Vulnerability and Adaptation to Climate Change: Understanding and Awareness Among Coastal Communities in The Gambia

BY

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

LIST OF ACRONYMS

AI	Adaptive Capacity Index
AR6	6TH Assessment Report
BMBF	Federal Ministry of Education and Research
CBO	Community based organisation
CC	Climate change
CCF	Christian Children's Fund
CCVI	Climate change vulnerability index
CIESIN	Center for International Earth Science Information Network
COP	Conference of Parties
CSO	Community service organisation
EI	Exposure index
FAO	Food and Agriculture Organisation
GBOS	Gambia Bureau of Statistics
GHG	Greenhouse gas
GIS	Geographic information system
HDI	Human Development Index
I	Impact
IPCC	Intergovernmental Panel on Climate Change
LCC	land cover change
LECZ	Low elevation coastal zone
LULC	land use land cover
MAX	Maximum

MIN	Minimum
NAWEC	National Water and Electricity Company
NDMA	National Disaster Management Agency
NEA	National Environment Agency
NGO	Non-governmental Organisation
SI	Sensitivity index
SoVI	Social vulnerability index
SVM	Support Vector Machine
UNDP	United Nations Development Program
USGS	United States Geological Survey
V	Vulnerability
WACA	West Africa Coastal Areas Management Program
WASCAL	West African Science Service Centre for Climate Change and Adapted Land Use
WHO	World Health Organisation
WMO	World Meteorological Organisation

ABSTRACT

The coastal zone of The Gambia provides important ecosystems services, including habitats and breeding grounds for aquatic animals, plants and migratory birds. This area is vulnerable to climate change hazards as cited in literature. Therefore, this study aims to assess the awareness and understanding of climate change among coastal communities in The Gambia and their level of vulnerability and adaptation to climate change. The research utilised Landsat imageries of the years 1990, 2000, 2010 and 2020, freely downloaded from the United States Geological Survey (USGS) website to evaluate the extent of land cover transformation along the coastal zone. Mann–Kendall trend test and Sen's slope estimator were utilized to assess the trend and slope magnitude of key climate variables (i.e. total annual rainfall (mm), minimum temperature, maximum temperature (^{o}c), windspeed (knots) and relative humidity (%)) along the coast. Furthermore, climate change vulnerability index assessment was conducted to evaluate and compare the vulnerability of coastal cells to extreme climate events from 1990 to 2020. Finally, qualitative approach was used to assess the level of participation of state and non-state actors in building resilience to climate change. The findings of the research had demonstrated that the coastal environment had undergone significant modifications as a result of multiple stressors within the last 30 years. The extent of transformation for each of the land cover characteristics indicated an increase in barren land by 46% and built up by 680% and a decrease in vegetation cover by 35%, water bodies by 31% and wetlands by 14%. Consequently, these changes are associated with increased human population around 10-25km of The Gambia's coastline from 1990 to 2020. The results further showed an increasing positive precipitation (mm), maximum and minimum temperature (^{o}c) trends along the coastal zone. Furthermore, the study shows that there is low level of climate change understanding (31%) among coastal communities even though majority (78%) are aware of climate change. Moreover, the coastal zone of The Gambia on average is vulnerable to climate change with a vulnerability index score of 0.58 and an exposure index of 0.57. However, the differences in adaptive capacity and socio-economic characteristics of the coastal households had resulted to differences in sensitivity, exposure and vulnerability observed among the study cells. With the limited ability of individual households to adapt to the varying consequences of climate change and with insufficient interactions and support from state and non-state actors in building resilience to climate change, these communities also lack organisational structures to enable them to tackle climate change issues affecting their livelihood. Therefore, there is need for mobilisation of appropriate level of capacity, funding, diverse skills and knowledge systems within households, communities and state and non-state institutions to address the socioeconomic and environmental hazards affecting the coastal environment and inhabitants.

Key words: Vulnerability, Adaptation, Exposure, Coastal Zone, Population

CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

It is generally understood that coastal regions are vulnerable to harmful environmental changes such as coastal erosion, deforestation and habitat fragmentations in developing countries resulting to multiple climate hazards. In this regard, expected adaptation programs to prevent these environmental degradation does not require waiting for specific climate scenarios, but must be more dependent on the assessment and understanding of existing threats and the various adaptation and mitigation approaches (Mustelin *et al.*, 2010).

The coastal zone of The Gambia is a region of socioeconomic importance where various activities including tourism, artisanal fishing, cultural and aesthetic and religious activities are prevalent. The coastal zone also serves important ecosystems services, including habitats and breeding grounds for aquatic animals, plants and migratory birds. Diverse activities are increasing along the coast and inland parts of the river Gambia which are threatening the livelihood of communities within the coastal zone. These activities are supported largely by individuals, Government and International organisations.

However, there is inadequate understanding of the effect of these activities on the coastal ecosystem as well as the livelihood of individuals living around these environments. Some of these activities include establishment of aquaculture farms along the estuary areas, building factories as well as exploitation of plants (mangroves) by communities used as firewood for cooking and construction which these communities depend on for their daily livelihood sustenance. Most of these activities along the coastal and inland water environment including sea level rise, flooding of coastal and inland habitats, and

phytoplankton death due to high temperature among others will increase the climate change risk and challenges on coastal communities and the environment.

Furthermore, impacts of land cover change and several other climate and non-climate stressors manifesting at global and local scales are stressing ocean ecosystems, making it difficult for aquatic organisms to adapt to changes in their natural environments (Dermawan, 2022). As the demand for marine and freshwater resources and their habitats continue to grow in The Gambia, opportunities to conserve much of the coastal land and water environment will fail. This has also resulted to increase in coastal population which is complemented by high infrastructural development, mining, and exploitation of coastal resources ultimately posing significant challenge to coastal inhabitants. However, this observed degradation of the coastal environment will continue to exert an increasing adverse effect well into the future no matter how hard we contest the process of land modification.

Considering the ongoing environmental degradation coupled with limited urbanization planning procedures, the coastal zone of The Gambia and its inhabitants are highly exposed and sensitive to the dangers associated with climate change. Although coastal inhabitants believe and are aware that the climate is changing within the last thirty years, majority of them lack sufficient knowledge and understanding required to relate these changes to the various harmful activities, and environmental degradation observed within their environment.

Additionally, the evaluation of climate and non-climate stressors of the coastal environment requires an understanding of the environmental changes due to multiple stressors at different period, which is necessary to determine the future interactions between

climate and non-climate impacts on coastal environments (Ostrowski *et al.*, 2021). While anthropogenic impacts of climate change are often difficult to change in the short term, individuals and families in coastal communities should be put in the forefront in the efforts to mitigate the impact of climate change. This is because communities might serve as practical linkage between individual and other organisations investing in climate actions. Therefore, expected adaptation programs to prevent the environmental degradation along the coastal zone of The Gambia does not require waiting for international support, but must be more dependent on the efforts and ability of all stakeholders including households, communities, state and non-state organisations.

Therefore, there is need for further research that specifically aims to assess the vulnerability of the coastal zone of The Gambia and help to provide appropriate means of understanding the impact of land cover degradation, climate variability and population growth on the coastal ecosystem.

1.2 Statement of Research Problem

It has been established that the coastal zone is vulnerable to climate change effects and the changes in land cover modification, climate variability and population growth observed currently will negatively impact the coastal environment and its inhabitants in The Gambia (Amuzu et al., 2018a, b, c; Belford *et al.*, 2020; Gomez *et al.*, 2020). These studies also highlighted significant levels of exposure and sensitivity of the households to climate change as well as the limited adaptive capacity of majority of the households to tackle the impacts of climate change. However, they further recommended that the public should be informed about the dangers of living in coastal lowlands that are affected by various

anthropogenic activities and climate extremes such as sea level rise, saltwater intrusion, flooding, erosion, high temperature and tropical windstorm.

In this regard, it is noted that without timely public education about the impacts of climate change, reducing future risks and vulnerability of households would be a great challenge. Furthermore, there is limited assessment of the level of vulnerability as well as the level of climate change understanding and awareness of coastal households in literature in The Gambia. This is necessary to guide the government and relevant stakeholders in providing more reliable and effective programs that would protect the environment and the coastal communities from climate change hazards and help in allocating priorities for funding and development projects within the coastal zones.

1.3 Research Questions

1. What are the climate and non-climate stressors on the coastal communities of The Gambia?
2. What are the level of believe, awareness and understanding of climate change among coastal households in The Gambia?
3. What is the level of vulnerability of the coastal zone of The Gambia to climate change?
4. What is the level of state and non-state actor participation in climate change adaptation and mitigation along the coast of The Gambia?

1.4 Objectives of the Study

1.4.1 General Objective

This study investigates the awareness and understanding of climate change and the level of vulnerability and adaptation to livelihood stress due to climate and non-climate hazards among coastal communities in The Gambia.

1.4.2 Specific Objectives

1. Determine the climate and non-climate stressors along the coastal zone of The Gambia.
2. Evaluate the believe, awareness and understanding of climate change among the coastal communities in The Gambia
3. Determine the level of vulnerability of coastal communities in The Gambia to climate change
4. Assess the level of participation of state and non-state actors in The Gambia in building coastal resilience to climate change

1.5 Scope of the Study

The study was conducted to assess the vulnerability and adaptation to climate change and the level of climate change awareness and understanding among coastal communities in The Gambia. This area extends from Buniadou point and Kerenti bolong in the north to the mouth of Allanhein in the South of the coastal zone of The Gambia. The area is divided into nine units called cells (Figure 3.1) based on the geomorphic characteristics of the sandy beaches and their surrounding environments as well as the level of vulnerability to sea level rise. The estimated population in 2010 was 1.9 million with annual growth rate of 2.6%

(CIESIN, 2021). However, 37% of the estimated total population were residing within 10-25km of the coastline by 2020 (Table 3.1). These characteristics served as part of the basis for selecting the studied cells during the household survey.

Furthermore, Land cover change analysis and climate variability analysis were conducted to determine the climate and non-climate stressors along the coastal zone of The Gambia. Binary logistic regression modelling was conducted to assess the main factors that influence the understanding of households to climate change and climate change vulnerability index analysis was also conducted to evaluate the vulnerability level of each of the coastal cells studied and to compare the cells based on their exposure, sensitivity, and adaptive capacity and vulnerability index. Subjective assessment was conducted to evaluate community resilience to climate change and the state and non-state actor participation in building resilience to climate change along the coastal zone.

The study was conducted for a duration of 3 years. The first year was spent on developing the proposal, conducting of review on the research topic and learning the appropriate models and approaches for the research design and analysis techniques.

The study was organised in different chapters where each of these chapters buttressed climate change issues affecting coastal communities in The Gambia. Chapter one discussed the background of the study on the coastal zone of The Gambia as a region of socioeconomic importance where varying activities supported by individuals, state and non-state organisations are exerting considerable adverse impacts on coastal people and the environment. The chapter further highlighted the statement of the research problem, research questions and the research objectives. The significance and justification of the study is also presented highlighting the basis for assessing land cover change, climate

variability, population growth and the understanding of the coastal households to climate change as well as the state and non- state actor participation in building climate resilience within the coastal zone of The Gambia.

Chapter two emphasised the literature review on previous studies conducted on the awareness and understanding of coastal zones to climate change and their level of vulnerability and adaptation. In this chapter, a detailed conceptual framework is outlined characterising and explaining various concepts of climate change, vulnerability, adaptive capacity and building resilience relevant to the study as well as established the relationship between these concepts in climate change nexus. The chapter also highlighted the empirical review drawing facts from previous studies to assist in providing answers to the main questions of the research. To establish the existing theories for the assessments of the issues to be investigated, theoretical review was also conducted in this chapter providing the basis of assessment models. The chapter finally points out the existing gap in literature and the theoretical framework to guide the development of this study.

Chapter three represents the methodology of the study considering the research design, area and population of the study. The technique utilised for the sample size determination was also discussed as well as the types and sources of data collected. Definition and measurement of variables and the validity and reliability of the research instrument as well as the methods employed to analyse the data.

Chapter four consists of the presentation and analysis of the data obtained for the research and the discussion of the results of the study. In the result section, presentation of analysis of data were stated in a logical pattern beginning with socio-demographic characteristics of respondents followed by data presentation on research issue's objective

by objective. This was followed by the discussions on the findings of the study and then the main problems encountered in the field during the collection of relevant information for the study.

The summary, conclusion and recommendations of the study were presented in chapter five and this chapter further discusses the contribution of the research to knowledge and the suggestions for further study. The document is concluded with the references and appendices.

1.6 Significance of the Study

To prioritise the existing and projected exposure, sensitivity and adaptive capacity of the coastal zone of The Gambia to climate change effects, there is need to highlight a basis for land cover change, climate variability and population growth with the understanding of their vulnerability and adaptive capacity to climate change hazards. This will help to determine the level of vulnerability of coastal communities to livelihood stress resulting from climate hazards and its effects on the coastal environment.

Nevertheless, while individuals, communities, state and non-state actors are working to address climate change impacts, it is evident that there is need for the study on the understanding of the causes of these impacts and formulate relevant policies and strategies to reduce further damage to the coastal communities, ecosystems, and the biodiversity they support. This will also help relevant stakeholders in formulating effective policies and programs needed to understand the level to which these ecological systems and inhabitants will be affected and aid in the development of climate change adaptation programs and projects.

Furthermore, analysing population growth and working towards proper urbanization planning procedures will help to influence relevant stakeholders in The Gambia in addressing climate change effects and thereby leading to better interventions by government, national and international partners. Therefore, the understanding of the multiple stressors, facilitated more by human activities on the coastal zone will be a motivating factor for proper policy development in protecting the coastal communities, environment and the biodiversity they contained.

CHAPTER TWO

LITERATURE REVIEW

2.1 Conceptual Review

Vulnerability in climate change research has been reviewed and conceptualized in various reports by the Intergovernmental Panel on Climate change (IPCC), Food and Agriculture Organisation (FAO), United Nations Development Program (UNDP), and scientists and researchers from all disciplines, usually in relation to specific situations (Füssel, 2007). The three main dimensions of climate change vulnerability presented by Polsky *et al.* (2007) were sensitivity, exposure and adaptive capacity to a particular social and environmental disturbances. They further highlighted that to be vulnerable to the impact of climate change, human environment systems must not only be exposed, but also sensitive to the impacts of climate change events they have limited capacity to adapt to. Climate change vulnerability according to Gumel (2022) is centred on the biophysical and socio-economic characteristics of a system, influenced by how exposed and sensitive a system is and the level of its adaptive capacity.

In further conceptualising vulnerability, Füssel (2004), understood climate change vulnerability as projected changes in the earth's climate that could influence human systems or activities. However, climate change vulnerability according to Adger (2006) and Turner *et al.* (2020) indicated that the definition of vulnerability varies among researchers and disciplines. They however continued to stress that climate change vulnerability represents sound understanding of the impact of climate change on physical, ecological and social systems and the extent to which these systems are susceptible to sustaining destruction from climate change.

For presenting social systems, Downing and Patwardhan (2004) devised a terminology for the vulnerability of social systems that indicates the hazards, the risks, the region, the sector, the inhabitants, the consequences and the period of time which is assessed considering specific sets of stressors. Furthermore, Brooks (2003) and Bohle (2002) defined climate change vulnerability based on an external concept of risk and shocks, to which a system is subject to climate change. These according to Brooks (2003) include socioeconomic factors determined by human ecology and political economy. The internal concept which is the inability to cope considering internal oriented factors determined by access to assets models, crisis and conflict theory, and action theory approaches. In examining the vulnerability to climate change, Dolan and walker (2003) conceptualised vulnerability using a multiscale, integrated framework for assessing vulnerability and adaptive capacity identified at the individual and community levels and situated within larger regional, national and international settings.

The conceptual frameworks by all these researchers had clearly highlighted the system, the threat, the significance and the situation. Vulnerability according to IPCC sixth assessment report is defined as the tendency to be negatively impacted by climate hazards which embraces diverse components, including, exposure, sensitivity and adaptive capacity. Exposure according to the report is understood to mean the existence of individuals, their livelihood, their environment and ecosystem services in areas that are exposed and sensitive to climate change effects while adaptive capacity is the capability to adjust to anticipated climate and its impact in order to minimise hazards or exploit essential opportunities (IPCC, 2022).

Resilience which has been used widely in different context in debates, negotiations, policies, disciplines and actions in vulnerability and adaption have become particularly popular in describing the connection between climate change adaptation and disaster risk reduction and those of poverty and development (Morecroft *et al*., 2012; Bernhardt and Leslie, 2013; Adler, *et al*., 2015; Timpane-Padgham *et al*., 2017; Rana, 2020). However, Barret and Constas (2014) and Rana (2020) underlined that all the concepts of resilience highlighted clearly emphasised resistance to change which is based on the ability of people, populations, communities, and systems to adapt and improve their integrity and functionality when subject to stress. They further explain development resilience focusing on ecological and human wellbeing as "the capacity over time of a person, household or other aggregate unit to avoid poverty in the face of various stressors and in the wake of myriad shocks. If and only if that capacity is and remains high over time, then the unit is resilient".

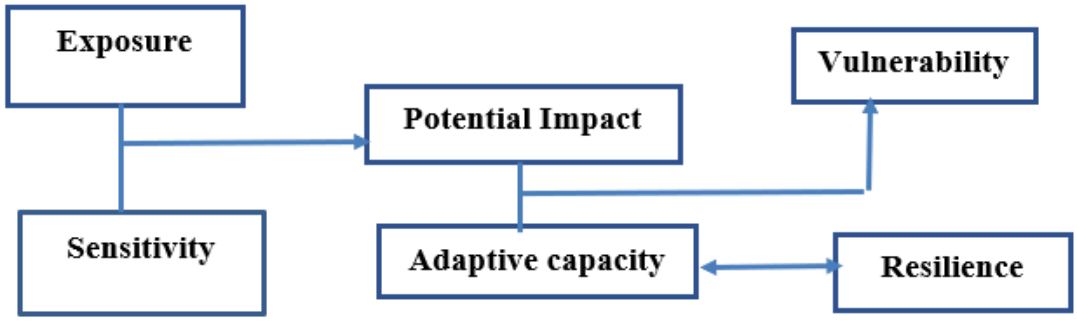
In another instance, Cinner *et al*. (2018) and IPCC (2022), highlighted the role of institutions in resilience building which must be seen as legitimate, and hence how effective they are in facilitating the developments of communities. This is because Institutions can operate at different scales and can support people in sharing of knowledge, cooperation and access to resources beyond their immediate domain.

Therefore, there is need for the understanding of Governance structures considering the role of various state and non-state actors in addressing climate change issues in order to make informed decisions on resilience of individuals, households and ecological systems to climate change hazards (Williams *et al*., 2019). Thus, this study adopts the IPCC concept of vulnerability which represents the degree to which a system is exposed or sensitive to or

unable to cope or adapt to the effects of climate change hazards including climate variability and extremes.

The main issues highlighted in all these frameworks specify the communities, households, actors, system, threats, concerns and time scale. These issues were utilised in this study to develop a conceptual framework in order to identify pathways that link climate change to the vulnerability, adaptation and resilience of coastal communities. It is hoped that this framework will help in identifying the most vulnerable coastal areas for proper climate actions.

The scenario presented in Plate 2.1 represents the concept of vulnerability and resilience framework design to suit the purpose of this study.



(Source: Authors Illustration, 2020)

Plate 2.1. Conceptual Framework of Climate Change Vulnerability, Adaptation and Resilience

2.2 Empirical Review

2.2.1 Climate and Non-Climate Stressors

The utilisation of land and land resources for numerous reasons including agriculture, infrastructure development, recreation, and mining determines land use which differs with the various purpose it serves (Briassoulis, 2020). Increased global population and increased living standards are significant factors affecting many parts of the earth system such as climate, biodiversity, human health and fundamental sustainability of lands and aquatic systems (Shaddick *et al*., 2020; Levin *et al*., 2020; Herrmann *et al*., 2020).

In trying to meet their material, social and cultural needs, humans modify landscapes in various ways usually with detrimental impacts on their wellbeing and on the environment (Briassoulis, 2009; Carpenter *et al*., 2009; De Serio *et al*., 2018; Mahajan and Martinez, 2021; Hassim *et al*., 2022;). Land cover change driven by individuals' responses to economic opportunity, as mediated by institutional factors is an important subject significant to the study of global forest change and holds major implications for sustainable development (Wei *et al*., 2018).

It is evident that Land use and land cover change and practices are part of the main socioeconomic factors driving modification and degradation of ecosystems affecting natural environments and human well-beings (Rimal *et al*., 2019). This is driven by agriculture and advanced infrastructure development due to increased population and has accelerated the pace of land modification and degradation to an unsustainable level (Huang *et al*., 2009). This is because land is subjected to increased transformation which makes it scarce around coastal and urban areas with high rate of industrialisation and urbanisation where it is

considered as a crucial asset for growth and advancement (Banzaf *et al*., 2017; Tiando *et al*., 2021).

As human population increase around the coast, the pressure on coastal communities affects the livelihood and health of individuals and biodiversity within coastal environments (Arulbalaji *et al.*, 2020; McDonald *et al*., 2020). It is evidenced that most of the climate induced pressures experienced by coastal communities were facilitated by the exploitation of coastal resources by humans for socio economic development, urbanization, food and other essential services obtained along the coasts (Hanson *et al*., 2011; Hossain *et al*., 2020). Increased socioeconomic development and urbanization is expected to negatively impact on sub-Saharan Africa as it continues to experience largest exposed population to climate hazards due to its inadequate capacity to address climate change challenges (Ofori *et al*., 2021).

Coastal ecosystems have been significantly disturbed by various human activities including settlements, transport systems, tourism, aquaculture, fisheries and mining (Abd El-Kawy *et al*., 2011; Lu *et al*., 2018; Zerebecki *et al*., 2022). These activities have been observed to increase climate change effects such as temperature rise, drought, etc., affecting coastal dwellers in low-lying areas by increasing their level of vulnerability to extreme climate events (IPCC, 2014).

It has been manifested in the IPCC Sixth assessment report that human activities are the determinant factors in ocean surface temperature rise around the world since 1970s and atmospheric carbon dioxide concentrations were higher in 2019 than any period in about two million years. This has led to increased negative effect of temperature rise and ocean

atmospheric temperature changes on species distribution and abundance in coastal environments (Pörtner *et al*., 2022).

Furthermore, the coastline being interface between the land and the ocean have suffered significant conversion due to intense human activity in the last two decades leading to the vulnerability of these areas to climate change (De Serio, *et al*., 2018). Therefore, as the widespread land modification caused by human activities continues to increase overtime, effective and efficient evaluations of land cover change in coastal areas is necessary to inform relevant stakeholders in developing a more vibrant coastal management policy by incorporating substantial vulnerabilities, adaptation, and mitigation issues (Tiando *et al*., 2021).

2.2.2 Understanding and Awareness of Climate Change

Climate Change Education is important to improve the understanding of the complexities and linkages of the various difficulties and aid in disaster risk reduction efforts by enabling individuals to adapt to unforeseen hazards due to climate change (Urquhart, 2016). Therefore, it is important to prioritise climate change understanding and awareness among relevant stakeholders and coastal communities whose livelihood depends of coastal resources (Kellstedt *et al*., 2008; Masson-Delmotte *et al*., 2021; Lee *et al*., 2022). This is because climate change effects are high among households that are most likely to be sensitive including poor and female headed households and exposed to the negative effects of natural disasters as well as conflict, economic and social effects (Poudel *et al*., 2020).

There is lack of awareness and understanding of the causes of land degradation which affects the development of environmental policies, population and poverty and

societies response to economic opportunities (Lambin *et al*., 2001; Ellis, 2021). Therefore, the use of media in sensitising communities on climate change is important for enhancing individuals believe, awareness and understanding and enhance community efforts in combating sustainable development challenges and undertake major efforts to prevent life-threatening outcomes (Weingart *et al*., 2000; Hine *et al*., 2014; Fuso *et al*., 2019).

Furthermore, Access to timely and useful climate information through media and other outreach services will help to adequately educate coastal communities and assist them in managing their activities in addressing climate change issues affecting their livelihood and environment (Amadi and Chigbu, 2014). This is because appropriate educational level significantly increases the economic conditions and social returns of individuals by not only providing skills and human capital but also their level of understanding of complex concepts like climate change (Ceci and Williams, 1997; Ashenfelter and Rouse, 2000).

Therefore, there is urgent need to prioritize the increased awareness and understanding of decision makers and coastal inhabitants whose livelihoods depend on the coastal resources on how to deal with natural and human induced hazards (Bunce *et al*., 2010; Ridha *et al*., 2022). In the same vain, there is need for improved socioeconomic, technical skills, awareness and understanding and living conditions of individuals at community levels especially around low-lying coastal zones in order to address the impact of climate change (Moss, *et al*., 2001; Brooks, 2003; Hahn *et al*., 2009; Lückenkötter *et al*., 2013; Zhou, 2021; Riede, *et al*., 2016;).

This is because the primary cause of climate change hazards is dominated by inadequate understanding and limited research on the development of environmental policies, which are often focused on either mitigation or adaptation (Sharifi, 2020).

Incidentally, proper environmental policy developments and implementation can help to increase public and political awareness of climate change impacts and improve wellbeing of individuals and communities (Pörtner *et al*. 2022). This as well will help to address the conflicting interest between human socioeconomic activities that negatively affect coastal environment and human wellbeing (Ramieri *et al.*, 2011; Hermann *et al*., 2020).

2.2.3 Vulnerability and Adaptation to Climate Change

Disturbances within coastal ecosystems due to anthropogenic activities have been observed to increase climate change effects such as temperature rise, high relative humidity, drought, pollution etc., affecting directly or indirectly coastal dwellers on a global scale (Fan, *et al*., 2007; Zang, *et al*, 2019; IPCC, 202; Pörtner *et al*., 2022). Furthermore, human activities on coastal environment have led to increased ocean acidity and reduces the saturation of important carbonated materials necessary for the formation of shells and skeletal materials in many coastal species as a result of carbon dioxide uptake in oceans (IPCC, 2021).

Moreover, the evaluation of socio-economic vulnerability to climate change must be based on an understanding of human populations which determines their ability to cope with or adapt to stress (Mafi-Gholami *et al*., 2020). The coastline that represents the interface between land and ocean have experienced significant transformation that modifies greatly their original landscape leading to the vulnerability of these areas to climate change in the last two centuries (Huang and Lin, 2009; De Serio *et al*., 2018). For this reason, the use of renewable energy has become adaptation pathways that could also encourage climate change mitigation efforts and sustainable energy sources for the future generation (Jeong and Ko, 2021).

Ocean life and other aquatic environments are essentially well adapted to changes in natural environments which can adapt to extreme conditions for a short time, but several human enforced activities are stressing such drastic changes in the ocean ecosystem (Dermawan, 2022). Coastal wetlands that serve as barriers between low lying land surface and the ocean is significantly subjected to shrinking especially from sea level rise and storm events, and therefore inducing surface and subsurface saltwater intrusion into wells and other environments (Guimond and Michael, 2021).

However, the inability of the coastal communities to adapt to these climate change effects may seriously affect the livelihood and health of individuals living around the coast (Saleem Khan *et al*., 2020; Burden *et al*., 2020). As the African settlements increase around the coast and urban areas, they will be subjected to climate change effects including sea level rise, extreme weather events, coastal erosion, food insecurity and increased health risks and species distribution and therefore increasing their vulnerability (Magadza, 2000; William *et al*., 2019; Komugabe-Dixon *et al*., 2019;). This is because physical conditions especially of households with lower educational level and insufficient income to meet household demands can lead to situations of vulnerability by increasing their exposure to flood and storm surges (Fatemi *et al*., 2020; Bera *et al*., 2020).

Most of these threats facing coastal settlements are enhanced by humans as they continue to be attracted to coastal zones for socio economic development, urbanization, food and other essential services obtained especially in the sub-Saharan Africa (Creel, 2003; Reside *et al*., 2018). As socioeconomic development and urbanization continue to increase, climate change is expected to threaten Sub-Saharan Africa's progress on human well-being (Dickerson *et al*., 2022). Besides, the assessment of social vulnerability to climate change

can be based on an understanding of urbanisation and increased human populations which determines their ability to cope with or adapt to stress (Mesta *et al*., 2022).

The dynamics and complex multi-function systems, characterized by important ecological and natural values of coastal environments has always been providing ecosystem services which are fundamental for human well-being (Hermann *et al*., 2020). In this regard, as the human-induced climate change in reality has increased over the past decades, effective and efficient evaluations of climate change in coastal areas is necessary in order to enhance the capacities of all sectors in developing a vibrant coastal management policy by incorporating substantial vulnerabilities, adaptation, and resilience building issues (Dale *et al*., 2019; Schipper *et al*., 2021).

2.2.4 State and Non-State Actor Participation in Building Resilience to Climate Change

It is prudent for local communities, governments and other non-governmental organizations to understand the local environment and broaden their interventions on coastal adaptation to climate change (Lee *et al*., 2022). Furthermore, individuals, communities, state and non-state organisations need to understand the local environment and widened their viewpoint on coastal adaptation to climate change especially among local communities in order to respond to increasing natural hazards and complex pressures due to climate change (Clarke *et al*., 2019).

With the believe that natural ecosystems greatly improve livelihood of humans, there is need for all individuals, communities, state and non- state actors to work collectively towards mitigating climate change effects in coastal areas (Hale, 2018; Hsu *et al*., 2020;

Hale *et al*., 2021). Increasing successful environmental management is a basis for the success or failure of the economics and social systems of entire countries (Hale, 2018; Hsu *et al*., 2020; Hale *et al*., 2021). This will help to address the conflict between human socioeconomic activities such as urbanization, tourism, industrialization, energy activities, port activities and agriculture and the need to preserve natural coastal ecosystems and their ecological processes, without which coastal environments' natural adaptive processes such as inland migration and vertical accretion of wetlands may be greatly affected (Ramieri *et al*., 2011). In all these uncertainties in the face of climate change impacts, Hale (2018) highlighted that the role of state and non-state institutions is significant in enhancing the potential and efforts of all actors in climate governance and to build resilience.

2.3 Theoretical Review

The review was conducted with reference to integrated assessment approach based on diverse knowledge and practices from a broader discipline. The assumption from these disciplines helps in identifying the appropriate assessment methods for this study by integrating available information from various studies. This provides interlinkages between vulnerability and adaptation to climate change with the understanding and awareness to climate change, climate and non-climate stressors and the role of institutions in building resilience to climate change. This integrated assessment approach according Weyant et, al (1995) is crucial in determining vulnerability for small countries or regions with specific emphasis to impact, sector, location, groups and time. This model as well incorporates knowledge from various disciplines and scopes in order to highlight the full range of factors that influence the vulnerability of the coastal zone of The Gambia to climate change.

The integrated assessment model according to UNFCCC (2022) provide relevant insights into global climate change and sustainable development issues by providing a quantitative description of key processes in the interaction between human and earth systems utilizing information from different scientific domains. Olanrewaju and Mbohwa (2017) employed an integrated assessment framework using Index Decomposition for the analysis and assessment of the several contributions to key drivers of carbon dioxide emissions.

Therefore, in assessing the vulnerability and adaptation of coastal communities to climate change in The Gambia, an integrated assessment model was utilised to characterize the main factors that affects the vulnerability of the coastal communities. These include climate change understanding and awareness, climate and non-climate stressors (land use land cover

change and climate variability extremes), impact (exposure and sensitivity) and building resilience to climate change (Plate 2.2). Consequently, in assessing the individual elements of the study, specific models utilised by various researchers were also adopted.

Adger and Kelly (1999) conducted a vulnerability assessment in coastal Vietnam. Their study focused on social economic and institutional factors that affect the capacity of individuals to respond to climate hazards. Their findings illustrated that the differences in economic, social and institutional characteristics of an individual, household or community lead to differences in the level of vulnerability that can occur within these groups.

However, the assessments of vulnerability using land cover change depends on the source, types and spatial groupings and data sets where human population change could be used as a proxy to measure of changes observed within environments (Metzger *et al*., 2006). Coastal vulnerability to climate change was assessed in the contest of land use change using GIS and remote sensing by assessing the level of vulnerability specific to the situation in 2018 compared to 2006 in large cities of Romania by (Botezan *et al*., 2022). They concluded that land use change has caused high disaster risk which gradually extend from lower vulnerable to highly vulnerable environments usually caused by urbanisation resulting to environmental degradation. Their method assists in identifying highly vulnerable areas and created linkages between land use change and disaster risk.

The relationship between land cover change and vulnerability was assess by Zhou *et al*. (2021), Beijing- Tianjin- Hebei region by analysing land cover change pattern using satellite data and they concluded a significant reduction of grass land and cultivated land, as well as the increase of construction land. Santos *et al*. (2021) in reviewing climate change assessment methods by various researchers within the last 30 years indicated that climate

change vulnerability that incorporates land use land cover and population change provide better explanation of the causes of exposure and sensitivity and proposed better approaches for tackling the impacts of climate change than those approaches that focus on climate change alone. In this regard, Biazin *et al*. (2013) employed GIS/ remote sensing, drought vulnerability analysis and field survey to highlight associations between land use land cover change, social characteristics, and climate variability in Ethiopia. They have observed that the main causes of land transformation were due to the interaction between various factors including recurrent drought, socioeconomic and institutional characteristics.

Land use land cover changes from 1947 to 2018 were analysed by Faria and Tenedório (2021) to study land use and land cover changes over a long period in Algarve region in Portugal using remote sensing techniques. They concluded that the combination of three dimensional and land use and land cover techniques provide the necessary information that highlight the much needed and sustainable urbanisation planning processes.

The demand for vulnerability assessment for proper decision making validates the utilisation of indicators for vulnerability assessments (Nguyen *et al*., 2016). Therefore Huang et al. (2012) applied indicator- based assessment technique to determine and compare the level of vulnerability of coastal communities in China and present a case study in China applying this framework. Using Exposure Index (EI), Sensitivity Index (SI) and Adaptive Capacity Index (AI), the vulnerability levels of different communities were compared for proper decision making. Their findings indicated that the level of vulnerability of communities was determined by the extent of land cover transformation of the different communities which was not equally distributed within communities.

In their study to assess the possibility of saltwater intrusion into coastal environment in North Carolina, Bhattachan *et al*. (2018) had highlighted that saltwater intrusion combined with several other factors were able to increase the vulnerability of coastal environment which is also intensified by climate change hazards such as droughts and coastal storms.

Mondal *et al*. (2012), investigated rainfall trend in Cuttack District, Orissa in India using Mann-Kendall trend test together with the Sen's Slope Estimator for determining the trend and slope magnitude. The data analysed for 41 years from 1971 to 2010 indicated both positive and negative trend in the area which were not much significant. Similarly, Gocic and Trajkovic (2013) used Mann-Kendal trend test and Sen's Slope Estimator to analyse yearly and periodic climate variables for a period of 40 years in Serbia and their findings showed significant positive trends in the time series data for maximum temperatures and a significant negative trend in the relative humidity. Furthermore, Yusuf (2018) used Mann-Kendall Trend test to estimate temperature variability trend in Nigeria and their findings highlighted a positive increasing trend in both maximum and average temperature trends. To analyse the changing trends of rainfall and temperature in Uttarakhand state using Mann-Kendall test, Yadav *et al*. (2014) determined that the temperature and precipitation trends does not show any consistent increasing or decreasing trend.

Poudel *et al.* (2020) indicated that climate change effects are high among households that are most likely to be sensitive including poor and female headed households and exposed to the negative effects of natural disasters as well as conflict, economic and social effects. Their research explores livelihood vulnerability assessment indices in Nepal using natural disaster, water, food security, social networks and livelihood strategies indicators.

Their result of the vulnerability level of households to climate change effects indicated that vulnerability increased among less privileged including poor and female headed households. In the same vein, Hadipour *et al*. (2020) build a social vulnerability index (SoVI) indicators by first categorizing the data into different vulnerability components based on IPPC conceptual framework which were normalized and weighted, and their result revealed essential facts that can be relevant in decision making processes.

Handayani *et al.* (2017) used vulnerability components aggregated into exposure, sensitivity and adaptive capacity to assess and compare the level of vulnerability of different cities in Indonesia and their study concluded that the bigger the city, different areas will have different levels of vulnerability of households and smaller cities may have less capacity in addressing climate change challenges. Likewise, Parthasarathy and Natesan, (2015) uses CCVI approach to determine the exposure, sensitivity and adaptive capacity index and the vulnerability index of coastal environment in the Gulf of Mannar and their result provided insight for proper climate action.

The role played by government and non-governmental organisations state and non-state actors in coastal resilience has been emphasized by IPCC (2022). The report stated that state and civil society organisations have the capacity to mobilise different skills and knowledge within an organisation to adapt and mitigate climate change. Therefore, to evaluate the capacity of individuals and communities in building resilience to climate change requires the participation of all stakeholders. Moreover Morelli *et al*. (2021) indicated that the contribution of state and non-state actors in governance, and disaster management must be recognised in funding resilience building.

Jones and Tanner (2017) and Jones (2019) conducted semi-structured interviews, an assessment technique through objective and subjective assessment models to identify the main concerns of all stakeholders including the local community. According to Clare *et al*. (2017), subjective assessment models of measuring resilience to climate change has been desired by various researchers in evaluating the main options for building resilience to climate change which is believed to provide appropriate and valuable information on resilience and improve the understanding of the main factors for improving resilience of systems. Furthermore, Adzawla *et al*. (2020), indicated that wider consultation is necessary to tackle the negative impact of climate change among farming households in Ghana using subjective assessment methods where respondents were given the opportunity to provide their own ideas on the subject matter without any indicator computation.

2.4 Existing Gaps in Literature

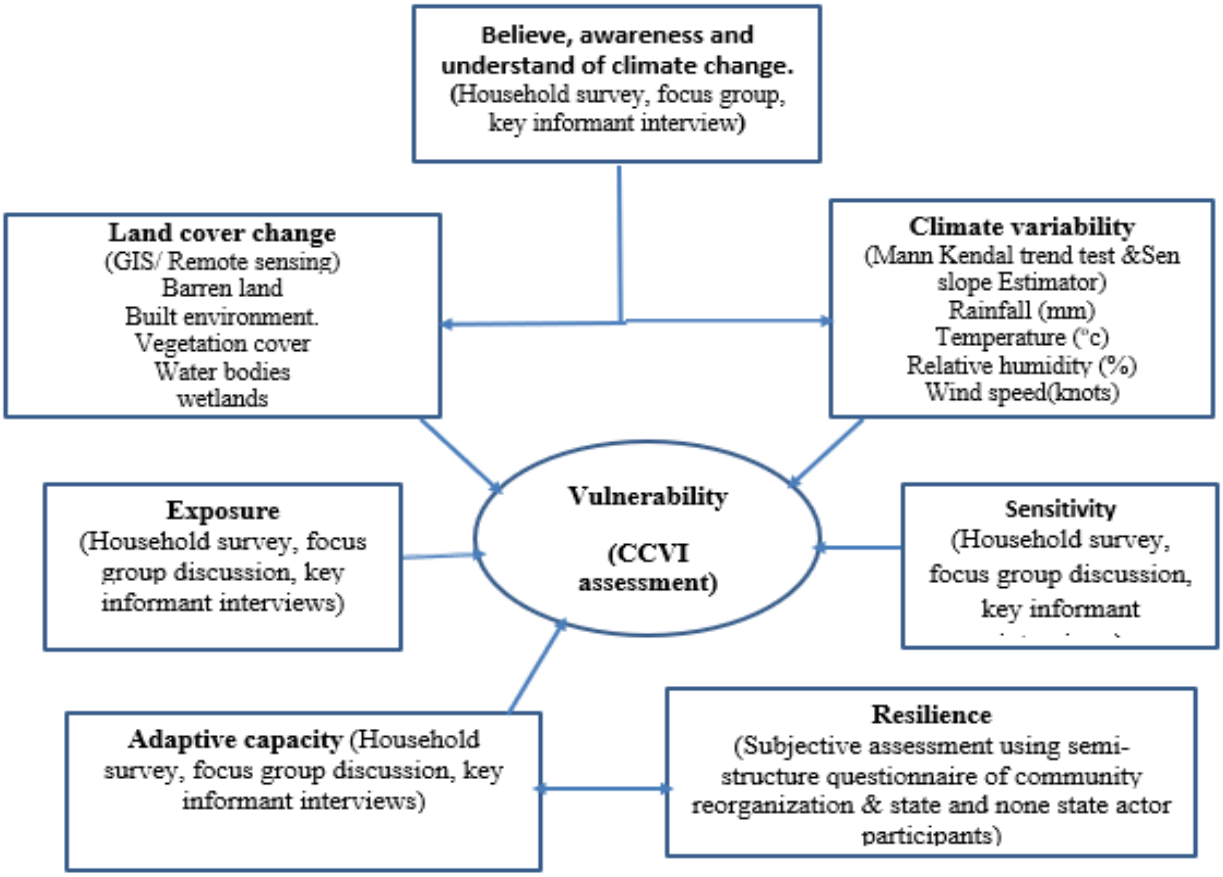
Vulnerability conceptualisation has been complexed and remains an unresolved issue where research areas and researchers are still tackling in dealing with policy formulation in natural hazards and vulnerability that will help in steering their decisions (Polsky *et al*., 2007). To systematically review exposure, sensitivity and adaptation to climate hazards had been stressful due to the fact that the same idea can be conceptualised differently, and different names were given to the same concept (Briassoulis, 2020). Recent resilience assessments did not adequately observe universal research facts regarding institutional and infrastructural dimensions and are still a topic of discussion with little agreement on systems of measurement and monitoring.

