/or mitigate the effects of climate on the health of populations. Finally, we will propose recommendations for a more effective management of social and health risks. Our research and application field are the Senegalese coastline, particularly the Langue de Barbarie, because this area is characteristic of coastal environments exposed to climate change phenomena and is marked by relative poverty, increased pressure on the coastline and a lack of awareness of health risks. This is why it constitutes an experimental field for our study on the analysis of indicators of change and health risks.

**Keywords :** health, climate change, adaptation, Langue de Barbarie.

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## Introduction

Coastlines are land-sea interface zones that include coastal strips, estuaries, deltas, and continental platforms. They represent strategic areas for socio-economic development. Coastlines in Senegal are exposed to numerous human-induced, urban, industrial, agricultural, fishing and tourist pressures, in addition to pressures induced by climate change (Breton, 1996).

In a broad sense, climate change is evidenced by global warming, accelerated desertification, coastal inundation, erosion, saline intrusion into aquifers, etc. (IPCC, 2007). Climate change has been observed to have a significant effect on the frequency of coastal marine inundation, as unequivocally concluded by the Intergovernmental Panel on Climate Change (Berkes, 2007). In the context of the Langue de Barbarie, climate change presents unprecedented challenges and socio-health risks which have materialized in the form of frequently occurring heat waves causing high morbidity in vulnerable population groups (Parola, 2003), as well as the spread of tropical diseases, such as malaria, Chikungunya fever, and dengue fever in areas where they had been nearly eradicated, the proliferation and dispersion of insect vectors, such as mosquitoes, and a greater frequency of allergies.

At present, the consequences of climate change on land use and land cover have been modelled using scientific parameters. However, there remains a considerable range of uncertainties (WHO, 2002). To meet these challenges and resolve these multiple uncertainties, the dissemination of extant scientific and popular knowledge and the involvement of communities in the decision-making process at the local/regional level are essential. For it is in this manner that a global approach and socially responsible responses can be developed to mitigate risks and capitalize on emerging opportunities (EEA, 2006).

This study examines the diverse perspectives regarding the extent to which populations take climate change into account and how it impacts their health, as evidenced, for example, by the occurrence of post-flood outbreaks of malaria, cholera, diarrheal diseases, etc. This research also examines the adaptability of individuals in social, economic, and environmental contexts. By doing so, it should empower individuals to respond and adjust to climate change in a manner consistent with their socio-professional status.

This study takes an applied research approach. It seeks to offer thought-provoking concepts that can contribute to improving the practices of humanitarian aid and social action in the field of disaster management and health protection. By drawing upon perceptions and local knowledge, it also aims to clarify the complex issues of risk and disaster management in relation to human health.

***The Langue de Barbarie: a fragile environment subject to climate change and safety and health hazards***

The Langue de Barbarie is a coastal strip of land in the Saint-Louis region. It spans approximately thirty kilometres between the Atlantic Ocean and the Senegal River. Its limited width ranging from 200 to 400 meters, as well as the dynamic marine and river conditions in the vicinity, have made it increasingly vulnerable, as depicted in Figure 1.

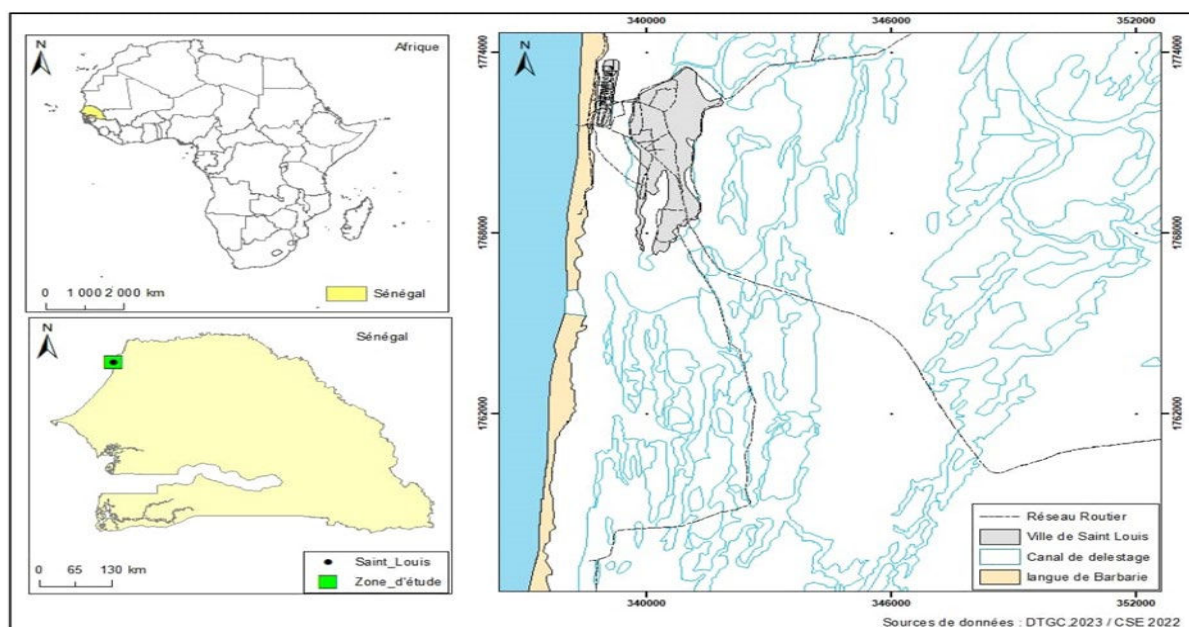


Figure 1: Location map of the Lanque de Barbarie

Today, human activities have altered natural processes. In 2003, a diversion channel was dug in the sandy strip to prevent flooding. The existence of this channel has now sparked numerous controversies (SY et al, 2013). At the same time, the coastal strip is an environment that exhibits notable biological productivity which makes it an attractive environment for many activities, such as tourism (leading to urbanization), fishing, and market gardening.

These diverse activities coexist in a complex and fragile ecosystem susceptible to climate change, the degradation of dunes and coastal vegetation, as well as the contamination of wells from the rise of seawater, etc. This human and functional pressure has greatly reduced available space and intensified a stronger competition for resources. These are factors that add strain on an already fragile coastal ecosystem. These divergent risks have not spared the tourist sector, which has significantly developed since 1996, nor the fishing industry which serves as the local population's mainstay (Kane, 1997). The inhabitants of this sandy strip are therefore exposed to safety risks arising from the effects of climate change: trawlers capsizing resulting in human casualties (fishermen having to venture ever further from shore in search of fish), salinization of wells and degraded water quality, shifting sandbanks and retreat of the shoreline, population displacements, risk of disasters occurring in succession, etc.

Studies carried out to date in the Langue de Barbarie have shown that its inhabitants possess a good knowledge of the river's dynamics, as well as of the importance of wetlands, lakes, and lagoons for the preservation of wildlife and tourism attraction. However, the

coastline is generally perceived solely as a utilitarian asset. Residents exhibit little interest in and/or have little knowledge of the natural and anthropogenic processes that can affect ecosystems and, by extension, their health.

## Methodology

The methodology adopted for this study was based on a participatory and inclusive approach the purpose of which is to examine the correlation between climate change and health. By employing a participatory approach, it was possible to acquire accurate information from each social category of responders. Having prioritized these individuals as the subjects of our research, we were thus able to formulate operational recommendations based on what we gathered from their experience with climate change and its resulting impact on their well-being. They articulated this with an assessment of their situational context and the challenges they face.

## Data collection and study techniques

### *Data collection*

Data were collected in the following three domains: climate, health, and socio-economics. The collection of climate data was funded by the National Agency for Civil Aviation and Meteorology (ANACIM). These data were utilized to analyse climate variability going back over a fifty-year period. Health data were collected in the Saint-Louis medical region, which centralizes data covering the Langue de Barbarie, with the use of a specific field interview guide customized to measure disease prevalence within the population.

