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IMPACTS OF CLIMATE CHANGE ON THE ENVIRONMENT IN COASTAL AREAS IN CAMEROON. A VULNERABILITY ASSESSMENT OF CLIMATE CHANGE IMPACTS

Case study: Limbe Down Beach area of the Southwest region of Cameroon

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Abstract

Climate change is a global warming phenomenon that has a significant impact on the environment. This study aims to evaluate the impact of climate change on the coastal areas of Limbe-Down Beach, Cameroon. The study area selected as a case was the vicinity of Limbe Down Beach and its surrounding areas. The aim was to investigate how climate change has impacted the population in this area. For the purpose of this study, the participants that were selected for the study were 80 respondents, including families, households, individuals, and officials. The majority of respondents (72.5%) agree that addressing climate change requires collaborative action and the adoption of more sustainable methods. There are risk factors associated with climate change in the environment such as high temperatures, frequent rainfalls, and heavy storms. More so, the study describes some human activities that are responsible for climate change, such as deforestation, and the burning of fossil fuels in industrial plants which leads to pollution and CO2 emissions. This study also shows that there has been frequent climate change impact in Limbe Down Beach which has made the population very vulnerable. It is important to implement strategies that can curb the impacts of climate change on this population but most importantly, sustainable development efforts should be made towards environmental protection.

Language: English

Key Words: Climate change, Sustainable development, Vulnerability and Resilience.

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1 Introduction

Cameroon has a long coastline drained by rivers with diverse regimes of lakes and springs. The most interesting sectors are the tidal mangrove reaches, creeks, and islands with vast amphibious colonies found in the estuaries of huge rivers, such as the Wouri, Sanaga, and Nyong. Cameroon opens into the Atlantic Ocean through the Littoral and Southwest regions respectively. The estuary of Wouri and the sea around the port city of Limbe, formerly Victoria, comprises a variety of plants and fish unmatched in Africa and continues to provide food, shelter, and income to about 5 million people in Cameroon. The importance of the biodiversity of freshwater and marine ecosystems provides a rationale for economic exploitation and the need for conservation. However, the biological productivity of marine resources along the coast has over the years been challenged by climatic factors. Future climate change stemming from anthropogenic (human) activities poses an immense challenge to stakeholders in the region.

Climate change has become a major topic of discussion and research among prominent scholars, researchers, and policymakers, this is because the issue with climate change is increasingly creating pressure on environments and the ecosystem thereby directly affecting every living thing. The frequency of extreme weather events is expected to increase over time, impacting ecosystems such as forests, mountain environments, and wetlands including mangroves which represent the coastal ecosystem bordering tropical seas (Evariste et al., 2018). In assessing coastal vulnerabilities to climate change, one has to pay attention to the increasing sea levels, coastal flooding, heavy precipitation, and its impact on the coastal environments. Climate change has a great impact on the coastal areas in Cameroon such as Douala, Limbe–Down Beach, Idenau, and many others. Usually, there are increasing sea levels, and severe floods which often lead to loss of lives, property, and land loss. The threat posed by these factors calls for immediate action to be taken in order to mitigate the effects of coastal climate crises.

According to Gargiulo et al. (2020), coastal vulnerability can be considered as the combination of sensitivity and social vulnerability of coastal areas. For this purpose, physical, socio-environmental, and socio-economic aspects of coastal areas are given attention. The analysis of vulnerability is occasionally carried out using complex indices.

Vulnerability is also strictly linked with adaptation, as the adaptive capacity is described as "the ability of systems, institutions, humans and other organisms to adjust and respond to potential damage, for example, due to weather extremes" this includes changes in land use patterns, adjustments to infrastructure, and technological adaptations. (IPCC 2001, 2014).

In the aspect of social vulnerability, features of communities as well as inequities point to an imperative factor in the ability of groups to respond to natural hazards and climate challenges (Cutter et al. 2003). Especially in coastal areas, social inequities, income, race, ethnicity, and demographic data are key factors in people's vulnerability to environmental hazards. Economic fatalities might be direct, damaging buildings, important infrastructure and their operations, or indirect, affecting local economy, causing problems in the supply chain, unemployment and investment decisions. To assess the direct costs related to natural hazards, the implementation of susceptibility functions (or damage functions) is the most frequently used method (Meyer et al. 2007). Also, economic models at local, regional or national level are used to assess indirect costs, (Meyer et al. 20107). However, it is rather difficult to define disaster cost, as it highly depends on the purpose of the assessment and the consequential uncertainties regarding the indirect cost (Hallegate and Przyluski 2010).