While there is some clarity on the factors that cause vulnerability and enhance resilience subjectively, the validity & reliability of subjective measures have not been tested systematically (Bahadur *et al*., 2013). Also there has not been clear relationship between resilience concepts, vulnerability and adaptive capacity where certain meanings were observed to overlap vulnerability with resilience whereby others treated them differently (Manyena, 2006; Klein *et al*., 2003).

In The Gambia, the dimensions of the limits of the coastal cells was not highlighted in literature to determine the length and breadth of each of the coastal cell which was demarcated based on the geomorphic characteristics and the conditions of the sandy beaches. The level of knowledge and understanding of climate change whether among coastal communities or other parts of The Gambia is limited in literature. Most of the studies on climate change effect on the coastal zone is centred on Cell 8 and as such is the area where most interventions are concentrated.

2.5 Theoretical Framework

The framework designed to guide the development of the study based on the theoretical review is presented in plate 2.2. This framework hopes to provide useful information in understanding the drivers of vulnerability and adaptation to climate change within the coastal zone of The Gambia.



(Source: Authors Illustration, 2020)

Plate 2.2. Theoretical Framework of the Study

CHAPTER THREE

METHODOLOGY

3.1 Research Design

This survey was conducted to assess and compare the understanding and awareness of climate change and assess the vulnerability and adaptation to climate change hazards among different socioeconomic groups within and among coastal communities in The Gambia. The study employed mixed method where both quantitative and qualitative data were utilised.

The quantitative data utilized for this study were collected from secondary and primary sources. Secondary data was obtained from Centre for International Earth Science Information Network CIESIN in their Low Elevation Coastal Zone (LECZ) Urban-Rural Population and Land Area Estimates, 2021; household and population data by local government area, District and settlement, 2013 of The Gambia compiled by The Gambia Bureau of Statistics (GBOS); Meteorological unit of the Department of Water Resources and World Bank Group, West Africa Coastal Areas Management Program (WACA, 2019).

Primary data was obtained by using structured and semi structured questionnaires for the assessment of households believe, awareness and understanding of climate change and their vulnerability and adaptation to climate change hazards as well as state and non-state actor participation in building resilience to climate change. Household surveys were conducted by interviewing the household heads or their representatives as well as focus group discussion and key informant interviews from August to December 2021. Institutional heads or their representatives were also interviewed for the assessment of their participation in building resilience to climate change. The qualitative data were obtained

during interviews and Focus Group Discussions where community members were gathered to discuss on issues pertaining to the study.

The coastal zone was divided into groups called cells based on their geomorphic characteristics and each of these cells comprise communities (towns and villages). These communities were further divided into sub-groups based on socio-economic activities and their dependence on the coast for their livelihood and population size. These characteristics served as part of the basis for selecting communities in each of the studied cells. The study was conducted for a duration of 3 years. The first year was spent on developing the proposal, conducting of review on the research topic and learning the appropriate models and approaches for the research design and analysis techniques. For the analysis of the findings, cross tabulation, percentages and means, were used to summarize the data.

Land use and land cover (LULC) change analysis was conducted using, three cloud free Landsat imageries for the year 1990, 2000, 2010 and 2020 downloaded from the United States Geological Survey (USGS) website to evaluate the extend of LULC cover Transformation along the coastal zone. To determined the magnitude of transformation of the coastal environment at different time periods. Correlation analysis was conducted to measure the degree to which changes in one LULC change class is related to changes in another LULC change class and to estimate the linear relationship between LULC change classes with population growth.

Trend analysis was condcuted using Mann Kendal trend analsysis and Sen's slope Estimator to determine climate variability trends and magnitudes for rainfall (mm), maximum temperature (^{o}c), minimum temperature (^{o}c), relative humidity (%) and wind speed (knots).

Furthermore, binary logistic regression modelling was conducted to assess the main factors that influence the understanding of households to climate change and climate change vulnerability index analysis was also conducted to evaluate the vulnerability level of each of the coastal cells studied and to compare the cells based on their exposure, sensitivity, and adaptive capacity and vulnerability index. Subjective assessment was conducted to evaluate community resilience to climate change and the state and non-state actor participation in building resilience to climate change along the coastal zone of The Gambia.

To enhanced validity, the instruments utilised in this study were reviewed by researcher, experts including the supervisors and feedbacks provide were incorporated. The survey instrument was then tested and retested using individuals with different designations at different times in order to determine the validity, similarities and reliability. The data from pre-test were then tabulated and analysed using simple statistical methods to get a preliminary indication of the expected outcome after the questionnaire administration is completed.

3.2 Area of Study

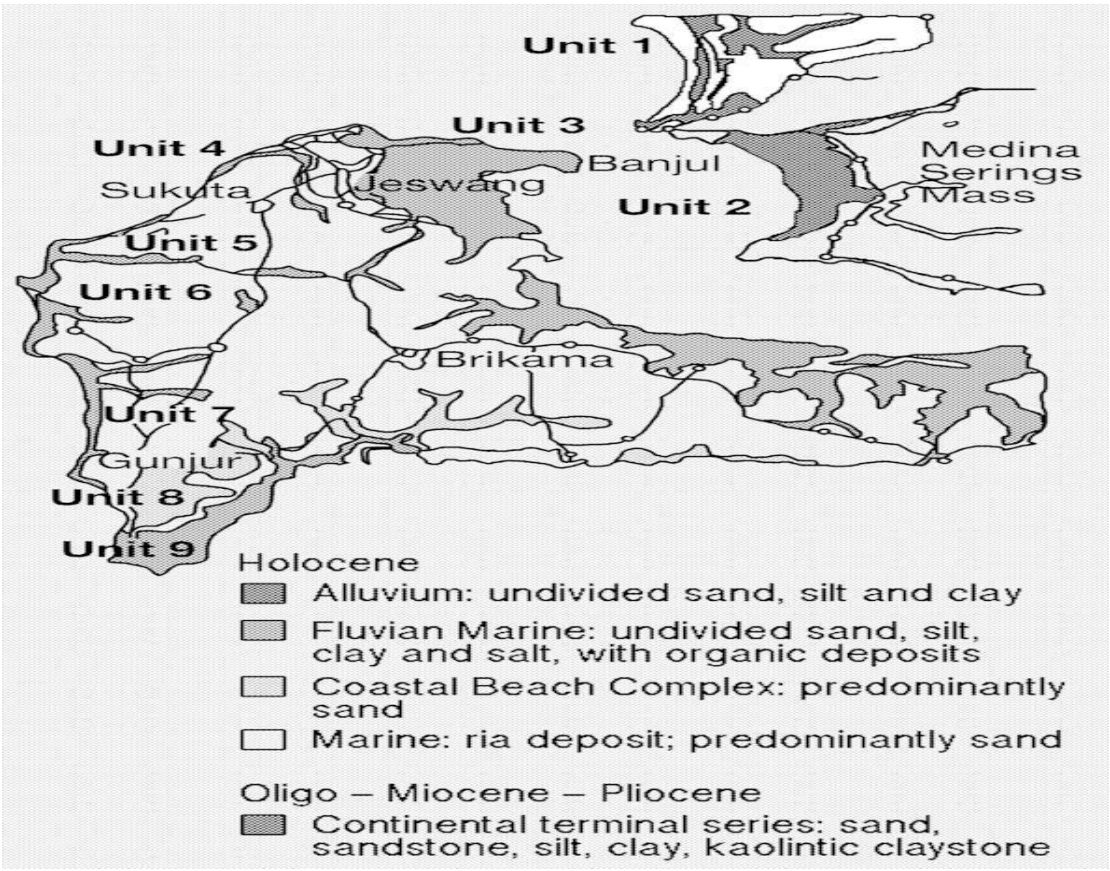
The Gambia has a total land area of 11,000km^2 with about one fifth of its surface area water. The river Gambia runs 680km from the Futa Jallon in the republic of Guinea to the Atlantic Ocean dividing the country into North and South Banks. The Gambia has an 80km coastline extending from Buniadou point and Kerenti bolong in the north to the mouth of Allanhein in the south. The country lies within the tropical sub-humid eco-climatic zone (Jaiteh & Sarr, 2010) characterised by the Sudano Sahelian Climate dominated by an irregular dry

Harmattan Northern Winds from the Sahara Desert and South-Westerly Monsoon winds from the Atlantic Ocean (National Environmental Agency, 2010).

The climate of the coastal zone of The Gambia according to Dia (2012) is characterized by sea level rise and associated inundation levels of 2m and 10m by 2100, coastal erosion, flood, reduced or erratic rainfall pattern of about 35% and salt intrusion into wells and other environments. However, there is increased in annual maximum temperature which is higher than the decreases in the annual minimum temperature indicating that the coastal zone The Gambia had experienced more warming than cooling from 1986 to 2016 (Amuzu et al., 2018b).

Apart from the terrestrial habitats, the coastline of the country also has different other habitats such as mangrove forests and wetlands, sandy beaches, brackish water and mudflats, that provide important ecosystem services including breeding and nursery grounds to organisms. The main occupation of most people around the coastal zones include agriculture, trade, service industry, fishing and horticulture. There has also been growing private sector involvement in tourism and hospitality industries, sand mining, and establishment of factories among others. Fishing activities such as exploitation of coastal vegetation for fish processing and clearing of land for agriculture continues to transform the coastal ecosystems thereby exerting extensive pressure on coastal environment.

The coastal zone of The Gambia is divided into 9 subunits called cells based on the geomorphic characteristics of the sandy beaches and their surrounding environments and the characteristics of the sea level as well as their vulnerability to climate and non-climate hazards.



(Source: Jallow, *et al.*, 1999)

Plate 3.1. Characteristic of the coastal zone of The Gambia

Jallow *et al*. (1999) described the characteristics of each of the subunits in Plate 3.1 as follows;

Cell 1: This area is identified by sandy beaches with extensive mangrove vegetation and wetlands which harbour different fauna and flora and provides spawning environment for fish birds, turtles and other organisms. Settlements in this cell include Jinack Kajata, Jinack Niji, Mbankam, Essau, and Barra

Cell 2: This cell starts from Buniadou point to about 4km wide into Banjul. The area is characterized by mangroves vegetation and mudflats and marshes. The area provides important spawning habitat for fish, shrimp, oyster and birds.

Cell 3: This is the area Between Banjul and Bakau Cape Point. This area is estimated to be about 2 meters above sea level and prone to beach erosion. No significant settlement exists along this zone. Some of the establishments around this area includes seafood processing factories, hotels and the prison. This area is the most threaten by erosion along the coastline.

Cell 4: This area extends from Bakau Cape Point and Wasulung to Bakau New town and Fajara. This area is highly vulnerable to coastal erosion and sea level rise. Around this area is the Bakau fish landing and smoking site along. Establishments in the area also include Medical Research Council, the Department of Agricultural Service and most expensive private residences of politicians, heads of diplomatic missions and some hotels.

Cell 5: This cell is between Fajara and Bald Point of the coastal zone of The Gambia. This area is affected by sea level rise and coastal erosion. The area is believed to be highly vulnerable to climate change effects and is highly affected by sea level rise and coastal erosion. Most hotels and other tourism establishments are located along this region including the luxurious Senegambia Hotel and Kairaba Beach Hotel. There are also parks and fish landing sites along this environment. The area is characterized by sandy cliffs of about 30 meters in some areas. Communities around this cell include Kotu and Kololi

Cell 6: This cell has the most significant geomorphic characteristics with sandy pits which attracts sand miners. In addition, there are also various fish landing processing sites along the beaches of the coastline. Communities around this area include Kerr Seringe, Bijilo, Medina, Brufut and Tanjeh,

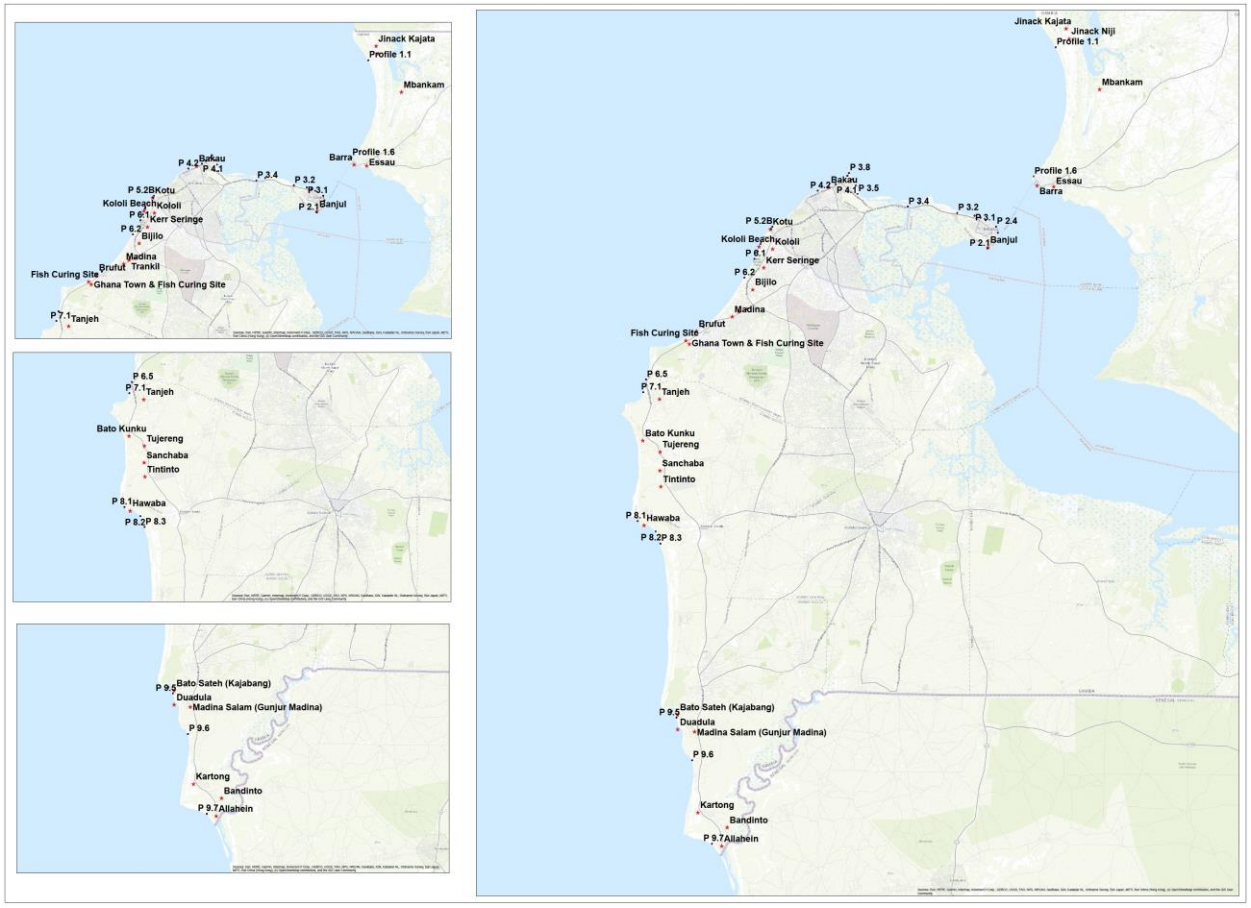
Cell 7: Sand beaches and flat plain strands of sand are observed in this cell and it is believed to be the least affected by industrialisation with no significant tourism establishments.

Present in this area are fish landing and curing sites. Communities found along this area include Tanjeh, Batokunku, Tujereng, Sanchaba and Tintinto.

Cell 8: This area is exposed to wave actions and coastal erosion due the developments along the coast. There exist some beach resorts, ice plants, fish landing and a fish meal factory. Communities present in this area include Gunjur, Medina Salam, Sanyang.

Cell 9: This zone is the southern end of coastline of The Gambia. The cell spread through Kartong point ending at the mouth of the Allahein River. The area is characterized by a series of sand dunes and beach ridges that runs parallel to the shoreline from Kartong. The area is threatened by inundation that may result from sea level rise.

The settlements in each of the cells were mapped in collaboration with the Integrated Coastal Zone Management Department of the National Environment Agency of The Gambia during the period of the study and are presented in Plate 3.2.



(Source: Author's Illustration, 2020)

Plate 3.2. Map of the Coastal Zone and the Communities around 10 to 25km of the Coastal Zone of The Gambia

3.3 Population of the Study

The Gambia's population was estimated by Center for International Earth Science Information (Network CIESIN) in their Low Elevation Coastal Zone (LECZ) Urban-Rural Population and Land Area Estimates, 2021 at 1.9 million by 2010, with annual growth rate of 2.6%. However, 37% of the estimated total population by 2020 were residing within 10-25km of the coastline (Table 3.1). The estimated percentage of population residing within 10 to 25km of the coastline represent 29.18, 31.62, 31.30 and 36.91 of the total population in 1990, 2000, 2010, and 2010 respectively showing an increase of 213% from 1990 to 2020.

Table 3.1. Estimated Population Living within 10 to 25km of the Coastal Zone from 1990-2020

Date	Population of the Gambia	Population living within 10-25km coastline	% of population living within 10-25km of coast	% Increase of population living within 10-25km of the coast from 1990 to 2020
1990	1040616	303662	29.18%	213%
2000	1437539	454531	31.62%	
2010	1937275	606345	31.30%	
2020	2573995	950010	36.91%	

(Source CIESIN, 2021: http://www.ciesin.columbia.edu/data/lecz-urban-rural-population-land-area-estimates-v3/)

The study population comprised the nine coastal cells and most of the communities within 10 to 25km in each cell for the study (Table 3.1 & Plate 3.2).

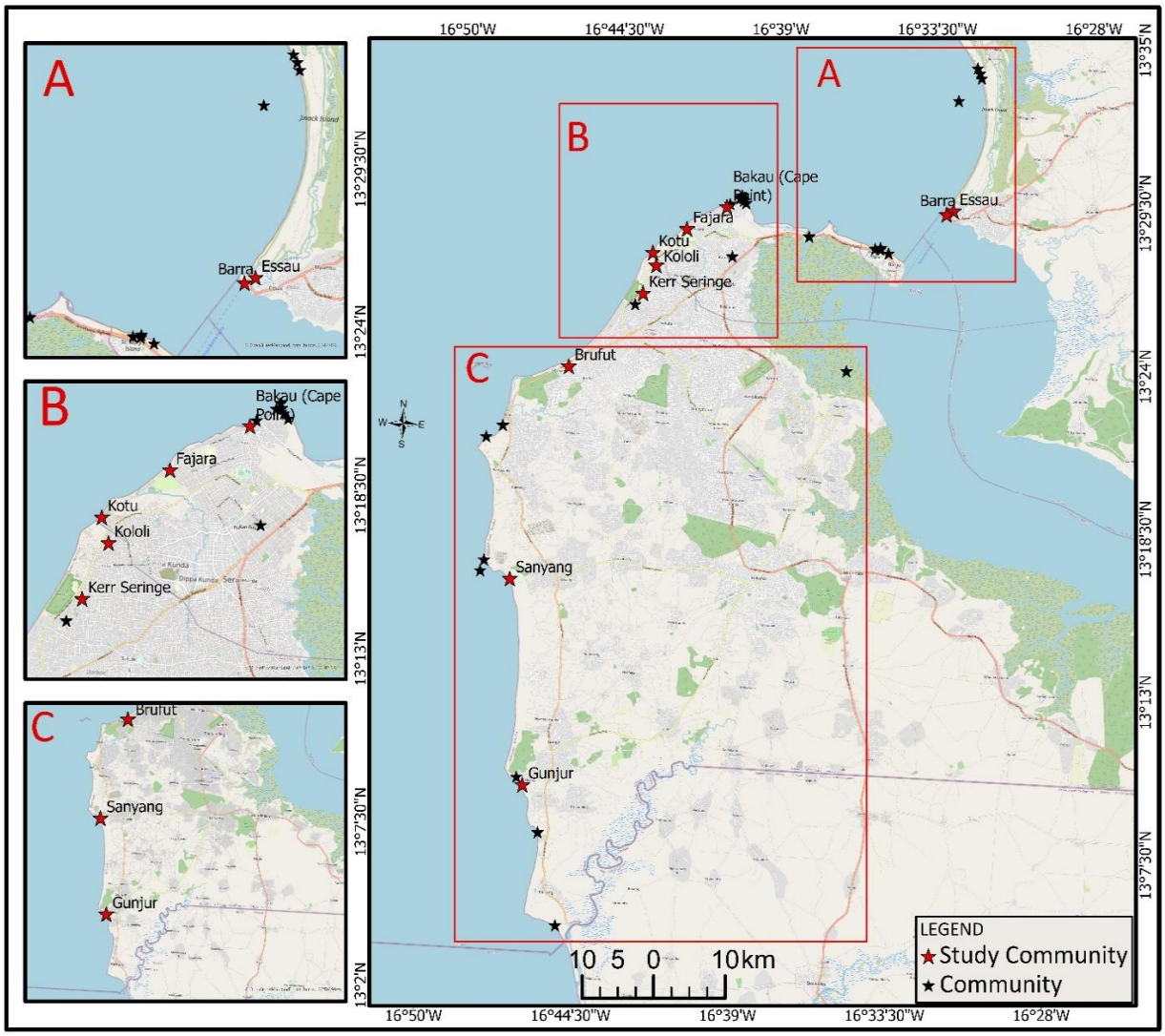
3.4 Sampling Technique and Sample Size

3.4.1 Site Selection

Coastal environments are conceived to consist of both natural and human systems. The natural systems include distinct coastal features and ecosystems such as rocky coasts, beaches, barriers and sand dunes, estuaries and lagoons, deltas, river mouths, wetlands, and coral reefs. The human systems include communities and various establishment such as hotels, fish landing and curing sites, and other secondary fishing activities.

These elements help define the seaward and landward boundaries of the coast as well as the provision of a wide-ranging varieties of regulating, provisioning, supporting, and cultural services (MEA, 2005). Considering these characteristics and in consultation with experts from the Integrated Coastal Zone Management unit of the National Environment Agency (NEA) of The Gambia, some of the prominent communities within the nine cells were outline. This process was also guided by household and population data by local government area, District and Settlement, 2013 of The Gambia compiled by Gambia Bureau of Statistics (GBOS). Therefore, the main communities in closed proximity and within 10 to 25km of the coastline were identified as follows (Plate 3.3).

Cell 1: Jinack Kajata, Jinack Niji, Mbankam, Essau, and Barra
Cell 2: Banjul
Cell 3: no significant settlement identified.
Cell 4: Bakau (old cape), Bakau New Town and Fajara
Cell 5: Kotu, Kololi,
Cell 6: Kerr Seringe, Bijilo, Medina, Brufut, Ghana Town
Cell 7: tanjeh, Batokunku, Tujereng, Sanchaba and Tintinto
Cell 8: Gunjur, Medina Salam, Sanyang
Cell 9: Sanyang, Bandinto, Kartong, and Allahein



(Source: Author's Illustration, 2020)

Plate 3.3. Map of the Study Communities

3.4.2 Types and Sources of Data Collection

3.4.2.1 Land Use Land Cover Change.

To estimate the extent of land use land cover (LULC) change on the coastal zone of The Gambia at different time period, using LULC change classification, three Cloud free Landsat imageries for the year 1990, 2000, 2010 and 2020 were downloaded from the United States Geological Survey (USGS) website. The satellite used and its sensor, year and spatial resolution of the images are presented in Table 3.2.

Table 3.2 Satellite Data Type and Characteristics

Satelite	Sensor	Year	Spatial Resolution	Acquisition Date	Path/Row
Landsat 5	TM	1990	30	11/03/1990	205/051
Landsat 7	ETM+	2000	30	11/06/2000	205/051
Landsat 7	ETM+	2010	30	12/20/2010	205/051
Landsat 8	OLI/TIRS	2020	30	11/21/2020	205/051

(Source: United States Geological Survey (UGS) Website, 2020)

3.4.2.2 Climate Variability Data

To assess the climate variability of rainfall(mm), temperature (^{o}c), Relative humidity (%) and windspeed(knots) trends along the coastal zone of The Gambia, climate variability data was utilised to determine their trend and potential impact along the coastal zone of The Gambia. annual average rainfall (mm), minimum temperature (^{o}c), maximum temperature (^{o}c), windspeed (knots) and relative humidity (%) where obtained from meteorology unit, the primary source of climate information at the Department of Water Resources in The Gambia . These data were recorded monthly from 4 meteorological stations within the coasta zone in Kerewan (North Bank Region), Banjul, Serekunda (Kanifing Municipality), and Yundum (West Coast Region) from 1980 to 2020.

3.4.2.3 Household Data

With the aim of assessing the understanding and awareness of coastal communities to climate change and their level of vulnerability to climate change hazards, primary data were collected through a structure questionnaire which was constructed in three phases.

Firstly, the research objectives, characteristics of respondents and data collection method were outlined. Secondly, the instrument was constructed and later pretested and revised. Finally, to examine whether the items included in the survey instrument would be relevant to the research questions, experts including the supervisors also reviewed the document and provided feedbacks.

All the surveys were conducted by interviewing the household heads or their representatives as well as focus group discussions and key informant interviews from August to December 2021. The household data were collected to assess believe, understanding and awareness of households to climate change and their level of vulnerability and adaptation to climate hazards. The data collected during the survey were socio-demographics of all individuals within a household in the selected coastal cells under consideration (see Annex 1). This includes age, educational level, gender, relationship of household members to household head, primary and secondary occupation of household members, ethnicity and health related issues of household members. Other information collected are on the following;

1. Dependents
2. Status of the household (descendants or migrated), the purpose of migration and the length of stay in the community if they were not descendants.
3. The income status and source of the household.

4. Household accessibility to essential facilities, services and assets such as electricity water, tools, transportation, communication, health care services, toilets, sources of fuel for cooking and ownership of livestock.
5. House ownership and status of house infrastructure such main construction materials of the walls and roofs of the house.
6. Household heads believe, awareness and understanding of climate change and the main causes of climate change.
7. Households main source of climate information
8. Household exposure, sensitivity and adaptive capacity to natural hazards and its frequency, severity, difficulty of coping and negative impact on their household.
9. Community participation in building resilience to climate and
10. Access to information and its importance for the households.
11. State and no state actor participations in building resilience to climate change

Different languages were used during the interview and discussions including English Mandinka, Wollof and Fulla in a typical one on one conversation between the enumerators who were trained on the content of the questionnaire for a period of 5 days prior to data collection and the respondents.

In addition, community outreach was held in 10 coastal communities (Barra, Essau, Bakau Old Cape, Fajara, Kotu, Kololi, Kerr-Seringe, Brufut, Sanyang and Gunjur where community members including male and female gathered to discuss their perception, and opinions on climate change issues affecting their environment and livelihood. key informant interviews were also conducted by selecting three individuals from each community who

have good knowledge of their environment including community leaders, professionals and residents.

3.4.2.4 Vulnerability Assessment Data

Primary and secondary data were used to evaluate exposure, sensitivity, adaptive capacity and vulnerability index of different coastal cells which were grouped as follows:

Exposure: Climate data for 30 years period (1990 to 2020) was utilised. This includes change in total annual precipitation (mm), change average annual maximum temperature (^{o}c), change average annual minimum temperature (^{o}c), change average annual relative humidity (%) and change average annual wind speed (knots). Further, additional data were derived from the household survey conducted on household exposure level to natural hazards taken into account flood, coastal and land erosions, maximum temperature, tropical windstorm, cold temperature events, rainfall events etc.

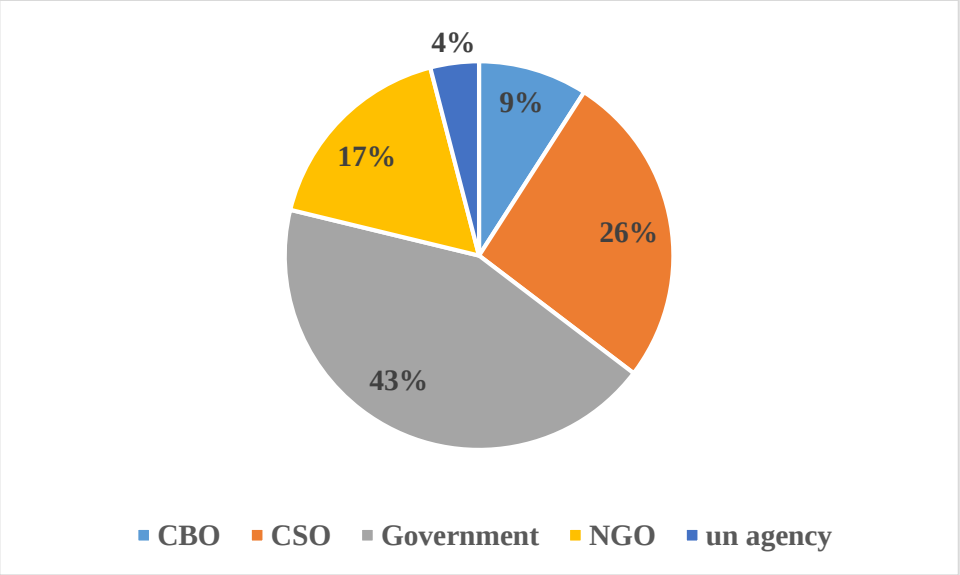
Sensitivity: Data utilized for measuring sensitivity of the coastal zone include demographic profile which considers average household size, female, young (7 years and below) and old (65 years and above) members; Socioeconomic status measures the quality of houses, earning status of the households whose income are usually not enough to meet important household expenses, and socially disadvantage households specifically those who migrated to the communities they were residing in. Data on livelihood activities include proportion of household members whose livelihood is skilled labour (carpentry, fishing, mining, farming etc.) and dependents including students, housewives and household members who doesn't engage in any economic activities.

Adaptive capacity: The various indicators for adaptive capacity for this research include literacy (at least a primary education level), and household members who were working. Data on economic security include household members who were literate, were earning salary, own the houses they were residing and own assets specifically livestock. Data on infrastructure considers the type of materials use for the construction of the walls and roofs of houses and access to health care. Data on access to basic facilities including sanitation, electricity, safe drinking water, and improved tools for production, communication and vehicles for transportation.

Selection of these indicators were based on availability of data, personal judgement and previous research.

3.4.2.5 State and Non-State Actor Participation to Climate Resilience Data

To subjectively assess the level of participation of state and non- state actors in building coastal resilience to climate change, 30 semi structure questionnaires were sent to heads of institutions, networks and NGOs, in the country (see Annex 10) and 23 questionnaires were returned back. These comprised (9% community-based organisation (CBO), 26% community service organisations (CSO), 43% government, 17% non-government and 4% UN Agency) (Figure 3.1).



(Source: Fieldwork, 2021)

Figure 3.1. State and Non- State Actors interviewed.

Data collected from these institutions includes their level of interest in climate change issues, availability of climate policy or any relevant document on climate change, the institutions plan, funding and adaptive capacity on climate change amongst others.

3.6 Definition and Measurement of Variables

3.6.1 Sampling Technique

To identify the most appropriate sample size with much consideration to planning stage, data collection procedures, and methods of assessment techniques, households within the selected coastal cells were considered for this study. As the coastline had already been demarcated into nine subunits called cells based on their geomorphic characteristics, settlements within these cells where further selected from each of the nine cells in other to ensure household homogeneity (Plate 3.1, 3.2 & 3.3).

3.6.2 Target Population

To evaluate the level of awareness, believe and understanding of coastal communities to climate change, this study targets the entire households of the towns and villages within the nine coastal cells of The Gambia. However, as it was practically impossible to conduct an interview in all the household units, a sampling frame was designed to select the cells and households that would serve as representative units from the entire population of the coastal zone of The Gambia. This sample was then used to represent the population for the statistical analysis.

3.6.3 Sampling Frame

The population of the study comprised the households within the communities of the nine coastal cells with household heads as the target respondents using a multistage sampling method. In the first stage 5 cells of 8 coastal cells were selected using simple random technique. Cell three was exempted during sampling of the cells because this area is

between Banjul and Bakau Cape Point without significant settlement. Using population data by Local Government Area, District and settlement (2013), for The Gambia by The Gambia Bureau of Statistics (GBOS) as reference, two communities with the highest number of households within each of the selected zones were selected.

Two communities with the highest population were selected from each sampled cell. Names of each of the selected community/settlement and the number of households were selected using convenient sampling technique to select households from each community. The sample size was determined using Raosoft software. This software has been used for household surveys by various research in different disciplines all over the world including Moniruzzaman et al. (2014), Yadeta and Abashula (2019), Aliyu et al. (2019), Amoah and Simatele (2021) etc., using the margin of error of 5%, confidence interval of 95% and population size of 16990. The sample size *n* and the margin of error *E* are calculated using the formula:

$$n = {Nx}\Big/{\left((N-1)E^2 + x\right)} \qquad (2)$$

Where N= the population size

r= the fraction of responses interested in, and

$z\left({c}/{100}\right) =$ Critical value for the confidence level c.

$$x = z\left({c}/{100}\right)^2 r(100-r) \qquad (1)$$

$$E\ (Margin\ of\ Error) = Sqrt\left[{(N-n)x}\Big/{n(N-1)}\right] \qquad (3)$$

n = sample size

Using Proportion to population size (PPS) method, where the probability of selecting a unit is proportional to its sample size, the number of households selected in each community and cell is proportional to the number of households within each community as follows:

$$Number\ of\ Target\ Household = \frac{Number\ of\ Household\ per\ Community}{Total\ Household} X\ sample\ size \quad (4)$$

The response rate was calculated for each cell as:

$$Response\ rate = \frac{number\ of\ responses}{target\ households} X\ 100 \quad (5)$$

Therefore, 380 household heads were obtained using the formula, to obtain the exact number of respondents from each cell presented in Table 3.3.

Table 3.3. Population and Sample of the Study Area

Coastal cells	Settlement	N.O. HH	Target HH	Number of HH interviewed	Sampled HH per Cell	Total HH interviewed per Cell	Response rate
Cell 1	Essau	1409	31	33	50	52	103%
	Barra	867	19	19			
Cell 4	Bakau Old Cape	2011	45	35	98	95	97%
	Bakau New Town	2405	53	60			
Cell 5	Kotu	2008	44	60	72	88	122%
	Kololi	1240	27	28			
Cell 6	Kerr Seringe	1512	33	31	92	85	92%
	Brufut	2654	59	54			
Cell 8	Sanyang	1368	30	26	64	60	94%
	Gunjur	1516	34	34			
Total		16990	376	380		380	

(Source: Fieldwork, 2021)

To analyse the socioeconomic factors affecting climate change understanding among coastal residents, binary logistic regression was utilized to analyse the relationship between dependent variable (understanding) and socio-economic characteristics to estimate their effects on understanding of climate change among coastal households.

The dependent variable understanding was coded as a binary variable where, 1 for a respondent who really understand and 0 for respondents who did not understand climate change. To affirm their claim or otherwise, respondents who claimed to understand climate change were asked to further explain how they understood climate change. Their responses were used to determine if the respondent really understood climate change or not. The socioeconomic variables that were considered to have effect on the understanding of households to climate change are described in the Table 3.4.

Table 3.4 Variable Description of the Factors that affect Climate Change Understanding within the Coastal Zone of The Gambia

No	Variables name	Description	Coding
1	Understanding	Understanding of climate change	1=yes or otherwise=0
2	Coastal zone	The coastal zone the household was located	1= urban coastal zone (cell 4, cell 5 & cell 6; Rural coastal zone (cell 1 & cell 8) =0
4	Awareness	Awareness to climate change	1=yes or otherwise=0
5	Gender	Sex of the household head/representative	1=male or otherwise =0
6	Age	Age of household head/representative	Number of years
7	Believe	The believe in climate change.	1=yes or otherwise =0
8	Ethnicity	The tribe the respondent belongs:	1=majority ethnic (Mandinka, Fula and Wollof); otherwise =0
9	Educational level	Education or no education of the respondents	1= formal education or otherwise=0
10	Primary occupation	The main occupation of respondents Working to earn salary or not working/self-employed)	1= salary work; 2=fishing; 3=farming; 4=business; 5=mining; 6=carpentry; 7=student; 8=housewife;
	Income level	Household income level based on household expenses	Enough income to meet important household expenses or otherwise=0
12	Access to information	Access to at least 3 of the various sources of climate change information	1= yes; or otherwise =0
13	Household status (migration or descendants)	Whether the household is a descendant or has migrated to the community they were residing	1=migrated or otherwise=0
14	Access to health care	Household access to health care services in your community	1=yes or otherwise=0
16	Adaptation to climate change	Whether the respondent or any member of their household had taken any actions to adapt to/cope with climate change	1= yes or otherwise=0

(Source: Fieldwork, 2021)

3.7 Validity and Reliability of Research Instruments

3.7.1 Validity

The validity of the instrument refers to the appropriateness, meaningfulness and usefulness of specific inferences made from test scores (Gall et al., 1996). The researcher had group of experts including the thesis supervisors, reviewed the instrument and provide feedbacks which were incorporated to enhanced validity.

3.7.2 Reliability

The survey instrument was tested and retested using individuals with different designations at different times to determine the consistency, similarities and reliability. The data was then tabulated an analysed using simple statistical methods to get a preliminary indication of the expected outcome after the questionnaire administration was completed. Alpha Cronbach's reliability statistics was used to measure the internal consistency coefficients of the items included in the questionnaire and Cronbach's alpha was 0.623 with standardised item value of 0.628.

3.8 Method of Data Analysis

3.8.1 Land Use Land Cover Change

3.8.1.1 Image Preprocessing and Classification

Prior to the LULC cover classification, the downloaded images were preprocessed using Earth resource data analysis system. As part of the preprocessing, a spatial subset was done to reduce the image to the study area after which atmospheric corrections were done to enhance the image quality (Starocoitov and Makarau, 2014). High-resolution images from Google Earth, topographic map, aerial photograph and ground-based knowledge after detailed field survey were used to select training samples for the supervised classification.

All the preprocessed images were categorized into five (5) major LULC classes using the supervised classification method and Support Vector Machine (SVM) classification as the decision rule for the supervised classification algorithms. The classes used were Water bodies, Vegetation cover, Built up, Barren land, and Wetlands. The decision to use this classes was informed by FAO (2000) LULC classification scheme (Table 3.5). Maps and tables were generated for the classified images in the ArcGIS Pro.2.9 for further analysis.