Finally, regarding the collection of socio-economic data, we carried out several surveys in the Langue de Barbarie among the residents of Goxu Mbacc, Santhiaba, Ndar Toute, Guet Ndar, and the village of Hydrobase (Keur Ibra Dièye), where we distributed questionnaires to various categories of respondents (household members, health workers, municipal officers, representatives of youth and women's associations, etc.). The dates of our three field missions were as follows: July 4 and 5, 2022, from July 22 to 24, 2022, and, lastly, from August 1 to 3, 2022.

Our sample population was primarily composed of fishermen (95), fishmongers (55) (at next level coming after fishermen), women engaged in the processing of dried fish (55), hoteliers (15), climate-displaced individuals (45), farmers (25), merchants (25), ice sellers (5), cleaning staff (5), etc.

To assess the health risks caused by climate change in the agriculture sector of the Langue de Barbarie, our investigation was extended to Gandiolais located close to the former river mouth south of Saint-Louis. During our various stays (initially on August 6, 2022, and then from August 10 to 15, 2022), we traversed a dozen villages between Bountou Ndour and Keur Barka and passed through the island villages of Doune Baba Dièye up to Taré situated at the site of the former river mouth (see Table1). In this specific sector, we also sought to learn about the effects of the opening of the sandbar breach on farming activities, market gardening, fishing, the Langue de Barbarie natural park and on its biodiversity, as well as the impact of climate change on the health of the local populations.

Table 1: Distribution of surveys

Localities	Number of people surveyed
Goxu Bathie	85
Ndar Toute	39
Guét Ndar	58
Hydrobase	26
Island of Saint-Louis	55
Gandioul	17
Displaced persons camps	45
<b>Total</b>	<b>325</b>

The correlation between climate change and human health was examined using active participatory research methods (MARF) based on focus groups involving members of local social categories (fishermen, farmers, educators, hoteliers, etc.) for the production of knowledge.

The collection of necessary information for our study was made possible through the assistance of community leaders (neighbourhood chiefs, imams, priests, etc.), as well as that of health professionals (head doctors, nurses, midwives, etc.), members of the Badien Gokh community, and local authorities (village chiefs).

## Analytical techniques

### *Analysis of the manifestations of climate change*

For the analysis of the effects of climate change, we focused on factors such as rainfall, wind patterns, water evaporation, temperature, sunlight, presence of dew, relative humidity, and the number of rainy days. Accordingly, the most relevant variables of our study were the amount of rainfall and the wind velocity measured by an anemometer. The minimum and maximum monthly averages of these two factors measured at the Saint-Louis weather station served as the basis for obtaining climatic data. Data obtained at the Gadga Lahrar wind station were utilized to calibrate the wind speed, since the station takes into account the impact of local conditions and the diurnal variability of wind speeds spanning a fifty-year period. The software application, Chrono Stat, was used for the calculations and non-parametric tests of data series (Pettitt’s test).

### *Analysis of perception indicators and monitoring of health parameters*

Perception studies enrich our understanding of the mechanisms that govern spatial transformations and the behaviours of local communities. They seek to analyse the level of vulnerability induced by climate change and shed light on the means implemented by local communities to mitigate the multiple adverse effects of climate change, including those on health, for example. This perception study, based on the results of the questionnaires, has

been supplemented with an analysis of vulnerability indicators provided with the use of Sphinx Software and presented on an Excel spreadsheet.

Several perception variables were examined, which included indicators reflecting shifts in socio-professional standing, the awareness and management of hazards, and the impacts of climate change on health. The analysis of these indicators was finalized with the assessment of adaptation strategies, which consequently led to an analysis of socio-spatial reorganizations.

### ***Analysis of adaptation strategies***

In the face of environmental changes, how do populations adjust and respond to the socio-health risks that ensue?

The investigation examines the means by which the inhabitants of the Langue de Barbarie have adapted to climate change was predicated on the transformative processes associated with the effects of climate change. This analysis considers five significant factors: the growing problems for fishermen (depletion of fish stock, fatal trawler accidents, etc.), the threat of shoreline erosion endangering the homes and communities that are the most exposed, the degradation of ecosystems affecting the tourism sector (the rise of the saltwater table and its implications on food security and human health), coupled with the expansion and more intensive exploitation of farmland, rapid urbanization (and, indirectly, issues associated with pollution, waste management, sanitation, and unsafe water, etc.), and, finally, the migration and displacement of people in need of socio-health care.

## **Results**

### **The evolution of climatic variables**

#### ***The variability of precipitation***

Multiple physical factors are implicated in the instability of the Langue de Barbarie. This coastal strip of land is affected by climatic conditions and dynamic forces arising from marine and fluvial processes. The data used in this study was derived from measurements of rainfall and temperatures taken at the Saint-Louis station.

Monthly precipitation records span the years between 1961 and 2017. The Saint-Louis station, facing the coastline, is exposed to maritime conditions that reduce the occurrence of temperature extremes. The Lamb rainfall index was used to obtain the interannual variability of rainfall at the Saint-Louis station where measurements report the differences between years with high precipitation and those with low precipitation (see Figure 2). Saint-Louis has had 27 wet years with an average annual precipitation of 263.8 mm.

However, beginning from the late 1960s, and through the early 1970s to 1995, the region experienced a very long period of rainfall deficit, in a context of widespread drought in the Sahel. At the end of the 2000s, conditions returned to normal.

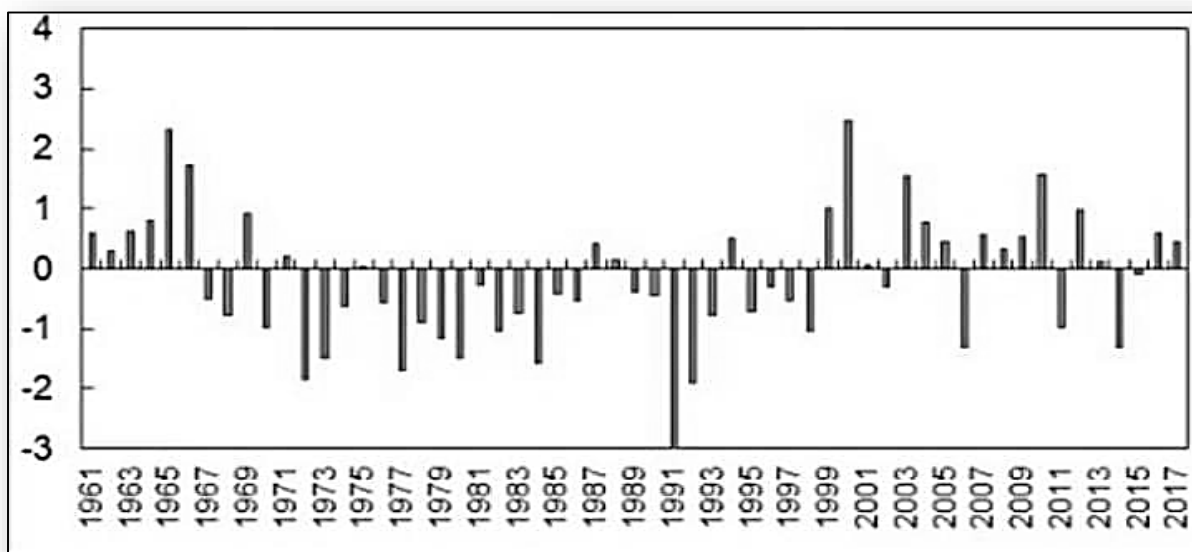


Figure 2: Variations in annual rainfall between 1961 and 2017, ANACIM

### *Temperature variations*

The average temperature in Saint-Louis is 26°C. The rise in temperature during the rainy season corresponds to the advent of a hot and humid monsoon, and to a greater degree of nocturnal radiation. The dry season's minimal temperatures are attributable to the ocean's regulatory function and to the upwelling of cold oceanic water. In Saint-Louis the lowest temperatures occur during the dry season (23°C in January-February) and the highest during the rainy season (29°C in August-September). In Saint-Louis, maximum temperatures do not exceed 35°C and minimum temperatures do not fall below 25°C. This is due to the ocean's tempering influence (see Figure 3).