1.1 Problem statement

When climate change occurs around coastal areas, the inhabitants of that environment go through a lot of suffering such as being displaced, loss of lives and property, socio-economic disruptions such as loss of source of livelihood. The exposure level is affected by the land use of coastal areas, the population and social factors, the shoreline type and the existing (and planned) infrastructure.

There are social factors such as population, nationality, economic status, age, gender, household type, quality of housing and health which are all affected by this change. The dependence of many regions on touristic and recreation activities deepens the vulnerability level because the coastal areas are mainly exposed to climate change and extreme weather events, and (Bevacqua et al. 2019). This also creates an uncertain environment for touristic activities (Uyarra et al. 2005).

For the past decade, the interest in climate change and its impacts on the earth has been a major concern for researchers, scholars, governments, and policymakers. There have been so many recommendations on how to handle climate change but over the years climate change crises still occur and have major impacts on coastal environments (Filho, 2017).

This research aims to understand how local population perceive and experience climate change, as well as how they can adapt to these changes.

1.2 Research Questions

1) How does climate change impact the coastal areas of Limbe (Down-Beach) Cameroon?

2) What is the most effective strategy to reduce climate change crises in coastal areas in Cameroon?

1.3 Organization of Study

The following sections will comprise the organization of the study. The Introduction, problem statement, research questions and objectives for the study which are presented in the first section. The second section examines the body of research concerning the subject matter and the gaps in it. The third section presents the methods used in the work with an account of sources and data used. The fourth section covers the findings and the short coming, and the last section covers policy recommendations.

2 LITERATURE REVIEW

This section reviews literature from past scholars on the impacts of climate change on environment in coastal areas in Cameroon and a vulnerability assessment of climate change impacts. This section will discuss issues such as the concept of vulnerability, resilience in vulnerability, approaches to understanding vulnerability, and steps involved in the development of indicator-based vulnerability assessment.

2.1 Climate Change

“Climate” is the average of the weather situations at a particular point on the Earth. Typically, climate is articulated in terms of expected temperature, rainfall and wind conditions based on historic annotations. Climate change has been perceived to be a long-term issue; meaning it does not just come and go. “Climate change” is a change in either the average climate or climate variability that persists over an extended period (Riedy, 2016). Greenhouse gases are considered as one of the most severe causes of climate change as it impacts the earth surface. Climate change is the long-term increase in the earth's average surface temperature and the large-scale changes in global, regional, and local weather patterns that result from that increase, caused by a significant rise in the levels of greenhouse gases that are created by the use of fossil fuels (O’Brien, 2021). The definition of climate change has been contested by various scholars just as Todorov ([1986], p. 259), states that the question of climatic change is perhaps the most multifaceted and controversial in the entire science of climatology. No strict criteria exist on how many years a particular climate pattern should occur to justify the use of the words “climatic change”. There is no common opinion and agreement among climatologists on the definition of the term climate, let alone climatic change, trends or fluctuation. When talking about the climate of a particular region one is interested in the distribution of certain variables (called the climate variables) of that region. These include the dynamic meteorological variables, i.e., the variables that describe the state of the atmosphere, such as the surface air temperature or the surface pressure. In the literature one often finds the statement that climate is the expected weather.

2.2 Concept of Vulnerability

The Intergovernmental Panel on Climate Change (IPCC) defines vulnerability as "the degree to which a system is susceptible to and unable to cope with, adverse effects of climate change, including climate variability and extremes" (IPCC, 2007). The unique characteristics of a given system to climate change can vary with the vulnerability of that system including its exposure, sensitivity, and adaptive capacity. When new stressors are introduced into a study group (system), climate change can impact the system and may also exacerbate existing stressors. Factors external to the system itself may influence its vulnerability

depending on how "the system" is defined for the purpose of conducting a vulnerability assessment.

-Development patterns.

-The surrounding physical environment.

-The distribution of resources.

-Other existing stressors (IPCC, 2007).

Vulnerability analysis has changed over time drawing attention on issues associated with entitlement, diversity, and resilience. The first renders a system more or less vulnerable and relates more to human needs. The second, diversity, looks into the need for redundant functions and the third has roots in ecology, suggesting a system's ability to maintain equilibrium (even if that equilibrium is dynamic) despite exposure and contact to disturbance or stress that cannot be controlled.

The concept of contextual vulnerability, otherwise referred to as the starting-point interpretation, viewed vulnerability as a current lack of capacity of a given system to deal with the changing climate conditions. Therefore, biophysical conditions and the changing social, economic political, institutional and technological structures and processes can affect vulnerability. This approach considers vulnerability to be a “function of the character of ecological and social systems which are shaped by multiple factors and processes” (Adger N, O'Brien et al., 2007).