Table 3.5. Land Use Land Cover Change Classes and their Description

Land Use Land Cover Class	Description
Natural and Semi-Natural Vegetation:	Natural vegetated areas are defined as areas where the vegetative cover is in balance with the abiotic and biotic forces of its biotope. Semi-natural vegetation is defined as vegetation not planted by humans but influenced by human actions.
Wetlands:	This class includes both cultivated and natural aquatic or regularly flooded areas. Cultivated aquatic are areas with purposely planted aquatic crops such as rice etc. While natural aquatic or regularly flooded areas describes areas which are transitional between pure terrestrial and aquatic systems and where the water table is usually at or near the surface, or the land is covered by shallow water.
Built environment	This class describes areas that have an artificial cover as a result of human activities such as construction (cities, towns, and transportation), extraction (open mines and quarries) or waste disposal.
Barren land:	This class describes areas that do not have an artificial cover because of human activities. These areas include areas with minimal vegetative cover including bare rock areas, sands and deserts.
Waterbodies:	These classes refer to areas that are naturally or artificially covered by water, such as streams, rivers and estuaries

Source: (FAO, 2000)

3.8.1.2 Statistical Analysis

The percentage change of the LULC change variables (barren land, built up, vegetation cover, water bodies and wetlands) for the different time period (1990, 2000, 2010, and 2020) were calculated to determine their increase or decrease within the study period. Furthermore, to estimate the relationship between LULC change classes with population growth, a correlation analysis was conducted to determine the degree to which changes in one LULC change class is related to changes in another LULC change class as well as changes in population from 1990 to 2020 and is computed as follows.

$$r = \frac{n(\sum xy) - (\sum x)(\sum y)}{[n\sum x^2 - (\sum x)^2][n\sum y^2 - (\sum y)^2]} \quad (6)$$

Were.

n=number of values or elements

∑x=sum of the x values

∑y=sum of the y values

∑xy=sum of the products of x and y values

$\sum x^2$= Sum of squares of x values

$\sum y^2$=sum of squares of y values

3.8.2 Climate Variability

Climate variability, such as annual total rainfall (mm), minimum temperature (^{o}c), maximum temperature (^{o}c), wind speed (knots) and relative humidity (%) have particularly been considered in determining climate conditions of a particular area. The extent of these variation trends over time is essential in examining the spatio-temporal dynamics of climate conditions of a particular location (Panda and Sahu, 2019). Few missing values mainly associated with missing observation were observed in the monthly data collected. This constitude 1.32% of the data collected. Inorder to fill in the missing gaps for the data collected from Kerewan, Banjul and Yundum stations, a more purposeful analysis, linear trendline interpolation was employed. This method of linear interpolation was based on determining the rate of change between the known values using simple slope formula as follows;

$$\boldsymbol{y = bx + a} \qquad (\mathbf{7})$$

Where;

Y= value to be estimated; a= slope ; X= known value; b= intercept

In serekunda in the kanifing municipality where the staion records only average monthly rainfall (mm) from 1980 to 2012, a two sample Ttest for paired comparison was conducted to compaire rainfall data between serekunda and the rainfall data of the other stations (Kerewan, Banjul and Yundum). However, a non significant difference was observed between serekunda and Yundum. Therefore, based on the Ttest, Yundum data for temperature (^{o}c), relative humidity (%) and windspeed (knots) were adopted as a proxy data for serekunda since yundum is observed be closer to serekunda and shows no significant difference in their total rainfall pattern.

Annual total rainfall (mm), maximum temperatures (^{o}c), minimum temperatures (^{o}c), wind speed (knots) and relative humidity (%), from the 3 meteorological stations (Kerewan, Banjul, and Yundum) along the coastal zone of The Gambia where analysed to determine homogeneity of the time series data using Pettitt, SNHT, Alexandersson (1986), Buishand's and Von Neumann's tests and Mann Kendal's trend test and Sen's slope estimator were used to determine and quantify their trends and the slope magnitude.

Then Mann–Kendall (Kendal, 1978) test as recommended by the World Meteorological Organization (WMO) in analysing climatic, hydrological and environmental data was utilized to determine monotonic trends. This test is less sensitive to abrupt changes as a result of inhomogeneity in time series data. Additionally, the test is robust, does not consider the data to be normally distributed or linear and it can cope with outliers Ali, *et al*. (2019) and was used by various researchers in determining trends of variables in meteorology and hydrology fields (Mondal, *et al*., 2012); Gocic and Trajkovic, (2013); Yadav *et al*., 2014; Yusuf, 2018:).

All these researchers proved the suitability of Mann Kendall's test to detect trend in climate variability indicators for testing climate variability of the coastal zone using the equations below. The time series data was not pre-whitening as the sample size is large and slope of trend was high (>0.01) in most of the variables (Bayazit and Önöz, 2007; Jain *et al*., 2013).

Statistic S can be obtained by:

$$s = \sum_{k=1}^{n-1} \sum_{j=k+1}^{n} sign\,(X_j - X_k) \qquad (7)$$

Where; $sign(x_j - x_k) = 1\ if\ x_j - x_k > 0$

$sign(x_j - x_k) = 0\ if\ x_j - x_k = 0$

$sign(x_j - x_k) = -1\ if\ x_j - x_k < 0$

A high positive value of S is an indicator of an increasing trend, and a very negative value indicates a decreasing trend.

Where n is the length of the sample, x_j and x_k are from *k*=1, 2… n-1 and *j*=*k*+1… n. If n is bigger than 8, statistic *S* approximates to normal distribution. The mean of *S* is 0 and the variance of S can be acquired as follows:

$$var(s) = \frac{n(n-1)(2n+5)}{18} - \sum_{K=1}^{p} qk(qk-1)(2qk+5) \quad (9)$$

The test statistic Z is denoted by equation 5 as.

$$Z = \begin{cases} \frac{s-1}{\sqrt{var(s)}}, if\ s > 0 \\ 0, if\ s = 0 \\ \frac{s+1}{\sqrt{var(s)}}, if\ s < 0 \end{cases} \quad (10)$$

If Z>0, it indicates an increasing trend, and if Z<0, it indicates a decreasing trend. Given a confidence level α, the sequential data would be supposed to experience statistically significant trend if $|Z|$>Z (1-α/2), where Z (1-α/2) is the corresponding value of P=α/2 following the standard normal distribution. However, it is necessary to compute the probability associated with S and the sample size, n, to statistically quantify the significance of the trend.

Magnitude of Trend

The magnitude of a time series trend was evaluated by a simple non-parametric procedure developed by Sen (1968). The Sen's slope test computes both the slope (i.e linear rate of change) and intercept according to Sen's method and is calculated as follows.

$$\beta = Median\left(\frac{x_j - x_i}{j - i}\right) \quad (11)$$

Where β is Sen's slope estimate. $\beta > 0$ indicates upward trend in a time series. Otherwise, the data series presents downward trend during the period.

3.8.3 Household Data Processing and Analysis

Simple descriptive statistical techniques such as cross tabulation, percentages and mean were utilised to describe and summarize the data. To analyse the socioeconomic factors affecting climate change understanding among coastal residents, binary logistic regression was utilized to analyse the relationship between dependent variable (understanding) and socio-economic characteristics to estimate their effects on understanding of climate change among coastal households. The binary logistic regression model for this study was expressed as;

$$\boldsymbol{Y_i = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \ldots\ldots\ldots \beta_n x_n} + \mu_i \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (12)$$

Where $\boldsymbol{\beta_0}$ is the constant

$\boldsymbol{\beta_{1,\ldots\ldots\ldots,}\beta_n}$= Regression coefficients

$\boldsymbol{Y_i}$= the function of N explanatory variables (presented in table 3.4)

3.8.4 Vulnerability Index Analysis

Vulnerability index is a numerical scale calculated from a set of selected variables used to compare regions. Based on the index different regions are ranked based on their relative less or more vulnerable. The index lies between 0 and 1 or as percentage by multiplying it by 100. In constructing vulnerability index for the coastal zone of The Gambia, several steps were employed. A list of possible and available indicators all related to the year 1990 to 2020, were selected based on availability of data, personal judgement and previous research.

The data utilized were obtained from secondary sources and household survey. Since the indicators were in different units, the methodology devised by UNDP's Human Development Index (HDI) by Watkins (2006) was utilized to normalize the data so that the values were standardized and weighted taking into account the functional relationships between the indicators and vulnerability. To establish the functional relationship, it was noted that vulnerability increases with increase or decrease in the values of the indicator. The functional relationship between vulnerability and the indicators are presented in Table 3.6.

Table 3.6. Indicators and Their Functional Relationship with Vulnerability

Domain	Indicator	Components	Functional relationship with vulnerability
Climate variability	Change in Total rainfall 1990 to 2020	E1	Vulnerability ↑ as precipitation ↑
	Change in av. Max temp	E2	Vulnerability ↑ as maximum temperature ↑
	Change in av. Min temp	E3	Vulnerability ↑ minimum temperature ↑
	Change in av. Relative humidity	E4	Vulnerability ↑ as relative humidity ↑
	Change in av. Wind speed	E5	Vulnerability ↑ as wind speed ↑
Natural hazard s	Flood	E6	Vulnerability ↑ as proportion households exposed coastal flood events↑
	Coastal erosion	E7	Vulnerability ↑ as proportion households expose to coastal erosion ↑
	Maximum temperature	E8	Vulnerability ↑ as proportion households expose to maximum temperature ↑
	Tropical windstorm	E9	Vulnerability ↑ as proportion households expose to tropical windstorm ↑
	Cold temperature	E10	Vulnerability ↑ as proportion households expose to colder temperature ↑
	Increase land erosion	E11	Vulnerability ↑ as proportion households expose to increased land erosion ↑
	Less rain	E12	Vulnerability ↑ as proportion households expose to less rainfall ↑
	More rain	E13	Vulnerability ↑ as proportion households expose to more rainfall ↑
	Changes in rainy and dry seasons	E14	Vulnerability ↑ as proportion households expose to changes in rainy and dry seasons ↑
Demographic profile	Av. Household size	S1	Vulnerability ↑ as the number of people per household ↑
	Proportion of female	S2	Vulnerability ↑ as the number of females per household ↑
	Proportion of young	S3	Vulnerability ↑ as the proportion of young (7years & below) per household ↑
	Proportion of old	S4	Vulnerability ↑ as the proportion of older people (65years and above) per household ↑
Socioeconomic status	House quality	S5	Vulnerability ↑ as the proportion of households living in mud and corrugated houses ↑
	Earning status	S6	Vulnerability ↑ as the proportion of households whose income are usually not enough to cover important household expense ↑
	Socially disadvantages	S7	Vulnerability ↑ as the proportion of households who migrated to the communities, they are residing ↑
	Literacy	A1	Vulnerability ↓ Proportion household members who a literate (at least a primary level) ↑
	Work	A2	Vulnerability ↓ proportion of household members who are working ↑

Livelihood activities	Skilled labour	S7	Vulnerability ↑ proportion of household members who depends on skilled labour (fishing, farming, trading, carpentry, mining etc.) For their livelihood ↑
	Non workers (dependents)	S8	Vulnerability ↑ as the Proportion of household members who doesn't engage in any economic activities (students, housewives…) ↑
Economic security	Salaried job	A3	Vulnerability ↓ as the Proportion workers who earn salary ↑
	Home ownership	A4	Vulnerability ↓ proportion of households who owns the house they are residing in ↑
	Assets	A5	Vulnerability ↓ proportion of households who have livestock, poultry and other household assets ↑
Infrastructure	Concrete houses	A6	Vulnerability ↓ proportion of households with cement or concrete as the main construction materials of the walls of the houses they were residing in ↑
	Corrugated roofing	A7	Vulnerability ↓ proportion of households with corrugated iron sheets as the main construction materials of the roof of their houses they were residing in
	Health care centres	A8	Vulnerability ↓ as the proportion of households who have access to health care centres ↑
Basic facilities	Sanitation	A9	Vulnerability ↓ proportion of households with flush toilets in their home ↑
	Electricity	A10	Vulnerability ↓ proportion of households with electricity ↑
	Safe drinking water	A11	Vulnerability ↓ proportion of households with safe drinking water ↑
	Improved tools for production	A12	Vulnerability ↓ proportion of households with improved tools for production ↑
	Communication	A13	Vulnerability ↓ proportion of household with radio, television and internet ↑
	Vehicles for transportation	A14	Vulnerability ↓ proportion of households with vehicles for transportation ↑

(Source: Fieldwork, 2021)
↑=Increases, ↓= Decreases

The values were further normalised based on their functional relationship with climate change vulnerability using the following formula below;

1. When vulnerability has a positive relationship with an indicator value.

$$\text{Positive } relationship\ x_{ij} = \frac{X_{ij} - \underset{i}{\text{Min}}\{X_{ij}\}}{\underset{i}{\text{Max}}\{X_{ij}\} - \underset{i}{\text{Min}}\{X_{ij}\}} \quad \text{.....(13)}$$

2. When vulnerability has a negative relationship with indicator value.

$$Negative\ relationship\ y_{ij} = \frac{\underset{i}{\text{Max}}\{X_{ij}\} - X_{ij}}{\underset{i}{\text{Max}}\{X_{ij}\} - \underset{i}{\text{Min}}\{X_{ij}\}} \quad \text{.....(14)}$$

Where, X_{ij} is the value of the indicator,

j is the corresponding value to the region,

i is the region.

Normalised values of the indicators are presented in Table 3.7.

Table 3.1. Normalised Values of Vulnerability Assessment Indicators of the Studied Cells within the Coastal Zone of The Gambia

Domain	Indicator	Description	Cell 1	Cell 4	Cell 5	Cell 6	Cell 8
Climate variability	Total rainfall	Change in Total rainfall 1990 to 2020	1.00	0.00	0.10	0.20	0.49
	Max temp	Change in av. Max temp 1990 to 2020	0.00	1.00	1.00	1.00	1.00
	Min temp	Change in av. Min temp 1990 to 2020	0.00	1.00	1.00	1.00	1.00
	Relative humidity	Change in av. Relative humidity 1990 to 2020	0.00	1.00	1.00	1.00	1.00
	Wind speed	Change in av. Wind speed 1990 to 2020	0.00	1.00	1.00	1.00	1.00
Natural hazards	Flood	Proportion households exposed coastal flood events	0.19	0.25	1.00	0.50	0.00
	Coastal erosion	Proportion households expose to coastal erosion	1.00	0.25	0.75	0.00	0.17
	Maximum temperature	Proportion households expose to maximum temperature	0.13	0.88	0.00	1.00	0.37
	Tropical windstorm	Proportion households expose to tropical windstorm	1.00	0.17	0.00	0.22	0.56
	Cold temperature	Proportion households expose to colder temperature	0.00	0.55	0.70	1.00	1.00
	Increase land erosion	Proportion households expose to increased land erosion	0.15	0.35	1.00	0.05	0.00
	Less rain	Proportion households expose to less rainfall	0.95	1.00	0.47	0.00	0.42
	More rain	Proportion households expose to more rainfall	0.00	0.28	0.83	1.00	0.81
	Changes in rainy and dry seasons	Proportion households expose to changes in rainy and dry seasons	0.00	0.56	0.74	0.96	1.00
Demographic profile	Av. Household size	Number of people per household	1.00	0.00	0.00	0.00	0.50
	Proportion of female	Number of females per household	1.00	0.79	0.95	0.63	0.00
	Proportion of young	Proportion of young (7years & below) per household	0.75	1.00	0.88	0.88	0.00

	Proportion of old	Proportion of older people (65years and above) per household	0.15	0.27	0.00	0.32	1.00
	House quality	Proportion of households living in mud and corrugated houses	0.00	0.16	0.67	0.27	1.00
Socioeconomic status	Earning status	Proportion of households whose income are usually not enough to cover important household expense	0.08	0.00	1.00	0.17	0.00
	Socially disadvantages	Proportion of households who migrated to the communities they are residing	0.36	0.41	0.82	1.00	0.00
	Literacy	Proportion household members who a literate (at least a primary level)	0.82	0.27	0.36	1.00	0.00
	Work	Proportion of household members who are working	0.33	0.00	0.67	1.00	0.33
Livelihood activities	Skilled labour	Proportion of household members who depends on skilled labour (fishing, farming, trading, carpentry, mining etc.) For their livelihood	0.60	0.00	0.00	1.00	1.00
	Non workers (dependents)	Proportion of household members who doesn't engage in any economic activities (students, housewives…)	0.33	0.00	0.67	1.00	0.33
Economic security	Salaried job	Proportion workers who earn salary	0.50	0.00	0.25	1.00	0.88
	Home ownership	Proportion of households who owns the house they are residing in	0.25	0.81	1.00	0.94	0.00
	Assets	Proportion of households who have livestock, poultry and other as households' assets	0.19	0.94	1.00	0.71	0.00
Infrastructure	Concrete houses	Proportion of households with cement or concrete	0.00	0.20	0.67	0.27	1.00

		as the main construction materials of the walls of the houses they were residing in					
	Corrugated roofing	Proportion of households with corrugated iron sheets as the main construction materials of the roof of their houses they were residing in	0.89	1.00	0.86	0.00	0.00
	Health care centers	Proportion of households who have access to health care centers	0.00	0.00	0.60	1.00	0.13
	Sanitation	Proportion of households with flush toilets in their home	0.46	0.00	0.42	0.23	1.00
	Electricity	Proportion of households with electricity	0.00	0.00	1.00	0.00	0.00
	Safe drinking water	Proportion of households with safe drinking water	0.63	0.21	1.00	0.05	0.00
Basic facilities	Improved tools for production	Proportion of households with improved tools for production	1.00	1.00	1.00	0.19	0.00
	Communication	Proportion of household with radio, television and internet	1.00	0.17	0.17	0.00	0.33
	Vehicles for transportation	Proportion of households with vehicles for transportation	0.08	0.00	1.00	0.67	0.92

(Source: Fieldwork, 2021)

Exposure and sensitivity together determine the potential impact and adaptive capacity is the extent to which this impact can be prevented. Vulnerability is potential impact (I) minus adaptive capacity (AC), expressed as

$$V = f(I - AC) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots .. (15)$$

Where $V = Vulnerability\ index$

$I = Impact\ (Exposure + Sensitivity)$

$AC = Adaptive\ Capacity$

Therefore, the measure of climate change vulnerability index (CCVI) of the coastal zone of The Gambia, was based on combinations of exposure, sensitivity and adaptive capacity. as follows:

$$\text{CCVI} = (\text{Sensitivity} + \text{Exposure}) - \text{Adaptive Capacity}$$

The vulnerability indicators were then used to rank the different coastal cells in terms of their index score in the order of highest to the lowest. The cell with the highest index is determined to be the most vulnerable.

3.8.5 State and Non-State Actor Participation in Building Resilience to Climate Change

Simple descriptive statistical techniques such as cross tabulation, percentages were used to summarise the data.

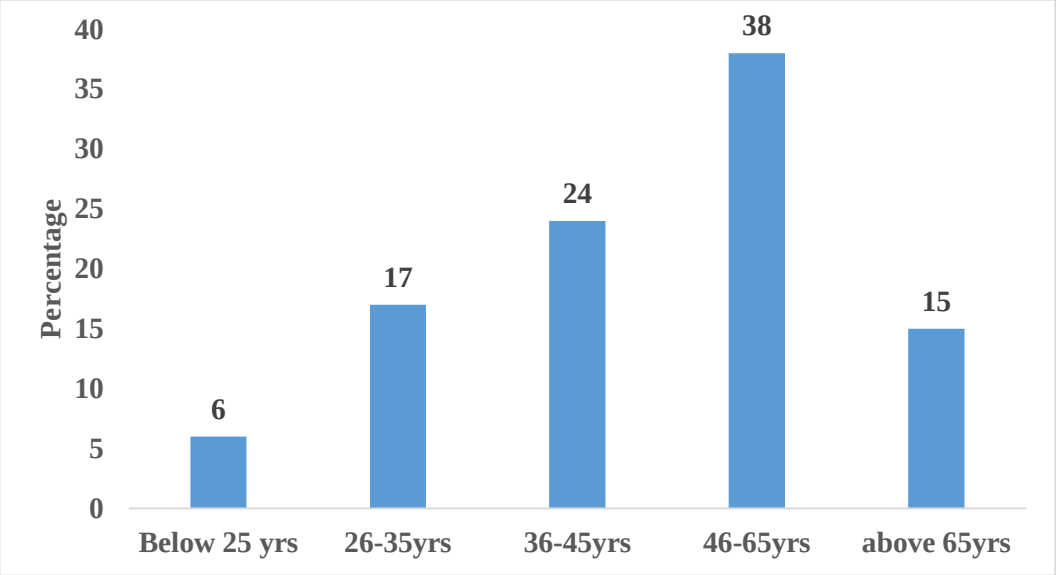
CHAPTER FOUR

DATA PRESENTATION, ANALYSIS AND DISCUSSIONS

4.1. Data Presentation and Analysis

4.1.1 Socio-Demographic Characteristics of Respondents within the Coastal zone of The Gambia

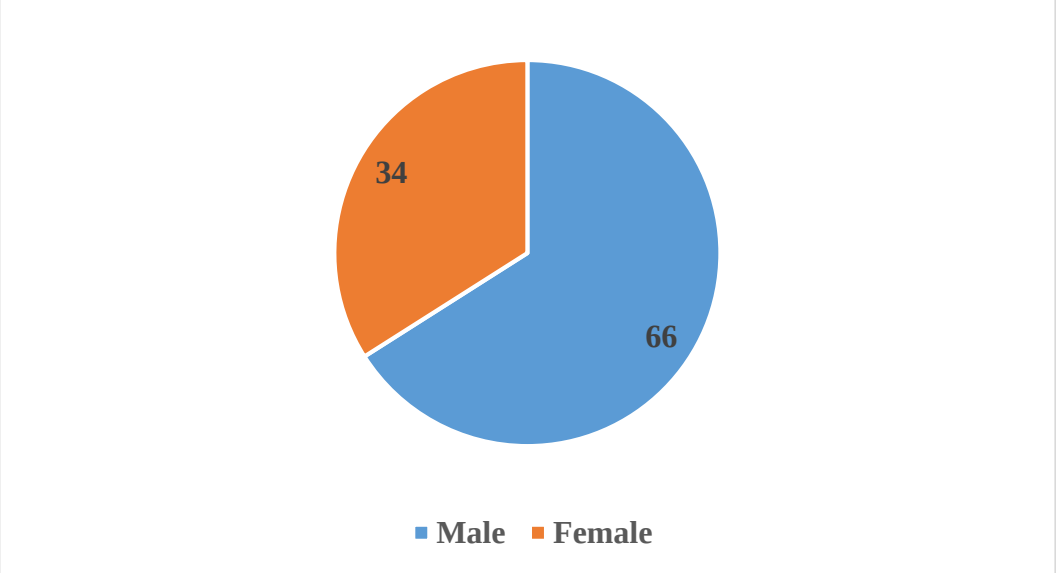
Information on the socio-demographic characteristics of respondents was obtained from the household survey within the coastal zone of The Gambia and the respondents included the household head (male or female) or their representative. The characteristics of the respondents presented in Figure 4.1 shows that majority of the respondents were within the age category 46-65 years with the highest proportion of 46-65 years recorded in cell 8 (Table 4.1).



(Source: Fieldwork, 2021)

Figure 4.1. Proportion of Respondents' Age Category within the Coastal Zone of The Gambia

In the analysis of gender disparities among respondents from the different cells presented in Figure 4.2, the results shows that 66% of the total respondents were male and 34% were female. Likewise, the result presented in Table 4.1 indicated that there are more male respondents than female in all the studied cells.



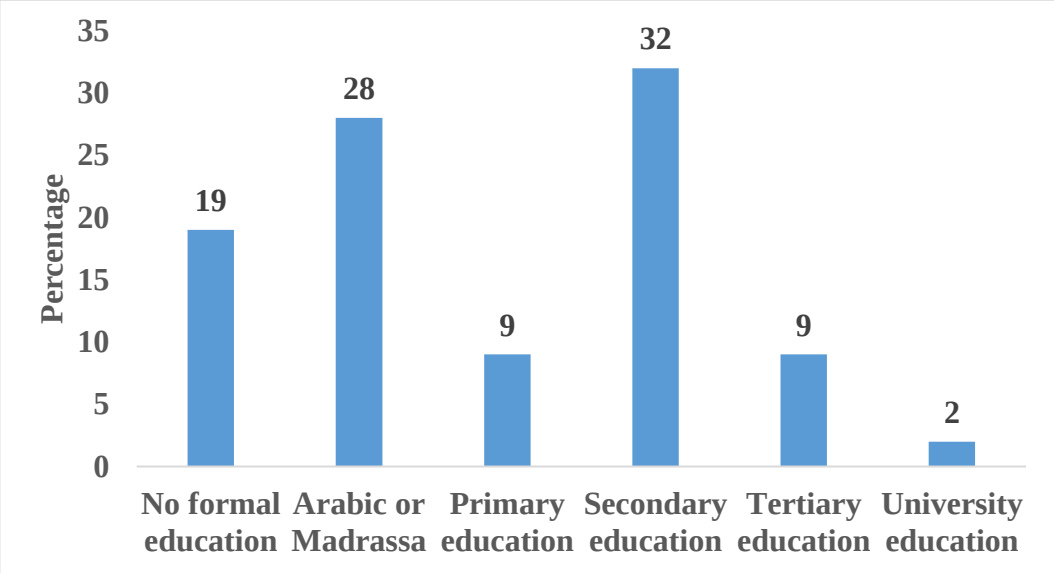
(Source: Fieldwork, 2021)

Figure 4.2. Proportion of Respondents' Gender within the Coastal Zone of The Gambia

The results presented in Figure 4.3 shows that 19% of the total respondents within the coastal zone indicated they had no formal education, 28% had attended Madarasa/ Arabic school, 9% and 32% had primary and secondary education respectively while only 9% and 2% had attained tertiary and university education levels respectively.

Furthermore, the result presented in Table 4.1 indicated that respondents without formal education was higher among respondents from cell 5 (28%) and cell 1 (25%). 43% and 31% of respondents from cell 4 and cell 5 respectively had attained at least a secondary

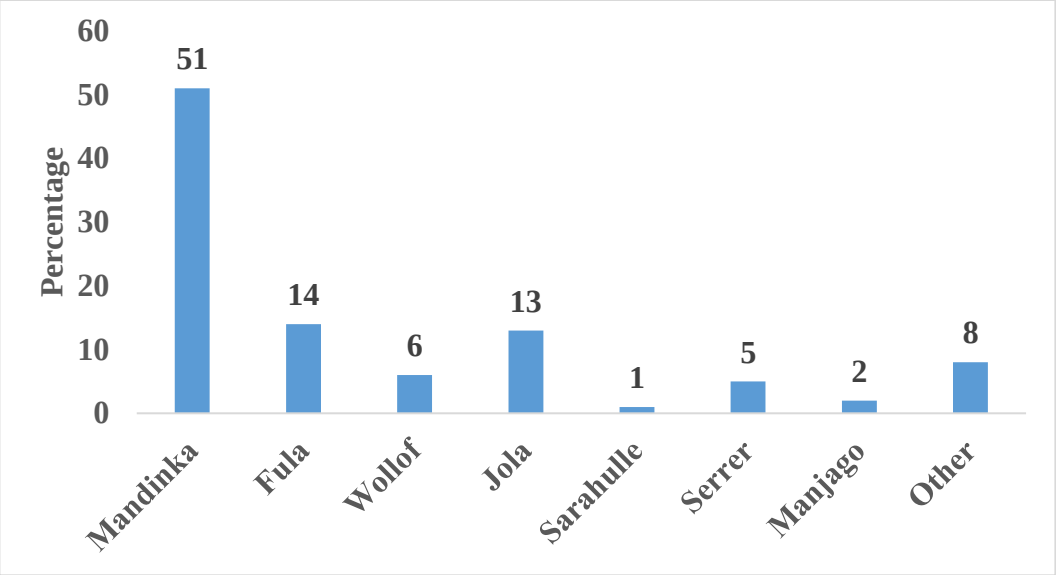
education level. Furthermore, the attainment of tertiary education level is higher among respondents from cell 1 (13%) and cell 4(11%) (Table 4.1).



(Source: Fieldwork, 2021)

Figure 4.3. Proportion of Respondents' Educational Level within the Coastal Zone of The Gambia

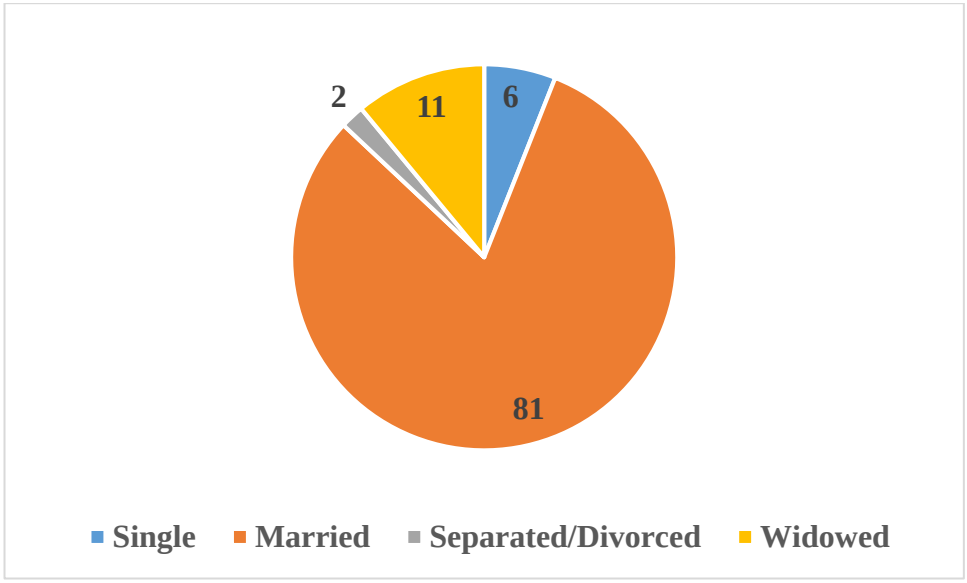
Additionally, the result presented in Figure 4.4 indicated that Mandinka ethnicity comprises majority (51%) of respondents interviewed in total during the survey who were predominantly from cell 1 (58%), cell 4 (60%) and cell 8 (77%). However, only 35% of respondents from cell 5 were from Jola ethnicity (Table 4.1).



(Source: Fieldwork, 2021)

Figure 4.4. Proportion of Respondents' Ethnicity within the Coastal Zone of The Gambia

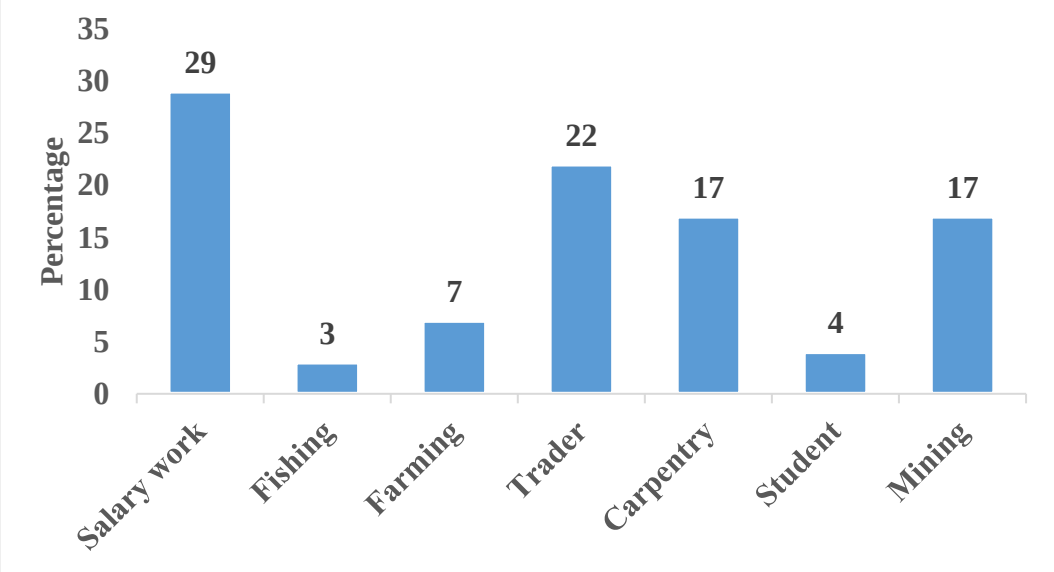
In terms of the marital status of respondents within the coastal zone of The Gambia, the result presented in Figure 4.5 indicated that, 81% of the total respondents were married comprising more than 70% of respondents in all the studied cells (Table 4.1).



(Source: Fieldwork, 2021)

Figure 4.5. Proportion of Respondents' Marital Status within the Coastal Zone of The Gambia

The primary occupation of respondents presented in Figure 4.6 shows that salary work (29%) and business (22%) were the main primary occupation of respondents in total within the coastal zone of The Gambia. The result in Table 4.1 further shows that 43% of respondents in cell 4 engage in salary work as their primary occupation while 35% of respondent in cell 1 engage in trading as their primary occupation.



(Source: Fieldwork, 2021)

Figure 4.6. Proportion of Respondents' Primary Occupation within the Coastal Zone of The Gambia

Table 4.1. Proportion of Respondents' Demographic Characteristics in the Studied Cells within the Coastal Zone of The Gambia

Characteristics		Cell 1	Cell 4	Cell 5	Cell 6	Cell 8
Age	Below 25yrs	12	6	8	2	2
	26-35yrs	15	16	25	14	10
	36-45yrs	25	23	22	28	25
	46-65yrs	33	38	32	42	47
	above 65yrs	15	17	14	13	17
Gender	Male	58	58	58	74	82
	Female	42	42	42	26	18
Educational level	No formal education	25	17	28	12	17
	Arabic or Madrassa	17	19	23	41	42
	Primary education	15	8	9	8	8
	Secondary education	25	43	31	29	23
	Tertiary education	13	11	7	7	8
	University education	4	2	2	2	2
Ethnicity	Mandinka	58	60	22	47	77
	Fula	17	11	18	15	10
	Wollof	8	8	6	7	2
	Jola	0	9	35	11	3
	Sarahulle	0	1	2	2	0
	Serrer	12	5	1	2	8
	Manjago	2	0	6	0	0
	Other	4	5	10	15	0
Marital status	Single	6	7	6	5	5
	Married	87	74	82	87	78
	Separated/Divorced	0	4	2	0	2
	Widowed	8	15	10	8	15
Primary occupation	Salary work	31	43	30	20	18
	Fishing	0	3	2	5	5
	Farming	6	5	6	4	17
	Trader	35	16	15	25	28
	Carpentry	10	9	17	28	18
	Student	0	5	8	2	3
	Mining	19	18	23	14	8

(Source: Fieldwork, 2021)

4.1.2 Climate and Non- Climate Stressors on the Coastal Zone of The Gambia

4.1.2.1 Land Use Land Cover Change

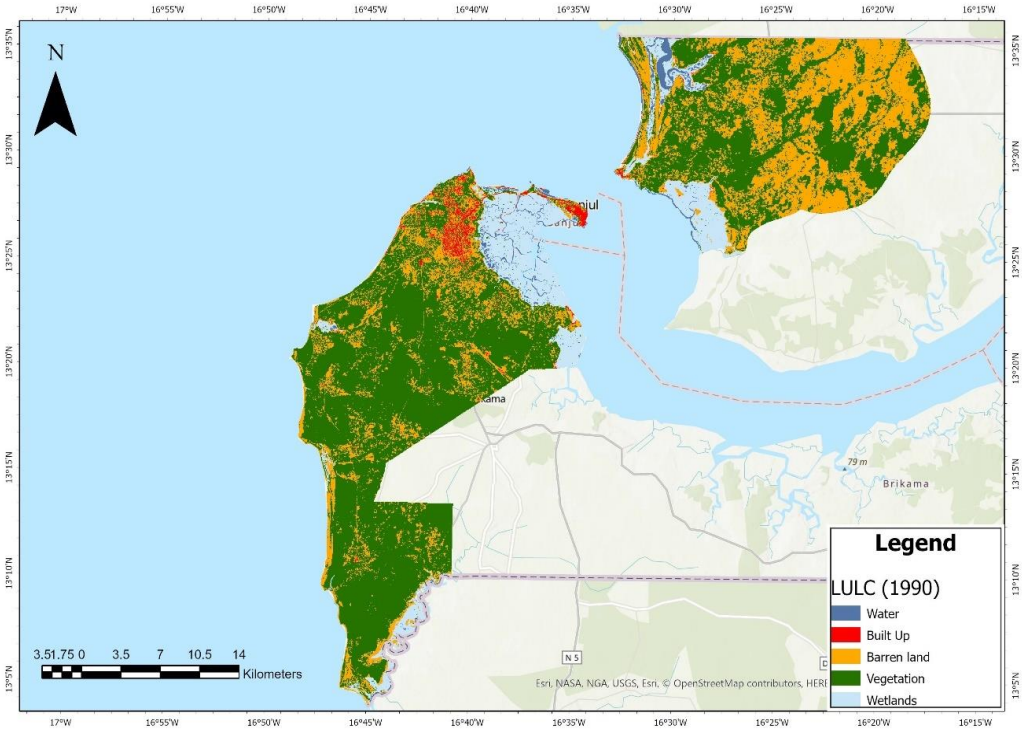
A single map of the coastal zone of The Gambia was produced for each study year (1990 to 2020) to evaluate land use and land cover (LULC) changes in the coastal environment using 1990 as the base year. The total land area and the percentage LULC changes were presented in Table 4.2.

Table 4.2. Land Use Land Cover Change Statistics of the Coastal Zone of The Gambia from 1990 to 2020

Land Cover	LULC_1990 (ha)	LULC_2000 (ha)	LULC_2010 (ha)	LULC_2020 (ha)	LCC_1990-2020 (%)
Barren	269.44	364.23	393.11	393.42	46
Built-up	12.8	39.78	47.93	99.8	680
Vegetation	543.85	432.48	399.66	351.44	-35
Waterbodies	13.27	13.02	13.48	9.15	-31
Wetlands	99.84	89.85	85.15	85.56	-14
Total	939.19	939.36	939.32	939.38	645

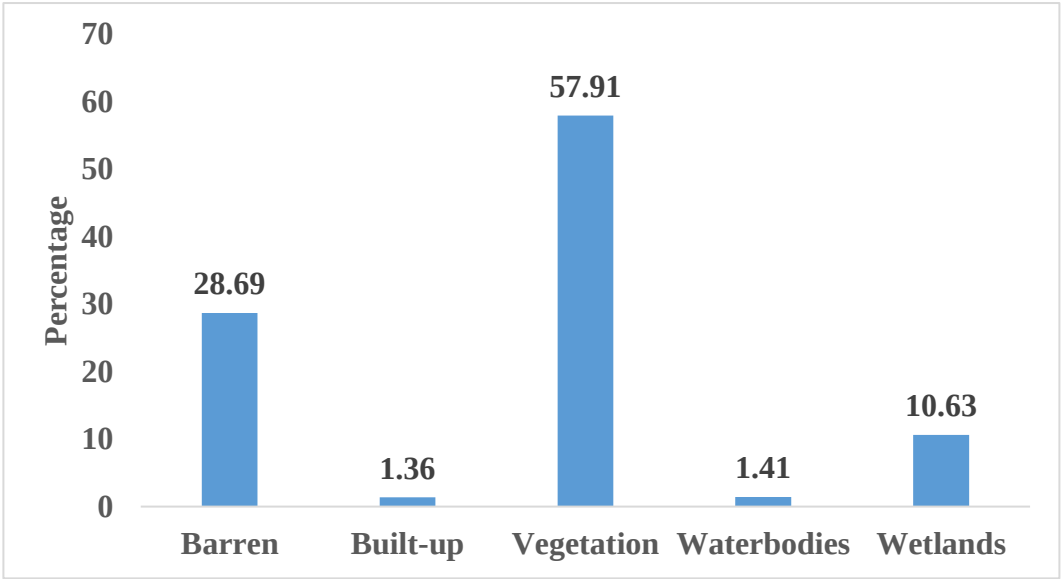
(**Source: Fieldwork, 2021**)

The Landsat 5 thematic mapper for the 1990 image, the base year for this study presented in Plate 4.1 and Table 4.2, shows that the total land area of coastal zone of The Gambia measured is 939.2ha. This total area includes barren land (264.44ha), Built environment (12.80ha), vegetation cover (543.85ha), waterbodies (13.27ha) and wetlands (99.84ha) (Table 4.2). This represents 28.69%, 1.36%, 57% 1.41% and 10.63% of barren land, Built-up, vegetation cover, water bodies and wetlands (10.63%) respectively (Figure 4.7).