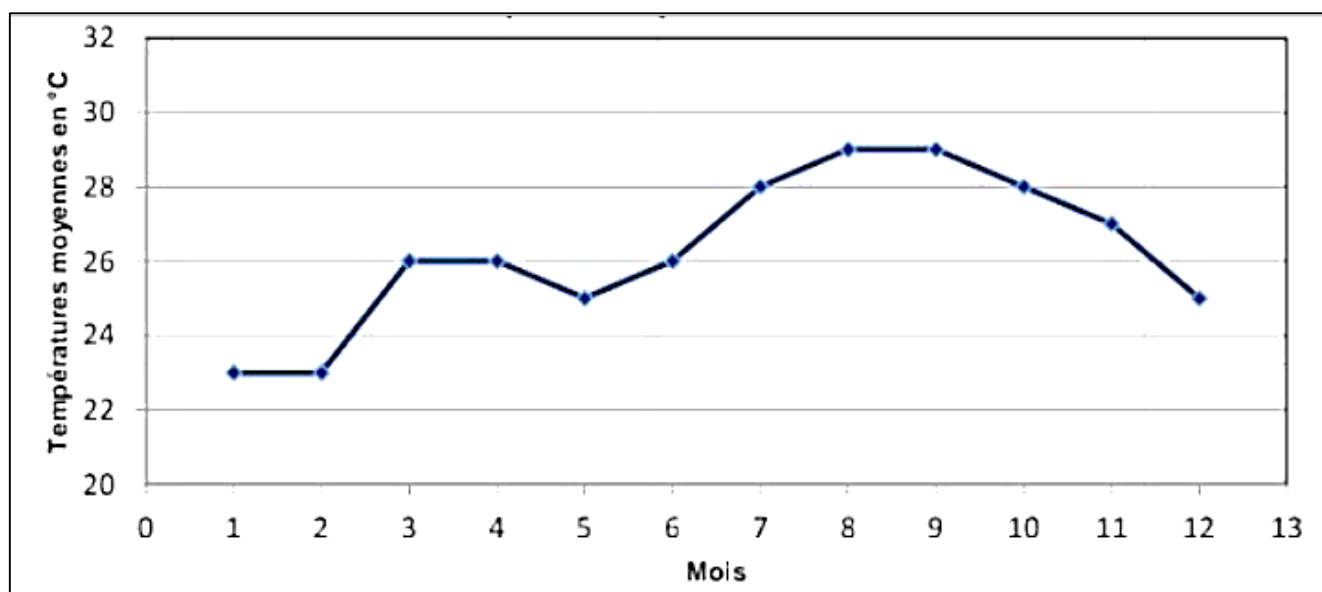


Figure 3: Temperature variations between 1961 and 2017, ANACIM

Winds exert a decisive influence. They primarily affect the elevated regions of the beaches and the dunes, where they transport substantial amounts of sand in a north-west to south-east direction, resulting in the formation of coastal sandbars. In addition, strong local winds can cause the ocean to swell and submerge low-lying sectors of the sandbar. The resulting inundation can cause the coastal strip to rupture at its most vulnerable locations. These climatic variances have intensified the impact of climate change on the Langue de Barbarie’s health system in recent decades. Due to the resulting lack of resources, infrastructure, personnel, etc., they have weakened the health system that is already compromised by high population densities in the localities studied.

### *Perceptions of climate risks by indigenous populations*

The study focused on the the localities of Goxu Mbacc, Ndar Toute, Guet Ndar, and Hydrobase (see Figure 1) to understand the perspectives of the inhabitants regarding climate change. The total population was estimated at approximately 40,000 inhabitants (ANDS, 2020). The Goxu Mbacc district has the largest number of residents. According to the regional statistics department, this district has a density of 1,491 inhabitants per hectare with fishing and fish processing being the main activities.

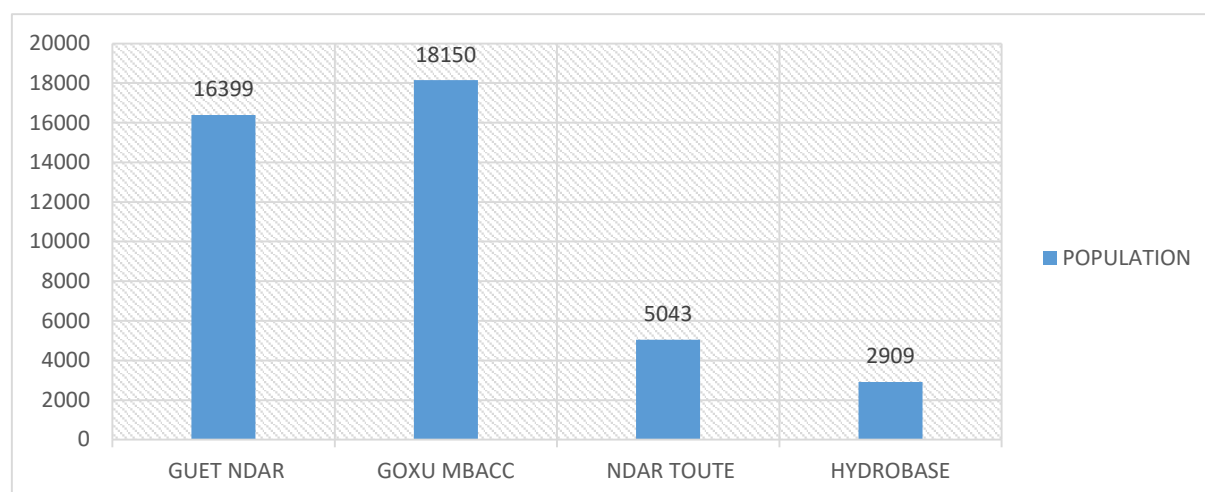


Figure 4: Population size in the target districts of Langue de Barbarie in 2020

In these localities, 80% of respondents have a basic understanding of climate change. They confirmed the notion that climatic hazards are more frequent and increasingly severe. Among them, people cite, starting from the most severe, inundations (86%), coastal erosion (82.1%), violent winds (54%), salinization, unseasonable rains (14.3%), accumulation of refuse (7.1%) (see Figure 5).

In fact, floods rank among the natural disasters that have had the greatest impact in Saint-Louis’s history since its foundation in the mid-17th century. Ever since the Diama and Manantali dams were constructed to regulate the flow of the Senegal river, the water level of the estuary has gradually risen, particularly in winter. This higher maximum flood level has caused the river to overflow and inundate the entire estuary, and, more particularly, Saint-Louis.