2.3 Risk Factors

In the framework of climate change impacts, risks result from dynamic exchanges between climate-related threats with the exposure and vulnerability of the affected human or ecological system to the threats. Hazards, exposure and vulnerability may each be an issue to uncertainty in terms of degree and probability of occurrence, and each may change over time and space due to socioeconomic changes and human decision-making (IPCC, 2020). Climate risk is the probability of adverse impacts to occur and results from the contact of hazards, vulnerability, and exposure (Oppenheimer, et al., 2014). Exposure is the existence of people and assets in an area in which hazard events may take place. In addition to the

debate about how to measure climate change risk perceptions, there are also various determinant factors of climate change risk perceptions documented in the literature. It is necessary to consider that the factors of developing countries may display somewhat different characteristics, particularly when it comes to the determinants of risk perceptions.

In order to tailor this study to the African context, a modified set of climate change risk perception determinants have been selected for inclusion such as heavy rainfalls, storms, and increasing temperatures. While explanatory factors are various, no one set of factors purports to identify 100% of the variance in climate change risk perceptions.

2.4 Impact of climate change in mangrove areas in Cameroon

Various efforts have been made to comprehend the impact of climate change and adaptation strategies in the coastal areas of Cameroon. Along the southwest coast of Cameroon, high tides, storm, flash floods, rainstorms, windstorms, and strong erosion were stated as the main natural hazards. These natural hazards have caused damage to houses, classrooms, farmland, and cars and the loss of household applications; in addition, many people have been injured or lost their lives in the process. Indicating that there is a high exposure of the populations living there, particularly to flooding. In this area, studies show that flood-triggered migration has meant the loss of around 989 hectars of mangrove forest cover due to relocation of settlements to around 3.5 km inland over the past 45 years, (Munji, et al., 2012). Similarly, the relocation of more than 1286 people has been reported analyzed in cape Cameroon following coastal erosion that caused significant coastline movement. Damage to the houses, total loss of houses, loss of farmland, loss of domestic animals, loss of agricultural crops, and landscape distortion were additional local effects.

The vulnerability of Cameroon's mangrove ecosystems in the Wouri estuary has been examined. There are some inherent vulnerabilities due to the low tidal amplitude of the area which has been reported although the mangroves of the Douala estuary in Cameroon have an overall resilience, (Evarist et al, 2018). The increase in vulnerability was evident due to the decreasing and irregular rainfall patterns, the increased occurrence of extreme climatic events, and the increased levels of coastal erosion. These factors resulted in several effects, including a low adaptive capacity. The interaction between adaptation and

mitigation directed to a way to advance resilient responses. In coastal areas, exploring adaptation options requires an evaluation and understanding of existing vulnerabilities.

2.4.1 Understanding adaptability.

Adaptive capacity is an important component of long-term adaptation to climate change. Adaptive capacity needs the assessment and degree of different characteristics inherent in its system to identify probable solution paths and tools to mitigate and manage risk. The adaptive capacity has been regarded as a part of a broader resilient model (Jones et al., 2017). The three ways to build resiliency in communities are:

a) Reduce exposure

b) Reduce sensitivity

c) Increase adaptive capacity.

Vulnerability describes the analysis to measure powerlessness, marginality, and how susceptible a group or individual can be to a harmful situation being caused by multiple stressors and pathways (Adger, 2006). It has become a central concept to climate change research as its effects are being widely observed and the development of vulnerability assessments are being used to raise awareness, develop policies, and monitor adaptation measures. Many adaptation measures need to happen at the local level, so rural communities and cities have a big role to play. Such measures include planting crop varieties that are more resistant to drought and practicing regenerative agriculture, improving water storage and use, managing land to reduce wildfire risks, and building stronger defenses against extreme weather like floods and heat waves.

2.4.2 Literature Gap

Climate change has been discussed by various scholars, world organizations and researchers overtime and most importantly issues such as impact of climate change, vulnerability assessment, resilience, adaptability and causes of climate change has been discussed and analyzed in many societies and cities all over the world. It is important to note that climate

change risk factors, causes and management may vary from country to country and society to society depending on political, geographical, environmental and socio-economic factors.