(Source: Authors Illustration, 2020)

Plate 4.1. Land Use Land Cover Change Map of the Coastal Zone of The Gambia in 1990

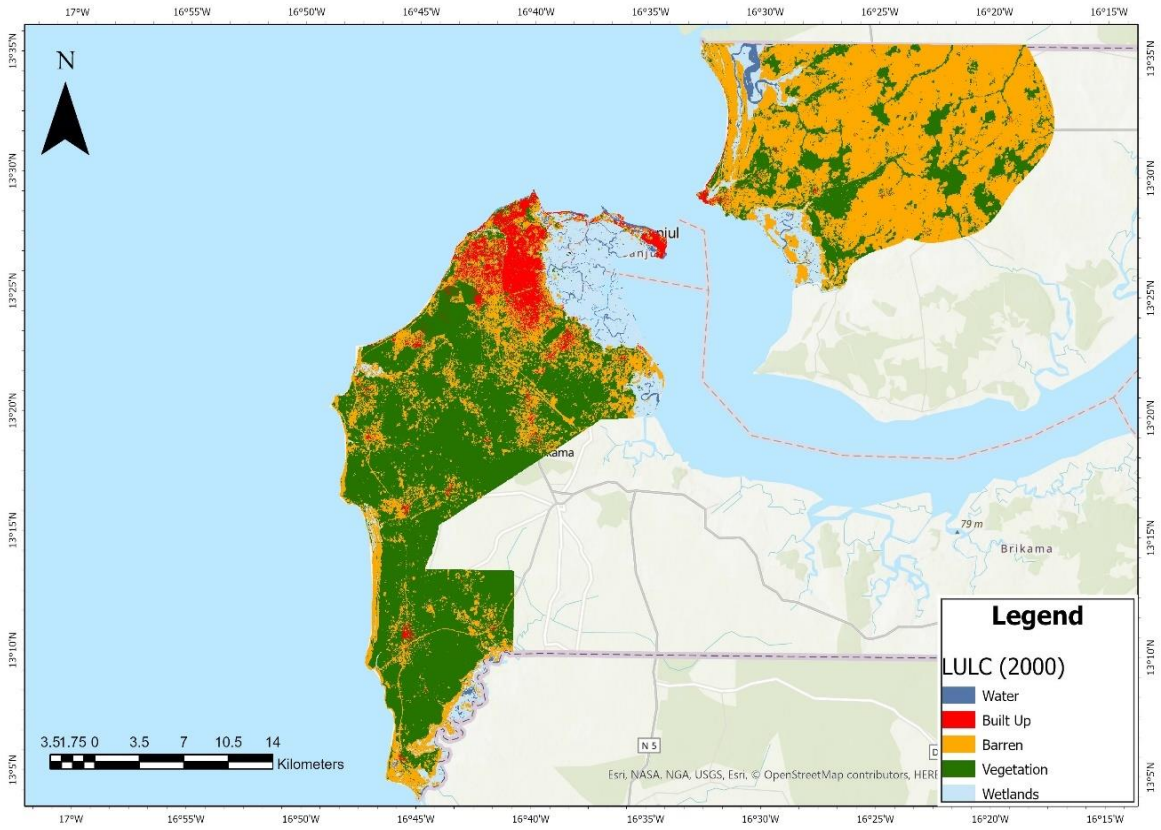


(Source: Fieldwork, 2020)

Figure 4.7. Proportion of Land Use Land Cover Change of the Coastal Zone of The Gambia in 1990

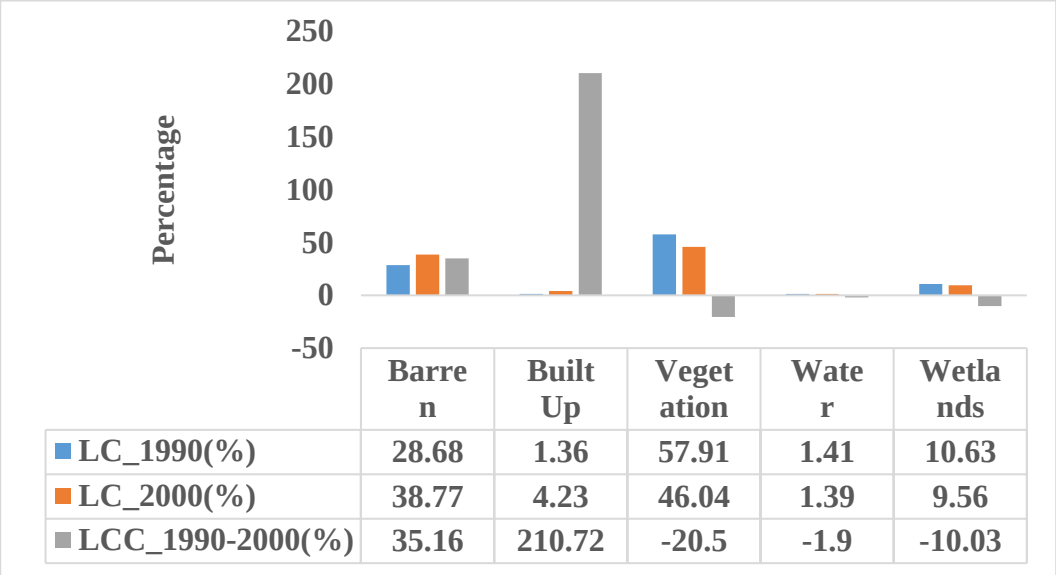
Landat 7 Enhanced Thematic Mapper Plus (ETM+) image obtained in 2000 measured a total land area of 939.4ha (Table 4.2 & Plate 4.2). The land cover areas were estimated as barren land (364.20ha), Built-up (39.78ha), vegetation cover (432.50ha), waterbodies (13.02ha), and wetlands (89.85ha) for built environment, vegetation, water and wetlands respectively (Table 4.2).

The results presented in Figure 4.8 represent 38.77%, 4.23%, 46.04%, 1.39% and 9.56% of barren land, built environment, vegetation cover, waterbodies and wetlands respectively Furthermore, the percentage LULC change from 1990 to 2000 presented in Figure 4.8 indicates that barren and built-up increased by 35.13% and 212.02% respectively while vegetation cover, water bodies and wetlands decreased by 20.50%, 1.42% and 10.07% respectively.



(Source: Authors Illustration, 2020)

Plate 4.2. Land Cover Change Map of the Coastal Zone of The Gambia (2000)

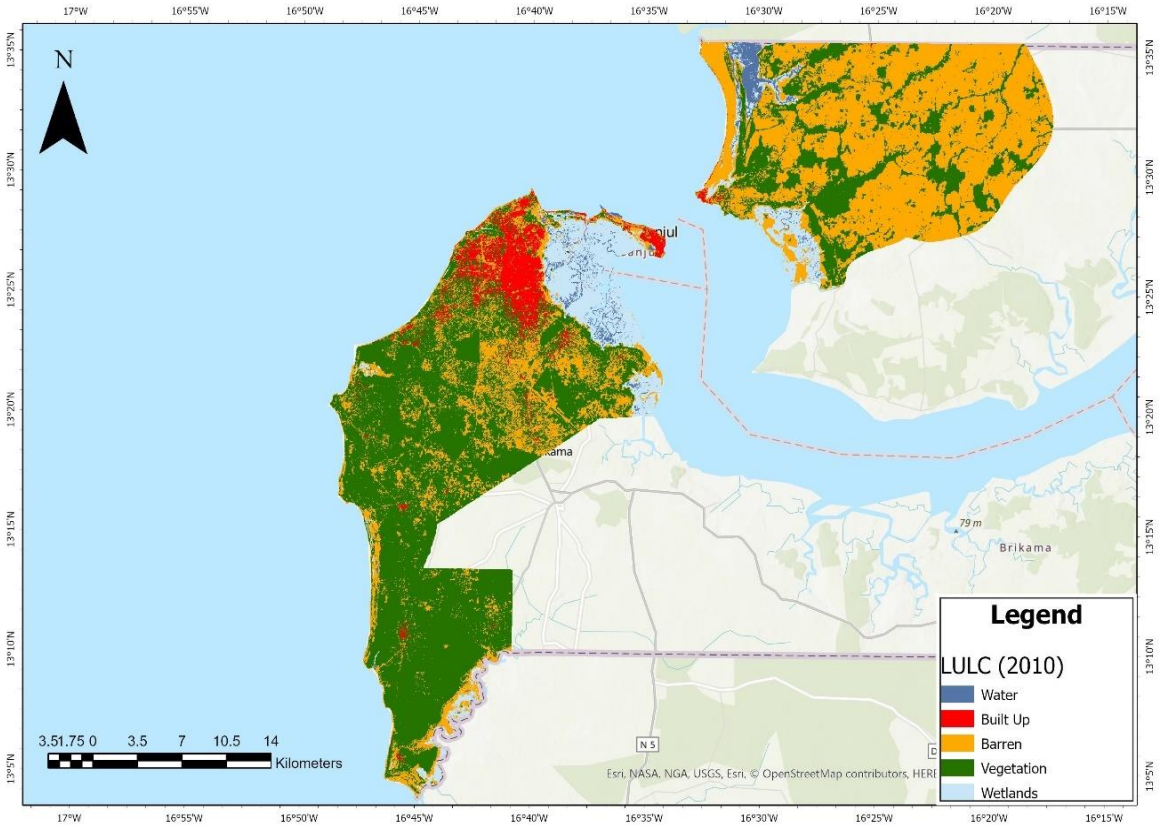


	Barren	Built Up	Vegetation	Water	Wetlands
LC_1990(%)	28.68	1.36	57.91	1.41	10.63
LC_2000(%)	38.77	4.23	46.04	1.39	9.56
LCC_1990-2000(%)	35.16	210.72	-20.5	-1.9	-10.03

(Source: Fieldwork, 2020)

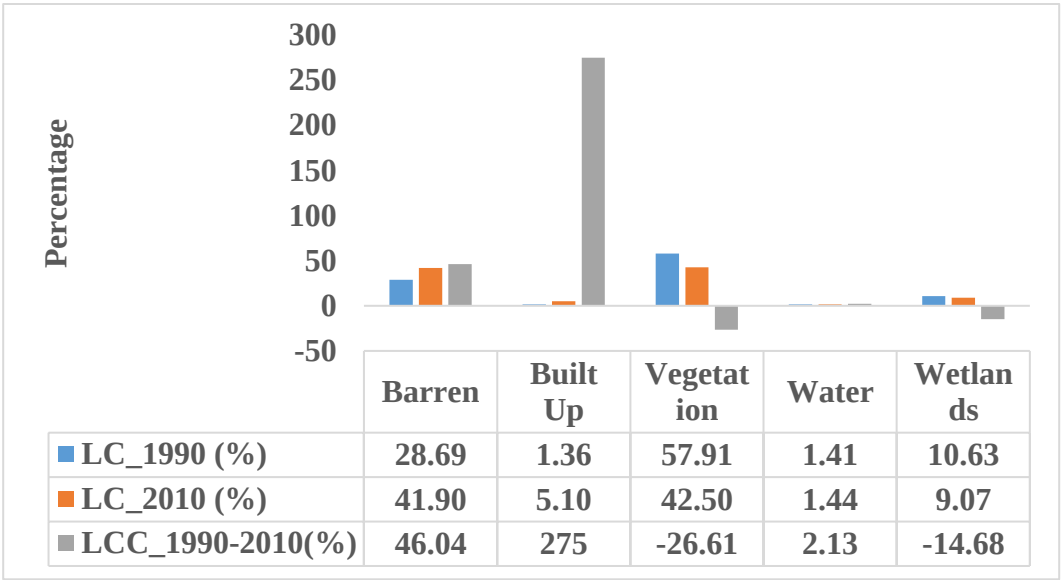
Figure 4.8. Proportion of Land Use Land Cover Change of the Coastal Zone of The Gambia from 1990 to 2000

Plate 4.3 shows the Landsat 7 Enhanced Thematic Mapper Plus (ETM+) image obtained in 2010. The result presented in Table 4.2 highlighted that the total land area measured is 939.32ha. This includes 393.11ha barren land, 47.93ha built-up, 399.66ha vegetation cover, 13.48ha water bodies and 85.15ha wetlands. The area in percentage of each of the land cover classes presented in Figure 4.9 indicates 41.90%, 5.10%, 42.50%, 1.44%, and 9.07% of barren land, built-up, vegetation cover, water bodies and wetlands of the total land area measure respectively. Figure 4.9 further highlighted an increased in barren land, built-up and water bodies by 46.04%, 275.00% and 2.13% respectively from 1990 to 2010 while there is a decreased in vegetation cover and wetlands from 1990 to 2010 by -27%, and -15% respectively.



(Source: Authors Illustration, 2020)

Plate 4.3. Land Cover Change Map of the Coastal Zone of The Gambia (2010)



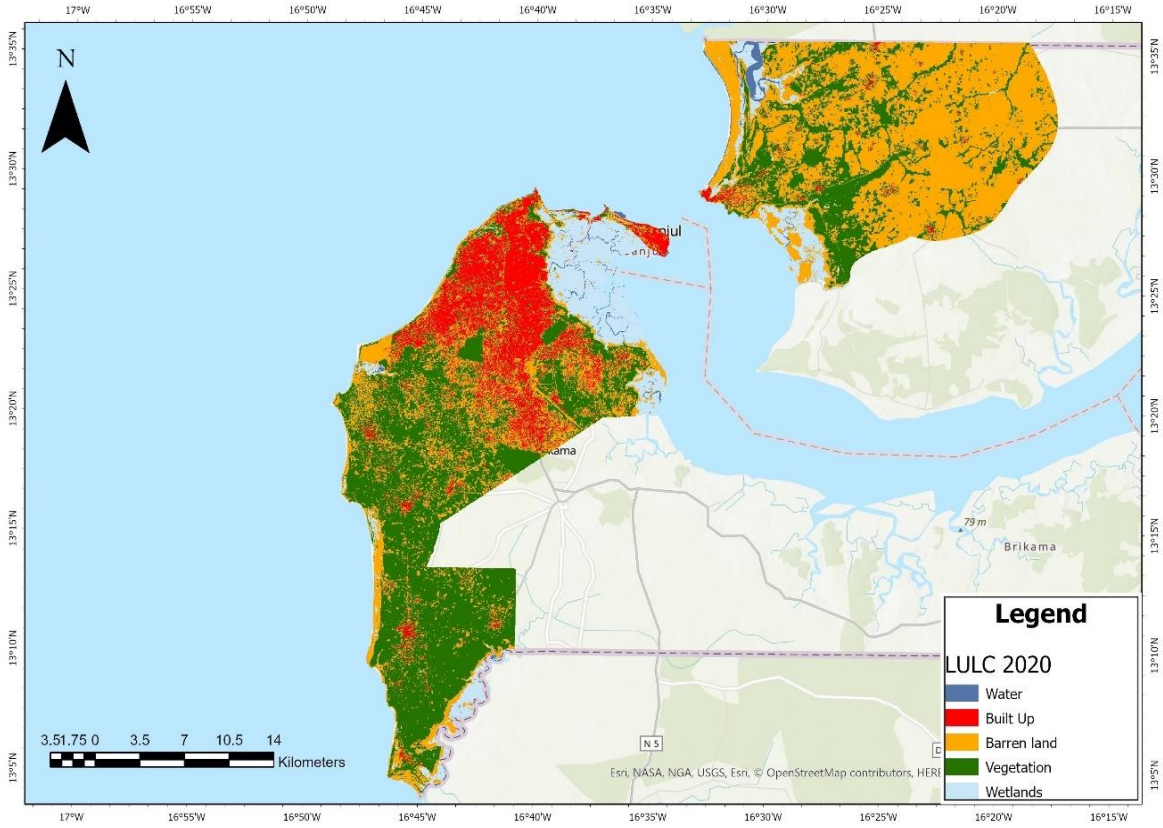
	Barren	Built Up	Vegetation	Water	Wetlands
LC_1990 (%)	28.69	1.36	57.91	1.41	10.63
LC_2010 (%)	41.90	5.10	42.50	1.44	9.07
LCC_1990-2010(%)	46.04	275	-26.61	2.13	-14.68

(Source: Fieldwork, 2020)

Figure 4.9. Proportion of Land Use Land Cover Change of the Coastal Zone of The Gambia from 1990 to 2010

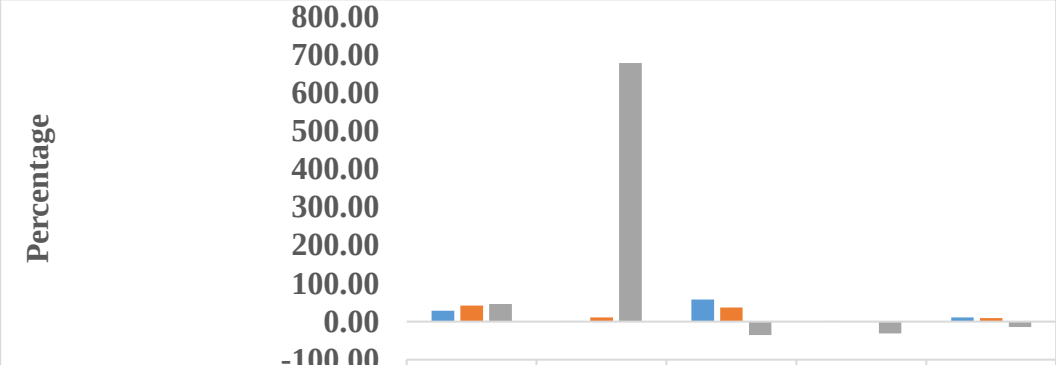
Plate 4.4 shows the Operational Land Imager (OLI) and Thermal Infrared Sensor (TIRS) image obtained for 2020 Land Use Land Cover. The analysis of the result presented in Table 4.2 shows the total land area of 939.38ha measured which includes 393.42ha of barren land, 99.80ha of built environment, 351.44ha of vegetation cover, 9.15ha of water bodies and 85.56ha of wetlands. The percentage land area measured for each of the LULC classes presented in Figure 4.10 represents 41.88%, 10.62%, 37.41%, 0.97% and 9.11% of barren land, built environment, vegetation cover, water bodies and wetlands respectively in 2020.

Furthermore, the total LULC change presented in Figure 4.10 from 1990 to 2020 shows an increase in barren land (46.00%) and built-up (679.52%) and a decrease in vegetation cover (-35.41%), water bodies (-31.06%) and wetlands (-14.32%).



(Source: Authors Illustration, 2020)

Plate 4.4. Land Cover Change Map of the Coastal Zone of The Gambia (2020)



	Barren	Built Up	Vegetation	Water	Wetlands
LC_1990(%)	28.68	1.36	57.91	1.41	10.63
LC_2020(%)	41.88	10.62	37.41	0.97	9.11
LCC_1990-2020(%)	46.00	679.52	-35.41	-31.06	-14.32

(Source: Fieldwork, 2020)

Figure 4.10. Proportion of Land Use Land Cover Change of the Coastal Zone of The Gambia from 1990 to 2020

4.1.2.2 Relationship Between Land Cover Change and Population

Table 4.3 displays the Pearson correlation matrix for land cover change variables and the population living within 10-25km coastline from 1990 to 2020. The results highlighted a significant associated between the variables. Further examining the correlation matrix, it is observed that correlation between barren land and vegetation is significantly different from zero at 5% significant level (P≤-0.9653). There is a negative relationship between barren land and wetlands at 5% significant level (P≤ -0.9964) and a negative relationship between built-up and vegetation cover at 10% significant level (≤ -0.9086).

A negative correlation also exists between built up and water bodies at 10% significant level (-0.9006). While population is observed to show a positive correlation with built-up at 5% significant level (≤ 0.9910), it registered a negative correlation with vegetation at 10%

significant level (≤ -0.9082). There is also a negative correlation between population and water bodies though the correlation coefficient is not significant.

Furthermore, the result shows a positive correlation at 5% significant level (≤0.9640) between vegetation cover and wetlands. These relationships between the variables are clear indication that the increase in population along the coast is an essential factor that describes the increase in built-up and barren land and a decrease in vegetation cover, water bodies and wetlands.

Table 4.3. Correlation between Land Use Land Cover Change Class and Population of the Coastal Zone of The Gambia from 1990 to 2020

Variables	Barren	Built Up	Vegetation	Waterbodies	Wetlands	Population
Barren	1					
Built Up	0.7683	1				
Vegetation	**-0.9653****	**-0.9089***	1			
Water	-0.4197	**-0.9006***	0.6416	1		
Wetlands	**-0.9964****	-0.7717	**0.9640****	0.4195	1	
Population	0.7739	**0.9910****	**-0.9082***	-0.8724	-0.7882	**1**

**** Correlation is significant at the 0.05 level (2-tailed test)
* Correlation is significant at the 0.10 level (2-tailed test)
(Source: Fieldwork, 2020)

4.1.2.3 Climate Variability Summary Statistics

Climate variability analysis for total rainfall (mm), maximum and minimum temperatures (^{O}C), relative humidity (%) and wind speed (knots) were analysed for the coastal zone of The Gambia from 1980 to 2020. The summary statistics of the climate variability presented in Table 4.4 shows that total annual rainfall (mm) ranges from 309.70 to 905.475 mm with a mean total rainfall (mm) of 591.7226. The mean maximum temperature (^{O}C) recorded ranges from 19. 5114 to 34.7591 and the mean temperature recorded was 33.3385. Mean minimum temperature (^{O}C) recorded ranges from a minimum 19.5114 to maximum of

22.0429. The mean relative humidity recorded (%) was 65.0085 with a minimum relative humidity of 61.3746 and a maximum of 70.2882. The result further indicates a mean wind speed (knots) of 13.7806 with a minimum of 9.9472 and maximum of 20.7524.

Table 2: Summary Statistics of the Climate Variability of the Coastal Zone of The Gambia from 1980 to 2020

Variable	Minimum	Maximum	Mean	Std. deviation
Total rainfall (mm)	309.7000	905.4750	591.7226	136.2369
Mean maximum temperature(^{o}c)	31.9661	34.7591	33.3385	0.6176
Mean minimum temperature (^{o}c)	19.5114	22.0429	20.8342	0.6795
Relative humidity (%)	61.3746	70.2882	65.0082	2.2995
Windspeed (knots)	9.9472	20.7524	13.7806	3.0372

(Source: Fieldwork, 2020)

4.1.2.4 Homogeneity and Change Point Detection of Climate Data from 1980 to 2020.

The change point detection of homogeneity of the data series was conducted using Pettitt's test, SNHT test, Buishand's test and Von Neumann's test. The result presented in Table 4.5 shows discontinuities in all the climate variables being considered. The results obtained from Petitt, Buishands and Von Neumann's test highlighted inhomogeneity in the annual total rainfall (mm) which were observed around 1998. In the same vein, all the tests show inhomogeneity with annual maximum temperature time series data around the year 1993 and 1994 and minimum temperatures time series data around 2005 and 2010. Furthermore, all the tests have shown discontinuity with the relative humidity time series data around 1993. Additionally, inhomogeneity in the wind speed time series data was detected by the SNHT and the Von Neumann's test for the year 1983.

Table 4.5. Homogeneity Test Based on Climate Data of the Coastal Zone of The Gambia from 1980 to 2020

	Pettitt's test			SNHT			Buishand's test			Von Neumann's test	
Variables	**k**	**t**	**p-value (Two-tailed)**	**T0**	**t**	**p-value (Two-tailed)**	**Q**	**t**	**p-value (Two-tailed)**	**N**	**p-value (Two-tailed)**
Total rainfall	202.000	1998	0.0363	7.2279	1998	0.0785	8.6909	1998	0.0246	1.4824	0.0447
Max temperature.	350.000	1994	< 0.0001	20.0456	1993	< 0.0001	13.9146	1994	< 0.0001	0.5544	< 0.0001
Min temperature	310.000	2005	0.0002	19.1208	2010	< 0.0001	12.9050	2005	0.0005	0.6810	< 0.0001
Relative humidity	202.000	2013	0.0293	12.1939	2013	0.0026	8.5179	2013	0.0415	0.8333	< 0.0001
Windspeed	176.000	2012	0.0875	9.2220	1983	0.0285	7.1152	2012	0.1143	0.5240	< 0.0001

** Significant at the 0.05 level (2-tailed test)
* Significant at the 0.10 level (2-tailed test)
(Source: Fieldwork, 2020)

4.1.2.5 Climate Variability Trend Analysis

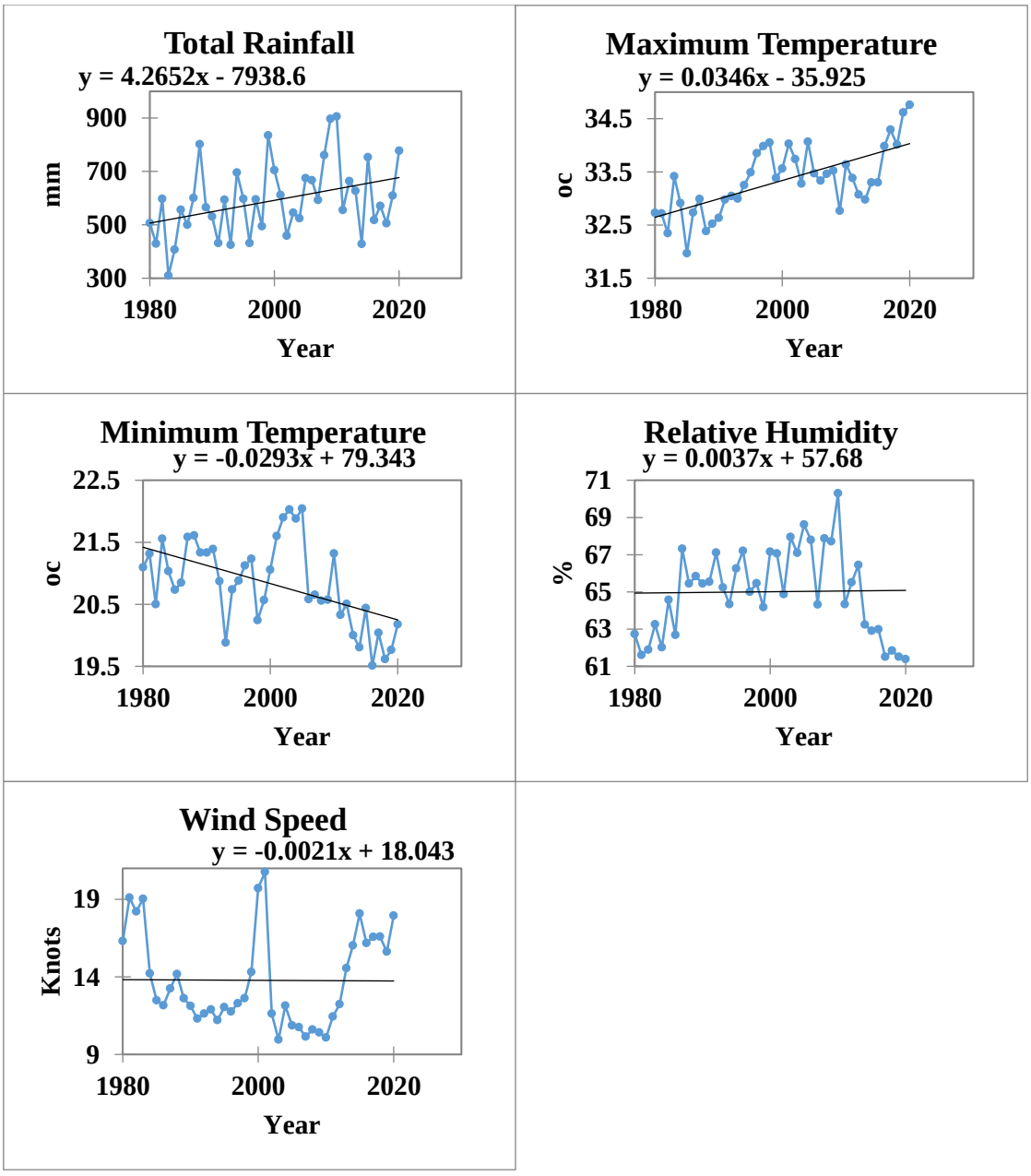
Mann Kendall's trend test analysis was conducted to determine and quantify the increase or decrease of total rainfall (mm), maximum temperature (^{O}C), minimum temperatures (^{O}C), and relative humidity (%) and wind speed (knots) from 1980 to 2020 for the coastal zone of The Gambia. The result presented in Table 4.6 shows a statistically significant trend for total rainfall (mm) at 5% significant level (P≤ 0.0207), maximum temperature (^{O}C) trend of at 1% significant level (P≤ 0.0001) and minimum temperature (^{O}C) of 0.0007 at 1% significant level (P≤ 0.0007). There was no trend observed for relative humidity (%) and wind speed (knots) (Table 4.6 & Figure 4.5).

Table 4.6 further highlighted that the Sen's slope values indicate a positive slope for total rainfall (mm) and maximum temperature (^{O}C) of 4.08744 and 0.0347 respectively while a negative slope of -0.0319 was observed for minimum temperature (^{O}C). However, the magnitude of the increasing trend is higher in annual maximum temperature (^{O}C) (0.0347) than the decreasing annual minimum temperature (^{O}C) (0.0319).

Table 4.6. Climate Variability Trends of the Coastal Zone of The Gambia from 1980 to 2020

	Kendall's tau	**S**	**Var(S)**	**P-value (Two-tailed)**	**Sen's slope:**
Total rainfall (mm)	0.2512	206.0000	0.0000	0.0207	4.08744
Maximum temperature (^{o}c)	0.4805	394.0000	0.0000	< 0.0001	0.0347
Minimum temperature (^{o}c)	-0.3610	-296.0000	0.0000	0.0007	-0.0319
Relative humidity (%)	0.0207	17.0000	7925.6667	0.8574	0.0048
Windspeed (knots)	-0.0707	-58.0000	7925.6667	0.5246	-0.0294

** Significant at the 0.05 level (2-tailed test)
* Significant at the 0.10 level (2-tailed test)
(Source: Fieldwork, 2020)



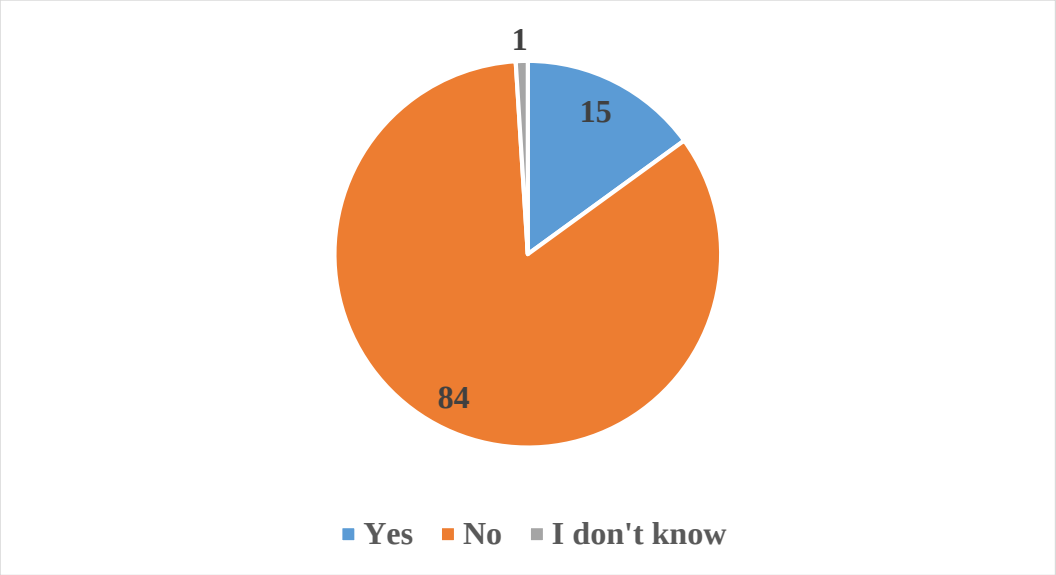
(Source: Author's Illustration, 2020)

Figure 4.11. Climate Variability Trends along the Coastal Zone of The Gambia (1980 to 2020)

4.1.3 Believe, Awareness and Understanding of Climate Change among Coastal Communities in The Gambia

4.1.3.1 Socio-Economic Characteristics of Respondents

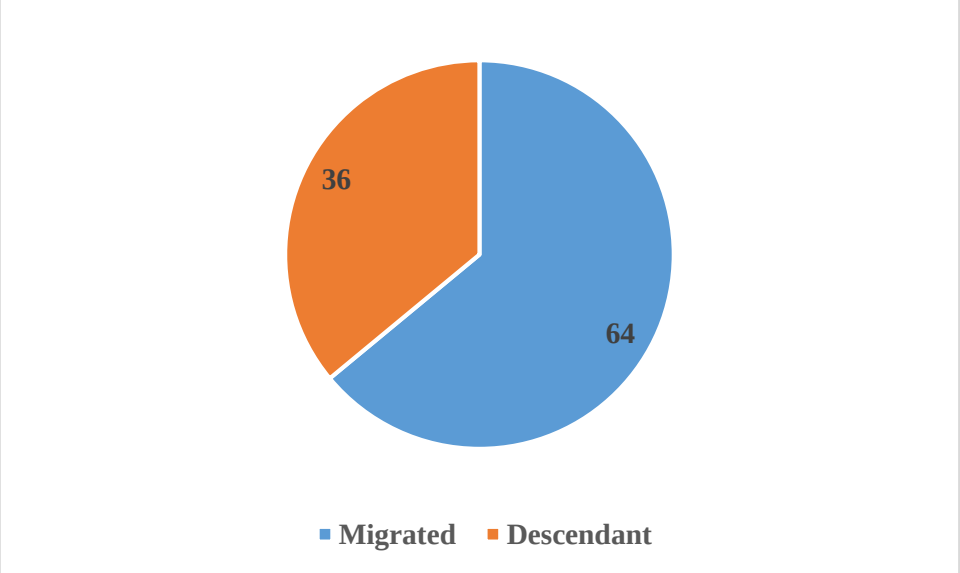
The analysis of the health issue of respondents presented in Figure 4.12 shows that 84% of the total respondents within the coastal zone of The Gambia stated they had no health-related issues. In addition, the analysis of health-related issues within the various coastal cells presented in Table 4.7 also indicated that more than 70% of respondents in all the studied cells had no health-related issue.



(Source: Fieldwork, 2021)

Figure 4.12. Proportion of Respondents' Health Issue within the Coastal Zone of The Gambia

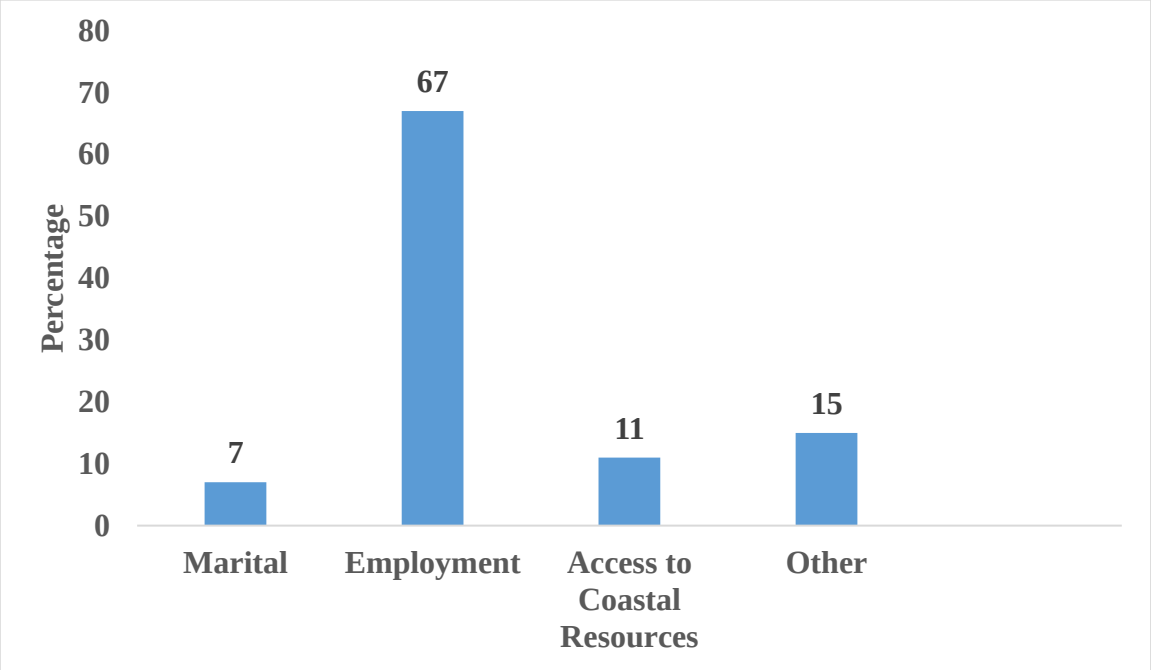
The result shown in Figure 4.13 highlighted that 64% of the households in total within the coastal zone of The Gambia had migrated to the communities they were residing. However, the result presented in Table 4.7 indicated that 68% of these households in cell 8 were descendants in the communities they were residing.



(Source: Fieldwork, 2020)

Figure 4.13 Proportion of Respondents' Residential Status within the Coastal Zone of The Gambia

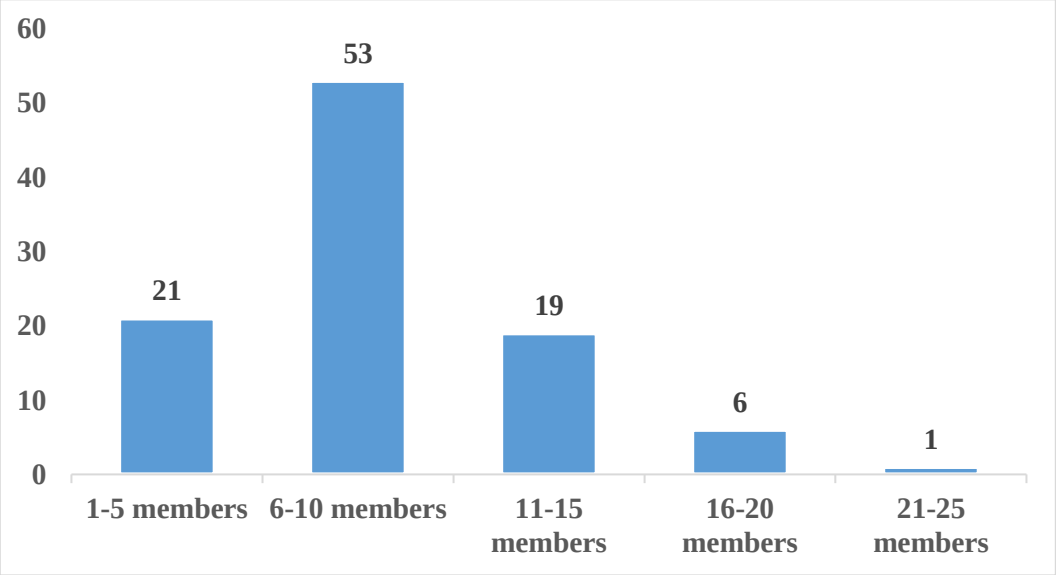
Furthermore, Figure 4.14 stressed employment as the main reason given by respondents for choosing to migrate in the settlement they were residing. This represents 67% of households in total within the coastal zone and more than half of respondents in the various studied cells. This represents 70%, 71%, 70% 60%, 63% of households in Cell 1, Cell 4, Cell 5, Cell 6 and Cell 8 respectively (Table 4.7).



(Source: Fieldwork, 2020)

Figure 4.14. Proportion of Respondents' Main Reason for Migrating to the Coastal Zone of The Gambia

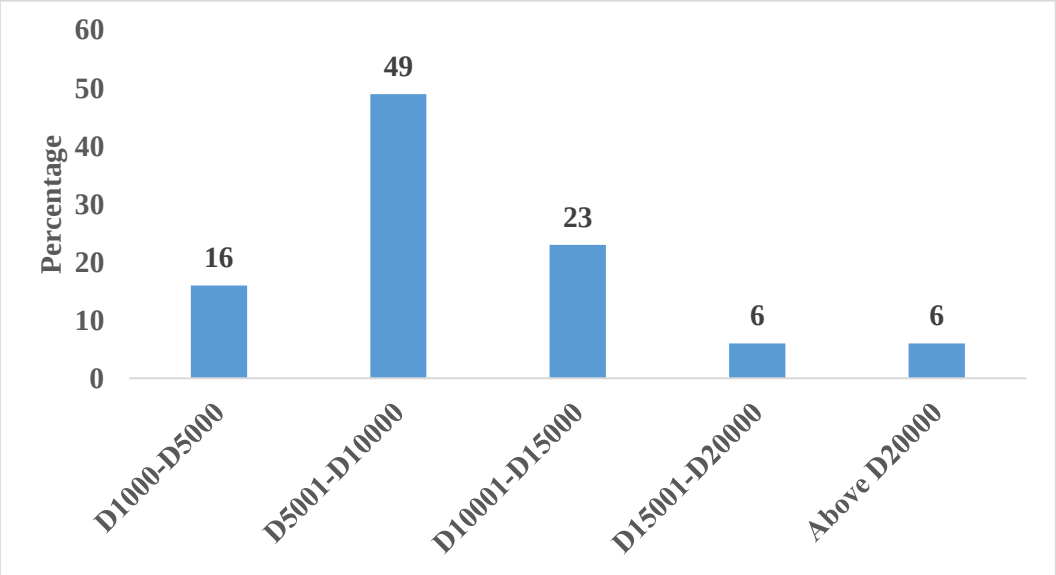
In addition, the analysis of household within the Coastal zone of The Gambia in total presented in Figure 4.15 indicated that 53% of households had 6-10 member. This is also observed in analysis of the result in Table 4.7 where almost half of the households in all the studied cells have 6- 10 members.