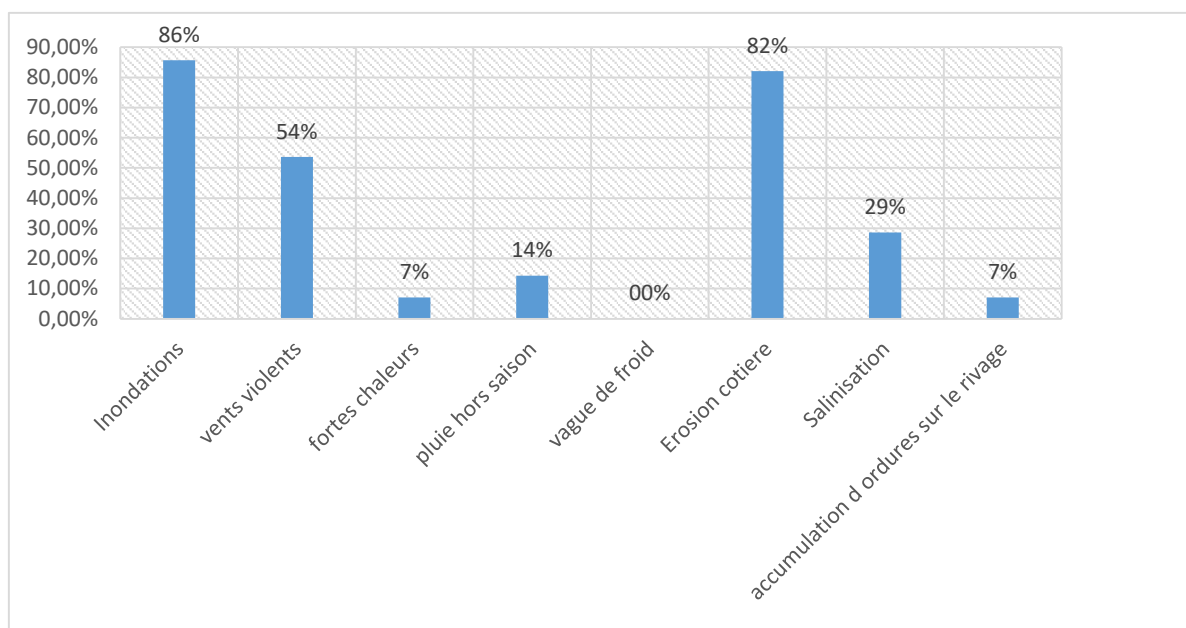


Figure 5: Percentage of respondents citing the greater severity of climate change impacts - Langue de Barbarie

Examining the perceptions of local residents helps better understand of the impacts of climate change and their consequences on people's living conditions, in particular, those due to flooding, coastal erosion, and violent winds, which are perceived as the most significant risks that warrant attention.

The presence of two dynamic forces (marine and fluvial) accounts for the transformation of the Langue de Barbarie's coastline that has been subjected to a pattern of erosion causing the destruction of numerous homes. To alleviate these consequences, casuarina trees were planted to stabilize the dunes, retard the retreat of the shoreline, and reduce the effects of sedimentation. As a consequence, sandbanks were formed that, in turn, impede navigation. Alternating erosion and sedimentation are responsible for the shallower depths of the water and the rapid modifications along the coastline of the Langue de Barbarie. These changes create significant challenges in coastal zone management that include the setting of limits of the artisanal maritime fishing zone, regular dredging of silted river channels at considerable expense, surveying the retreat of the shoreline, etc. (see Photo 1).



Photo 1: Climatic hazards observed in the Langue de Barbarie, M.NDIAYE 2022

### *The perception of fishermen*

The study of the perception of fishermen (150), who totalled more than 15,000 in 2018, revealed a number of problems. Fishing activities are faced with rising sea levels that cause frequent accidents and fatalities estimated at approximately twenty per year. Rising sea levels cause delays in the offloading of sardinella (small fish), and this has an impact on the fishermen's work and their livelihood. At the same time, some fishermen claim that they catch fewer fish than in the past:

*"In the past, we would spend less than 24 hours at sea, and we would bring back large catches of fish. Our fishing zone was easy to reach, which made it possible to sell fish at cheaper prices to consumers. But in the current era of climate change, to catch fish, you now have to venture into high seas with all the risks that it entails. This requires more people and more money, but also more time at sea, at least five days. Because sometimes we even navigate as far as the waters of Mauritania. Despite all this expenditure of time and energy, our total catches are not enough."*

Ever since the opening of the breach in the sandbar, the fishermen in the populous district of Guet-Ndar have had less activity. In addition, fishing has had a harmful human impact, like the capsizing of trawlers leading to fatalities and injuries. The tragic situation of these fishermen and their families has worsened due to the lack of health facilities and access to health services.

Fishing plays a crucial role in the area, particularly in Guet-Ndar. Fishermen find it distressing to discuss the breach that the authorities opened up in the sandbar to keep the city from flooding, as hundreds of fishermen have perished since 2003 when the breach was made. Our local official was adamant: *"Just take a closer look at it. It's a death trap. It has swallowed up all of our children. I will never venture through this breach."* He went on: *"Last January, thirty people lost their lives after their trawler capsized and ran aground on a sandbank that wasn't visible."* The regional fisheries directorate estimated that there were around 3,695 registered trawlers in 2018, for more than 15,000 fishermen. In 2021, there were 4,500. The year 2013 also was a particularly deadly. That year, there were 157 fatalities and 141 survivors involving 27 trawlers. It is noteworthy that between 2018 and 2021, another series of storms struck the Langue de Barbarie causing numerous accidents and human casualties (see Figure 6).

Concerning safety, the means of surveillance and protection, and, specifically, the wearing of life jackets and use of rescue equipment, are insufficient (in addition to the obsolescence of equipment and absence of suitable fishing gear) due to a lack of field inspectors. The utilization of life jackets has been reported to be optional. Also, despite the availability of a trawler and an ambulance for sea rescue operations, communities have resorted to carts as an alternative means of land conveyance because of limited resources. And this has augmented the risks for patients in need of urgent medical attention.

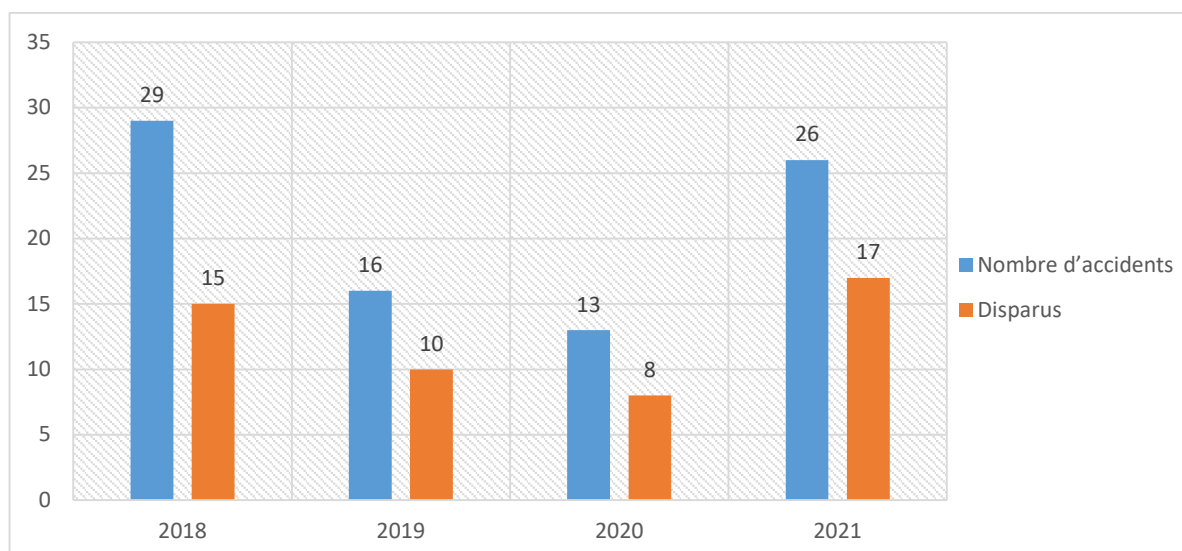


Figure 6: Rise in the number of accidents and fatalities. Source: Saint-Louis Fisheries Department, 2021

### *The perception of health personnel*

Health personnel state that climate change has had significant repercussions on the health of populations. Health risks attributable to climate-related hazards have been on the rise over the course of several decades. Vulnerability to climatic changes has led to the emergence of numerous medical conditions that were previously unknown in the region, such as malaria, asthma, diarrhoeal diseases, acute malnutrition resulting from insufficient rainfall, rheumatic diseases, etc. Also, certain illnesses, such as parasitoses, dermatoses, and allergies have returned due to a lack of sanitation and hygiene (e.g. in Guet-Ndar) brought about by the dumping of household refuse and wastewater. It should be noted that some neighbourhoods unconnected to the drinking water supply network use contaminated well water that has undergone salinization caused by seepage from the rising saltwater table. This study of the perception of Saint-Louis regional hospital health personnel points to a correlation between climate change and health, as shown by the number of cases of reported diseases. The number of cases of reported diseases does not take into account the months of September through December of the year 2022 (see Figure 7).