In Cameroon, some previous vulnerability assessments have been carried out in the Littoral region, focusing on climate change. However, very few of these studies have quantitatively and holistically measured the vulnerability level of the entire social-ecological system, including analyzing their spatial differences. Although little or nothing have been done with regard to the Limbe city coastal area, Down beach; considering that the population who inhabit the areas close to the sea have been exposed to many sorts of hazards caused by climate change. This study intends to carry out research on this area and close the gap by contributing to knowledge drawn from the research. Also, considering how much vulnerability is perceived in the Limbe- Down Beach coastal Area, the government and concerned bodies does little or nothing manage the impact of climate change in this area. Hence, this research is taken up to create a vulnerability assessment on the population or inhabitants of the Limbe Down Beach coastal area.

3 RESEARCH METHOD

This chapter includes the research method used to carry out the research in the study area. In more details, the following are outlined; research design, research approach, population, area of study, selection of sample and sampling technique, sources of data, data collection instruments, and finally method of analyzing data.

3.1 Research Design

In order to satisfy the objectives of this research work, a quantitative research design (method) was used for the study. The reason for choosing a quantitative research design is that it classifies features, counts them to explain what is observed as it seeks to know the impact of climate change on the lifestyle of the population. A descriptive quantitative design was used to carry out this study. This method is conclusive in its purpose as it tries to quantify the problem and understand how prevalent it is by looking for projectable results to a larger population.

3.2 Research Approach

A case study research design was used for this study. The selected area as a case study is the Limbe Down Beach vicinity and its environs to evaluate the vulnerability assessment impact that climate change has on the population. This area was chosen because it is very close to the sea and more vulnerable to climate change impacts within the Limbe municipality. The research begins with observation, followed by the collection and analysis of statistics to be drawn and conclusions made.

3.2.1 Study Area

The study was carried out in Cameroon, and the case study area is Limbe. Limbe, also known as Limbé (and as Victoria from 1858 to 1982), is a seaside city in the South-West Region of Cameroon. According to the 2005 Census, the population was 84,223. The Southwest regions official language is English, although French is spoken due to the city's geographic proximity to Douala, where the official language is French. Most of the population speaks English and Cameroonian Pidgin English. The native language of the region is Bakweri and a smaller group from Wovia and Bimbia speak Bimbia or Isubu. Limbe is located on a bay against the backdrop of a major mountain range. Black sand beaches make Limbe one of two coastal towns (Kribi being the other) that are popular among Western tourists. Attractions include the Limbe Wildlife Centre and Limbe Botanical Gardens also the Bimbia slave trade route. Limbe is also home to a small port which offers ferry services to Calabar Nigeria, Bakassi and Douala. There were plans to upgrade it to a fully equipped commercial deep sea port with the creation of the Limbe Port authority, but several delays and the ongoing Anglophone Crisis have kept the project in uncertainty. Limbe is the center of Cameroon's oil industry. Other important industries are fishery and tourism. The Port of Limbe is one of four commercial ports in Cameroon).

3.3 Sources of Data

For these studies, I used both primary and secondary sources of data to complete the work. For primary data collection, questionnaires were drawn up and distributed to the concerned population, which were analyzed when collected. For secondary sources, the researcher made use of published works, books, articles, and journals, all of which were connected to the subject matter. By collecting existing data, comparing, and analyzing it, this helped me gain valuable insights into the subject matter.

3.4 Sample Size and Sampling Techniques

3.4.1 Sample Size

For the purpose of the study, 80 respondents were selected, including families, households, individuals, and officials from the Limbe Down Beach environs (Figure 2)

3.4.2 Sampling Technique

The sampling technique is the procedure used to collect elements from a population in a way that accurately represents the characteristics of the entire population selected for the study. For this research, I chose the inhabitants of Limbe Down Beach because they have experienced the impact of climate change in this area. My brother, who lives there, assisted me in collecting data for this research began by identifying families and individuals who have resided in the area for more than 5 years and have been affected by climate change vulnerabilities such as floods, erosion, or high tides be it on their properties or agricultural land. This data collection took place during the months of March and April 2024.

3.4.3 Population

The population of the study covers all individuals or things or elements that fit a certain specification, which means all the items under consideration in any field of inquiry to contribute. In this case the population of this study includes all the inhabitants of Limbe Down Beach area (Figure 2) who have been experiencing the high tides of the sea and have had to suffer impacts of flood on their environment.

3.5 Data Collection tools

The instrument used for data collection was unstructured questionnaires which contained a total of 17 questions which were drawn up to gather information about the experiences of the population that lives in the Limbe Down-Beach area. In addition, questionnaires gave the researcher enough flexibility and room to maneuver and ask extra/follow-up questions so that the person we were interviewing could clarify unclear issues (Appendix 1).