(Source: Fieldwork, 2020)

Figure 4.15. Proportion of Respondents' Household Size within the Coastal Zone of The Gambia

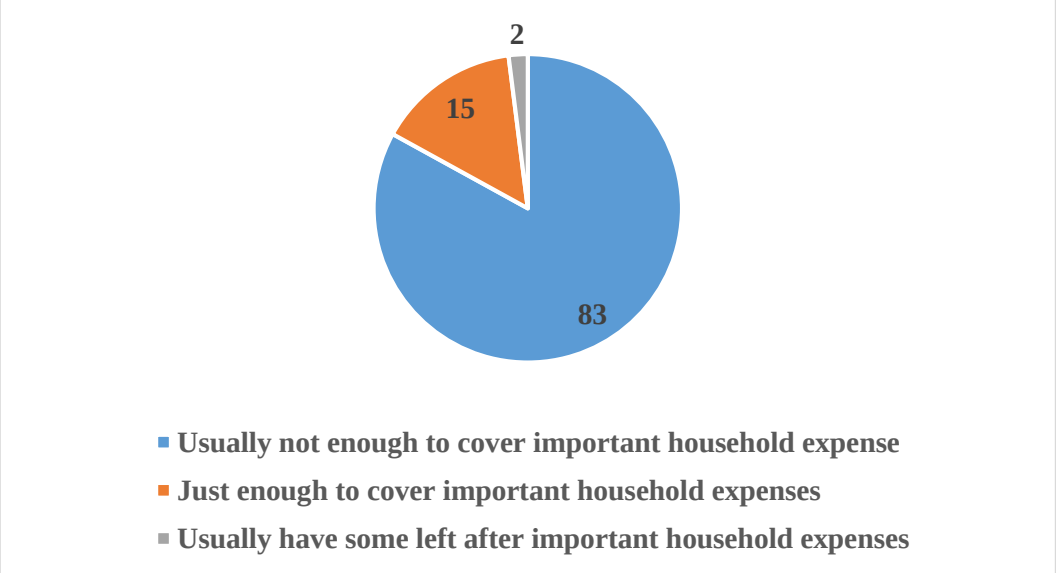
Furthermore, the result presented in Figure 4.16 indicated that the monthly income level of 49% of households in total within the coastal zone was D5001-D10000. In the same vain, the analysis of the result in Table 4.7 indicated that the monthly income level of 59% and 54% of respondents in cell 4 and cell 5 respectively was D5001-D10000. However, more than 23% of respondents in cell 1, cell 6 and cell 8 had monthly income level of D10001-D15000.



(Source: Fieldwork, 2020)

Figure 4.16. Proportion of Respondents' Monthly Household Income Level within the Coastal Zone of The Gambia

In rating the sustainability of their monthly household income based on their expenses, the analysis of the result presented in Figure 4.17 shows that the monthly income level of 83% of respondents in total within the coastal zone of The Gambia is usually not enough to cover important household expenses. This represents majority of respondents in all the studied cells (Table 4.7)



(Source: Fieldwork, 2020)

Figure 4.17. Proportion of Respondents' Sustainability of Monthly Household Income within the Coastal Zone of The Gambia

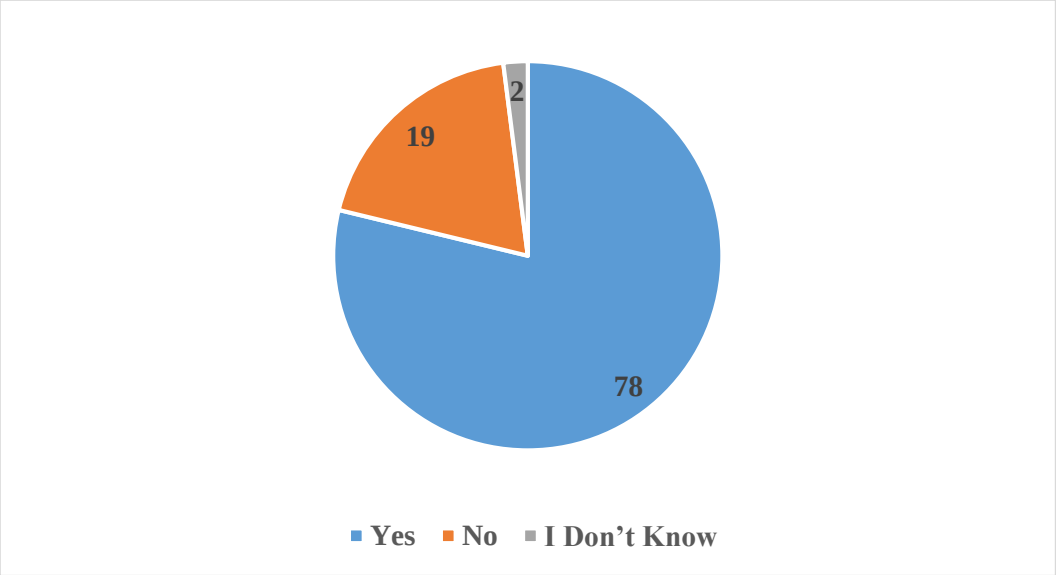
Table 3: Proportion of Respondents Socio-economic Characteristics in the Studied Cells within the Coastal Zone of The Gambia

Characteristics		Cell 1	Cell 4	Cell 5	Cell 6	Cell 8
Health issue	Yes	25	18	14	9	10
	No	71	82	85	91	90
	I don't know	4	0	1	0	0
Residential Status	Migrated	52	55	78	88	32
	Descendant	48	45	22	12	68
Reason for migrating to the community	Marital	7	17	7	0	11
	Employment	70	71	70	60	63
	Access to Coastal Resources	7	2	10	17	16
	Other	15	10	13	23	11
Household size	1-5 members	12	25	25	26	10
	6-10 members	48	57	56	49	50
	11-15 members	31	16	13	19	27
	16-20 members	8	2	7	6	10
	21-25 members	2	0	0	0	3
Household income level (month)	D1000-D5000	19	11	23	14	12
	D5001-D10000	35	54	59	44	48
	D10001-D15000	29	20	15	32	25
	D15001-D20000	6	8	2	6	7
	Above D20000	12	7	1	5	8
How would you rate your household income level, based on your expenses (month)	Usually not enough to cover important household expense	81	80	92	82	80
	Just enough to cover important household expenses	19	17	8	15	17
	Usually have some left after important household expenses	0	3	0	2	3

(Source: Fieldwork, 2021)

4.1.3.2 Awareness, Believe and Understanding of Climate Change

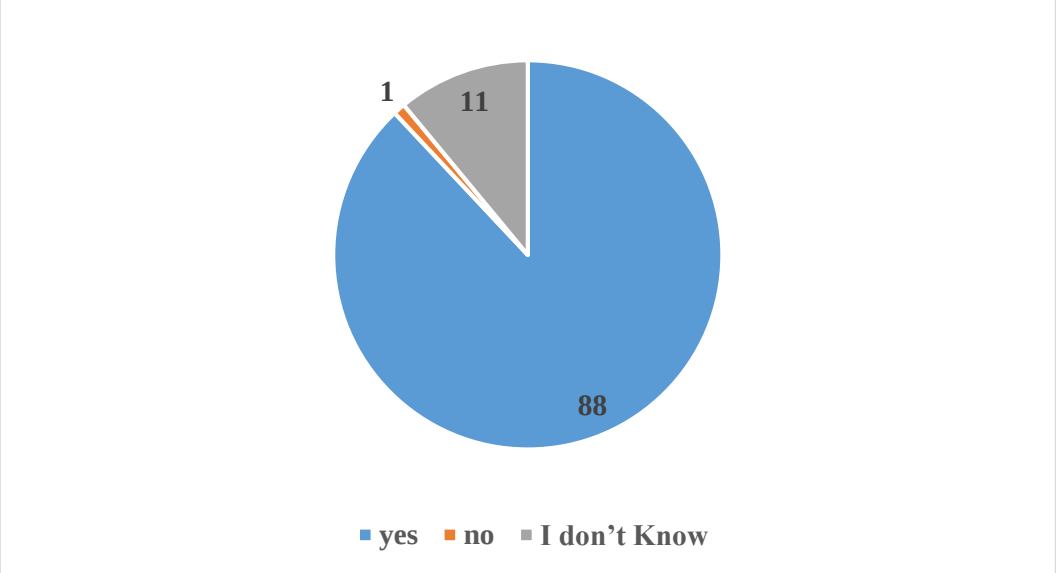
In assessing the level of awareness within the coastal zone of The Gambia, the analysis of the result presented in Figure 4.18 indicated that 78% of respondents were aware of climate change. The results presented in Table 4.8 shows that more people in cell 1 (79%), cell 4 (78%), Cell 5 (63%), cell 6 (86%) and cell 8 (92%) were aware that the climate is changing.



(Source: Fieldwork, 2021)

Figure 4.18. Proportion of Respondents' Awareness of Climate Change within the Coastal Zone of The Gambia

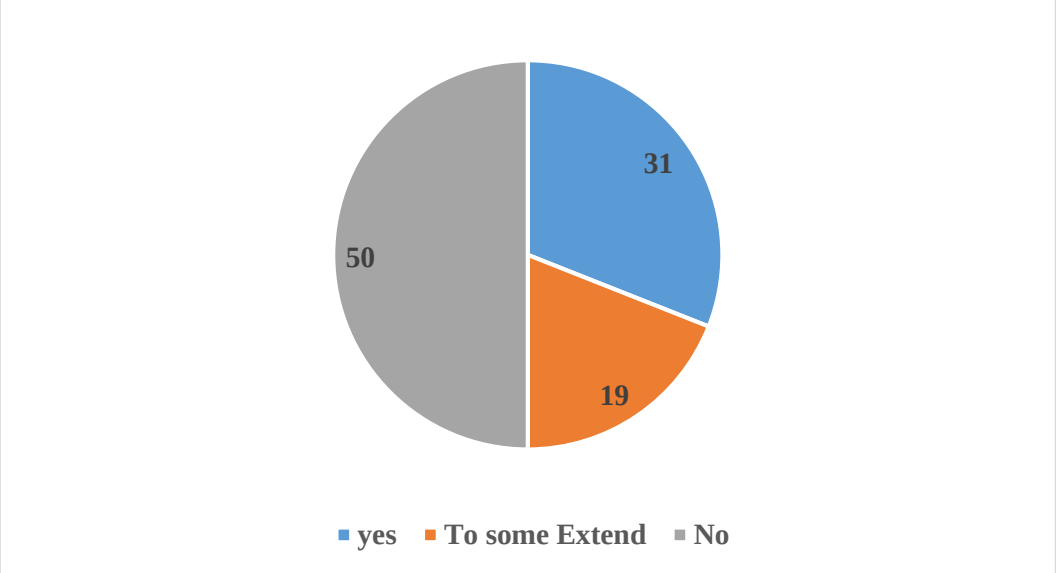
In the same instance, the analysis of the result presented in Figure 4.19 indicated that 88% of the respondents also believed that the climate is changing. The Believe within coastal cells presented in Table 4.8 shows that more than 80% of the respondents in each of the cells studied believed in climate change.



(Source: Fieldwork, 2021)

Figure 4.19. Proportion of Respondents' Awareness of Climate Change within the Coastal Zone of The Gambia

However, the analysis of the result presented in Figure 4.20 established that only 31% of the respondents really understand what climate change means while 19% understood climate change to some extent. The result presented in Table 4.8 further highlighted that climate change understanding is highest among respondents in cell 4 (37%).



(Source: Fieldwork, 2021)

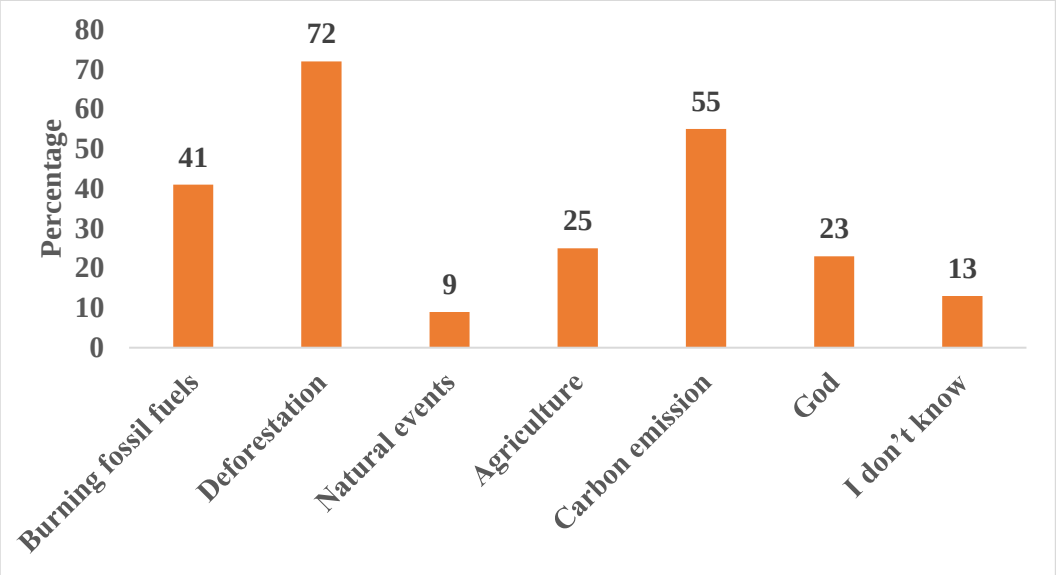
Figure 4.20. Proportion of Households' Understanding of Climate Change within the Coastal Zone of The Gambia

Table 4.8. Proportion of Households' Awareness of Climate Change in the Studied Cells within the Coastal Zone of The Gambia

Characteristic	Responses	Cell 1	Cell 4	Cell 5	Cell 6	Cell 8
Awareness	Yes	79	78	63	86	92
	No	21	20	32	13	8
	I Don't Kknow	0	2	6	1	0
Believe	Yes	87	91	81	88	93
	No	0	1	3	2	0
	I Don't Kknow	13	8	16	9	7
Understanding	Yes	33	37	19	35	28
	To some extend	13	12	20	24	30
	No	54	51	61	41	42

(Source: Fieldwork, 2021)

The results on the Causes of climate change presented in Figure 4.21 indicated that the respondents within the coastal zone who believe that the climate is changing mentioned deforestration (77%), carbon emission (55%) and burning of fossil fuels (41%) as the main causes of climate change. In addtion, the analysis of the result presented in Table 4.9 indicated that deforestration was said to be the main cause of climate change in all the studied cells representing 78%, 72%, 77%, 63%, 75% in cell 1, cell 4, cell 5, cell 6, and cell 8 respectively. Furthermore, 52%, 59%, 60%, and 63% of repondents in cell 4, cell 5, cell 6, and cell 8 respectively also highlighted carbon emission among the causes of climate change**.**



(Source: Fieldwork, 2021)

Figure 4.21. Proportion of Households' Understanding of Climate Change within the Coastal Zone of The Gambia

Table 4.9. Proportion of Households' Understanding of the Cause (s) of Climate Change in the Studied Cells within the Coastal Zone of The Gambia

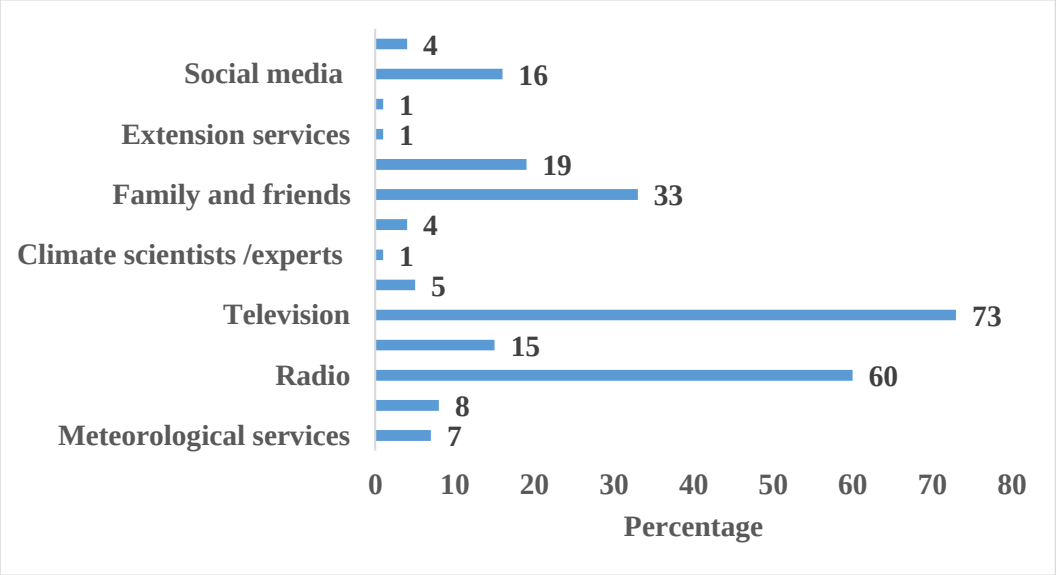
Causes (%)	Cell 1	Cell 4	Cell 5	Cell 6	Cell 8
Burning fossil fuels	38	44	35	41	43
Deforestation	78	72	77	63	75
Natural events	31	14	1	1	4
Agriculture	9	23	27	32	29
Carbon emission	33	52	59	60	63
God	31	21	18	27	18
I don't know	9	14	10	12	18
Others (sand mining)	0	0	0	0	2

(Source: Fieldwork, 2021)

4.1.3.3 Main Source of Climate Information for The Coastal Communities

From the results of the study presented in Figure 4.22, it is highlighted that the main sources of climate information within the Coastal zone of The Gambia were radio and television representing 60% and 73% of the total respondents respectively. In addition, the analysis of result presented in Table 4.10 revealed that family members and friends (47%) and

government (30%) were also significant source of climate information for respondents in cell 8 within the coastal zone of The Gambia.



(Source: Fieldwork, 2021)

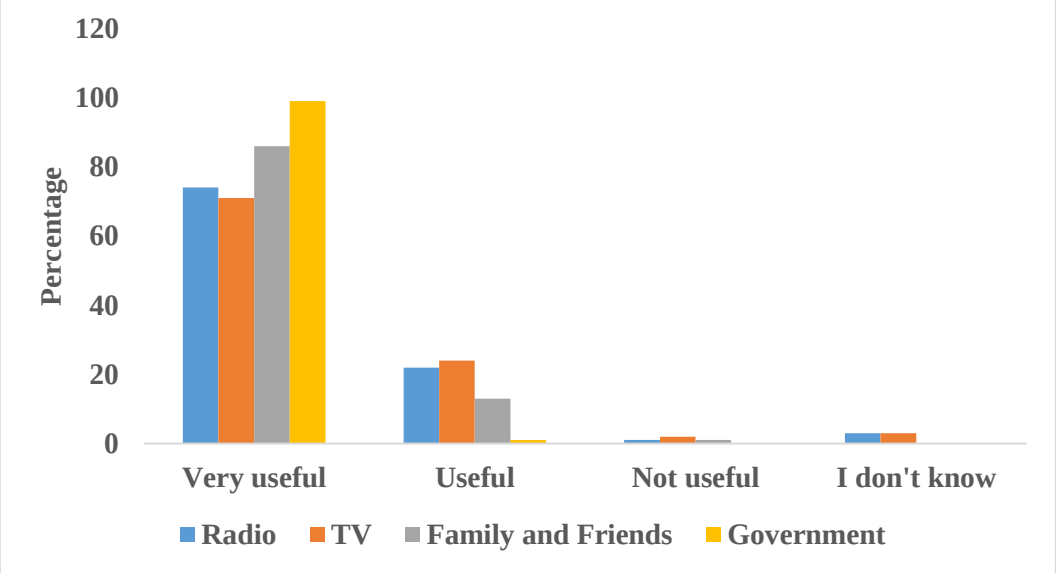
Figure 4.22. Proportion of Households' Main Sources of Information within the Coastal Zone of The Gambia

Table 4.10. Proportion of Households' Main Sources of Information in the Studied Cells within the Coastal Zone of The Gambia

Sources of information	Cell 1	Cell 4	Cell 5	Cell 6	Cell 8
Meteorological services	10	5	2	11	8
Newspaper	19	14	2	4	3
Radio	73	53	59	53	73
Internet	25	19	10	13	10
Television	73	86	58	79	63
School/ teachers	10	3	2	7	3
Climate scientists /experts	4	2	0	1	0
Village leaders	8	4	1	0	13
Family and friends	15	31	34	36	47
Government	2	16	20	24	30
Extension services	2	1	0	0	2
Posters/billboards	4	1	0	0	0
Social media	8	21	13	20	15
Other (during workshops)	8	3	2	4	7

(Source: Fieldwork, 2021)

Furthermore, the analysis of the result presented in Figure 4.23 indicated that the information from radio (74%), television (71%), family and friends (86%) and government (99%) has been very useful to the respondents within the Coastal zone of The Gambia. Furthermore, from the result of the study presented in Table 4.11, majority of the respondents emphasised that the information obtained from these sources was very useful.



(Source: Fieldwork, 2021)

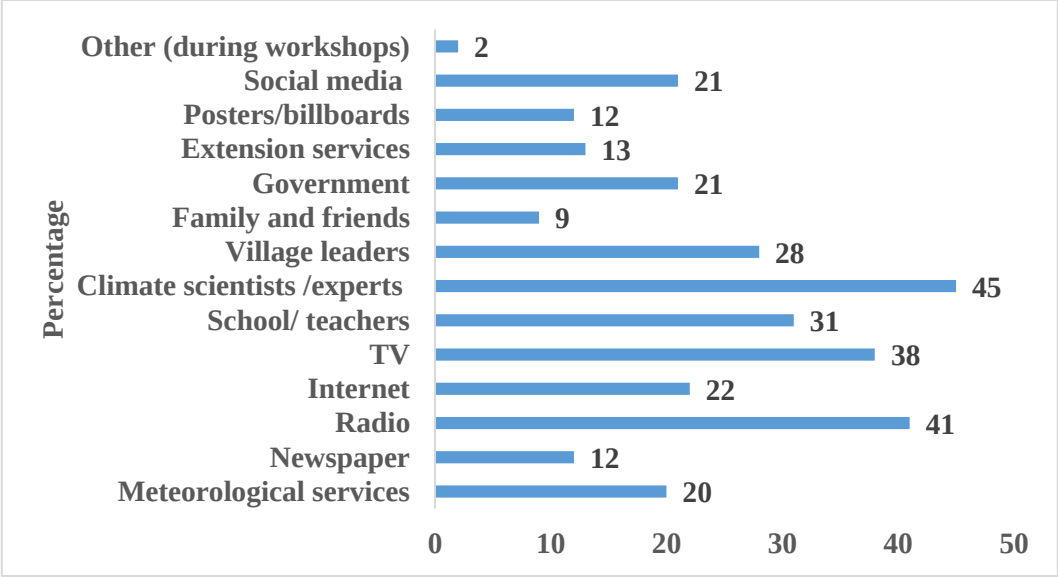
Figure 4.23. Proportion of Households' Assessment of the Usefulness of the Main Sources of Information within the Coastal Zone of The Gambia

Table 4.11. Proportion of Households' Assessment of the Usefulness of the Main Sources of Information in the Studied Cells within the Coastal Zone of The Gambia

Sources	Usefulness	Cell 1	Cell 4	Cell 5	Cell 6	Cell 8
Radio	Very useful	82	72	71	73	75
	Useful	16	22	29	20	23
	Not useful	0	2	0	2	2
	I don't know	3	4	0	4	0
TV	Very useful	87	60	71	72	79
	Useful	11	35	22	22	18
	Not useful	0	0	4	3	3
	I don't know	3	5	4	3	0
Family and friends	Very useful	63	93	80	90	85
	Useful	38	3	20	6	15
	Not useful	0	3	0	3	0
Government	Very useful	0	100	100	100	100
	Useful	100	0	0	0	0

(Source: Fieldwork, 2021)

In the same instance, the analysis of the result presented in Figure 4.24 highlighted that radio (41%), TV (38%), schools/teachers (31%) and climate scientist (45%) and village leaders (28%) are the sources of information respondents within the coastal zone of the Gambia in total would want to be getting climate information from. The result presented in Table 4. 12 continues to highlight that 50% and 58% of respondents in cell 1 would want to be receiving climate information through radio and television respectively, while 62% of respondents in cell 8 would want to get climate information through climate scientists and experts.



(Source: Fieldwork, 2021)

Figure 4.24. Proportion of Households Who would want to get Climate Information through the Main Sources of Information within the Coastal Zone of The Gambia

Table 4.12. Proportion of Households Who would want to get Climate Information through the Main Sources of Information in the Studied Cells within the Coastal Zone of The Gambia

Source of climate information	Cell 1	Cell 4	Cell 5	Cell 6	Cell 8
Meteorological services	25	35	15	15	5
Newspaper	31	20	9	1	5
Radio	50	40	47	38	33
Internet	44	32	22	13	3
TV	58	40	35	38	25
School/ teachers	15	34	35	35	28
Climate scientists /experts	21	46	43	49	62
Village leaders	15	35	33	28	20
Family and friends	15	13	9	2	5
Government	38	31	19	12	7
Extension services	13	16	10	7	18
Posters/billboards	17	13	11	7	17
Social media	19	17	27	18	23
Other (during workshops)	2	4	1	0	2

(Source: Fieldwork, 2021)

4.1.3.4 Socio-Economic Factors Affecting Climate Change Understanding among Coastal Communities

The analysis of the socio-economic factors that affect climate change understanding of households presented in Table 4.13 shows ethnicity has a significant relationship with understanding of climate change at 5% significant level (P≤ 0.029). The regression coefficient of -0.6978 indicates that respondents from the minority ethnic (Serrer, Manjago, Aku, etc) group have a better understanding of climate change than those from the majority (*Mandinka, Fula and Wollof*) ethnicity.

Furthermore, the income level indicating whether the household has enough income to meet important household expenses is significant at 10% significant level (P≤ -0.054). The regression coefficient of 0.7121 indicates that households with enough income to meet important household expense has better understanding of climate change than households whose income were not enough to meet important expenses.

Moreover, the believe that the climate is changing is also significant at 5% significant level (P≤ 0.024) and the regression coefficient of 1.8020 determines that those respondents who believed that the climate is changing has better understanding of climate change than those who claimed not to believe.

Likewise, awareness of climate change is significant at 1% significant level (P≤0.003) with a regression coefficient of 3.0533 indicating that respondents who were aware of climate change have better understanding. In addition, respondents who claimed to have done something to adapt or cope with the impact of climate change has better understanding than those respondents who said they have done nothing significant at 1% significant level (P≤0.000). Furthermore, access to information is significant at 5% significant level (P≤ 0.013) and regression coefficient of 0.7808 indicates that respondents

who have access to at least 3 main sources of climate information in The Gambia have better understanding of climate.

Table 4.13. Factors Affecting the Understanding of Climate change among Coastal Households: A Binary Logistic Regression Analysis

Understanding	Coef.	Std. Err.	z	P>|z|
_Cons	-6.4352	1.6429	-3.92	0.000***
Coastal zone	0.4760	0.3227	1.48	0.140
Sex	0.3929	0.3329	1.18	0.238
Age	-0.0157	0.0102	-1.55	0.121
Marital status	0.0897	0.3004	0.30	0.765
Ethnicity	-0.6978	0.3191	-2.19	0.029**
Education	-0.0512	0.4292	-0.12	0.905
Primary occupation	0.3894	0.3069	1.27	0.204
Income level	0.7121	0.3702	1.92	0.054*
Residential status	-0.2987	0.2975	-1.00	0.315
Access to health care	-0.1911	0.6209	-0.31	0.758
Awareness	3.0533	1.0377	2.94	0.003***
Believe	1.8020	0.8004	2.25	0.024**
Experience	1.0061	0.8357	1.20	0.229
Adaptation	1.3816	0.3067	4.50	0.000***
Access to information	0.7808	0.3148	2.48	0.013**

*** Significant at the 0.01 level
** Significant at the 0.05 level
* Significant at the 0.10 level
(Source: Fieldwork, 2021)

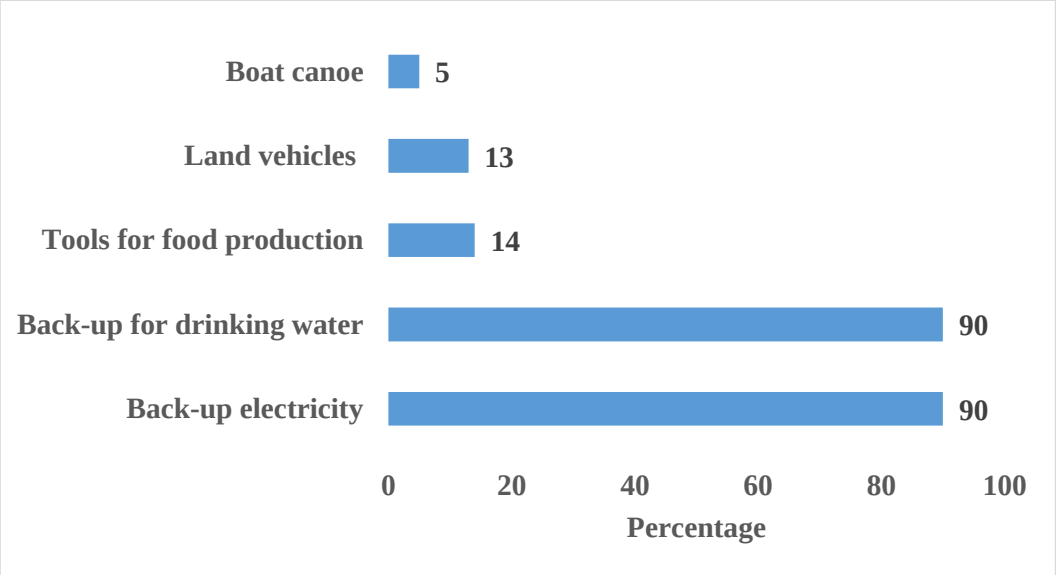
4.1.4 Vulnerability of Coastal Communities to Climate Change in The Gambia

4.1.4.1 Access to Resources

In the assessment of access to resources within the coastal zone of The Gambia, the results presented in Figure 4.25 highlighted that households within the coastal zone of The Gambia had access to Back-up electricity (90%) and back-up drinking water (90%). Few respondents also stated that they had access to boat (5%), land vehicle (13%) and tools for food production (14%). Furthermore, the analysis of results in Figure 4.26 indicated the source of back-up electricity and back-up drinking water for 90% of respondents is NAWEC and 92% of respondents who had access to tools for food production utilises traditional farm implements.

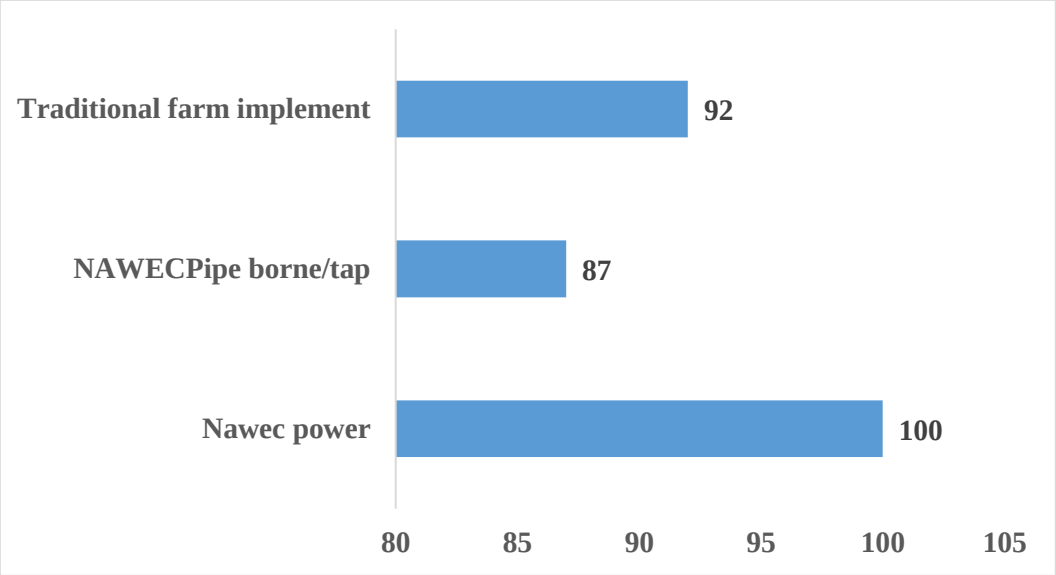
The analysis of the result on the studied cells presented in Table 4.14 determined that more that 90% of households in all the studied cells had access to back-up electricity (90%) from NAWEC as their main source of energy. However, only 1 % of population in cell 5 were using solar power as their main source of electricity. Furthermore, majority of households within the cells had access to pipe born water from NAWEC as their main source.

Notwithstanding, more than 80% of respondents within the studied cells specified the type of tools their household used for crop production as traditional farm implements. Likewise, only 13% and 5% of respondents in total indicated their households had land vehicle and boat respectively for transportation. Additionally, more households in cell 4 (20%) than all other zones had land vehicle while the presence of boats as means of transportation is more in cell 1 (15%) (Table 4.14).



(Source: Fieldwork, 2021)

Figure 4.25. Proportion of Households Access to Resources within the Coastal Zone of The Gambia



(Source: Fieldwork, 2021)

Figure 4.26. Proportion of Households Source of Resources within the Coastal Zone of The Gambia

Table 4.14. Proportion of Households Access to Resources in the Studied Cells within the Coastal Zone of The Gambia

Resources		Cell 1	Cell 4	Cell 5	Cell 6	Cell 8
Access to electricity	Back-up electricity	94	96	82	96	82
Type of back up electricity	Nawec power	100	100	99	100	100
	Solar power.	0	0	1	0	0
Access to drinking water	Back-up for drinking water	85	93	78	96	97
	Pipe borne/tap	86	92	93	83	76
Source of Water	Household borehole	9	2	1	10	3
	Community borehole	5	6	1	6	3
	Well	0	0	4	0	12
	Other	0	0	0	1	5
Access to tools for production	Tools for food production	4	14	11	9	32
Type of tools for production	Animal drawn implement	0	0	0	13	16
	Traditional farm implement	100	100	100	88	84
Transportation	Land vehicles	8	20	9	11	13
	Boat canoe	15	4	3	5	0

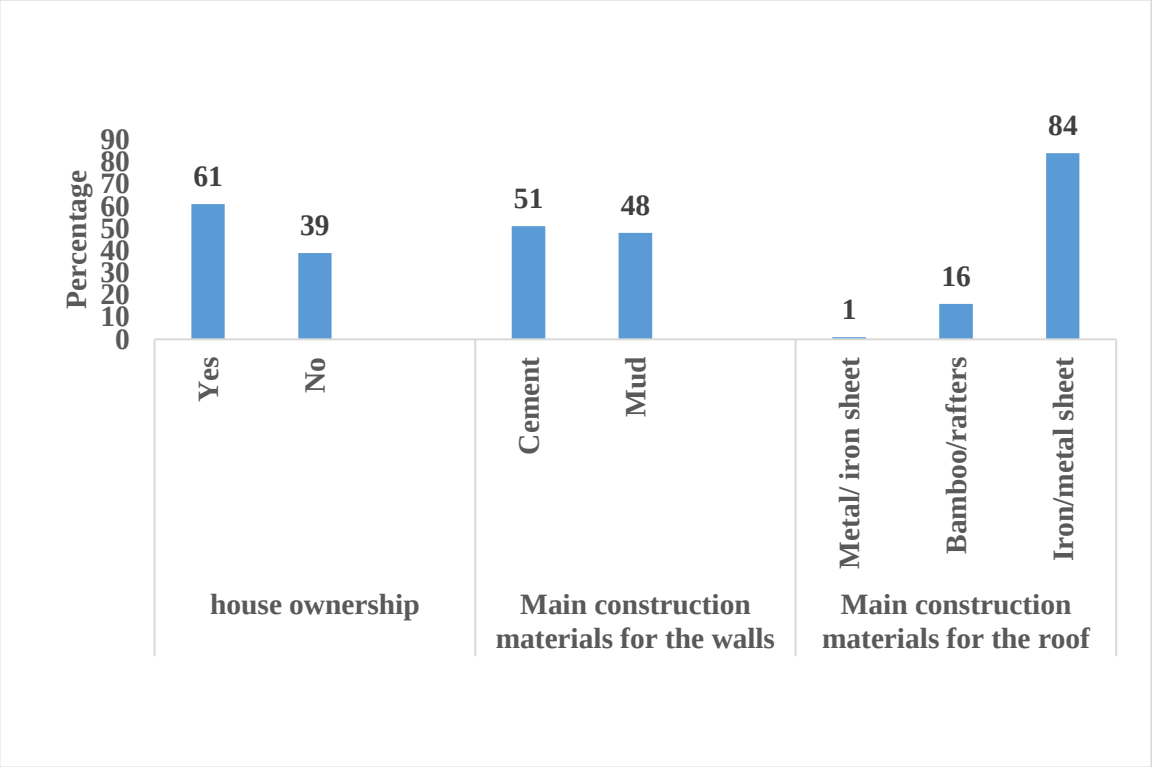
(Source: Fieldwork, 2021)

4.1.4.2 Household's Access to Assets

To determine ownership of property, respondents were asked if they own the house they were living in, and the result presented in Figure 4.27 indicated that 61% of households within the coastal zone of The Gambia own the houses their households were living in with cement (51%) and mud (48%) as the main construction materials of the walls and corrugated iron sheets (84%) representing the main construction materials of walls and roofs of the houses respectively.

Furthermore, the result presented in Table 4.15 further stated that 75%, 57%, 51%, 53% and 83% of respondents in cell 1, cell 4, cell 5, cell 6 and cell 8 respectively owns the households their households were residing in. To further evaluate the main construction material of walls of their houses, it was observed that cement walls represent majority of households in Cell 1 (73%), Cell 4 (63%), and Cell 6 (59%). However, the walls of 61% of houses in cell 5, and 78% of houses in cell 8 were made of mud as the main construction materials. Nonetheless, it was observed that few houses in cell 4 (2%) were made of corrugated iron sheet as the main construction materials of the walls of their houses.

Moreover, corrugated iron sheet made up of the main construction materials of the roof of more than 70% of houses in all the studied Cells. However, 25%, 28% and 24% of houses in cell 1, cell 4 and cell 5 respectively, had bamboo rafters as main construction materials of the roof of their houses.