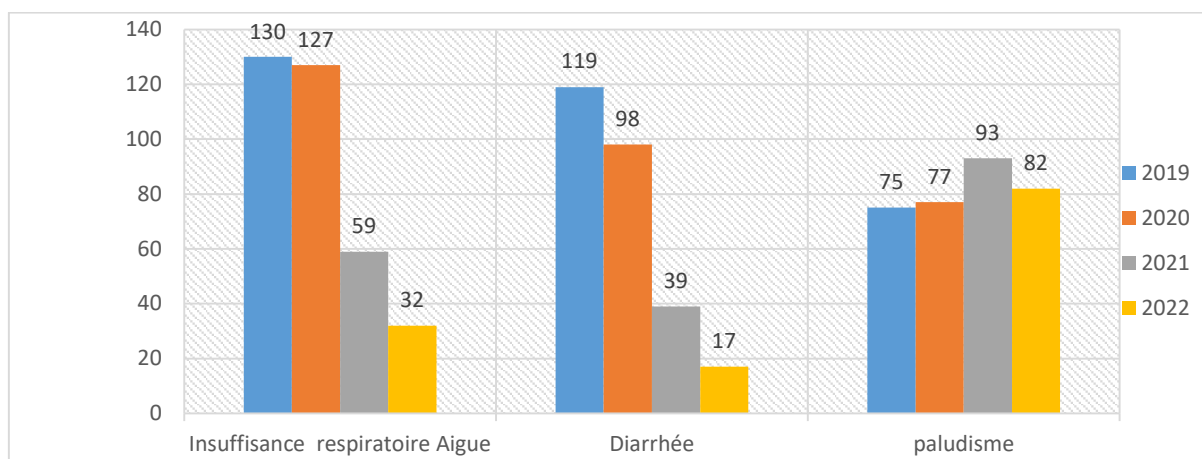


Figure 7: Number of frequently occurring cases of reported disease from 2019 to 2022, Saint-Louis Regional Hospital, 2023

Figure 7 shows that in contrast to the number of cases of malaria, diarrhoeal diseases, and respiratory failure diseases, the number of reported cases of patients suffering from respiratory failure shows a declining trend. Respiratory failure is characterized by injury to the lungs resulting from the inadequate exchange of oxygen and carbon dioxide, depriving the body of vital oxygen necessary to function properly.

The number of confirmed cases of malaria per year in the study area was largely consistent between 2019 and 2022, even if a slight uptick in the number of cases was recorded in 2021. The National Malaria Control Program that surveys the local population has made tremendous strides in containing this disease. These include the implementation of an early rapid diagnosis test for patients exhibiting a fever, chemoprevention, and intermittent preventive treatment to pregnant women with the administration of three doses of antimalarial medication. As for vector control, campaigns for the massive and cost-free distribution of Long-Lasting Impregnated Mosquito Nets (LLINs) every three years have been recommended as means to safeguard the public from malaria.

Diarrhoeal illnesses, similar to respiratory failures, predominantly impact children. The incidence of diarrhoea cases saw a sharp decline between 2021 and 2022 with an approximately 7% mortality rate among children under five years of age (Survey, 2023). Rotavirus is the leading cause of mortality due to severe diarrhoea in children under five years old and is the primary reason why children are hospitalized. The decline in reported cases can be attributed to enhanced hospital medical services and expanded vaccination programs targeting those who are the most exposed to these diseases.

### ***The perception of local populations on exogenous health risks***

Not only health personnel, but resident populations (including fishermen, farmers, personnel in the tourist services industry, those employed in salt flats, etc.) also have perceptions regarding the impact of climate change on human health and health risks. An illustration of this is the extended exposure of workers to various harmful factors in the Tassinère salt flats and fish processing plants. Exposure to the heat in salt marshes causes eye ailments. In addition, cases of zoonoses (malaria, rage, candidoses, etc.) due to the proximity of the inhabitants to animals have been identified in the locality of Guet Ndar. Climate change has increased the incidence of medical conditions, such as malaria, asthma, rheumatism, and malnutrition (see Figure 8).

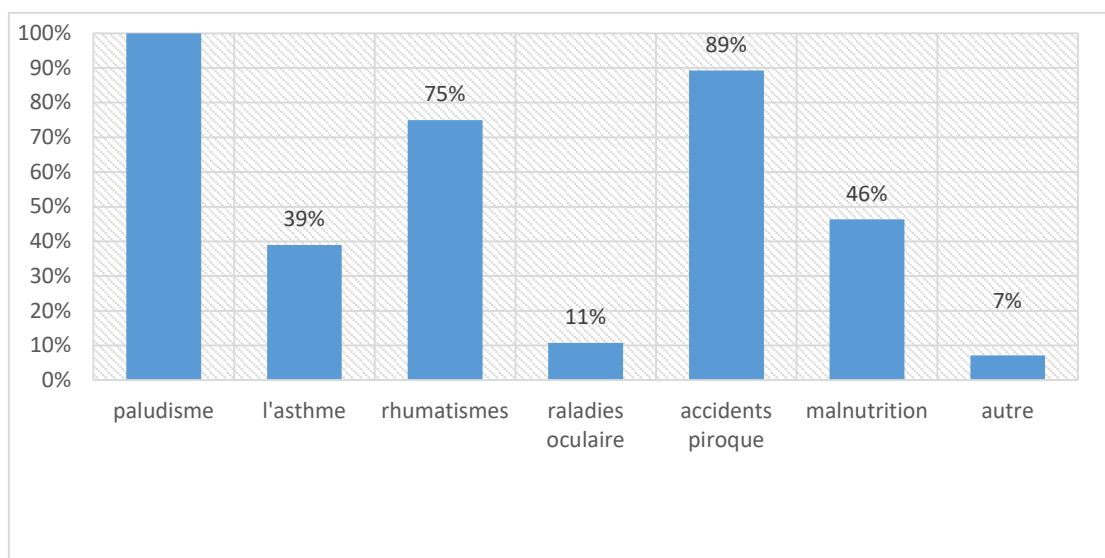


Figure 8: Degree of perception of health risks by the local population

The study of the perception of health risks among 135 local residents reveals that the most prevalent are malaria, as reported by 100% of respondents, trawler accidents and their consequences (physical, professional and family impacts) by 89.30%, rheumatism by 75%, malnutrition by 46.4%, asthma by 39.3% and eye ailments by 10.7%. Malaria continues to be a persistent health threat in Saint-Louis. Fishing exposes individuals to mosquito bites. The main geographical variables associated with the prevalence of malaria in the Langue de Barbarie are as follows: the proximity to a river or the ocean, the disposal of household refuse on the shore, the density of casuarina vegetation, etc.

The number of injuries and fatalities are also very prevalent in the area, especially during the fishing season that runs from January to April. Cases of rheumatism and asthma have been documented among people who live near the sea. According to the head medical officer of the Saint-Louis district, no study has ever been carried out on zoonoses or eye ailments that affect individuals who working in the salt flats

### ***Social groups impacted by climate change***

Climate change has impacted all the communities in the Langue de Barbarie. Surveys taken according to social groups can assess the degree of sensitivity and the extent to which climate change has affected the population of the Langue de Barbarie (see Figure 9) .