3.6 Method of Analysis

For the methods of analysis used, the data was sorted, categorized, connected, and interpreted. The open-ended questions were coded and analyzed accordingly. I couldn't record every response given because some respondents were elderly men and women and unable to write on the distributed questionnaires. Therefore, I filled out the questions for them based on their responses to each question. I began by transforming raw data into information that provided valuable insights into the subject matter. This was necessary because we were dealing with a large number of respondents, more than 50 individuals. Conclusions were drawn from the review of past research works in the area of study, and the data was presented in tables.

4 RESULTS

4.1 Demographic factors

From (Table 1) below, it can be observed that the majority of the respondents are female, while the rest are male. This is primarily because women were more prevalent in the population under study. Furthermore, women tend to experience vulnerability issues more frequently, which is why the researcher was particularly interested in capturing their real-life experiences.

Table 1 Gender of the respondents

Gender	**Male**	**Female**	**Other**	**Total**
No of people	38	42	0	80

Percentage %	47.5	52.5	0	100

As shown in (Table 2), the ages of the respondents range from 20 years to 56 years and above. The researcher selected these age groups to gather accurate information, considering that individuals within these age brackets can effectively articulate their life experiences. As indicated in (Table 2), the highest percentage of respondents (52.5%) were aged between 36 and 55 years. This suggests that these people have resided in Limbe Down Beach area for an extended period and have experienced climate change. **Table 2 The showing the age range of the respondents**

Age range	**Number of people**	**Percentage (%)**
20-35	28	35
36-55	42	52.5
56+	10	12.5
Total	80	100

As shown in (Table 3), the majority of respondents (55%) are married. The study primarily focuses on married couples, as they typically have families and can better explain the issue of climate change vulnerability.

Table 3 Marital status of the respondents

Marital status	**Number of people**	**Percentage (%)**
Single	32	40
Married	44	55
Divorced	02	2.5
Widow	02	2.5
Total	80	100

Furthermore, (Table 4) below indicates that the respondents constitute the highest number of income earners. They were selected by the researcher due to their ability to provide

tangible data regarding the impacts of climate change on themselves and their properties.

Table 4 Income earned by farmers

Income earned	Number of people
15,000-25,000	5
25,000-35,000	28
35,000-45,000	11
65,000 and above	36
Total	80

4.2 RESEARCH OBJECTIVE

4.2.1 How does climate change impact the coastal areas of Limbe (Down-Beach) Cameroon?

As seen in (Table 5), 97.50% of the population agrees that there have been climate changes at Limbe Down Beach in the past decade.

Table 5 Climate change impacts as perceived by the respondents and the number of people affected.

Climate change impact	Number of people affected	Percentage (%)
YES	78	97.5
NO	02	2.5
Total	80	100

4.2.2 The different climate change impacts that have occurred in your environment recently

As seen in (Table 6), flooding is a more frequent climate event that occurs on Limbe Down Beach, with 50% of the population agreeing to this. Flooding events have become more frequent in the area, leading to an overflow of water onto land and causing damage to infrastructure, property, and agricultural areas. These floods can be attributed to increased rainfall intensity or changes in drainage patterns.

According to the perceptions of the respondents, the area has also experienced erosion, which refers to the gradual wearing away of land or coastal areas due to the action of wind,

water, or other natural processes. Erosion can lead to the loss of land, the degradation of ecosystems, and the displacement of communities.

Furthermore, based on the research and the respondents' perceptions, the frequency of high tides has increased in the Limbe-Down Beach area. High tides, also known as tidal surges, can result from various factors such as sea-level rise, changes in ocean currents, or atmospheric conditions. These high tides can lead to coastal flooding, saltwater intrusion into freshwater systems, and coastal erosion.

Table 6 The table shows climate change impacts that have occurred in your environment.

Climate change impact	Number of people affected	Percentage (%)
Flood	40	50
Erosion	24	30
High tides	16	20
Total	80	100

4.2.3 Human activities are responsible for climate changes

As shown in (Table 7), a majority of the respondents agree that human activities are responsible for climate change in the Limbe Down Beach area.

Industrialization, which involves large-scale production and consumption of goods, can significantly contribute to climate change. Industrial activities often depend on fossil fuels, resulting in substantial greenhouse gas emissions. Furthermore, industrial processes can release other pollutants, such as aerosols and particulate matter, which can have both direct and indirect effects on the climate system.

Table 7 The table shows if human activities are responsible for change climate change.

Human activity	Number of people affected	Percentage (%)
YES	52	65
NO	28	35

Total	80	100

4.2.4 Climate change poses a threat to you and your environment.

As seen in (Table 8), a larger proportion of the respondents (85%) agree that climate change poses a threat to their environment.