(Source: Fieldwork, 2021)

Figure 4.27. Proportion of Housing Characteristics of Households within the Coastal Zone of The Gambia

Table 4.15. Proportion of Housing Characteristics of Households in the Studied Cells within the Coastal Zone of The Gambia

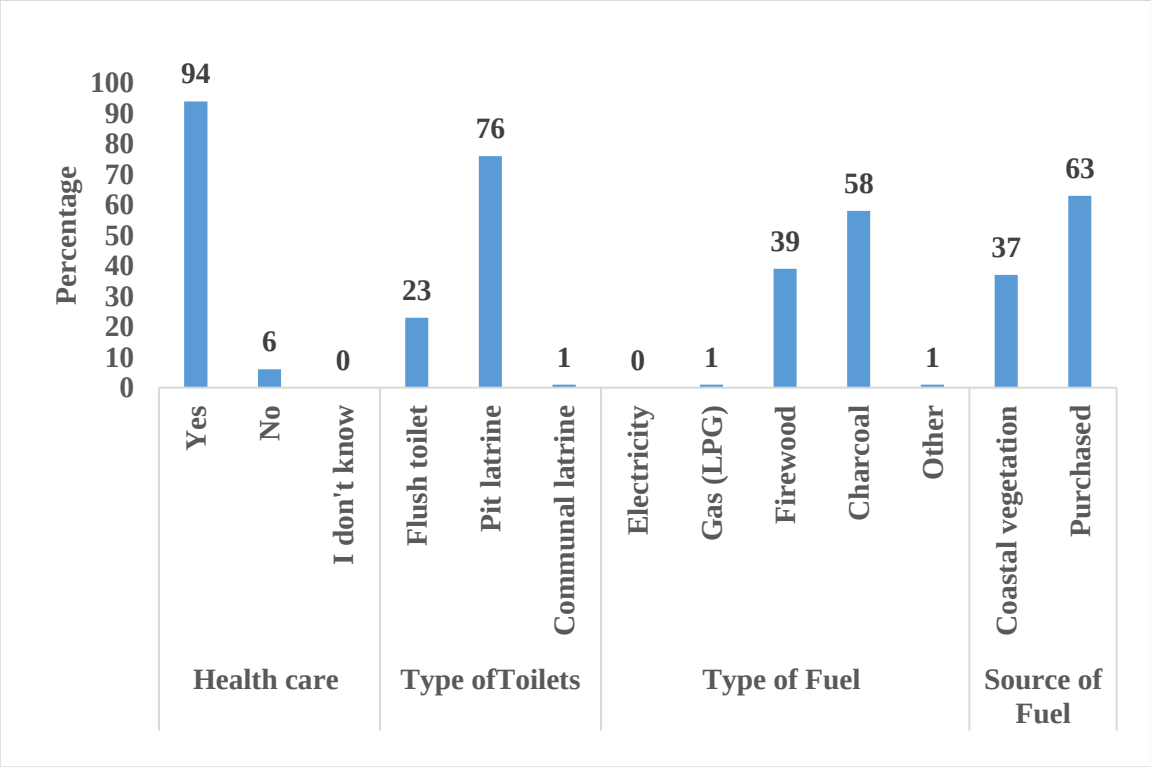
Household residence		Cell 1	Cell 4	Cell 5	Cell 6	Cell 8
House ownership	Yes	75	57	51	53	83
	No	25	43	49	47	17
Main construction material of the walls	Cement	73	63	39	59	22
	Mud	27	35	61	41	78
Main construction material of the roof	Metal/ iron sheet	0	2	0	0	0
	Bamboo/rafters	25	28	24	0	0
	Iron/metal sheet	75	72	76	100	100

(Source: Fieldwork, 2021)

4.1.4.3 Access to Basic Facilities

In assessing household's access to basic facilities and services, the analysis of the results presented in Figure 4.28 highlighted that 94% of respondents had access to health care services. The result further indicated that the main type of toilets for 76% of respondents was pit latrine. Furthermore, it is determined from the analysis of result that charcoal (58%) and firewood (39%) were predominantly used for cooking and other household functions within the coastal zone of The Gambia which is mostly bought from neighbours (63%) or is collected from the coastal vegetation (37%) .

Furthermore, Table 4.16 highlighted that more than 90% of respondents in the coastal cells studied confirmed that their households had access to health care services. However, the use of firewood as fuel for cooking is more among households in cell 8 (75%) and cell 1(46%) while the use of chacoal is more among households in cell 4(64%), cell 5(76%) and cell 6 (64%). It is further affirmed that households in cell 1(100%), cell 4 (87%) and Cell 5 (57%) buy firwood or charcaol used for fuel and other household functions from their neighours while 65% and 58% of households in cell 6 and cell 8 collect firewood or chacoal used for fuel and other domestic use from the bush or surrounding coastal vegetation (Table 4.16).



(Source: Fieldwork, 2021)

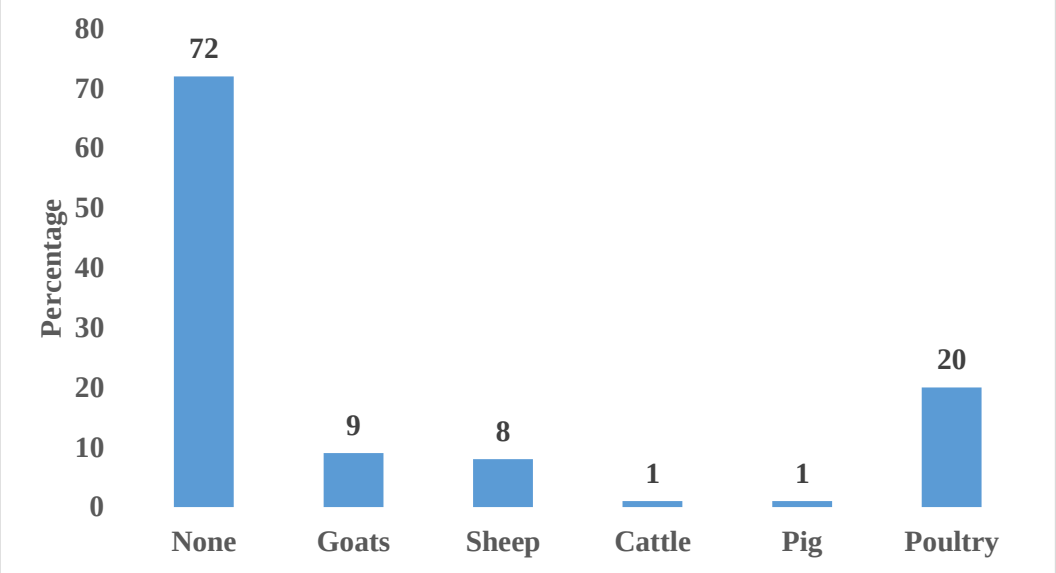
Figure 4.28. Proportion of Households' Access to Basic Facilities/ Services within the Coastal Zone of The Gambia

Table 4.164. Proportion of Households' Access to Basic Facilities/ Services in the Studied Cells within the Coastal Zone of The Gambia

Access to Basic Facilities		Cell 1	Cell 4	Cell 5	Cell 6	Cell 8
Health care services	Yes	100	100	91	85	98
	No	0	0	9	14	2
	I don't know	0	0	0	1	0
Toilets	Household flush toilet	21	33	22	27	7
	Household pit latrine	79	67	78	71	93
	Communal latrine	0	0	0	2	0
Fuel for cooking and other household functions	Electricity	0	1	0	0	0
	Gas (LPG)	0	2	1	2	0
	Firewood	46	33	23	34	75
	Charcoal	48	64	76	64	25
	Other	6	0	0	0	0
Source of firewood and charcoal for cooking and other household use	Collect from Coastal vegetation	0	13	43	65	58
	Buy from neighbourhood	100	87	57	35	42

(Source: Fieldwork, 2021)

Respondents were asked to identify the type of livestock they had in their households and the result presented in Figure 4.29 shows that 72% of respondents within the coastal zone of The Gambia had no livestock in their household but about a 20% of respondents were rearing poultry especially in cell 1 (27%), in cell 6 (25%) and cell 8 (32%) as shown in Table 4. 17.



(Source: Fieldwork, 2021)

Figure 4.29. Proportion of Households' who owns livestock within the Coastal Zone of The Gambia

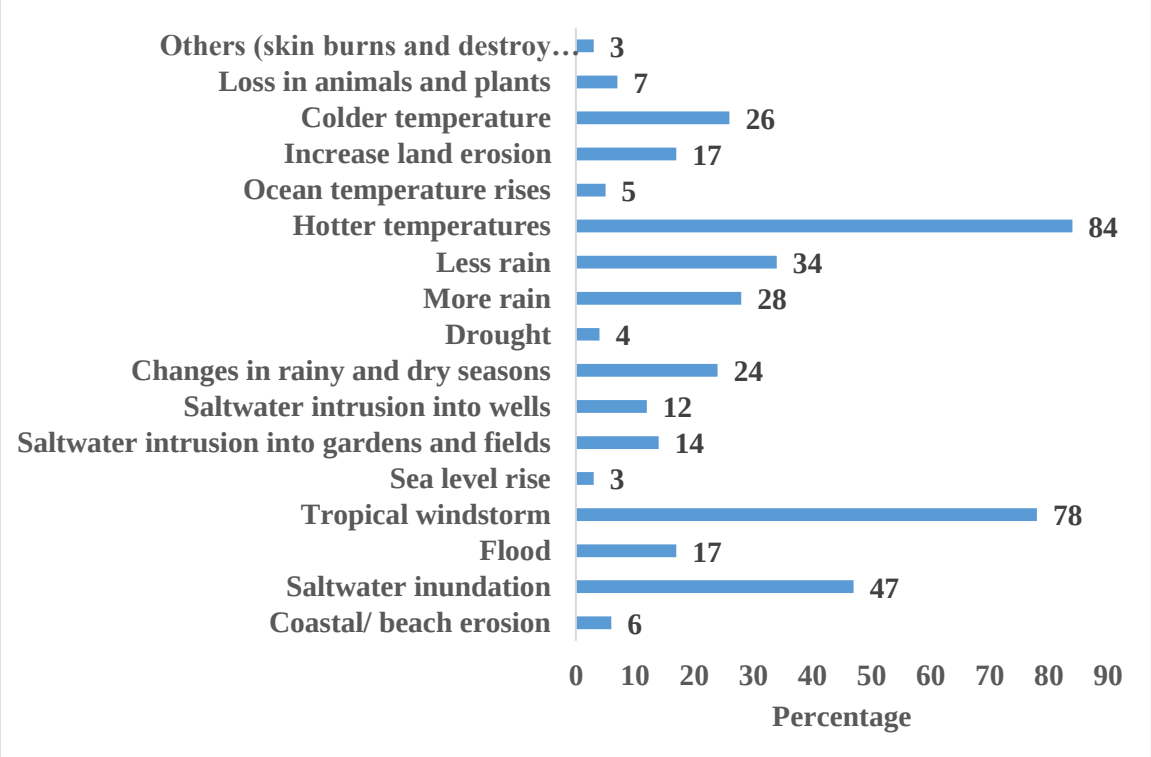
Table 4.17. Proportion of Livestock Ownership among Households in the Studied Cells within the Coastal Zone of The Gambia

Livestock	Cell 1	Cell 4	Cell 5	Cell 6	Cell 8
None	58	81	83	74	52
Goats	19	6	3	4	22
Sheep	23	4	5	5	10
Cattle	2	1	0	1	2
Pig	0	0	1	0	2
Poultry	27	15	10	25	32

(Source: Fieldwork, 2021)

4.1.4.4 Exposure to Climate Hazards

In order to determine all the climate hazards households were exposed to within the last 30 years, the result presented in Figure 4.30 indicated that respondents within the coastal zone of The Gambia had emphasised that their households were exposed to hotter temperatures (84%), tropical windstorm (78%), and saltwater inundation (47%). Furthermore Table 4.18 highlighted that Cell 1 (90%) and cell 8 (82%) were the most exposed to tropical windstorm and cell 4 (87%) and cell 6 (88%) the most exposed to hotter temperatures while cell 6 (54%) and cell 8 (60%), were the most expose to saltwater inundation.



(Source: Fieldwork, 2021)

Figure 4.30. Proportion of Households' Exposed to Natural Hazards within the Coastal Zone of The Gambia

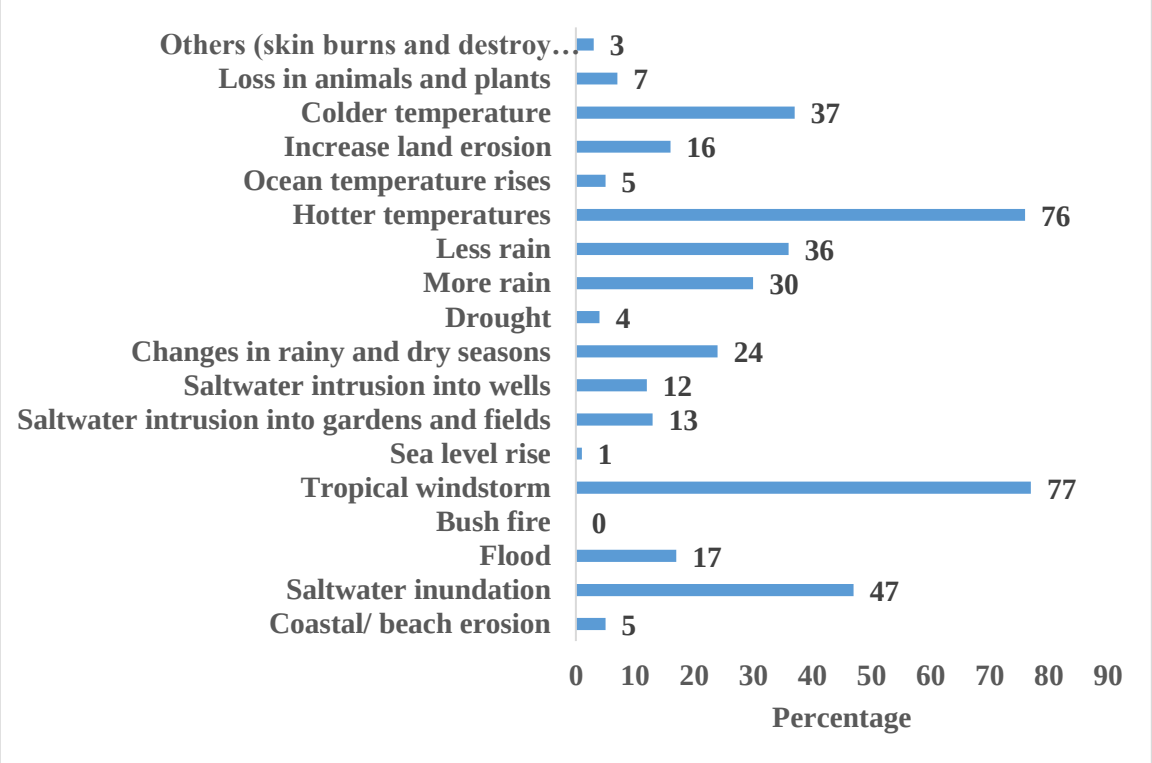
Table 4.18. Proportion of Households Exposure to Natural Hazards in the Studied Cells within the Coastal Zone of The Gambia

Exposure	Cell 1	Cell 4	Cell 5	Cell 6	Cell 8	Total
Coastal/ beach erosion	13	4	10	1	3	6
Saltwater inundation	38	45	38	54	60	47
Flood	13	14	26	18	10	17
Tropical windstorm	90	75	72	76	82	78
Sea level rise	13	2	1	1	0	3
Saltwater intrusion into gardens and fields	27	32	3	0	8	14
Saltwater intrusion into wells	19	26	8	0	5	12
Changes in rainy and dry seasons	6	21	26	32	33	24
Drought	10	12	0	0	0	4
More rain	6	16	36	42	35	28
Less rain	42	43	33	24	32	34
Hotter temperatures	81	87	80	88	83	84
Ocean temperature rises	17	4	0	6	2	5
Increase land erosion	13	17	30	11	10	17
Colder temperature	12	23	26	32	32	26
Loss in animals and plants	17	4	3	9	5	7
Others (skin burns and destroy corrugates)	0	0	2	6	7	3

(Source: Fieldwork, 2021)

4.1.4.5 Sensitivity to Climate Hazards

The analysis of the result presented in Figure 4.31 indicated that 47%, 77%, 76%, of total respondents within the Coastal Zone of The Gambia confirmed that their households had experienced saltwater inundation, topical windstorm and hotter temperatures respectively from 1990-2020. Furthermore, the result in Table 4.19 highlighted that cell 6 (52%) and cell 8 (58%) had the most experience of saltwater inundation and tropical windstorm was experienced by more than 72% of households in all the studied cells. Furthermore, hotter temperatures were also experienced by majority of respondents in cell 1 (83%), cell 4 (85%), cell 5 (83), and cell 6 (71%) cell 8 (52) (Table 4.19).



(Source: Fieldwork, 2021)

Figure 4.31. Proportion of Households' Sensitivity to Natural Hazards within the Coastal Zone of The Gambia

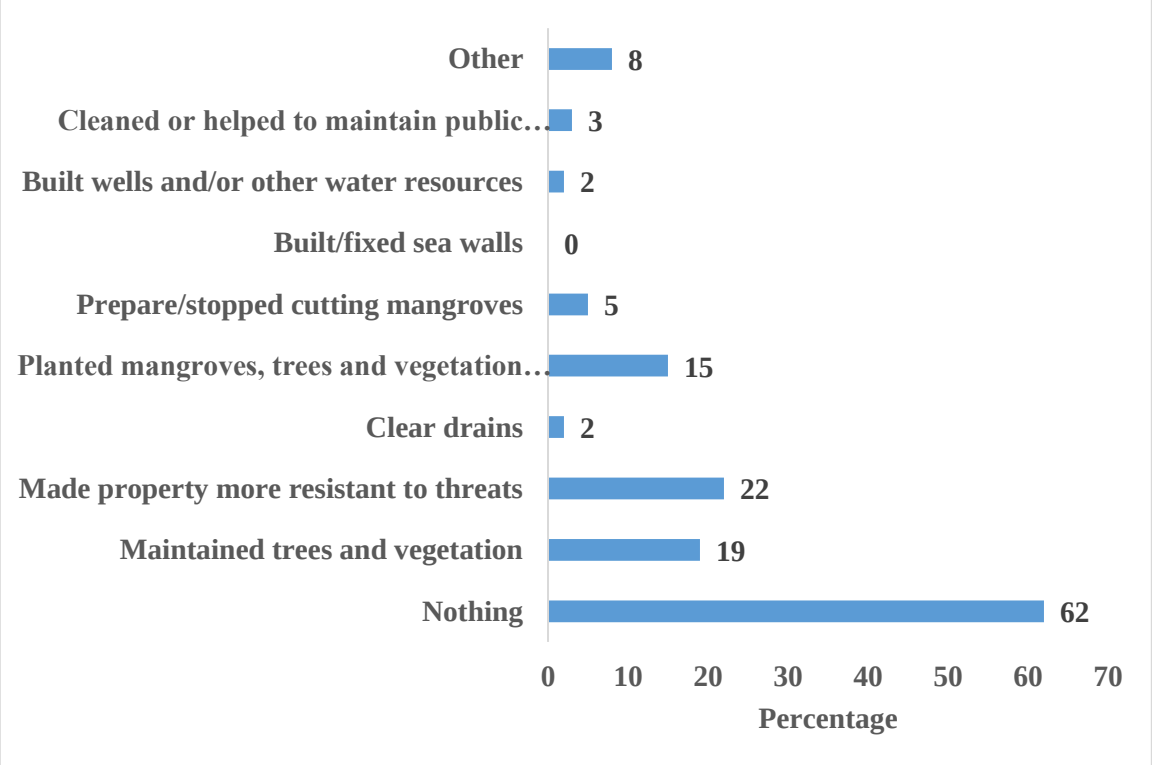
Table 4.195. Proportion of Households that Experiences Natural Hazards in the Studied Cells within the Coastal Zone of The Gambia

Experience	Cell 1	Cell 4	Cell 5	Cell 6	Cell 8	Total
Coastal/ beach erosion	13	4	8	0	3	5
Saltwater inundation	38	45	40	52	58	47
Flood	12	14	32	14	12	17
Bush fire	2	0	0	0	0	0
Tropical windstorm	87	75	74	79	73	77
Sea level rise	4	0	2	0	0	1
Saltwater intrusion into gardens and fields	27	32	6	0	0	13
Saltwater intrusion into wells	17	29	8	0	0	12
Changes in rainy and dry seasons	8	18	27	32	35	24
Drought	12	9	1	0	0	4
More rain	10	16	26	44	58	30
Less rain	48	44	48	25	13	36
Hotter temperatures	83	85	83	71	52	76
Ocean temperature rises	15	5	0	5	2	5
Increase land erosion	10	14	28	13	8	16
Colder temperature	12	22	31	55	67	37
Loss in animals and plants	12	7	3	8	5	7
Others (skin burns and destroy corrugates)	2	1	2	7	2	3

(Source: Fieldwork, 2021)

4.1.4.6 Adaptive Capacity

The findings of this study presented in Figure 4.32 revealed that 62% of respondents or any member of their households within the study area have not taken any action to adapt to or cope with climate change effects. However, the result in Table 4.20 indicated that some respondents in cell 8 and/or members of their household have maintained trees and vegetation within their communities (52%), made property resistant to threats (45%) and planted mangrove trees and vegetation along the shoreline (50%) (Table 4.20).



(Source: Fieldwork, 2021)

Figure 4.32. Proportion of Households' Adaptation/ coping strategies to Climate change within the coastal zone of The Gambia

Table 4.20. Proportion of Households' Adaptation/Coping Strategies to Climate Change in the Studied Cells within the Coastal Zone of The Gambia

Adaptation/ Coping to climate change	Cell 1	Cell 4	Cell 5	Cell 6	Cell 8	Total
Nothing	69	77	73	54	30	62
Maintained trees and vegetation	13	5	9	24	52	19
Made property more resistant to threats	10	19	14	26	45	22
Clear drains	4	2	0	5	2	2
Planted mangroves, trees and vegetation along the shoreline	13	6	2	13	50	15
Prepare/stopped cutting mangroves	15	3	0	5	5	5
Built/fixed sea walls	0	0	0	0	0	0
Built wells and/or other water resources	0	0	3	5	2	2
Cleaned or helped to maintain public drainage systems from waste	6	2	0	5	2	3
Other	4	3	13	12	10	8

(Source: Fieldwork, 2021)

4.1.4.7 Vulnerability Index

Climate change vulnerability index assessment was conducted along the coastal zone of The Gambia to evaluate the vulnerability of coastal residents to extreme climate events from 1990 to 2020. Vulnerability index scores were calculated for the 5 coastal cells under consideration and the result presented in Table 4.22 & Figure 4.34 revealed that the coastal zone of The Gambia on average is vulnerable to climate change with a vulnerability index score of 0.58 and an exposure index of 0.57.

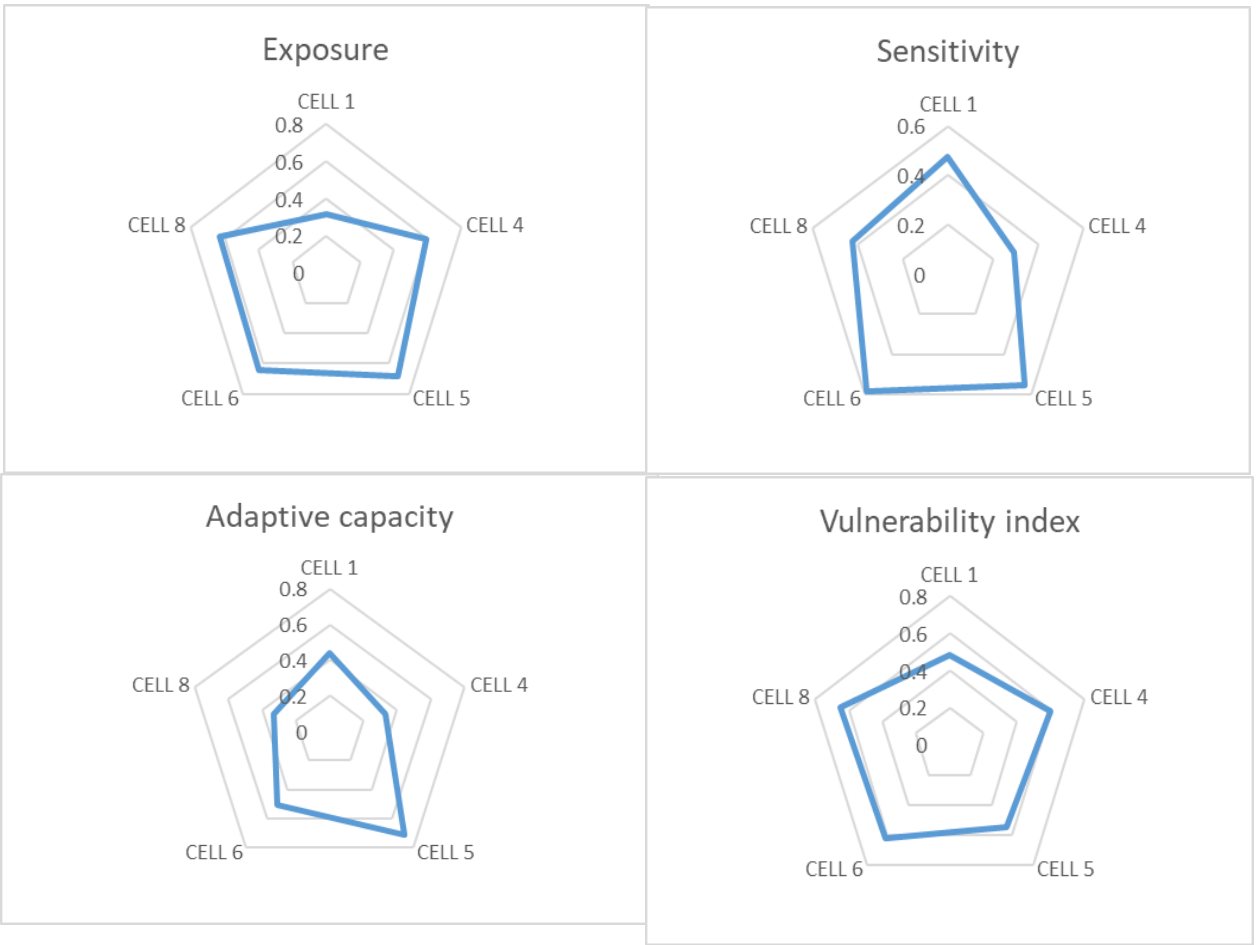
In terms of the level of exposure, sensitivity and adaptive capacity of the studied cells, it is determined that cell 8 with high exposure index of 0.63 and with the lowest adaptive capacity index of 0.32 is ranked the most vulnerable to climate change registering a vulnerability index score of 0.73. Cell 6 was observed to be high in exposure with an exposure index of 0.64 and recording the highest sensitivity index of 0.58 ranking 2nd with a vulnerability index score of 0.72.

Furthermore, Cell 4 ranking 3rd scored an exposure index of 0.59 and but recorded the lowest sensitivity index of 0.29 and therefore ranking 3rd with a vulnerability index score of 0.55. Cell 5 has the highest exposure index of 0.69 and highest adaptive capacity index of 0.71 ranking 4th in terms of its vulnerability index score of 0.52. However, cell 1 with the lowest exposure index of 0.31 ranks 5th and is the least vulnerable to climate events scoring a vulnerability index of 0.35.

Table 4.21. Households' Vulnerability to Climate Change in the Studied Cells within the Coastal Zone of The Gambia

Components	CELL 1	CELL 4	CELL 5	CELL 6	CELL 8	Total AV.
Exposure	0.31	0.59	0.69	0.64	0.63	0.57
Sensitivity	0.48	0.29	0.55	0.58	0.43	0.47
Adaptive capacity	0.44	0.33	0.71	0.50	0.32	0.46
Vulnerability index	0.35	0.55	0.52	0.72	0.73	0.58
Vulnerability index ranking	**5**	**3**	**4**	**2**	**1**	

(Source: Fieldwork, 2021)



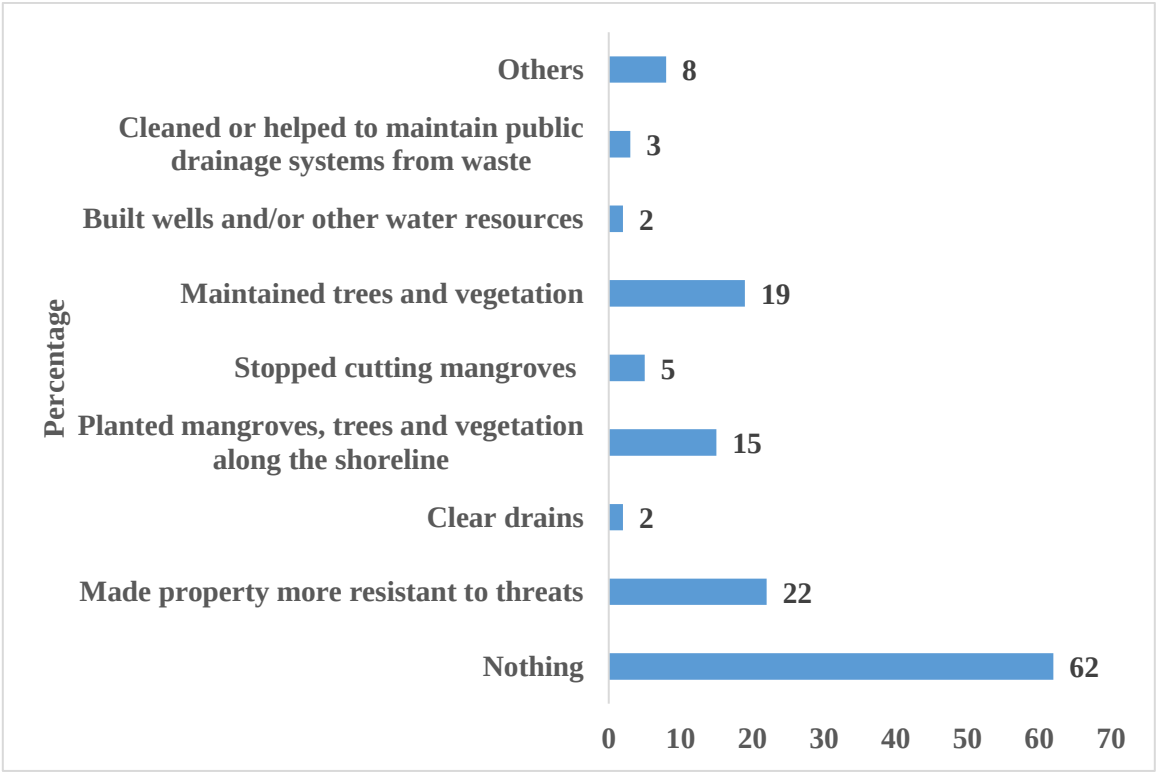
(Source: Fieldwork, 2021)

Figure 4.33. Exposure, Sensitivity and Adaptive Capacity within the Coastal Zone of The Gambia

4.1.5 State and Non-State Actor Participation in Building Resilience to Climate Change in The Gambia

4.1.5.1 Household's Resilience to Climate Hazards

In assessing households' level of preparedness to climate change threats, the analysis of the results presented in Figure 4.33 shows that 62% of the respondents within the coastal zone of The Gambia and/or their family members had done nothing in Building resilience to climate change. Furthermore, the results in Table 4.21 indicated that some respondents in cell 8 who claimed to have done something indicated that they or members of their household had made property more resistant to threats (45%) and had maintained trees and vegetation within their communities (52%) and planted mangrove trees and vegetation along the shoreline (50%) (Table 4.21).



(Source: Fieldwork, 2021)

Figure 4.3.4. Proportion of Households' Resilience Strategies to Climate Change within the coastal zone of the Gambia

Table 4.2.2. Proportion of Households' Resilience Strategies to Climate Change in the Studied Cells within the Coastal Zone of The Gambia

Resilience to climate change	Cell 1	Cell 4	Cell 5	Cell 6	Cell 8	Total
Nothing	69	77	73	54	30	62
Made property more resistant to threats	10	19	14	26	45	22
Clear drains	4	2	0	5	2	2
Planted mangroves, trees and vegetation along the shoreline	13	6	2	13	50	15
Stopped cutting mangroves	15	3	0	5	5	5
Maintained trees and vegetation	13	5	9	24	52	19
Built wells and/or other water resources	0	0	3	5	2	2
Cleaned or helped to maintain public drainage systems from waste	6	2	0	5	2	3
Others	4	3	13	12	10	8

(Source: Fieldwork, 2021)

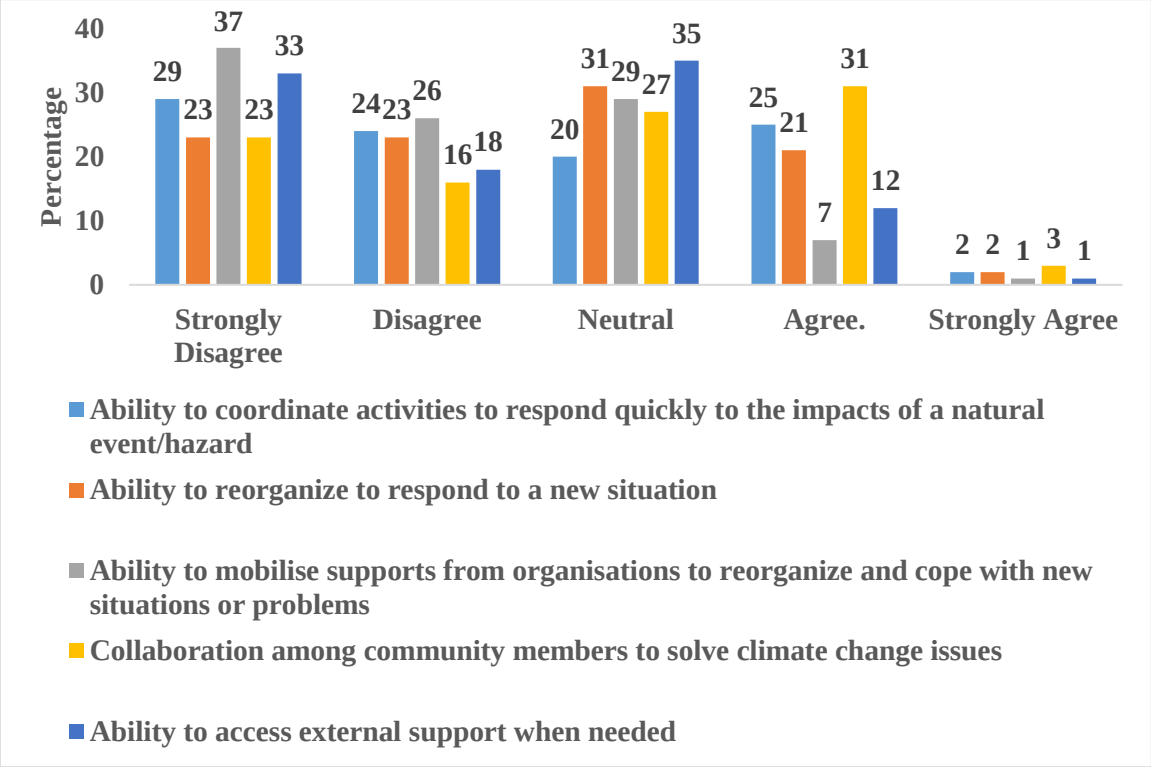
4.1.5.2 Community Re-organisation in Building Resilience to Climate Change

In terms of community re-organisation and structure in addressing climate change threats presented in Figure 4.35, it has been determined from the result of this study that 29% and 24% of respondents strongly disagree and disagree respectively that their community is able to coordinate activities to respond quickly to the impact of natural events.

In the same vein, 23% and 23% of respondents in total strongly disagree and disagree that their community is able to reorganise to respond to a new situation except. Similarly, 37% and 26% of total respondents strongly disagree and disagree respectively that their community has ability to mobilise supports from organisations to reorganise and cope with new situations (Figure 4.35).

Moreover, while 31% of total respondents agreed that their community members collaborate well with each other in addressing climate change issues, 33% and 18% of the

respondents in total strongly disagree and disagree respectively that their community is able to access external support when needed (Figure 4.35).



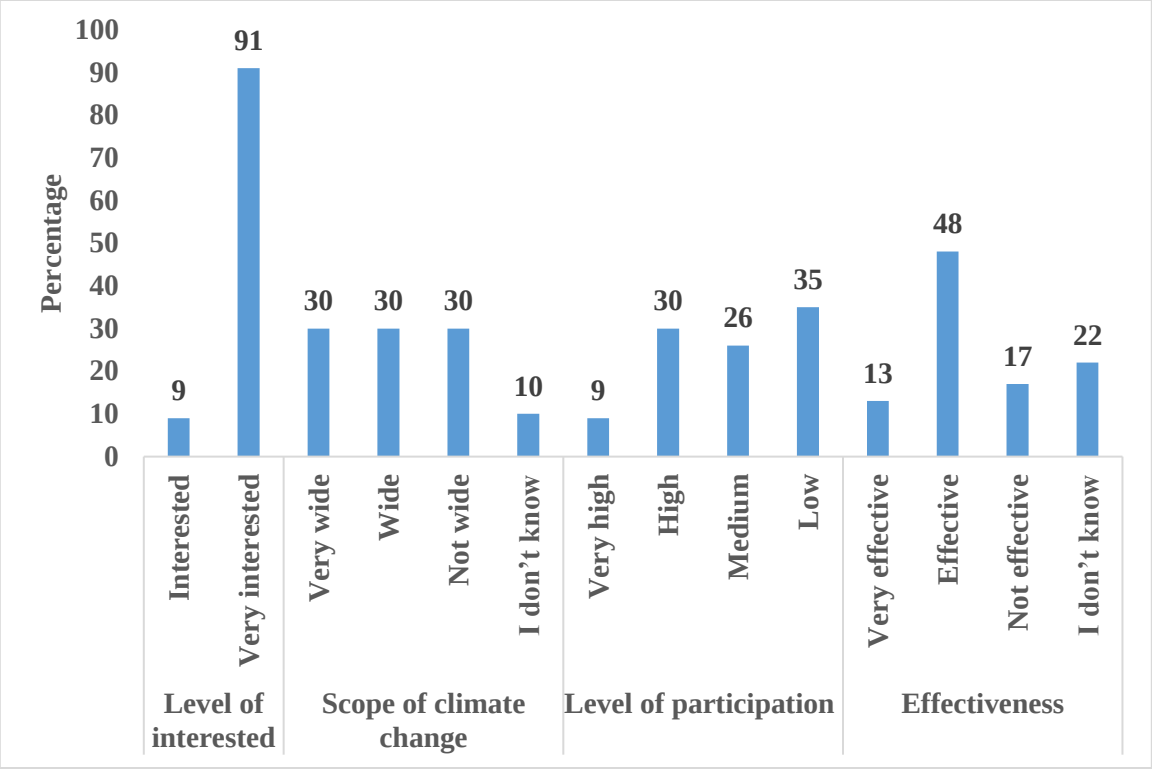
(Source: Fieldwork, 2021)

Figure 4.35. Community Resilience to Climate Change issues in the Coastal Zone of The Gambia

4.1.5.3 Actor Participation in Building Resilience to Climate Change

The analysis of the state and non-state actor participation in building resilience to climate change was based on a survey conducted from institutions within the country. 43% of these organisations were government institutions and 57% were non- state institutions. The analysis of the result presented in Figure 4.36 indicated that 91% of these institutions in total were very interested in climate change indicating high level of interested among actors in building resilience to climate change. In the same instance, 30% and 30% of these institutions in total indicated that the scope of climate change issues in their institutions is very wide and wide respectively however, 48% of these institution in total claimed that their climate change intervention in the coastal communities were effective.

In further assessing the state and non-state actor participation in building resilience to climate change, the result presented in Table 4.23 indicated that more than 90% of both state and non-states institutions were very interested in climate change issues.. In the same instance, 50% of state and 46% of non-state institutions rated their level of participation in working with coastal communities' medium and low respectively. However, 60% of state and 38% of non-state institutions indicated that their climate change intervention in the coastal communities were effective.