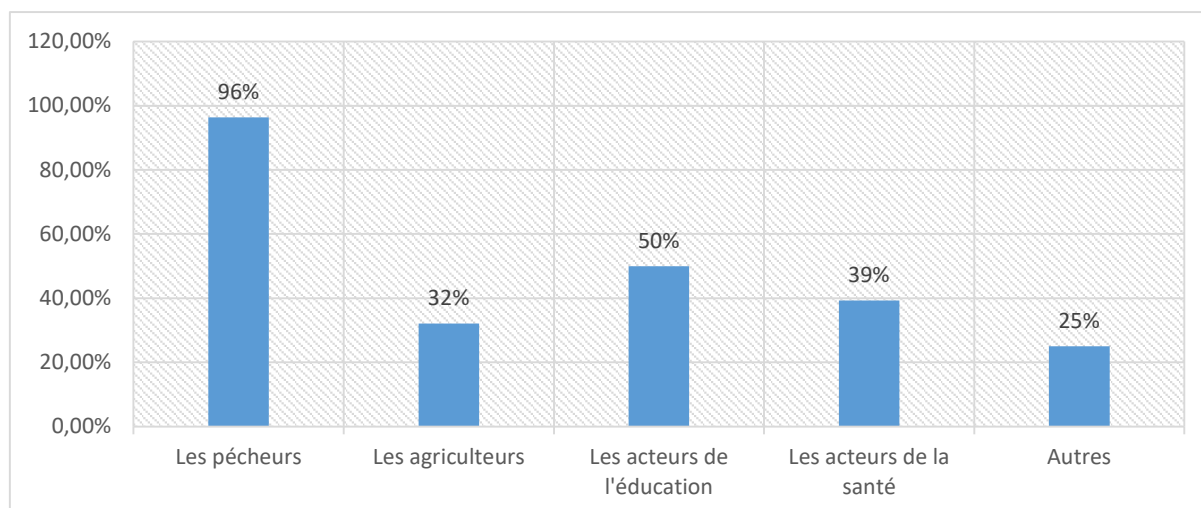


Figure 9: Degree of sensitivity to climate change according to social groups

According to surveys carried out among individuals in the socio-economic sector, the social groups most exposed to the consequences of climate change are firstly fishermen (96%), educators (50%), health personnel (39%), farmers (32%), etc. The factors impacting the daily lives of fishermen are trawler accidents, fatalities, the scarcity of the resources and its consequences (the emergence of conflicts, unemployment, poverty), which are all aforementioned challenges.

The education sector is also very vulnerable to climate change. In fact, climate change has precipitated inundation and increased erosion, which have caused schools to collapse. As a result, the children of climate-displaced individuals cannot complete their school year. Third in the list of social groups that have been impacted are health personnel. These professionals comprise physicians, nurses, midwives, etc. who are at the vanguard of medical responses. The Langue de Barbarie only has a single health outpost and a single hospital for the entire region of Saint-Louis and surrounding localities. Also, there is the lack of qualified human resources, in terms of numbers of personnel and adequate working conditions. Health personnel are insufficiently empowered and informed to adequately address the challenges of climate change.

### ***The areas and infrastructures most exposed to rising water levels***

In the Langue de Barbarie, infrastructures in several areas are exposed to rising water levels. According to the respondents, the shoreline, the breach in the sandbar, the hotels, the agricultural land, etc. are the most exposed. In 2003, the rise in the water level from excessive rainfall in the upper basins obliged the authorities to open a four-metre-wide breach in the sandbar to prevent Saint-Louis and its surroundings from being inundated.

This breach, which was opened 20 years earlier, was examined over the course of one year after which it was seen to stabilize over a width of 800 metres. Today, the former river mouth is silting over due to the sandbanks having shifted southwards. These displacements have caused the water to become excessively salinized reaching salinity levels of up to 35 gr/L with visibly adverse impacts on market gardening, tourist activities, and Langue de Barbarie's environment.

Furthermore, certain hotel facilities, threatened by water encroachment, have been obliged to close and/or relocate further south, as was the case for the Hotel La Saint-Louisienne and the Faro resort.

It is to note that the issue of readapting agricultural land exposed to salinization is central to the region's socio-economic development. Salinization has reached an alarming level of concern for residents. The accumulation of salts (particularly sodium salts) affects plant development and decreases soil fertility. This impacts food safety and health (see Figure 10).

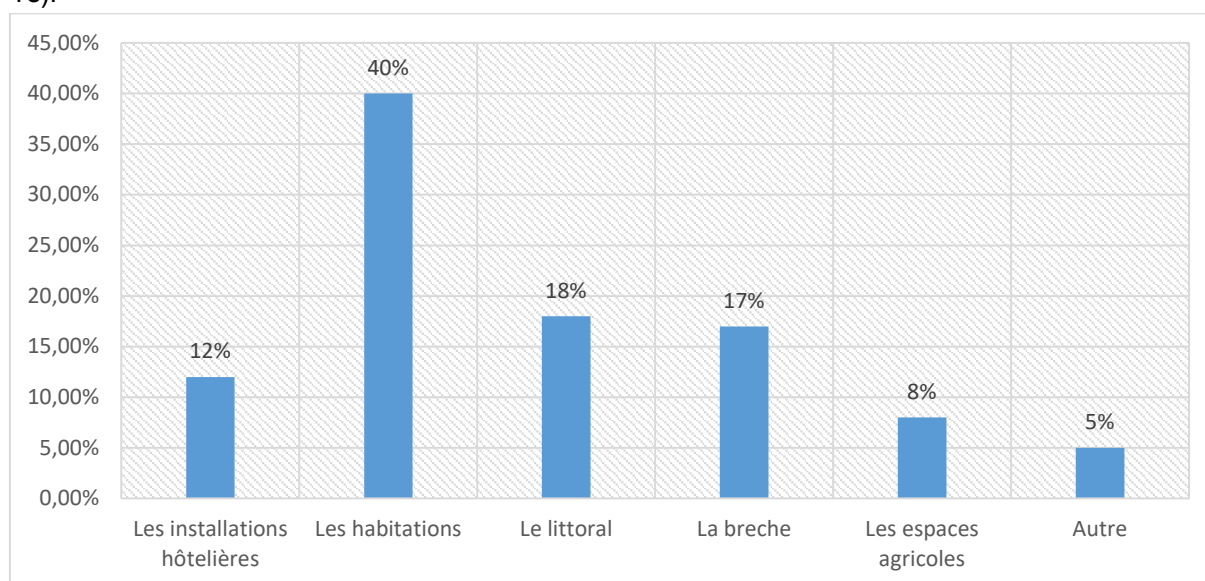


Figure 10: Percentage of the areas and structures most exposed to rising water levels

A study of the areas most exposed to the impacts of rising waters shows that human habitations are affected at a proportion of 40%, followed by the coastline and the breach at 18% and 17% respectively, hotel facilities at 12%, and agricultural land at 8%. According to local residents, the encroachment of the sea constitutes the main problem. They state that previously, the distance which separated the sea from their homes was roughly 100 metres, while today it is estimated at 40 metres, or less than half.

This coastal erosion, which was aggravated by the opening of the breach, has caused homes on the coast to become unstable and collapse. Hotels (e.g. Hotel La Saint-Louisienne) and agricultural areas (known locally as *niayes*) are at risk as well.

### The humanitarian situation of climate-displaced people

Displaced and remaining populations in the Langue de Barbarie have been adversely affected by climate change across various domains, including those involving social, economic, and health aspects. On a social level, the collapse of homes has led to the break-up of families who were grouped together. People often watched helplessly as their dwellings and communities collapsed due to inundation and violent storms. The vulnerable areas of the Langue de Barbarie have been localized (see Figure 11).