Table 8 Respondents' perceptions on climate change threats to the environment.

Threat to environment	Number of people affected	Percentage (%)
YES	68	85
NO	12	15
Total	80	100

4.2.5 The risk factors that contribute to climate change in your environment

In (Table 9), a majority of the respondents (60%) agree that there are risk factors associated with climate change in the Limbe Down Beach area. These risk factors can vary and have different impacts on various groups and aspects of society. Based on the data provided, the following risk factors can be identified:

Table 9 Respondents' perceptions on risk factors that contribute to climate change.

Threat to environment	Number of people affected	Percentage (%)
YES	48	60
NO	32	40
Total	80	100

In (Table 10), the majority of respondents (53.3%) perceive increasing temperatures as a risk factor associated with climate change. Rising global temperatures can have widespread impacts, including more frequent and severe heatwaves, changes in precipitation patterns, and altered ecosystems. Higher temperatures can also lead to health risks, particularly for vulnerable populations such as the elderly, people with pre-existing health conditions, and

those living in urban areas with limited access to cooling infrastructure. Meanwhile, 30% of the population agrees that heavy storms are a risk factor contributing to the persistent and increasing climate changes occurring in the Limbe Down Beach environment. A few of the respondents (16.7%) believe that frequent rainfall is a risk factor associated with climate change.

Table 10 Risk factors that have contributed to climate change based on the respondent's perception.

Risk factor	Number of people affected	Percentage (%)
Increase temperature	32	53.3
Heavy storms	18	30
Frequent rainfall	10	16.7
Total	60	100

4.2.6 The most affected by climate change in your environment.

From (Table 11) below, it shows that a significant portion of the respondents (43.75%) agree that elderly people are the most affected when climate change crises impact the environment. This is because they often find it difficult to move during a climate change event, and their weak immune systems make them vulnerable to illnesses. As mentioned earlier, the elderly are often more susceptible to heat-related illnesses due to their reduced ability to regulate body temperature. They may also face challenges in evacuating during extreme weather events due to limited mobility or reliance on assistive devices. Preexisting health conditions, which are more common among the elderly, can be exacerbated by climate change impacts, leading to increased health risks. Social isolation and limited support systems may further compound their vulnerability during climate-related events. Approximately 28.75% of respondents identify children as a group at risk associated with climate change. Children are particularly vulnerable to the impacts of climate change due to their physiological and developmental characteristics. They may face increased risks of heat-related illnesses, malnutrition, infectious diseases, and displacement due to extreme weather events. Climate change can also disrupt access to education, affect mental health, and limit opportunities for future generations. About 27.5% of respondents consider individuals with disabilities as a group at risk associated with climate change. People with

disabilities may face additional challenges in adapting to climate change impacts due to physical, sensory, cognitive, or mobility limitations. They may have difficulties accessing emergency services, evacuation routes, or healthcare facilities during extreme weather events. Additionally, changes in environmental conditions can exacerbate existing health conditions and limit their ability to cope with climate-related risks.

Table 11 The number of respondents affected by climate change in their environment.

Risk factor	Number of people affected	Percentage (%)
Elderly	35	48.75
Children	23	28.75
Disability	22	27.5
Total	80	100

4.2.7 How adaptive are you on a scale of 1-10 to climate change in your environment?

The majority of respondents (42) perceive the adaptive capacity to climate change in their environment to be low, as indicated by their rating of 2. This suggests that they believe the environment has a limited ability to adapt and respond effectively to climate change impacts.

Additionally, there are 18 responses indicating a rating of 4, which suggests a moderate level of adaptive capacity. This could indicate that some measures or initiatives are being taken to address climate change impacts, but there is still room for improvement.

It is worth noting that there are no responses for ratings 6, 7, 8, 9, or 10, which could indicate a general perception that the environment's adaptive capacity to climate change is relatively low or inadequate.

4.2.8 Statement for solution

In (Table 12), the majority of respondents (72.5%) agree that addressing climate change requires collaborative action and the adoption of more sustainable methods. This indicates a recognition that individual efforts alone may not be sufficient, and collective action is necessary to mitigate and adapt to climate change. However, a significant minority (27.5%)

disagrees with this statement, suggesting that there may be differing opinions on the importance of collaboration and sustainability in tackling climate change. The overwhelming majority of respondents (93.75%) agree that there is a need for increased public awareness and education on climate change adaptation strategies in coastal communities like Limbe-Down Beach. This indicates a recognition of the importance of informing and educating the public about the impacts of climate change and the measures that can be taken to adapt and mitigate its effects. The small percentage of respondents (6.25%) who disagree may have differing perspectives on the necessity or effectiveness of public awareness and education initiatives. The majority of respondents (83.75%) express willingness to participate in community initiatives aimed at addressing climate change impacts on coastal environments in Cameroon. This indicates a positive inclination towards community engagement and collective efforts to tackle climate change. However, a notable proportion of respondents (16.25%) indicate a lack of interest or willingness to participate, suggesting potential barriers or differing priorities.