(Source: Fieldwork, 2021)

Figure 4.36. Actor Participation in Building Resilience to Climate Change within the Coastal Zone of The Gambia (%)

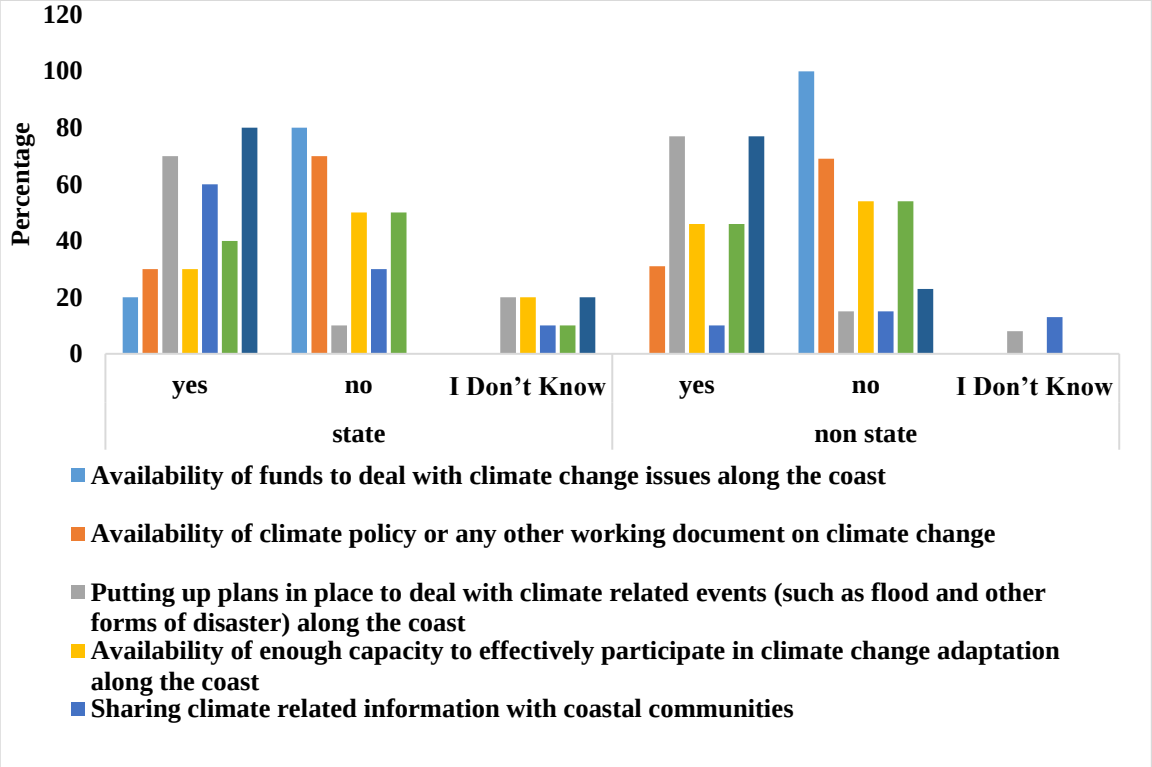
Table 4.63. State and Non-State Actor Participation in Building Resilience to Climate Change within the Coastal Zone of The Gambia (%)

		Organisations	
Actor participation to climate resilience	**Responses**	**State (%)**	**Non-State (%)**
Type of Organisation	Type	44	56
Level of interested in climate change issues	Interested	10	8
	Very interested	90	92
Scope of climate change issues	Very wide	40	23
	Wide	10	46
	Not wide	40	23
	I don't know	10	8
Level of participation in working with coastal communities	Very high	10	7
	High	20	39
	Medium	50	8
	Low	20	46
Effectiveness in climate change intervention in the coastal communities	Very effective	0	23
	Effective	60	39
	Not effective	10	23
	I don't know	30	15

(Source: Fieldwork, 2021)

Furthermore, the analysis of the result presented in Figure 4.37 indicated that, 91% of respondents in total indicated that their institution had no special funding to deal with climate change issues along the coast. This represents almost all the non-state actors interviewed and 80% of state institutions. Moreover, majority of these institutions (70%) in total did not have climate policy or any other working document on climate change representing 70% state and 69% non-state institutions. However, more than 70% of both state and non-state institutions indicated that they have put up plans to deal with climate change hazards and climate related events (such as flood and other forms of disaster) along the coast.

However, 52% of these institutions (50% of state and 54% of non-state) indicated that they did not have enough capacity to effectively participate in climate change adaptation along the coast. Notwithstanding, 52% of the institutions representing 60% state and 46% of non-state institutions had worked with coastal communities in terms of sharing climate related information, although 52% of the institutions in total stated that their institution is not in the position to provide communities with support in terms of resources and or expertise in climate change adaptation and mitigation exercises. Majority (78%) of these institutions in total and representing 80% of state and 77% of non- state institutions have claimed to have taken some actions to adapt or deal with climate change along the coastal zone.



(Source: Fieldwork, 2021)

Figure 4.37. State and Non-State Actor Participation in building Resilience to Climate Change (%)

4.3 Discussion of Findings

4.3.1 Socio-Demographic Characteristics of Respondents

The demographic characteristics of respondents within the coastal zone of The Gambia shows that there were more male headed households than female. This can be because of the culture and religion of the country where unless there is no adult male living within the household, women headed households are usually frowned on by society thereby showing the dominance of male gender as household heads than female. This is corroborated by Badjie *et al*. (2019) in their study in The Gambia on climate change and availability of food among households. The average age of respondents was above 40 years due to the fact that the target respondents for this study were individuals who were matured enough to understand and respond appropriately to the issues being discussed.

The findings of this research shows that majority of respondents had not gone beyond secondary education level education. It has been confirmed by various researchers that the level of education of households determine an individual's level of awareness and understanding of climate change (Ceci and Williams, 1997; Ashenfelter and Rouse, 2000). In this regard the findings of this study simply imply that the low level of understanding of climate change among coastal residents may be attributed to the low level of education.

Climate change education is important in determining people's level of understanding the concept of climate change in The Gambia. This was observed during the focus group discussion and key informants' interview where individuals who have beyond secondary level education were able to explain better the concept of climate change than those with Madarasa/Arabic, secondary level and below. Knowledge regarding this phenomenon helps people to understand and devise means to address the causes of global

warming and encourage them to re-organise and enhance their adaptive capacity (McKeown and Hopkins, 2010).

Mandinka's were the dominant tribe forming majority of respondents in cell 1, cell 4, cell 6 and cell 8. This is probably because Mandinka's were among the first settlers and formed majority ethnic groups in that part of the coastal area. However, Jola's on the other hand formed majority of respondents in cell 5 (4.1) were most of them migrated and were engage in various economic activities (Table 4.7). Furthermore, salary job and trading were the primary occupation of most of the respondents and since the coastal zone of The Gambia is observed to have increased industrial development and urbanisation within the last 30 years (Hildebrand, 2013).

In terms of the socio-economic characteristics, the findings of this research demonstrated that most of the respondents had no health-related issue and had access to good health care system in their communities. It was challenging to measure accurately the scale and impact of climate sensitive health risks during the survey. However, the result of this study contradicts the findings of WHO in their COP26 Special Report 2021 that extreme climate change events are negatively impacting on the health and wellbeing of individuals and societies in immeasurable ways and impacting on social elements that determines individuals' health and wellbeing (Sala, *et al*., 2021).

Similarly, the study also contradicts the IPCC 6th assessment report in 2022 that climate change will pose various health risk on human health by threatening mental health, increased heat related mortality and non-communicable diseases (IPCC, 2022). However, to reduce reduce climate change-related disease burden on the coastal of The Gambia, Urquhart (2016) highlighted in the national climate change policy for The Gambia that proper

approaches are required for water- and vector-borne diseases that considers climate projections in order to reduce climate change relate disease burden. The report further stressed the need to promote collaboration between health, meteorology, hydrology, environment departments and other relevant stakeholders including UN agencies, research institutions, NGOs, and CBOs, Traditional communicators and the Association of Health Journalists within the country to discuss, identify and respond to climate change-related health impacts.

Considering the residential status of the households, this study discovered that majority of households along the coastal zone of The Gambia migrated to the communities they were residing mainly in search of paid employment (Table 4.1). As agriculture sector is declining in The Gambia, Loum and Fogarassy (2015) and Ceesay and Njie (2022), coupled with low-income level and large household size, individuals relocate to the coastal zone which has increased industrial development to seek salary paying jobs in order to meet the demand of household income levels. The migration of individuals to the coast contributes to increased human population within 10 to 25km of the coastline to 213% from 1990 to 2020 (Table 3.1).

It has also been reported by Lucas (2015) and Swe *et al*. (2015) that declining growth in agriculture sector, and lack of quality amenities are among the elements that enhanced the movement of labour towards more developed, industrialised, and other service sectors in sub-Saharan Africa. This phenomenon is observed in the coastal zone of The Gambia where most farmers rely on traditional farm implement (Table 4.14) which were usually locally invented for production. These traditional farm tools alone are said to be unsustainable, reducing their agriculture productivity and therefore limiting their adaptive capacity. This is

consistent with the findings of Sheahan and Barrett (2007) indicating that the reliance on human power for agriculture focusing on simple farm tools such as hoes, shovels, cutlasses dominant in sub-Saharan Africa basically limits productivity and mechanization is therefore necessary to enhance productivity, while reducing human drudgery and cost.

4.3.2 Climate and Non- Climate Stressors on the Coastal Zone of The Gambia

4.3.2.1 Land Cover Change

The findings of this research have demonstrated that the coastal environment had undergone significant modifications as a result of multiple stressors within the last 30 years. The land cover map and the area under each land cover class calculated indicates the extent of modification for each of the land cover characteristics along the coastal zone of The Gambia from 1990 to 2020. Using the characteristics of land cover in 1990 as the base year, it was discovered that there is, major changes in all land cover classes.

The results of this study showed clear evidence that while barren land and built-up increases, there is significant reduction in vegetation cover, water bodies and wetlands. The increased in human population along the coastline is associated with increased built-up such as housing, health and education amenities and transport infrastructure to serve the need of the growing population from 1990-2020. As in the case of The Gambia, it is evident that increase in coastal population is associated with increased infrastructure development affecting the coastal land use, land cover patterns (Herrmann, *et al*., 2020). This increase in coastal population has also been a great concern expressed by all they surveyed communities (Survey 2021).

Barren land has increased for the past 30 years along the coast and is observed to be significantly associated with reduction of vegetation cover and wetlands believed to be mainly due to deforestation and the activities of mining companies operating along the coast.

This have been established by various researchers that as human continues to derive essential goods and services from the use of land and environments, the state of the degradation of these environments over time will be determined by the socio-economic processes which alters their landscape (Carpenter *et al*., 2009; De Serio *et al*., 2018; Mahajan and Martinez, 2021). This also corroborates with the findings from Abd El-Kawy *et al*. (2011) that mining and land alteration by anthropogenic activities for agricultural *purposes* and socioeconomic developments were identified as part of the drivers of land modification in the Western Nile Delta of Egypt. The reduction in vegetation cover was also confirmed by all the communities during the survey where it was stated that:

> *The forest cover and land scape have drastically changed due to human activities such as unregulated logging for fuel wood or charcoal, human settlement urbanization and industrial activities and activities of real estate developers. This has impacted negatively not on our environment alone but also our households discomfort including hot weather due to rising temperature on land and in the sea (Field Survey, 2021).*

The land cover of the coastal zone of The Gambia has significantly increased in built environment by 680% from 1990 to 2020 (Table 4.2 & Figure 4.10) as a result of increased population along the coast within the last 30 years. This study confirms that while population increase is associated with increased in built-up to meet the demand for the growing population, it has also significantly caused the disappearance of most of the vegetation cover. Built-up has been identified as the utmost irreversible human impacts on our environment and ecosystems due to urbanisation and population growth thereby calling for more research and increased understanding of land cover transformation patterns occurring at local and international scale (Williams et al., 2009).

This study had also established that urbanisation associated with built environment are part of the drivers of land transformation patterns and loss of vegetation cover in The

Gambia, thereby exposing coastal communities to climate change hazards and thus increasing their vulnerability to climate change and this is corroborated by (Amuzu *et al*., 2018a, b). The decline in the vegetation cover was among the concerns highlighted by community members some of who indicated that:

> *The reduction in vegetation cover has resulted to hotter temperatures on land and in the sea, intrusion of salt water in our wells and farmlands and windstorm destroying our buildings (Focus Group Discussion/ Gunjur, 2021).*

In other West African countries, mangroves and other vegetation cover along the coast are cleared to establish structures such as fish and shrimp ponds, human settlements, agriculture and industrial development (Creel, 2003). The coastal zone of The Gambia which was dominated with vegetation cover of about 57% of total land cover in 1990 (Plate 4.1) had experienced significant reduction of 35% mainly due to increased population thereby increasing built environment and barren land within the last 30 years. It was also stated during the survey that:

> *The mangrove vegetation along the coast is declining rapidly which is believed to be associated with high amount of salt intrusion and domestic used such as firewood. The vegetation cover within the community is gradually disappearing as increased residential infrastructure has claimed major part of the environment. The rice fields that were cultivated by women has all been converted now to building infrastructure as the population continue to increase (Focus Group Discussion/ Bakau old cape, 2021).*

Since most of the coastal communities are located within the vicinity of water bodies such as estuaries, rivers and streams, the increase in built-up had resulted to the shrinking of water bodies and wetlands in the last 30 years within these environments. This is believed to be as a consequence of land and water use systems that is not only limited to settlement but also include agriculture, mining, aquaculture, manufacturing industries, trade, tourism and transport infrastructures which are all putting pressures on the water bodies and wetlands

along the coast as outlined by various researchers in other parts of the world (Lu *et al*., 2018; Tiando *et al.*, 2021; Zerebecki *et al*., 2022).

These environmental degradations have become more critical as communities are grappling with the challenges of rapid unplanned urbanization resulting to shrinking of water bodies and wetlands due to pollution from waste disposal, encroachments, illegal mining activities and unplanned tourism activities (Tiando *et al*., 2021). However, the reduction of wetlands along the coast which was negatively associated with increase in barren land and built-up from 1990 to 2020 is a clear indication that, environmental degradation exposes the coastal environment of The Gambia to the impact of erosion and eutrophication. As a result, sediments from the eroded areas when deposited in water bodies may also contribute to the shrinking of the aquatic ecosystems.

This concern was raised during the survey, in which community members alleged that the sand mining and other infrastructural development activities occurring along the shores is causing their water bodies to shrink and also caused erosion of the coast leading to loss of essential benefits they obtained from these ecosystems over the past 30 years. This was emphasised during survey that:

> *The sand mining activities and uncontrolled dumping occurring in the other parts of coast is causing our water bodies to shrink leading to loss of essential benefits such as shellfish, crabs and other seafood we obtained from these ecosystems over the past 30years (Key informant interview/ Essau, , 2021).*
>
> *The transformation of the beach has impacted us negatively by limiting our livelihood options and economic activities that people engaged in along the beach. These include, weaving fishing nets, fish smoking, and many different businesses because of the erosion and sea level rise we observed. Even some residential houses along the beach are affected. All this destruction started with the various projects from the building of the bridge to sand mining activities around other parts of the coastal zone (Focus Group Discussion/ Bakau, 2021).*

4.3.2.2 Climate Variability and Trend

Studies on climate change require that the data be homogenous (where in-homogeneities are caused only by variations in weather and climate and non-climate factors) in order to determine whether changes or lack of changes result from non-climatic or climatic influences such as observation methods, relocation of stations, population growth around the stations, urbanization and other natural influences which may lead to deterioration of homogenous structures of recorded time series data and usually resulting to wrong conclusions (Peterson *et al*., 1998; Li-Juan and Zhong-Wei, 2012).

The purpose of the homogeneity test was to identify unnatural climatic change points which are unexpected or structural change in the time series data of the coastal zone of The Gambia in the process of yearly climate data analysis. The homogeneity test for yearly climate data of the coastal zone of The Gambia was conducted with assumption that there is at most two change points in the annual time series data. Based on this assumption, it is observed that both the Pettit, Buishand's SNHT and Von Neuman's test indicated some discontinuities in the annual total rainfall (mm), maximum temperature (^{o}c), minimum temperature (^{o}c), relative humidity (%) and wind speed (knots).

Except for wind speed where discontinuity was observed in 1983, all the discontinuities detected where observed within the last 30 years. These may be explained by the fact that the coastal zone of The Gambia has been severely affected by anthropogenic activities within the last 30 years due to increased population along the coast (Table 3.1). This growth in the coastal population exerts a lot of pressure on the coastal environment by increasing the need for urbanization and increased infrastructure. This increase in population

and infrastructure is also expected to affect the climate time series data recordings causing unnatural climatic change points (Li-Juan and Zhong-Wei, 2012).

Therefore, the findings of this research can assert that the in-homogeneity in annual time series data from 1980 to 2020 used in this study for total rainfall (mm), maximum temperature (^{o}c), minimum temperature (^{o}c), relative humidity (%) and wind speed (knots) along the coastal zone of The Gambia could be partially attributed to human activities in general associated with population growth which exerts strong pressure on the demand for infrastructure. In addition, high concentration of aerosol particles in air which is highly affected by high relative humidity is closely related to meteorological conditions of an environment by exerting significant influence on air quality and climate variability (Fan *et al*., 2007; Zang *et al*., 2019).

In consistent with these findings, the relative humidity (knots) recorded along the coast at certain times exceeds 70% (Table 4.4), which may increase aerosol concentration in the air, affecting the quality of time series data and thereby resulting to its inhomogeneity. However, the Meta data that provides the minimum information that should be known for all types of stations was not available at the time of this research and therefore making it not possible for an in-depth analysis of the reasons for in-homogeneities in the recorded time series data.

Understanding of climate variability of the coastal zone of The Gambia requires a thorough analysis of trends and magnitude of rainfall (mm), temperature (^{o}c), relative humidity (%) and wind speed (knots). The findings of the study reveal an increasing positive precipitation trend along the coastal zone of The Gambia. This is validated by Sen's slope test showing an increasing slope of annual rainfall from 1980 to 2020. This finding

contradicts studies that were conducted earlier where rainfall pattern along the coast showed decreasing trend (Jaiteh and Sarr, 2011; Dia, 2012;).

However, as observed in other West African region, The Gambia has experienced significant increase in rainfall intensities and temperature trends thereby exerting severe impact along the coastal zone, causing severe heatstroke, and natural hazards such as flood, on individuals residing along the coast (IPCC, 2014; Amuzu, *et al*., 2018a; Nkrumah *et al*., 2019), and by the end of the 21st century, temperature and high precipitation intensities will likely be the highest impact on the coastal zone of The Gambia which was emphasised by various researchers in The Gambia and other countries including (Ampomah *et al*., 2012; Dia, 2012; Salau, 2016; Amuzu *et al*., 2018b,c; Nkrumah *et al*., 2019; Belford *et al*., 2020).

The minimum temperature (^{o}c) of the coastal zone shows a decreasing trend. However, the magnitude of the trend of minimum temperature (^{o}c) is lower (-0.0319) than that of the maximum temperature (^{o}c) trend (0.0347). This was confirmed that the coastal zone experienced warmer than cooler climate from 1980 to 2020. This authenticates the findings of Amuzu *et al.* (2018b) in their study on socio economic impact of climate change in The Gambia where they observed that the increase in the maximum annual temperature is higher than the decreases in the annual minimum temperature of the coastal zone of The Gambia. However, it is indicated by all the surveyed communities that:

> *The climate is changing with regards to weather patterns as the temperature is rising and rainfall usually start late and ends early, which lowers agriculture yield discouraging many to venture into agriculture practices (Field Survey, 2021).*

Though not showing significant increasing or decreasing trend, this study established that the mean relative humidity recorded (%) was 65.0085 with a maximum humidity of 70.2882 from 1980 to 2020. Relative humidity is equally invariably different in different parts of The

Gambia with the coastline areas sometimes above 70% whilst conditions dropping to 44% as one moves inland (Ampomah *et al*., 2012; Dia, 2012).

The relative humidity of more than 70% couple with high temperature is also registered along coastal areas in other West African regions which is said to have negative impact on the coastal residents including discomfort and heatstroke (Salau, 2016). As relative humidity increases from 40 to 70%, the suspension of tiny particles such as dust, gasses, secondary ions and other pollutants increases which does not only directly or indirectly affect the climate system of a region, but also affects human health when suspended particles in air are inhaled into the respiratory systems (Fan *et al.,* 2007; Zang *et al*., 2019**).**

4.3.3 Believe, Awareness and Understanding of Climate Change among Coastal Communities in The Gambia

This study had highlighted that a greater number of households believed and are aware that the climate is changing which is essential in recognising the public perception and understanding of environmental degradation occurring in large scale. This is further confirmed during the focus group discussions and key informant interviews during the survey where almost all the respondents agreed that:

> *Climate is changing, and it is changing for the worst. This is evident on irregular rainfall pattern, high or rising temperature. The forest cover and land scape have drastically changed especially along the coast, as a result of logging and mining activities. There is also land and coastal erosion. Water bodies and wetlands are destroyed due to mining and salt water is encroaching into fields (Field Survey, 2021).*

However, only few of these individuals really understand the concept of climate. The low level of understanding of climate change among the respondents in The Gambia coastal zone might be due to the complex nature of the concept of climate change which requires sufficient level of education to comprehend. This finding was supported by Kellstedt *et al*.

(2008); Masson-Delmotte *et al*. (2021) and Lee *et al*. (2022) that one of the reasons why the public has limited knowledge of climate change might be due to the scientific nature of the concept as the scientific knowledge regarding individual's role in accelerating climate change is constantly expanding, making emerging concepts of climate change complex for public understanding.

In this regard, increased awareness and believe in climate change alone is not enough to motivate people to act climate-friendly but also the understanding of climate change is a motivating factor that helps to eliminate social and institutional barriers that act to limit public participation in addressing global environmental issues. Furthermore, the understanding of climate change according to Urquhart (2016), is necessary in order to enhance the understanding of the complexities and linkages of the various difficulties and aid in disaster risk reduction efforts by enabling individuals to adapt to unforeseen hazards due to climate change in The Gambia. This is also highlighted by various researchers around the world (Bulkeley, 2000; Kellstedt *et al*., 2008; Vanio and Paloniemi, 2014; Petrescu *et al*., 2022).

Therefore, public believe, awareness and understanding of climate change is necessary in enhancing public participation and facilitating efforts of all stakeholders in climate friendly actions in The Gambia. This is because people's way of perceiving climate change in The Gambia is important in motivating or demotivating their climate actions as perceptions about the causes and impact of climate change are needed for the participation of all stakeholders in climate change mitigation and adaptation activities (Cattino and Reckien, 2021).

Deforestation, carbon emission and burning of fossil fuels were understood as the main causes of climate change within the coastal zone (Figure 4.21). The rate of deforestation was also a major concern highlighted by all the community members within the coastal zone where most people believed is facilitated by increased real estate developers around the coast. This is confirmed by the findings of this study (Table 4.2).

Charcoal and firewood were predominantly used for cooking and other household functions that communties around the coast rely on for their day to day survival and which were obtained from coastal vegetation and is also contributing to rapid rate of deforestration observed along the coast. Evidence obtained from scientific research had highlighted that, the concentration of greenhouse gases (GHG) is beyond the recommended level currently due to anthropogenic activities despite some skepticism (Pacala *et al*., 2003; Suh, 2006). Furthermore, there is inadequate capacity to adequately plan proper adaptation and mitigation strategies, by individuals and societies thereby putting significant uncertainty about the rate of climate change as individuals and groups are putting effort in monitoring and understanding its effects on their environment and livelihood (Karl and Trenberth, 2003).

Furthermore, the believe among coastal households in The Gambia that carbon emission and burning fossil fuel is among the major causes of climate change may enhance their motivation and behavioural changes toward reducing greenhouse emission and be more concern about their effects. This will enhance support and discussions about climate change to be placed in people's mind, as a means of increasing their trust for state and non-state actors that promote climate change adaptation, mitigation and resilience activities and programs in their communities.

Moreover, access to information through media (especially radio and television) was observed as a significant source of information used by households to obtain climate information and increase their knowledge and understanding of climate change along the coastal zone of The Gambia. These households do not only see the importance of media in their adaptation and mitigation efforts, but also its significance in their continued efforts to building resilience to the effects of climate hazards (Appendix 6).

It had been also emphasised by various researchers that media in principle is a valuable communication tool for enhancing climate change believe, awareness and understanding with significant influence on national policy responses and community efforts in combating sustainable development challenges and undertake major efforts to prevent life-threatening outcomes (Hine *et al*., 2014; Fuso *et al*., 2019; Weingart *et al*., 2000).

The findings of this study indicates that there are statistically significant socioeconomic and demographic factors that affects household understanding of climate change. These factors that were observed to have significant effect on households understanding of climate change in The Gambia were ethnicity, income level, awareness, believe and adaptive capacity. Research on roles of independent social status such as ethnicity, race and socioeconomic status on climate change understanding suggest that these factors can independently and systematically shape peoples believe and understanding of climate change and motivates individuals to address it (Pearson *et al*., 2017).

In the same instance, the result of this study indicated that households from minority ethnic groups have better understanding of climate change than those from majority ethnic groups in the coastal zone of The Gambia. In line with this finding, Macias, 2016 highlighted

that minority groups (race and ethnicity) were specifically more concern with climate change than majority race in America.

Household income level had been identified as a determinant factor for climate change understanding in coastal zone of The Gambia as households with enough income to meet important household expenses had better understanding of climate change than household without enough income. With the assertion that high level of education significantly increase the economic conditions and social returns of individuals by not only providing skills and human capital but also their level of understanding of complex concepts like climate change by Ceci and Williams (1997) and Ashenfelter and Rouse (2000), the low level of education among households (Table 4.1) associated with low household income level might explain the phenomenon that households with enough income to cover importance household expenses have better understanding of climate change. This signifies that the high level of understanding of climate change among coastal households with enough income to cover their household expenses may be due to their high level of education which is a driver of gaining better income level.

Providing timely and useful climate information through media and other outreach services will help to adequately inform coastal communities in addressing climate change issues affecting their livelihood and environment. This may give them opportunities to better manage their activities and make appropriate decisions in climate change adaptation and mitigation processes and thus improve their knowledge and understanding of climate change as indicated by (Amadi and Chigbu, 2014).

4.3.4 Vulnerability of Coastal Communities to Climate Change In The Gambia

This study determines that almost all the households within the study area, have access to electricity and water mainly from the country's main supplier National Water and Electricity Company (NAWEC) and the use of renewable energy is not exploited among coastal households. As renewable energy has become adaptation pathways that could also encourage climate change mitigation efforts, there is need to explore renewable energy to serve the demand for energy for current and future population (Jeong and Ko, 2021)

The findings of the study highlighted that most people own the houses they were residing in even though they were not descendants of those communities with mostly cements walls as the main construction materials of the walls and corrugated iron sheet as the main roofing materials (Table 4.15). This is because most of these households had settled in their respective communities for more than 2 decades.

Physical conditions of houses especially for households with lower educational level and insufficient income to meet household demands can lead to situations of vulnerability by increasing their exposure to flood and storm surges (Fatemi *et al*., 2020; Bera *et al*., 2020). It is typical that many low income people were the most who build mud houses in The Gambia which is common among the residents and who are likely households whose income were not sufficient to meet important household expenses. During the survey, these were mostly the type of structures that were seen to collapse in the country when hazards such as flood from heavy downpour and tropical windstorm occur. It was further indicated during the survey that:

> *Climate Change associated with windstorm and heavy downpour has caused lots of problems for us. Our compounds and houses flood destroying our foodstuffs and other essential items. It has caused a lot of our houses to collapse and wind blowing*

roofs of some households causing serious injury to some people and even our pit latrines overflowed threatening our health (Key Informant Interview/ Kotu, 2021).

Therefore, Advocating for climate resilient and sustainable human settlements should be encouraged by relevant authorities to ensure proper planning procedures in addressing climate change (Urquhart, 2016). Furthermore, majority of the coastal households in The Gambia relied on pit latrines as their main means of sanitation for the household. Like in The Gambia, pit latrines are the most common system for discarding human excreta in low-income countries (Graham, 2013). However, the regular flooding instances observed around some areas of the coastal zone usually of poor infrastructure and low-income, likely contributed to not only ground water contamination but also pose serious health risk as they overflow during flooding events thereby increasing household vulnerability level.

4.3.4.1 Exposure, sensitivity and adaptive capacity

Majority of the households along the coastal zone of The Gambia were exposed or had experienced high temperature, tropical windstorm and saltwater inundation. These households do not only observe high frequencies of these hazards but also high severity, high difficulty of coping and high degree of negative impact on them and their households (Appendix 2, 3, 4, 5).

The phenomenon of exposure and sensitivity to high temperature could be explained by the findings of this research (Table 4.4 & Figure 4.11) and by several other researchers indicating that, like The Gambia, temperature trends will keep increasing in many parts of the world and will be the highest impact on the coastal zone leading to severe implications by the end of the 21st century (Dia, 2012; IPCC, 2014; Salau, 2016; Amuzu, *et al*., 2018a,b; Belford *et al*. 2020; Nkrumah *et al*., 2019; Ampomah *et al*., 2012).

The results of this study indicated no increasing or decreasing trend in the wind speed along the coastal zone of The Gambia but had highlighted an increased rate of deforestation (Table 4.2 & Figure 4.10) and loss of ecological services such as wind breaks, flood and erosion control amongst others, provided by plants. Therefore, the high proportion of household's exposure and sensitivity to tropical windstorm could be partly attributed to declining tree population and poor infrastructure (Table 4.14) as the main construction materials of the walls of most of the houses were mud with bamboo rafters used for roofing in few houses especially in cell 4.

In line with these findings, Pratt (2021), had also highlighted that the temporal pattern of wind speed (knots) does not seem to suggest any well-defined uniformity but marginally indicating an increasing strength during the winter season. This was highlighted by community members during the survey that:

> *The high rate of logging around this area has change the landscape a lot. You walk around the community; you will see only few trees. Even our community forest is not spared. And it is difficult for communities to stop logging since majority used wood materials for cooking and some will sell to take care of their families. Now we have seen wind destroying our houses because plants that used to protect us are disappearing gradually at a high rate (Key Informant Interview/ Brufut, 2021).*

In addition, cell 6 and 8 were exposed and sensitive to saltwater inundation. Coastal wetlands serve as barriers between low lying land surface and the ocean which is subject to shrinking especially from sea level rise and storm events, and therefore inducing surface and subsurface saltwater intrusion (Guimond and Michael, 2021). Communities within the coastal zone had indicated during the survey that:

> *Due to saltwater intrusion, there is no fertile farmland as the soil fertlility has degraded seriously (Focus Group Discussion/ Brufut, 2021).*

In the same instance, It was also revealed during the survey in cell 5 that:

> *All the activities going on in our area have caused salt in air destroying our corrugated irons sheets and sometimes it extends into our agricultural lands leading to loss of properties and plants we used to feed ourselves and our families. At the moment most of us women have stopped vegetable production as we don't have the necessary support to minimise saltwater intrusion into our wells and gardens. Instead of the government helping us, they have now sold almost all the land we used to grow our vegetables. Even if we have support now, our gardens have all been transformed to residential houses and lodges" (key Informant Interview/ Kololi, 2021).*

Most of the households and family members have taken no action to adapt to climate change and as well have taken no action to enable them to withstand or recover from future climate events. Even though the coastal households were aware and believed that there is climate change (Figure 4.18 & 4.19) and had access to climate information (Figure 4.22), their low level of understanding of climate change (Figure 4.20), their low-income level (Figure 4.16), low educational level (Figure 4.3) and inadequate support and access to information on adaptation and mitigation strategies (Table 4.35 & Table 4.23) highlighted in this study were be part of the main barriers limiting their adaptive capacity as well as their preparedness for future climate events.

However, in contrast to the report of this survey where adaptive strategies is limited to tree planting, opening windows when temperature is high, buy fan for cooling or leaving the faith of the households to God, some communities had indicated as follow:

> *To cope with climate change, we are planting early maturing crops to adapt to changes in rain fall pattern. A community-based organisation called Youth Tesito Development have planted coco-nut seedlings along the beach to reduce coastal erosion. With regards to soil fertility, there is an ongoing training to teach women farmers on compost making to cope with low soil fertility which is organised and manage by the community members. (Focus Group Discussion/ Sanyang, 2021).*

> *The community has adopted putting sandbags as part of coping strategy in controlling erosion as well as beach cleaning to protect marine life. But I observe almost all the projects have similar project goals and almost all of them come to do the same activity which sometimes leads to duplication of efforts and leading to clash of interest between donors (Key Informant Interview/ Sanyang, 2021).*

In this community, the youths mobilise themselves to plant trees and mangroves along the coast and also come out in large numbers to help affected households during flood, windstorm and fire outbreaks. For many of us, we are not adapting in any way to climate hazards. The only coping mechanism we employ is to use devices like fans, or open our windows or go out to rest under a tree if available when the environment is hot (Focus Group Discussion/ Bakau, 2021).

4.3.4.2 Vulnerability index assessment

Climate change vulnerability index assessment conducted to evaluate and compare the level of community vulnerability to climate change along the coastal zone of The Gambia indicates that the coastal zone is vulnerable to climate change. This corroborates with the findings of various researchers most of who highlighted the high level of vulnerability of coastal zone in The Gambia (Ampomah, 2012; Sanneh *et al*., 2014; Amuzu *et al.* 2018a; Omotosho and Sylva, 2018; Komma, 2019; Belford *et al*., 2020; Gomez *et al.*, 2020). The result showed that households within Cell 8 and Cell 6 ranked highest in terms of their vulnerability score.

Cell 8 the most vulnerable among the coastal cells is most exposed to climate variability events with average precipitation of 918mm and yearly maximum temperature of 35^{o}c over 30 years period. Additionally, most households in this zone were exposed to high frequency, severity, difficulty of coping and negative impact of natural hazards such as high temperature and tropical windstorm from 1990 to 2020 (Appendix 2, 3, 4, 5). Furthermore, these households had low adaptive capacity which is centred on access to basic facilities such as basic health care services, electricity, safe drinking water and climate information through radio, television and internet. In terms of economic security, majority of the household in cell 8 own the houses they were residing.

This finding is in line with Gomez, *et al.* (2020); Gomez (2015), in their study on coastal vulnerability to climate change indicating that households within Cell 8 were highly vulnerable to climate change. These concerns were also raised by communities during the survey that they believed their lack of adaptive capacity is contributing to their vulnerability to climate change hazards (Survey, 2021). It has been stated by some community members in Cell 8 that:

> *A lot is happening in this community. Which we can blame it on the government for giving out license to golden lead factory and mining companies. But we also have to blame ourselves because it is the community members that sell their lands to these establishment and we can't do anything because these individuals always claim it is their right to sell their property to whoever they wish. Now we are facing the consequences of climate change hazards. Our houses were destroyed during windstorm and floods, and even our foodstuffs were destroyed. I believe this trend will continue unless we change our attitude (key Informant Interview/ Gunjur, 2021).*

Cell 6 is 2nd in terms of their vulnerability to climate change and the most sensitive and highly exposed as well. This area is exposed to climate variability for average annual temperature and average annual relative humidity and natural hazards with high frequency, severity difficulty of coping and high degree of negative impact of high temperature and tropical windstorm (Appendix 2, 3, 4, 5).

Similarly, more rain and changes in the rainy and dry seasons over the years were high which they have high difficulty adapting with (Appendix 2, 3, 4, 5). This cell also had high demographic sensitivity of large household's size and their socio-economic sensitivity determined by the earning status of households where majority of households do not have adequate income to cover important household expenses and socially disadvantaged households with highest proportion of households that migrated to the cell (Table 4.7).

In terms of the livelihood activities, most of the household members in Cell 6 do not engage in any economic activity (Annex 1). Furthermore, Komma (2019), in his study on

coastal adaptation to climate change and human impacts classified cell six as high-risk zone. However, it was highlighted during survey that:

> *Due to loss of vegetation, through logging for fuel wood and urbanisation and industrialisation, saltwater evaporation is destroying our iron roofs and increasing the vulnerability of our community to windstorm, higher temperature and sea level rise (Key Informant Interview/ Brufut, 2021).*

Although households in Cell 4 ranked 3rd in the level of vulnerability and are exposed to climate change, they are also the least sensitive within the study zones among all the coastal cells. The level of exposure of these households was based on climate variability of high temperature and relative humidity. In the same vein, most of the households within this cell were exposed to natural hazards such as maximum temperature (^{o}c) and tropical windstorm with high frequency, severity, negative impact and high difficulty of coping (Appendix 2, 3, 4, 5). It was also emphasised during the survey in zone 4 that:

> *Climate change has affected food security greatly in this area by causing loss of income and high food prizes which is unaffordable to majority of households (Key informant interview, Bakau, August, 2021).*
>
> *Food security has changed a lot in the area. Food Items that could be obtained freely or at reduced price 10 years ago especially at the beach are now very expensive for the average person in the community. For example, bonga fish is now very expensive and one would be very lucky now to get it free from the fishermen as most of these fishermen are also complaining of high cost of fuel used to power their boats and competition with big fishing trawlers as they now must move deeper in the sea to enable them to have good catch. Crabs that used to be abundant are now scarce because their environment have been destroyed for building various types of infrastructure (Focus Group Discussion/ Bakau old cape, 2021).*

Furthermore, Cell 5 ranking 4th in in terms of their vulnerability to climate change, is also the most exposed within the coastal zone. However, households within this cell had the most adaptive capacity and the exposure level of households within this cell is determined by climate variability in maximum temperature, relative humidity and household exposure to natural hazards such as maximum temperature and tropical windstorm. Their adaptive

capacity index is determined by literacy, where most household members had at least a primary or secondary education (Annex 1), infrastructure where, almost all of households had corrugated iron sheet as the main construction material of the roof of their houses (Table 4.15) and access to health care centres (Table 4.16).

In the same vein, majority of households had access to basic facilities such as electricity, safe drinking water and climate information through radio, television and internet. However, it was indicated during survey in this zone that:

> *The development within this area is affecting our food security. We used to have access to sea food as most of us were fishermen. Currently we are competing with foreign fishermen and also big fishing trawlers as we don't have proper fishing gears to venture deeper in the sea to catch fish. Fuel to power small boats is not sustainable as many times we don't have enough catch to compensate for fuel used. Even vegetable crops that we used to cultivate have to be bought to feed our families as all our land have been transformed into settlements and other infrastructure (Key Informant Interview/ kololi, 2021).*

> *Our food security is undoubtedly affected, and this problem is not only limited to my community. I believe all other communities within the coastal zone is experiencing the same problem when it comes to food security. The occurrence of flood during the rainy season also contributes to food scarcity as it usually destroyed foodstuffs stored in our houses which we have no control of. At the moment, community members are doing whatever it takes to survive. Some of them have taken up employment as housekeepers in hotels and residential houses while others are engaging in petty trading (Key Informant Interview/Kotu, 2021).*

Cell 1 the least vulnerable is also the least exposed to climate. Nonetheless, several issues affecting this area were highlighted during the survey that:

> *The vegetation cover is depleting which is believed to be associated with population increase leading to clearing large areas for built building infrastructure and for domestic use. Some areas have inundated with stagnant water due to sea level rise and saltwater intrusion has affected soil fertility causing many to take up trading instead of farming as a livelihood option (Focus group discussion/ Barra, 2021).*

> *Livelihood around this area is getting more and more difficult. There is huge deposit of sand which we believe is due to industrial activities occurring in other parts of the coastal zone. Activities such as building harbour and sand mining in Banjul and other areas causes the seas to push loose sand from these activities to be deposited along the beach. This has affected food security in this area and most sea food such*

as crabs and shrimps that were abundant in this area are now disappearing making the sea food very expensive. Waste from other parts of the coastal zone is also dumped by the beach side which is also causing dead of many organisms. All these activities coupled with declining soil fertility and expensive food prices makes livelihood of residents more and more difficult (Focus Group Discussion/ Essau, 2021).

Increased population along this area has caused migration of all types of people to migrate to this area for better opportunities such as employment, trading and fishing. The amount of mental imbalance individuals has increased who normally decided to stay if they were denied entry into the ferry to enable them to cross to other side of the sea. The abundance of sea food has decline significantly affecting fishermen a lot (Key Informant Interview, Barra, 2021).

Therefore, from this study it is determined that each of the coastal cells of The Gambia has different social, economic, natural hazards and demographic characteristics resulting to differences in sensitivity, exposure and adaptive capacity and the level of vulnerability observed. Low exposure and low sensitivity with high adaptive capacity to climate change reduce the level of vulnerability of households in cell 1 and cell 5 of the coastal zone of The Gambia. However, high exposure and high sensitivity with lower adaptive capacity to climate change increases the level of vulnerability of households to climate change in cell 8 and cell 6.

Therefore, the results of this study had highlighted that enhancing the socioeconomic, technical skills and living conditions of individuals at community levels will counteract the impact of climate change along the coastal zone of The Gambia as highlighted by various researchers around the globe (Moss *et al.*, 2001; Brooks, 2003; Hahn *et al*., 2009; Lückenkötter *et al*., 2013; Riede *et al*., 2016; Zhou, 2021).

4.3.5 State and Non-State Actor Participation in Building Resilience to Climate Change in The Gambia

The results of this study showed that community members along the coastal zone of The Gambia had no mechanisms outline to challenge climate change and related events and were

unable to organise activities to promptly respond to the climate change impacts. Furthermore, these community members were unable to reorganize to respond to a new situation and they do not have support from other external bodies when they are faced with problems. In addition, there is lack of collaboration among community members and were not able to access outside support when needed as well.