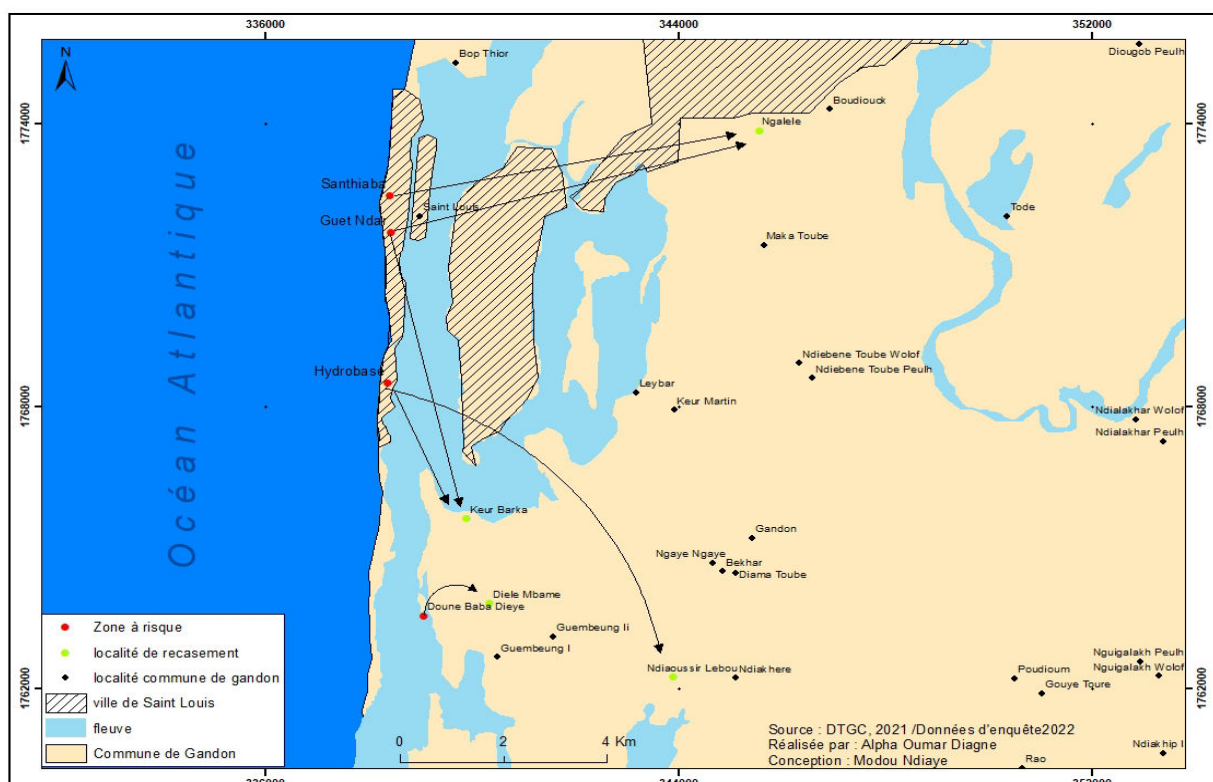


Figure 11: Location map of risk areas and reception sites for displaced people.

This map delineates the vulnerable areas and the reception sites of displaced persons. It provides information on the migration patterns of people from the Langue de Barbarie towards the climate-displaced persons camps located in Saint-Louis or its region (Boudiouck, *Khar yalla*, Bountou Ndour are the three camps). These population movements have impacted the health of the individuals we studied.

### ***The Boudiouck climate-displaced person camp***

This climate-displaced person camp is located in the continental zone of Ngalelle, approximately ten kilometres from the city of Saint-Louis. It shelters more than 800 families who have experienced alarmingly precarious humanitarian conditions. This camp was set up in 2018 (see Figure 12) .

From our interviews with these climate-displacement persons (45), it was found that they have numerous expectations in terms of social, economic, and health protection. Climate-displaced people assert that they have not yet received any compensation or been provided with accommodation from the authorities to date. They are also faced with health and economic issues, such as the cessation of their source of income, particularly from fishing, which was crucial for them to support their families. Life has accordingly become very difficult for them in this reception site.

Daily expenses have become a burden for family leaders who have been dispossessed of their main activities. Without the provision of inclusive support measures, a food crisis is doomed. During our focus group discussion, a woman expressed her deep sadness: *"You know, it's almost 3 p.m. and we still don't know if we'll be served lunch."* These words reflect the deplorable conditions in which these climate displaced people live.

At the health and social level, the people do not have access to adequate health facilities or schools. They must go to the village of Ngalelle or to the Gaston Berger University for treatment or to continue their studies. Also, vulnerable persons living with chronic illnesses are obliged to go to the Saint-Louis regional hospital located approximately 15 kilometres away to receive medical care, and this represents the problem of having to afford transportation costs to receive treatment. This humanitarian scenario exists in other climate-displaced camps, although not to the same extent as in the Bamba Dieye camp .



Photo 2: Boudiouck climate-displaced person camp, M. NDIAYE 2022

### ***The Bamba Dieye climate-displaced person camp***

The Bamba Dieye climate-displaced camp was created in 2016 to shelter families impacted by coastal erosion. However, the residents of the 61 homes have been going through an ordeal for the past eight years. At the displaced persons site called "*Khar yalla*" (see Figure 13), the respondents told us that their most frequent difficulties have to do with the absence of basic social services and the lack of houses adapted to their needs (the lack of privacy, the lack of ventilation, the heat, etc.). According to the president representing the women of the camp, the main problems are access to water and sanitation, waste treatment, the fight against water-borne infections, and the absence of basic social services. Also, we observed a sense of prevailing insecurity which prevents them from going out at certain times of the day or from going to work at the risk of leaving their children alone at home. These climate-displaced persons also mourn the loss of their loved ones and suffer from the trauma caused by the collapse of their dwellings and the flight from their local community.

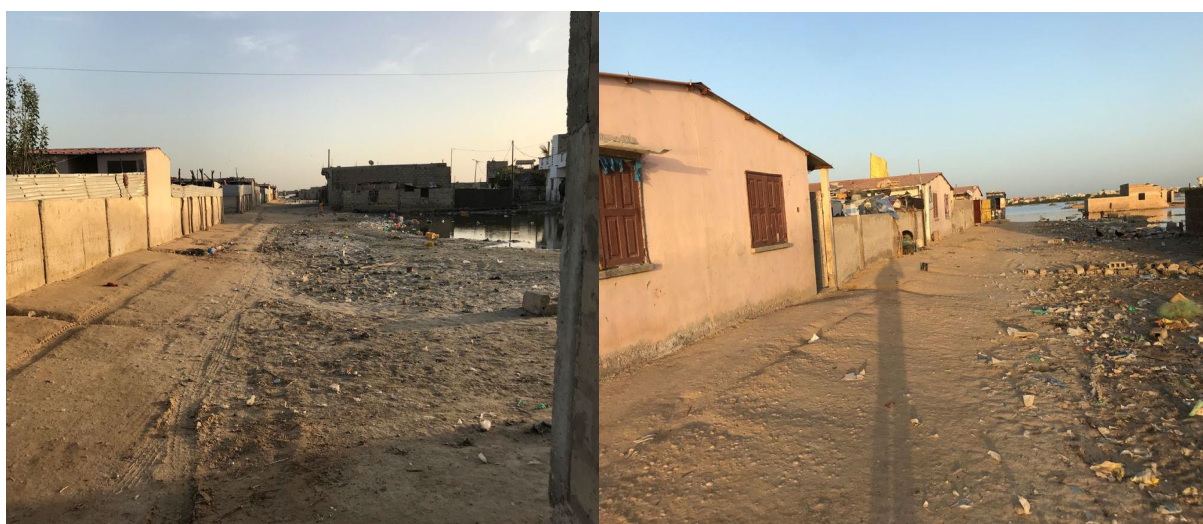


Photo 3: The camp for climate-displaced people called Bamba Dieye (*Khar yalla*), M. NDIAYE

### ***Bountou climate-displaced person camp Ndour***

The Bountou Ndour camp is located near Parc Gueumbeul at the entrance to the city of Saint-Louis. It presents an unusual situation. We noted that this displaced persons camp shelters families from the village of Doune Baba Dieye that was devastated by the ocean waves after the breach was opened in 2003. This village had more than 1,000 inhabitants. The houses had collapsed, causing many deaths and injuries. The villagers agonized over the loss of their material assets (houses, livestock, farms, money) and community property (mosques, cemeteries, etc.). In our interview, the representative of the displaced persons in Bountou Ndour stated: "*What we experienced in our village of Doune Baba Dieye is beyond comprehension. We witnessed all kinds of devastation (loss of material goods and human lives), everything was destroyed. The people struck by the heavy waves preferred to leave the land of their ancestors (Doune Baba Dièye). Only the vestiges remain.*"