Table 12 Statement for solution questions and responses

Questions asked a number of responses	YES	NO
A solution to climate change involves a collaborative action which includes a more sustainable method.	58 (72.5%)	22 (27.5%)
There is a need for increased public awareness and education on climate change adaptation strategies in coastal communities like Limbe-Down Beach.	75 (93.75%)	05 (6.25%)
Everyone should participate in community initiatives aimed at addressing climate change impacts on coastal environments in Cameroon.	67 (83.75%)	13 (16.25%)

4.3 Discussion of Findings

This study on the impacts of climate change on the environment in coastal areas in Cameroon a vulnerability assessment of climate change impacts; a case of Limbe Down Beach, reveals the climatic conditions of the Limbe coastal areas especially during climate change. The data collected from the field provides detailed responses for the two research questions asked. The first research question, how does climate change impact the coastal

areas of Limbe (Down-Beach) Cameroon. Data collected from the field reveals that most of the respondents agree that there have been recent climate changes in the Limbe coastal area and also gave the following as climate change events: floods, erosion, and high tides which are common occurrences in the area, especially during the rainy seasons (Table 6). The study also reveals that the frequent climate changes at Limbe Down Beach renders the local population highly vulnerable. Also, the data collected from the field shows that human activities are responsible for climate change such as the emission of greenhouse gases (GHGs) which is a significant factor. Human activities like burning fossil fuels (coal, oil, and natural gas) for energy production, transportation, and industrial processes release carbon dioxide (CO2), methane (CH4), and nitrous oxide (N2O) into the atmosphere was noted. These GHGs trap heat, contributing to the earth's surface warming and leading to climate change. Sea pollution, especially through the discharge of industrial and domestic waste, which can indirectly affect the climate was also noted. For example, releasing pollutants into water bodies can disrupt marine ecosystems, leading to biodiversity loss and the release of stored carbon in coastal ecosystems. Additionally, sea pollution can contribute to ocean acidification, which affects marine organisms and disrupts the balance of marine ecosystems. However, some of the respondents believe there could be other natural factors responsible for climate change.

Moreover, the study also answers the second research question: What is the most effective strategy to reduce climate change crises in coastal areas in Cameroon? Firstly, the study reveals that the Limbe coastal areas are exposed to climate change occurrences. It also identifies risk factors associated with climate change, such as high temperatures, frequent rainfall, and severe storms (Table 10). This reveals the perceptions of the population who believe that the Limbe coastal area is vulnerable to such occurrences. In addition, data collected from the field most of the respondents (83.75%) agree that there is a need for public awareness and collaborative action with the local population to help mitigate the impact of climate change within the Limbe Down-Beach area (Table 12). The data collected from the field shows that a majority of the population is unable to adapt and cope with climate change occurrences.

Finally, the impacts of climate change on the environment, particularly in the coastal areas of Cameroon such as Limbe Down Beach, have not been extensively studied. However,

similar research studies have been conducted in other coastal regions of Cameroon. For instance, places like Kribi and Douala have experienced significant shoreline erosion, flooding, and habitat loss due to rising sea levels and increased storm intensity. Vulnerability assessments conducted in these areas reveal that their coastal regions are highly susceptible to socio-economic disruptions, with industries such as fisheries and tourism facing severe threats. Research carried out in the Wouri Estuary emphasizes the compounding effects of pollution on climate change, leading to degraded water quality and health hazards for local populations. Comparative research analysis shows that the ability of these populations to adapt is often limited by inadequate infrastructure, insufficient policy implementation, and limited public awareness. Across these regions, communitybased adaptation strategies have been highlighted as essential, involving both the government and local stakeholders in resilience-building efforts. However, this study has several limitations.

- The study covers issues related to vulnerability assessment. However, the researcher was unable to assess the tools for measuring vulnerability. Consequently, the responses given by the participants were based on their perceptions.

- Secondly, climate change is a comprehensive subject that encompasses many aspects. However, this study is limited to the impact of climate change on the Limbe Down Beach coastal area. Therefore, issues such as the impact of climate change on health, the economy, politics, and so forth were not included.

- Finally, the availability and quality of data were not guaranteed, as most of the data used for the study were merely information collected from participants.