Today, many people reside with relatives in other villages, while the wealthy have bought plots of land elsewhere to start a new life. Before it disappeared, this village directly

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<sup>1</sup>Waiting for God's will

and indirectly employed around 5,000 people, in sectors such as market gardening, the hotel business, trading, and especially fishing. Other people were relocated by the government to Bountou Ndour. But in this camp, climate-displaced people have received no social assistance. The health coordinator for displaced people who was sitting in a place of worship told us, *"You see, in the village, there is no health facility, and it is only very recently that we were connected to water and electricity thanks to our own contributions."* He added in despair, *"You know this space where we discuss is our place of worship, you see how it is, it's just a makeshift hut."*

People in this reception camp say that they were rehoused in a desolate area without any materials or financial aid. The socio-economic and health conditions of these communities show a people that have greatly suffered both in their native home village and at this host site. This climate-displaced camp, which has now become a village itself, presents numerous humanitarian problems, including the absence of essential social services, particularly a health facility. The absence of such a facility adds to the loss of jobs and increased poverty.

### ***The continuing ordeal of families who have remained in the Langue de Barbarie***

Aside from climate-displaced persons, some families have chosen to remain in the Langue de Barbarie. They have continued to suffer from the harsh realities of this strip of land which has been impacted by social and climate changes, particularly since 2003 when the breach was opened. Psychological trauma emerged during our interviews with residents of these communities. This situation is especially tough for households whose members are unwell, have limited mobility, are elderly, etc. Those who have decided to remain have continued to be battered by the sea, albeit with fewer and smaller waves thanks to the French Development Agency's funding of protective dikes in the most vulnerable areas of Goxu Bathie, Ndar Toute, and Guet Ndar.

This study reveals severe health hazards and a concerning humanitarian situation stemming from a high population density, combined with the lack of sanitation, as well as the unsanitary conditions in certain dwellings and on the fishing pier. The living conditions of these people have given rise to afflictions that were previously unknown in this region, in particular malaria, acute respiratory disorders, diarrhoea, zoonoses, etc.

## **Adaptation and resilience strategies for victims of climate hazards**

### ***Strategies deployed by the populations remaining on site***

The people remaining on site have been able to cope by deploying a variety of multifaceted adaptation strategies. These include changes in their line of activity, socio-professional retraining, illegal emigration, etc.

During the interviews, we observed a low capacity for adaptation among fishermen, hoteliers, and farmers. Such a situation reflects a strong desire to migrate and change jobs. Relocating is the most convenient and most usually chosen option.

### ***Strategies deployed by climate-displaced persons***

Climate-displaced persons have devised resilience strategies that we observed in the camps of Bountou Ndour, Cité Bamba Dieye, and Boudiouck.

In Bountou Ndour, located in Gandiole, the oldest displaced persons camp housing the residents of a village in the Langue de Barbarie that is now submerged in water, has become a village whose basic services (water and electricity) were connected by the people themselves. This was accomplished thanks to monthly allowances received from their children who had emigrated elsewhere in Senegal or abroad in search of better opportunities. The elderly, the women, and young children from fishing families who remained on site have been trained to work in farming.

The Bamba Dieye camp (*khar yalla*), established in 2016, shelters people who have been able to organize themselves into economic interest groups. In the local language (Wolof), its name reflects the most commonly used expression to talk about the present and the future, which is "*khar yalla*" meaning "waiting for divine will". This expression, *khar yalla*, is an important concept, because it reflects the low level of resilience of those affected by climate change. Also, it is a way for people to convey their hardship and distress in their quest to be suitably relocated.

The Boudiouck camp was set up in 2018. The interviews carried out with the focus groups reveal that most young people have migrated elsewhere within the country or abroad in order to provide for their parents. Women have been retrained for employment in other sectors, mainly in sewing, hairdressing, and other small businesses, while others, despite the distance, have continued to work in the Langue de Barbarie. The older men are obliged to venture out to sea even as fish are becoming scarcer, because they say that fishing is all that they know how to do.

Beyond these resilience strategies, the State and non-governmental organizations support these people by granting them financial aid, food, and medicine. For example, in 2018, the 800 displaced households in Boudiouck each received a gift of 100,000 CFA francs, a bag of rice, and cooking oil from the town hall of Saint-Louis with the support of the French Development Agency.

### ***Strategies deployed through public policies***

This study describes a region that has been subject to the effects of climate change, notably coastline erosion and salinization. At the institutional level, the Senegalese government, in collaboration with the French Development Agency, has launched a project to build a protective dike along the most exposed coastal areas of the Langue de Barbarie in order to protect people and their homes against seawater intrusion.

These strategies are part of the regional plan to mitigate the adverse impact of dams and breaches. The Diama dam, located 25 kilometres to the north of Saint-Louis, is primarily a dam designed to prevent the flow of salt water into the river. This dam was built as part of the plan for the Development of the Senegal River (involving Senegal, Mauritania, and Mali).

However, the Diama dam has exacerbated the salinization of water and soil downstream as a result of floodgates remaining closed for several months. They are just opened for a short time at the end of the rainy season. In addition, the breach that was opened up on the Langue de Barbarie by the Senegalese government in 2003 to control flooding aggravated the problem with a rapid discharge of river waters into the Atlantic Ocean .

Finally, the State has also begun to construct of several housing units in camps like Boudiouck to rehouse populations exposed and vulnerable to climatic hazards. However, this work has been delayed and the victims of hardship are seeking compensation (see Figure 14).



Photo 4: Housing construction project for victims of climate change. M. NDIAYE

## Conclusion

We can conclude that the Langue de Barbarie is under threat from climate change that induces variability in rainfall and temperatures, flooding, salinization, coastal erosion, etc. Populations are also exposed to health hazards (malaria, dermatological ailments, trawler accidents). By examining the situation of climate-displaced persons and monitoring their living conditions in the reception camps, it is possible to confirm the notion that there is a close correlation between health hazards and climate change. Several initiatives have been taken at the local and regional levels to mitigate or adapt to these rapid transformations.

This study argues that there is a need to gain a better understanding of the problems arising on the coastline in order to sustainably manage the marine and coastal environments, as well as to avoid natural disasters and future health risks.

The findings of this research suggest that an adaptation plan should be implemented to build on prior accomplishments, and to gain better knowledge of the correlation between climate change and health. This would involve mapping climate risks that impact human health in the areas subject to coastal erosion and population displacement. It appears from the work carried out thus far that the local people have a solid understanding of the river's dynamics and the importance of wetlands, lakes, and lagoons in maintaining biodiversity and the tourism attraction.

However, the Langue de Barbarie, as a functional unit, generally does not stand out enough to people who are more interested in recreational beaches than in the natural and man-made processes that created them. Furthermore, there is poor knowledge on the health risks linked to the consequences of climate change. Coastal erosion, salinization of the water table, capsizing of trawlers, and unsanitary conditions are among the risks which the people of the Langue de Barbarie have become aware of and that endanger the quality of life. As part of this investigation, we recommend comprehensive and in-depth studies to clearly measure the risks and determine their causes. The people of the Langue de Barbarie have a low capacity for adaptation. Health risk management consists of combating risk factors in order to reduce the likelihood of an adverse event from happening. We also advocate strengthening the existing alert and surveillance system in order to prevent any trawler from leaving the shore in the event of danger that has been reported.

This fragmented view of the Langue de Barbarie coastline also reflects a dire lack of scientific knowledge and utilization of databases on the land-sea interface. For a paradigm shift, new information must be acquired based on the prerequisites of prevention and adaptation. Adaptation entails significant adjustments that necessitate reconsidering how existing life circumstances can reverse negative patterns.

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