5 Conclusions and Recommendations

This section presents a summary of the entire findings and suggests important recommendations to consider.

5.1 Conclusion

The Limbe Down Beach coastal environment is a vibrant and economically significant region that attracts tourists and other business ventures. The communities of Limbe Down Beach

have experienced and suffered from various climate changes and their impacts over the years. This study shows that the population lacks the adaptive capacity to be resilient to the impacts of climate change in their environment. The researcher encourages that more studies should be carried out in this environment to ascertain the real causes of climate change and measures taken to reduce the risk factors noted in the study and mitigate the consequences of climate change on this population. This could reduce climate change in this environment and boost the city's opportunities.

5.2 Recommendations

To mitigate the effects of climate change in the Limbe Down Beach area, several adaptation strategies are to be implemented. These include:

- Encouraging afforestation and reafforestation of the mangrove forests. By planting mangrove trees in degraded coastal areas, we can create a natural defense against coastal erosion. Additionally, mangrove forest promotes carbon sequestration and biodiversity conservation in coastal areas.

- By promoting the use of renewable energy sources such as solar panels and biogas for cooking and electricity generation in rural areas, we can reduce our dependence on fossil fuels and mitigate greenhouse gas emissions.

- Furthermore, we can enhance climate change education and awareness among the population by implementing community-based education programs. These programs aim to raise awareness about the impact of climate change on rural communities. They may also include training programs for farmers on sustainable agriculture practices.

- The Limbe Sea Down Beach should be protected from waste being dumped around the coastal area of the sea by the surrounding population. Strict measures and punishments, if necessary, should be enforced for offenders.

- Promoting climate-resilient agriculture involves creating a robust system for agriculture, forestry, and land use to combat climate change. This system should

incorporate strategies for both adapting to and mitigating the effects of climate change, while also promoting sustainable development across all agricultural and ecological areas of the country.

- Lastly, the planting of coconut trees along the banks of the open sea to help reduce coastal erosion.

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Appendix 1

QUESTIONNAIRE

In the context of my bachelor's degree thesis studies at the Novia University of Applied Science in Ekenas, I am carrying out research on "Impacts of climate change on environment in coastal areas in Cameroon. A vulnerability assessment of climate change impacts. " This is the final stage for completing my degree studies in Sustainable Coastal Management, and whatever information you supply will be kept in strict privacy and used just for my academic purpose and nothing else. Kindly respond accurately and truthfully to each of the following questions.

Instructions: Please tick **(✓)** the circle next to the answer of your choice or write your response in the space provided.

I - Demographic information (Information that describe the populations and their characteristics in our study area Limbe-Down Beach in Cameroon)

1. Gender

A. Male ◯ B. Female ◯

2. Age

A. 20-35 ◯ B. 36-55 ◯ C. 56+ ◯

3. Marital Status

A. Single ◯ B. Married ◯ C. Divorced ◯ D. Widowed ◯

4. Income Level

A. 15000 - 25000frs ◯ B. 25000 – 35000frs ◯ C. 35000 – 45000frs D. 60000frs and above

II – Research Question: How does climate change impact the coastal areas of Limbe (DownBeach) Cameroon?

5. Have you been impacted by climate change in your environment, or have you noticed any changes in weather patterns at Limbe-Down Beach over the past decade?

Yes ◯ No ◯

6. If YES, can you list the different climate changes that have occurred in your environment recently?

……

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……

7. Do you agree that human activities are responsible for climate change?

Yes ◯ No ◯

8. If YES, can you name some of these activities

……

……

……

9. Do you think climate change poses a threat to you and your environment?

Yes ◯ No ◯

10. Are there risk factors that contribute to climate change in your environment? Yes ◯

No ◯

11. If YES, what do you think are the risk-factors?

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……

……

12. Who do you think is more affected by climate change in your environment?

……

……

……

13. From a scale of 1-10, how adaptive are you to climate changes in your environment?

1◯ 2◯ 3◯ 4◯ 5◯ 6◯ 7◯ 8◯ 9◯ 10◯

14. Do you think a solution to climate change involves collaborative action which includes a more sustainable method?

Yes ◯ No ◯.

15. Do you think there is a need for increased public awareness and education on climate change adaptation strategies in coastal communities like Limbe-Down Beach?

Yes ◯ No ◯.

16. Do you think that adequate measures are being taken to mitigate the effects of climate change on coastal communities in Cameroon?

Yes ◯ No ◯.

17. Would you be willing to participate in community initiatives aimed at addressing climate change impacts on coastal environments in Cameroon?

Yes ◯ No ◯.