These were also heavily emphasised during the survey where community members agreed that they lack structures to tackle climate issues affecting their livelihood. It has been indicated during the survey that:

> *We have not seen any government or NGO intervention in our community. Notwithstanding the VDC has been very effective within the community, however, they lack authority to implement or control issues emanating from the central authority, one of such examples is mining licenses issued to firms to mined in the community (Focus Group Discussion/Brufut, 2021).*
>
> *NDMA that provide relief for disaster victims is active in the community. The NEA is also active in the community as it has extension workers in the community who worked with the youths and other persons in the settlement through sensitization about climate change and its impact. The WFP is equally present in the settlement through giving food support to disaster victims and the Geology Department that gives licenses for mining in the community (Key Informant Interview/Gunjur, 2021).*
>
> *Only National Environmental Agency had worked with us few times in cleaning drainage systems which were not effective in addressing flood occurrence in this area (Key Informant Interview/ Barra, 2021).*
>
> *Non-governmental organisations such as Future in Our Hands, Action Aid The Gambia, Child fund, Turkish Embassy, and Smile Gambia are currently active in building resilienc to climate change in the community. Sanyang Youth for Environmental Change, Youth Tesito for Development are some of the CBOs working with communities on climate change. In addition, the community has also been assisted by National Disaster Management Agency (NDMA), NEA, Department of Parks and Wildlife in tackling climate change issues. Turkish Embassy and Smile Gambia are working with the community on sea turtle conservation. Child Fund conducts sensitisation programs in schools and also encourage individuals to plant trees by giving each child within the community two seedlings to plant. In addition to sensitisation, NEA also gives relevant climate information to communities as well (Focus Group Discussion/ Sanyang, 2021).*
>
> *Apart from the youths within the community who mobilise themselves to assist in climate impact, there has not been any organisation working or dealing with the*

community in addressing climate change challenges (Key Informant Interview/ Kotu, 2021).

This community is only assisted by Bakau Environment Movement, comprising youths who organises themselves into a CBO to help address climate change issues by planting coconut trees and mangroves along the beach and wetlands. These youths have also been very instrumental in assisting community members during disaster such as flood, fire outbreaks and windstorm (Key informant interview/Bakau, 2021).

Since the vulnerability (Table 4.22) and the limited capacities of households to adapt to the varying consequences of climate change (Figure 4.32) is undoubtedly emphasised in this study, it is therefore necessary to enhance the capacity of public and private institutions through support from local councils and external funding agencies to enable them to adequately respond to climate change threats in the coastal zone of The Gambia (Urquhart, 2016) This could also be achieved by identifying and utilising the different skills, capacities, and knowledge of individuals and groups within their communities to tackle the climate change challenges affecting their communities.

This has been emphasised by IPCC AR6 (2022) that, vulnerability to climate change is multi-dynamic and does not only limit to households but also defines exposure and sensitivity of societies and communities to the impacts of climate change. The report further stressed that players need to work in all-encompassing and supportive ways to combine divergent views and build on awareness and understanding of climate hazards and adaptation alternatives obtained from diverse skills and knowledge systems within their communities. This indicates that, community resilience to climate change is most effective when societies and community members work together to merge different ideas. Therefore, it will be practical for the entire coastal communities of The Gambia to reorganise and be well structured to tackle the socioeconomic and environmental hazards affecting their livelihood

and to complement the efforts of the individual households if they are to sustain their biotic and abiotic as well as their livelihood for a long term.

Furthermore, as stated by Wilson (2012), enhancing the capacity of coastal communities in building resilient to climate change require the development of their economic, social, and environmental ideologies that will enable them to manage and safeguard their resources. This according to him is because communities are observed as the link between households and other stakeholders where its members share the same opinions and predispositions in logically addressing climate change effects. This emphasised the need for cooperation between communities as well as state and non-state actor participation including government, civil society organisations, community-based organisations, private sectors etc. in building resilience to climate change in the coastal zone of The Gambia.

In this regard, state and non-state actor participations in climate resilience along the coastal zone of The Gambia was assessed and the result of the study indicated that, these communities do not have sufficient interactions with state and non-state actors working on climate change adaption and mitigation in the country (Appendix 7). During the survey, majority of the respondents indicated that they did not know of any actor or organisation dealing with climate change issues within their respective communities. Although few respondents had claimed to have worked with Government (specifically NDMA, NEA and Forestry Department), NGOS, CSOS, Gambia Tourism Board, Christian Children's Fund (CCF) (Appendix 8) whose engagements with them were rated as fairly or not effective in addressing the various climate change challenges their community is dealing with (Appendix 9).

Moreover, Vignola *et al*. (2009); Meijerink, *et al.* (2015), had indicated that there is need for the adoption of unified methods in developing countries whose livelihood depends on environmental resources and services in formulating policies for adaptation to climate change, taking into account the characteristics of all stakeholders in increasing the resilience of societies in accordance with their mandates by enhancing appropriate level of capacity, funding and other necessary utilities. The need for collaboration between state and non-state organisations in building resilience to climate change within coastal settlements in The Gambia had been undoubtedly emphasised by Omotosho and Sylva (2018); Amuzu et al. (2018c).

Therefore, to substantiate the claims of the communities, a follow-up survey was conducted to assess the state and non-state actor participation in building resilience to climate change along the coast. The results indicated that majority of these organisations had strong interest in working with communities in future and the scope of climate change issues in most of these institutions is wide. However, while majority of the institutions have plans in place to deal with natural hazards such as (floods, tropical windstorm, and other forms of disaster) along the coastal zone, majority had inadequate funding, policy or related documents to enable them to deal with climate change issues.

Furthermore, majority of these organisations claimed that they had worked well with communities in leading coastal adaptation and mitigation activities in the past, although this contradicts the claims of most respondents during survey (Appendix 7). Most of the community members indicated that few organisations were working with them on climate related issues and were unable to mobilise supports from organisations to access outside support when needed (Table 4.23).

The study further highlighted that less than half of the institutions surveyed have enough capacity to effectively participate in climate change adaptation and mitigation along the coastal zone of The Gambia. In the same instance, less than half of the institutions had worked with coastal communities in terms of sharing climate related information. Nonetheless, most of these institutions were not in the position to provide communities with support in terms of resources and or expertise in climate change adaptation and mitigation exercises.

Although majority of these institutions claimed to have taken some actions to adapt or cope with climate change in which their interventions were ineffective. Therefore, Urquhart (2016) had highlighted the need for proper governance approach to climate change taking into account structured, institutionalized and sustainable approach for exploring opportunities for climate finance in the short, medium and long term in The Gambia to support the resilient of the coastal zone to climate change. He further emphasised that it is required for the capacity of the government departments to be improve to effectively mobilize financial resources for implementation of their programmes as well as enhancing availability of credit and insurance facilities in coastal and inland communities in The Gambia to support disaster recovery.

4.4 Problems Encountered in the Field.

The household data collection was mostly conducted in local languages which was a great tasked to the enumerators as they did not only need to understand the rules of these languages but also the lifestyle of the household members to some extent. Most importantly, respondent's participation was also a big challenge as most households shut their doors and

show no interest in speaking to the enumerators, and for some individuals, the interview process was time consuming.

Many a time most people will assign other family members who were mostly not the right individuals to understand all the issues to be discuss with regards to the household to attend to the enumerators. Mostly, some of the questions such as the declaration of one's household's income level were deemed to be too sensitive and private for some respondents.

To gather sufficient number of people during the focus group discussions were challenging and time consuming as it was the corona virus pandemic period, and most people were sceptical to join gatherings at the time. In the same instance most of the state and non-state organisations the questionnaires were sent to but do not respond on time while some did not respond at all even when several follow-ups were conducted.

The climate variability data collected from the Department of Water Resources has lots of gaps which were corrected for analysis and some of the stations record only rainfall data that needs to be upgraded.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Summary

The coastal zone of The Gambia is a region of socioeconomic importance where various activities including tourism, artisanal fishing, cultural and aesthetic and religious activities are prevalent. The coastal zone also serves as an important ecosystems services, including habitats and breeding grounds for aquatic animals, plants and migratory birds. This research specifically aims to assess the understanding and awareness of coastal communities to climate change and their level of vulnerability and adaptation.

The research utilises land cover change conversion using Cloud free Landsat imageries of the years 1990, 2000, 2010 and 2020, freely downloaded from the United States Geological Survey (USGS) website which was correlated with population of coastal zone as a proxy to determine the degree of association between the land cover classes and population growth. Mann–Kendall trend test and Sen's slope estimator were utilized to assess the trend and slope magnitude of the annual average rainfall (mm), minimum temperature (^{o}c), maximum temperature (^{o}c), windspeed (knots) and relative humidity (%) obtained from meterology unit of the department of water respources. Furthermore, household data were collected using structured questionaire to assess the believe, awareness and understanding of coastal communities to climate change and their level of esposure, sensitivity and adaptive capacity to climate hazards.

Furthermore, climate change vulnerability index analysis was conducted along the coastal zone of The Gambia to evaluate and compare the level of vulnerability of households to extreme climate events in each coastal cell studied from 1990 to 2020. Finally state and

non-state actor participation in building resilience to climate change was subjectively assess using semi-structured questionnaire in different organisations across the country.

The findings of this research have demonstrated that the coastal environment had undergone significant alterations as a result of multiple stressor within the last 30 years and the extend of modification for each of land cover characteristics indicated an increase in barren land and built-up and a decrease in vegetation cover, water bodies and wetlands, associated with increased human population around 10 to 25km of the coastal strip of The Gambia from 1990 to 2020.

This study further confirms that while population growth is associated with increase in built environment to meet the demand for the growing population, it has also significantly caused the disappearance of most of the vegetation cover, water bodies and wetlands. This increase in population, human activities and associated infrastructure build up is also partially attributed to the in-homogeneity in annual time series data from 1980 to 2020 used in this study for total rainfall (mm), maximum temperature (^{o}C), minimum temperature (^{o}C), relative humidity (%) and wind speed (knots) along the coastal zone of The Gambia. The findings of the study also revealed an increasing positive precipitation, maximum and minimum temperature trends along the coastal zone of The Gambia.

With low level of education among coastal households, majority believed and are aware that the climate is changing. However, only few really understand what climate change means. Moreover, socio-economic factors that affect climate change understanding of households were ethnicity, income level of households, believe and awareness that the climate is changing, adaptive capacity and access to information. Additionally, the

differences in socioeconomic characteristics of coastal households have resulted to different degree of climate impact.

This study had further emphasised that the coastal zone is vulnerable to climate change with different exposure, sensitivity and adaptive capacity of the different coastal cells. Each of these cells have different social, economic, natural hazard and demographic characteristics resulting to differences in sensitivity, exposure and adaptive capacity and differences in the level of vulnerability observed.

With the limited ability of individual households to adapt to the varying consequences of climate change and with insufficient interactions and support in terms of resources and or expertise from state and non-state actors working on climate change adaption and mitigation in the country, these communities also lack organisational structures to enable them to tackle climate change issues affecting their livelihood as whole.

5.2 Conclusion

The findings of this study had deduced that coastal environment of The Gambia had undergone significant transformation because of multiple stressors within the last 30 years. While population increase is associated with increase in built environment to meet the demand for the growing population, it has also significantly caused the disappearance of most of the vegetation cover, water bodies and wetlands. In addition, population growth along the coastal zone of The Gambia is also partly attributed to in-homogeneity in annual time series data from 1980 to 2020 used in this study. However, the study shows an increasing positive precipitation, maximum and minimum temperature trends along the coastal zone.

The findings of the study further discovered that there is low level of understanding of climate change among coastal households. Also, difference in socioeconomic characteristics of coastal households has resulted in different degrees of climate impact and vulnerability.

Finally, coastal communities do not only lack organisational structures to enable them to tackle climate change issues affecting their livelihood but also lacks sufficient interactions and support in terms of resources and or expertise from state and non-state actors working on building resilience to climate change within the country.

5.3 Recommendations

Several problems affecting the coastal environment of The Gambia due to human-oriented activities require the understanding and awareness of the socio-economic and ecological processes of the coastal habitats. Therefore,

- It is prudent for the government of The Gambia and relevant stakeholders to put population issues into account in formulating well defined management goals and objectives that are derived from a deep understanding of the level of land transformation along the coast. This will help to ensure that the long-term sustainability of the coastal ecosystems is not compromised.
- To reduce the uncertainty in the time series climate data and improve the quality of data, further studies are required to ascertain the climate and non-climate factors affecting the quality of time series data. Emphasis should be put on collecting and processing metadata that provides the minimum information for all meteorological stations in the country.

- In order to adequately address the socioeconomic and environmental hazards affecting their livelihood, there is need for community members to reorganise and re-structure to better serve the needs of its inhabitants and work together to merge different ideas.
- The situation of vulnerability in terms of exposure and sensitivity to climate hazard along the coastal zone has call for an urgent need to mobilise appropriate level of capacity, funding, diverse skills and knowledge systems within communities, state and non-state organisations. This will enhance collective efforts in adaptation and building resilience to climate change in the coastal zone of The Gambia.

5.4 Contribution to Knowledge

- This study has not only revealed the alterations of the coastal zone due to multiple stressors but has also indicated the extent of transformation for each of the land cover characteristics studied.
- Although majority of respondents were aware and believed that the climate is changing, only few really understand climate change.
- This study did not only establish the vulnerability of the coastal zone to climate change but has also determined that each of the coastal cells of the Gambia has different exposure, sensitivity, and adaptive capacity to climate change.
- The high proportion of household's exposure and sensitivity to tropical windstorm were attributed to declining tree population and poor infrastructure as the windspeed trends did not show increasing or decreasing trend from 1990 to 2020.
- The low level of understanding of climate change, low-income level, low educational level and inadequate support and access to information on adaptation and mitigation

strategies were part of the main barriers limiting the adaptive capacity as well as the preparedness for future climate events of coastal communities in The Gambia.

- The coastal zone of The Gambia is not only grappling with low household adaptive capacity to climate change, limited community reorganization and structures to tackle climate change but also limited state and non-state actor participation in building resilience to climate along the coastal zone of The Gambia.

5.5 Suggestions for Further Studies

- Encouraging research into coastal vulnerability to climate change, building capacities of the coastal inhabitants on adaptation and mitigation and the provision of relevant and timely climate information through media and other outreach services is required.
- Further research is also required to understand the land cover transformation patterns occurring within coastal zone and its impact on climate variability trends, population and the coastal ecosystem.
- In addition, there is need for further research into the understanding of the impact of population growth on socio-economic and ecological processes within the coastal zone.

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APPENDICES

Appendix 1: Demographic characteristics of household members

Characteristics		Cell 1	Cell 4	Cell 5	Cell 6	Cell 8	total
Age	A.v age	23	26	23	29	22	24
Gender	Male	41%	45%	42%	48%	60%	47%
	Female	59%	55%	58%	52%	40%	53%
Educational level of household members	No formal education	25%	19%	21%	27%	16%	21%
	Arabic or Madrassa	9%	11%	16%	20%	32%	16%
	Primary education	25%	24%	27%	19%	19%	23%
	Secondary education	28%	36%	30%	28%	22%	30%
	Tertiary education	12%	9%	6%	6%	11%	8%
	University education	1%	1%	1%	0%	0%	1%
Health issue of household members	Yes	5%	5%	3%	3%	3%	4%
	No	92%	94%	96%	96%	94%	95%
	I don't know	3%	1%	1%	1%	3%	1%
Ethnicity of household members	MANDINKA	52%	59%	24%	55%	77%	51%
	FULA	12%	12%	16%	15%	8%	13%
	WOLLOF	15%	7%	10%	5%	3%	8%
	JOLA	1%	8%	29%	9%	4%	11%
	SARAHULE	1%	1%	1%	1%	1%	1%
	SERER	14%	4%	3%	2%	5%	5%
	AKU	1%	1%	0%	0%	0%	1%
	MANJAGO	2%	0%	2%	4%	1%	2%
	OTHERS	2%	8%	15%	9%	1%	8%
Marital status of household members	Single	62%	64%	66%	62%	66%	64%
	Married	34%	30%	31%	35%	28%	32%
	Separated/Divorced	1%	2%	1%	0%	1%	1%
	Widowed	3%	4%	2%	3%	5%	3%
Primary occupation of household members	Salary work	11%	15%	13%	7%	8%	11%
	Fishing	2%	1%	1%	1%	1%	1%
	Farming	1%	3%	2%	4%	6%	3%
	Trading	13%	6%	4%	7%	7%	7%
	Mining	0%	0%	0%	0%	1%	0%
	Carpentry	4%	6%	10%	9%	7%	7%
	Student	54%	53%	54%	53%	51%	53%
	Housewives	15%	16%	16%	18%	18%	16%

Appendix 2**: Frequency of climate threats for the household**

Frequency	Rating	Cell 1	Cell 4	Cell 5	Cell 6	Cell 8	Total
Frequency of Saltwater inundation	Low	15%	7%	6%	5%	17%	9%
	Medium	25%	33%	23%	5%	11%	19%
	High	60%	60%	71%	91%	71%	72%
Frequency of Tropical windstorm	Low	33%	51%	38%	40%	23%	39%
	Medium	29%	17%	17%	10%	23%	18%
	High	38%	32%	45%	49%	55%	43%
Frequency of more rain	Low	0%	7%	9%	5%	14%	9%
	Medium	80%	67%	43%	38%	37%	44%
	High	20%	27%	48%	57%	49%	47%
Frequency of less rain	Low	12%	17%	24%	10%	25%	17%
	Medium	24%	38%	50%	62%	25%	42%
	High	64%	45%	26%	29%	50%	41%
Frequency of hotter temperatures	Low	5%	12%	32%	33%	39%	23%
	Medium	28%	58%	25%	29%	0%	32%
	High	74%	56%	55%	52%	61%	58%
Colder temperatures	Low	0%	0%	4%	30%	43%	23%
	Medium	0%	10%	37%	11%	23%	19%
	High	100%	90%	59%	60%	35%	59%

Appendix 3**: Severity of climate hazards on household**

Severity	Rating	Cell 1	Cell 4	Cell 5	Cell 6	Cell 8	
Severity of Saltwater inundation	Low	5%	9%	6%	2%	14%	7%
	Medium	30%	37%	11%	11%	14%	20%
	High	65%	53%	83%	86%	71%	72%
Severity of Tropical windstorm	Low	22%	30%	35%	34%	16%	29%
	Medium	29%	20%	11%	24%	30%	22%
	High	49%	51%	54%	42%	55%	50%
Severity of more rain	Low	0%	27%	13%	11%	9%	12%
	Medium	40%	40%	30%	38%	54%	42%
	High	60%	33%	57%	51%	37%	46%
Severity of less rain	Low	12%	7%	17%	5%	13%	11%
	Medium	16%	48%	60%	76%	50%	50%
	High	72%	45%	24%	19%	38%	39%
Severity of hotter temperatures	Low	2%	9%	34%	25%	29%	20%
	Medium	23%	30%	10%	18%	13%	19%
	High	74%	62%	56%	57%	58%	61%
Severity of colder temperatures	Low	0%	0%	7%	40%	43%	27%
	Medium	0%	11%	79%	17%	29%	48%
	High	100%	90%	52%	51%	18%	49%

Appendix 4**: Difficulty of coping with climate hazards on households**

Difficulty of coping		Cell 1	Cell 4	Cell 5	Cell 6	Cell 8	
Difficulty of coping with Saltwater inundation	Low	25%	7%	10%	13%	45%	27%
	Medium	10%	33%	29%	34%	31%	29%
	High	65%	65%	69%	61%	54%	63%
Difficulty of coping with Tropical windstorm	Low	16%	15%	22%	21%	16%	18%
	Medium	27%	25%	26%	40%	43%	32%
	High	58%	59%	52%	39%	41%	50%
Difficulty of coping with more rain	Low	0%	13%	9%	3%	3%	5%
	Medium	20%	33%	26%	49%	71%	48%
	High	80%	53%	65%	49%	26%	47%
Difficulty of coping with less rain	Low	16%	10%	2%	5%	38%	9%
	Medium	20%	48%	62%	76%	38%	51%
	High	64%	43%	36%	19%	25%	40%
Difficulty of coping with hotter temperatures	Low	14%	5%	19%	17%	13%	13%
	Medium	26%	40%	29%	32%	26%	32%
	High	60%	56%	52%	52%	61%	55%
Difficulty of coping with colder temperatures	Low	0%	0%	11%	40%	55%	31%
	Medium	0%	10%	37%	15%	33%	23%
	High	100%	90%	52%	45%	13%	46%

Appendix 5. **Negative impact of climate threats on households**

Degree of Negative Impact		Cell 1	Cell 4	Cell 5	Cell 6	Cell 8	
Degree of negative impact Saltwater inundation	Low	10%	7%	6%	2%	6%	6%
	Medium	20%	42%	29%	23%	31%	30%
	High	70%	51%	66%	75%	63%	64%
Degree of negative impact of Tropical windstorm	Low	27%	32%	41%	25%	23%	30%
	Medium	29%	23%	13%	33%	27%	24%
	High	44%	45%	47%	42%	50%	45%
Degree of negative impact of more rain	Low	40%	33%	22%	8%	14%	17%
	Medium	20%	40%	17%	46%	60%	43%
	High	40%	27%	61%	46%	26%	40%
Degree of negative impact of less rain	Low	16%	12%	14%	5%	38%	14%
	Medium	16%	45%	62%	67%	38%	48%
	High	68%	43%	24%	29%	25%	38%
Degree of negative impact of hotter temperatures	Low	2%	12%	37%	28%	32%	23%
	Medium	26%	36%	14%	17%	10%	22%
	High	72%	52%	49%	55%	58%	56%
Degree of negative impact of colder temperatures	Low	0%	0%	11%	36%	50%	29%
	Medium	0%	5%	33%	15%	38%	23%
	High	100%	95%	56%	49%	13%	49%

Appendix 6**. How useful is the information from Radio, tv, friends and family and government?**

Source of Information		Cell 1	Cell 4	Cell 5	Cell 6	Cell 8	Total
Radio	Very useful	82%	72%	71%	73%	75%	74%
	Useful	16%	22%	29%	20%	23%	22%
	Not useful	0%	2%	0%	2%	2%	1%
	I don't know	3%	4%	0%	4%	0%	2%
Tv	Very useful	87%	60%	71%	72%	79%	71%
	Useful	11%	35%	22%	22%	18%	24%
	Not useful	0%	0%	4%	3%	3%	2%
	I don't know	3%	5%	4%	3%	0%	3%
Family and friends	Very useful	63%	93%	80%	90%	85%	86%
	Useful	38%	3%	20%	6%	15%	13%
	Not useful	0%	3%	0%	3%	0%	2%
Government	Very useful	0%	100%	100%	100%	100%	99%
	Useful	100%	0%	0%	0%	0%	1%

Appendix 7. State and non- state actor participation in building resilience to climate change.

Participation	Cell 1	Cell 4	Cell 5	Cell 6	Cell 8	total
Yes	15%	16%	7%	19%	30%	17%
No	77%	78%	74%	59%	52%	68%
I don't know	8%	6%	19%	22%	18%	15%

Appendix 8. Organisations that collaborates with coastal communities in dealing with climate change issues.

Organisations	Cell 1	Cell 4	Cell 5	Cell 6	Cell 8	total
Government	75%	47%	67%	88%	56%	65%
community leaders	13%	0%	0%	0%	6%	3%
NGOs	38%	20%	0%	6%	17%	16%
CSOs	13%	27%	17%	0%	11%	13%
Projects	13%	13%	0%	6%	0%	6%
Other	0%	7%	17%	0%	22%	10%

Appendix 9. Community assessment of Government's effectiveness in fighting against climate change.

Addressing climate change issues	Cell 1	Cell 4	Cell 5	Cell 6	Cell 8	total
Effective	75%	47%	67%	88%	56%	65%
Fairly Effective	13%	0%	0%	0%	6%	3%
Not effective	38%	20%	0%	6%	17%	16%
I don't know	13%	27%	17%	0%	11%	13%

Appendix 10. State and non- state institutions interviewed.

Name of institution	Type of institution	Affiliation
Action Aid International, The Gambia	NGO	Environment, education, agriculture, health, governance
Agency for development of women and children (ADWAC)	NGO	Agriculture, development
Child fund international	NGO	Education
Daughters of The Gambia	CSO	Education, health
Gunjur youth movement	CSO	Environment, youth development
Bakau environment movement	CSO	Environment, youth development
Department of soil and water management	GOVT	Environment
Department of water resources	GOVT	Water resources, climate
Education for all (EFANET)	CSO	Environment, education, fisheries, health, youth empowerment
Fisheries department	GOVT	Environment, education, agriculture, fisheries, health, peacebuilding, and conflict resolution
Gambia horse and donkey trust fund	CSO	Environment, education, agriculture, health
GAMRUPA (youth people without borders	CBO	Environment, health
Geological department	GOVT	Environment water resources and climate
GRTS	GOVT	Communication
Ministry of agriculture	GOVT	Agriculture
Ministry of basic and secondary education	GOVT	Education
MOHERST	GOVT	Education, science and technology
NAVY	GOVT	Security
NEA	GOVT	Environment, public health
Sanyang youth tesito association	CSO	Environment
The Gambia red cross society	NGO	Environment, health
World health organisation	UN AGENCY	General issues
Young people without borders	CBO	Humanitarian

Appendix 11. Household survey questionnaire

University of The Gambia

Doctoral Research Program on Climate Change and Education

Farafenni Campus, North Bank Region, The Gambia

CONSENT LETTER

INTRODUCTION:

My name is Bintou Dibba. I am currently studying PhD in climate change and education at the University of the Gambia. I would like to invite you to participate in a research study which aims to assess the awareness and understanding of the risk and adaptation to livelihood stress due to climate and non-climate hazards among coastal communities in The Gambia. Be assured that your answers will be anonymous and treated with confidentiality. Please understand your participation in this research is on a voluntary basis and you have the right to discontinue participating at any time. Also, if you have question at any time about the interview, you may contact me on tel: 3856350 email: binsdd@gmail.com. Thank you very much for your time.

HOUSEHOLD SURVEY QUESTIONAIRE

TITLE: Vulnerability and Adaptation to Climate Change: Understanding and Awareness among coastal communities in The Gambia

Interviewer name:		
Questionnaire Number	**Residence**	**date**

PART A: SOCIO-ECONOMIC STATUS HOUSEHOLD

1. How many individuals/ dependents are there in the house?
Total …….
Male ……..
2. Female…….
3.
4. **Demographic characteristic of the respondent (household head or representative)**

Household member (all individuals living in the house by roles)	Age in years	sex	Education level (use code 1)	Does this member have any health-related issues/ disability? (Fill question 6 for anyone marked yes)	Ethnicity (use code 2)	**Marital status (use code 3)**	**Primary occupation (Code 4)**	**Secondary occupation (Code 5)**
1.								
2.								
3.								
4.								
5.								
6.								
7.								
8.								
9.								
10.								
			Code 1		Code 2	Code 3	Code 4	Code5
			1.Non-Formal Education 2.Primary education 3.Secondary education 4.Tertiary education 5.Arabic/Madarasah		1.Mandinka 2.Fula 3.Wollof 4.Jola 5.Sarahulle 6.Serrer 7.Aku 8.Manjago 9.Others,	1. single 2. married 3. divorced 4. widow	1. salary work 2.fishing 3. farming 4. trader 5. mining 6. carpentry 7. others (specify)	1. salary work 2.fishing 3. farming 4. trader 5. mining 6. carpentry 7. others (specify)

5. Has this household migrated to this community or descendant?
   a. Migrated b. descendant.
6. If the household is not a descendant in this settlement, please indicate why you choose to reside in the settlement.
   a. Marital b. employment c. access to coastal resources d. others (please specify)
   ……..
7. How long have you lived in this community?.....

8. Please briefly describe the health-related issue of the family member (s)
   1.……
   ……
   ……
   2.……
   ……
   ……
   3.……
   ……
   ……

9. What is the average monthly household income…….....

10. How would you rate your household income level, based on your expenses?
    a. Usually not enough to cover important household expense
    b. Just enough to cover important household expenses
    c. Usually have some left after important household expenses.

PART B: ACCESS TO RESOURCES

11. Does your household have access to the following resources or services?

Resources/ services	**Yes/no**	**Type of resource/services (if applicable using corresponding codes)**	**codes**
a. Back-up electricity (			1.electirc power 2.solar power. 3. generator 4. others (pls specify)
b. Back-up for drinking water			1.pipe/tap 2.household borehole 3.community borehole 4.rainwater harvesting 5.well 4.others (please specify)
d. Tools for food production			1. Tractors 2. Animal drawn implement. 3. Traditional farm implement
e. Land vehicles			
f. Boat canoe			
g. Radio			
h. Telephone			
i. Internet access			
j. Do you own the house you are living in?			
k. indicate the main construction material of the walls of your house			1.cement 2.mud 3.bamboo/plant materials 4. metal/ iron sheet 5.others (please specify)
l. Indicate the main materials used for the roof of your house			1.bamboo/rafters 2.iron/metal sheet 3.straw 4.others (please specify)
m. Does your household have access to health care services in your community			
n. Access to toilets			1.household flush toilet 2.household pit latrine 3.communal latrine 4.bush 5. others (please specify)
o. main source of fuel for cooking and other domestic activities in your household?			1.electricity 2.gas 3.firewood 4.charcoal 5.others (please specify)

p. If your answer in question (o) is 1, 3 or 4, indicate the sources			1.coastal vegetation 2.others (please specify)
q. Do you have livestock			
r. If your answer in question (q) is yes, state the types and numbers			1.goat 2.sheep 3.cattle 4.pig 5.poultry 6. others (please specify)

PART C: DEPENDENCE ON RESOURCES AND SERVICES

12. What are the main livelihood sources for your household for both cash income generation and hous ehold use?) Check all that apply.

Source	**Monthly Household income from each source (record 00 if no income from the source)**	**Number of household members engaged in the activity**
Fishing		
Harvesting other marine resources		
Farming		
Livestock		
Handicrafts		
Mining		
Salary from employment		
Support from friends and family abroad(remittance)		
Private business (e.g., store)		
Pension/social security		
Tourism		
Construction		
Others (specify)		

PART D: KNOWLEDGE AND AWARENESS OF CLIMATE CHANGE

13. Before this interview, have you heard of climate change?
    a. yes b. no (If no, explain what climate change means and then go to Question 13)
14. Do you understand what climate change means?
    a. Yes b. to some extent c. not really d. no
    if yes, explain how you understand climate change
    ……
    …..

15. Do you believe climate change exists? / Do you believe the climate is changing?
    a. yes b. no c. I don't know
16. If yes, what do you believe is/are the cause(s)?(multiple responses)

a. burning fossil fuels, such as oil and coal
b. deforestation
c. natural events
d. agricultural, such as methane from livestock and manure and nitrous oxide emissions from fertilizers
e. carbon emissions from vehicles and large businesses
f. God
g. I do not know.
h. Other _____

17. Does your house expose to the following climate impact?

	Climate hazards	Yes/no
	Coastal/beach erosion	
	Saltwater inundation	
	Flood	
	Bush fire	
	Tropical windstorm	
	Sea level rise	
	Saltwater intrusion into gardens/fields	
	Saltwater intrusion into wells	
	Changes in rainy and dry seasons, leading to changes in planting seasons, etc.	
	Drought	
	Climate-related land or mud slides	
	more rain	
	less rain	
	hotter temperatures	
	oceans' temperature rises	
	increase land erosion	
	colder temperatures	
	loss in animals and plants	
	Others (please specify)	

18. Awareness of household vulnerability to climate hazards

Climate hazards and impacts	a. Which of the following climate events has your household experienced in the past 30 years? (Check all that apply	b. How would you rate the frequency of this occurrence? 3 = high, 2 = medium, 1= low	c. How would you rate the severity of this hazard? 3= high, 2 = medium, 1= low	d. How would you rate the degree of negative impact on your household by this hazard? 3 = high, 2 = medium, 1 = low	e. How would you rate the difficulty of coping with this hazard for your household? 3 = high, 2 = medium, 1 = low	f. What effects did it have on you and your family ? 1. Damage to Property 2. loss in Livestock

						3. Loss in Agricultural Production 4. Loss in Income 5. Health Hazards 6. Lack of Potable Water 7. Other (please specify) 8. None 9. I don't know
Coastal/beach erosion						
Saltwater inundation						
Flood						
Bush fire						
Tropical windstorm						
Sea level rise						
Saltwater intrusion into gardens/fields						
Saltwater intrusion into wells						
Changes in rainy and dry seasons, leading to changes in plantin g seasons, etc.						
Drought						
Climate-related land or mud slide						
more rain						
less rain						
hotter temperatures						
oceans' temperature rises						
increase land erosion						
colder temperatures						
loss in animals and plants						
Others (please specify)						

PART E: ATTITUDE TOWARDS CLIMATE CHANGE

10. Have you or any member of your household taken any actions to adapt to/cope with climate change impacts?
    a. yes b. no c. I don't know
11. What have you done already to adapt to/deal with/cope with climate change? [Tick all that apply]

a. planted mangroves.
b. planted trees and vegetation along the shoreline.
c. stopped cutting mangroves.
d. maintained trees and vegetation.
e. built/fixed sea walls.
f. built wells and/or other water resources.
g. cleaned or helped to maintain public drainage systems from waste.
h. turn off lights when not in use.
i. turn off water tap/pipe when you are not using it.
j. built or helped to build green spaces, such as parks or gardens.
k. stopped taking a car or bus and walk or cycle to school.
l. not litter even when bins are not available.
m. nothing
n. I don't know.
o. other _____

12. What did you do to prepare yourself in case it happens again?

a. made property more resistant to threats.
b. Clear drains
c. planted mangroves, trees and vegetation along the shoreline.
d. stopped cutting mangroves.
e. maintained trees and vegetation.
f. built/fixed sea walls.
g. built wells and/or other water resources.
h. cleaned or helped to maintain public drainage systems from waste.
i. nothing
j. I do not know.
k. other _____

21. On a scale from 1 to 5 (1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, and 5 = strongly agree), What are some of the ways you are adapting or adjusting to deal with the changes you have describe below?

		1	**2**	**3**	**4**	**5**
a	Our community has plans in place to deal with climate-related events (such as afforestation)					
b	Our community is able to coordinate activities to respond quickly to the impacts of a natural event/hazard					
c	Our community is able to reorganize to respond to a new situation					
d	Our community has institutions that support us when we need to reo rganize to cope with new situations or problems					
e	Our community has institutions that support us when we need to reo rganize to cope with new situations or problems					
f	Our community members work well with each other					

g	Our community is able to access outside support when needed					

PART F: AVAILABILITY AND UTILISATION OF CLIMATE INFORMATIOM

23. Access to and use of information and climate related knowledge

Sources of climate-related knowledge	Check if you get climate information from this source, and n/a if the source is not available for your household	How useful is the information from this source? (Use code) 1. Very useful 2. Useful 3. Not useful 4. I don't know.
Meteorological services		
Newspaper		
Radio		
Internet		
Tv		
School/ teachers		
Climate scientists /experts		
Village leaders		
Family and friends		
Government		
Extension services		
Posters/billboards		
Social media		
Others, specify		

24. By which of the following methods would you like to receive information about Climate Change and adaptation methods?

Sources of climate -related knowledge	**Check if you want to get climate information from this source, and n/a if the source is not available for your household**	**How useful is this information from this source important to your household? (Use code) 1. Very useful 2. Useful 3. Not useful 4. I don't know**
Meteorological ser vices		
Newspaper		
Radio		
Internet		
Tv		
School/ teachers		
Climate scientists /experts		
Village leaders		
Family and friends		
Government		
Social media		
Posters/billboards		
Others, specify		

PART G: EFFECTIVENESS OF STATE AND NON-STATE ACTORS IN CLIMATE CHANGE ADAPTATION AND MITIGATION

25. Do you know of any government or non –government Organisation dealing with issues of the weather, climate change, land and water use in this area

1. Yes 2. no

26. What are the formal and informal environmental related networks or NGOs in this community?

Name of the actor	Key role/ activities played in C adaptation and mitigation	How would assess their effectiveness in fighting against CC 1. Very Effective 2. Effective 3. Fairly Effective 4.not effective
Government		
Community Leaders		
NGOs		
CSOs		
Gambia Tourism Board		
MECCNA		
Projects		
Others specify		

27.If you believe the climate has indeed changed in the last 10 years or so, to what extent has this change affected food-security in this area?

Appendix 12. Key informant interview/focus group discussion

CHECKLIST

1. Would you say the climate or weather pattern is changing? If yes, please explain in detail the changes you have observed with reference to the following.

    a. Rainfall in the area
    b. Changes to rivers and watersheds
    c. Changes to the forest lands and landscape itself
    d. Changes to vegetation cover
    e. Changes to temperature
    f. Changes in the seasons
    g. Changes to soil fertility

2. In your understanding, how would you say the climate is changing; better or worse? Please elaborate.
3. What are some of the ways you are adapting or adjusting to deal with the changes you have seen or described above {hint the use of irrigation ; different varieties of crops; new or improved farming or fishing techniques, use of fertilizers, herbicides etc].
4. Do you know of any government or non –government Organisation dealing with issues of the weather, climate change, land and water use in this area? If yes elaborate on their activities
5. Is the population in this area increasing or decreasing within 10 years or so? What could be the possible reasons, for the observed population change elaborate?
6. What are some of the strategies used by households in this community to adapt to climate change impacts?
7. If you believe the climate has indeed changed in the last 10 years or so, to what extent has this change affected food-security in this area?
8. What are the formal and informal environmental related networks or NGOs in this community?
9. Can you please highlight some of the roles of formal an informal environmental related networks of NGOs in climate change adaptation and hazards mitigation in this area?
10. Do you think their efforts are effective in climate change adaptation and hazards mitigation?

For state and non-state actors (Heads Institutions, Networks and NGOs)

1. Name of institution……

2. Type of institution……

3. Which of the following options below is your institutions affiliated with?
    a. Environment
    b. Education
    c. Agriculture
    d. Fisheries
    e. Health
    f. Media
    g. Mining
    h. Others (please specify)

4. How interested is your institution in climate change issues and the impacts on the coastal zone?

a. Very Interested b. interested c. not interested d. I don't know.

5. Does this institution have a climate policy or any other working document on climate change?
    a. Yes b. no

6. What is the scope of climate change issues your institution addresses?
7. Does your institution have plans in place to deal with climate-related events (such as a flood and other forms of disaster) along the coastal zone?
8. How has your institution able to coordinate activities to respond quickly to the impact of natural events along the coast?

9. Did your institution have special funding to deal with climate change issues along the coast?

10. How well has your institution work with coastal communities in responding to climate situations or problems……(please specify below the challenges you face if there is any)…..
.....
.....
.....
11. How well has your organization led communities through climate adaptation and mitigation activities in the past?
12. Does your institution have enough capacity to effectively participate in climate change adaptation along the coast?
13. Do you work with communities in terms of sharing climate related information?
14. Is your institution in the position to provide communities with support in terms of resources and or expertise in climate adaptation and mitigation exercises?
15. Has your institution taken any actions to adapt/cope with climate change along the coastal zone?
    b. yes b. no c. I don't know
16. What have you done already to adapt to/deal with/cope with climate change along the coastal zone? [Tick all the apply]
    a. planted mangroves.
    b. planted trees and vegetation along the shoreline.
    c. stopped cutting mangroves.
    d. maintained trees and vegetation.
    e. built/fixed sea walls.
    f. built wells and/or other water resources.
    g. cleaned or helped to maintain public drainage systems from waste.
    h. turn off lights when not in use.
    i. turn off water tap/pipe when you are not using it.
    j. built or helped to build green spaces, such as parks or gardens.
    k. stopped taking a car or bus and walk or cycle to school.
    l. not litter even when bins are not available.
    m. nothing
    n. other
    _____
    o. I don't know/remember.

15. What is your institution currently doing to prepare in case climate disasters happen again?

    l. made property more resistant to threats for coastal communities.
    m. Clear drains
n. planted mangroves, trees and vegetation along the shoreline.
    o. sensitise coastal communities to stopped cutting mangroves.
    p. maintained trees and vegetation.
    q. built/fixed sea walls.
    r. built wells and/or other water resources for communities.
    s. cleaned or helped to maintain public drainage systems from waste for the communities.
    t. nothing

u. I do not know.
v. other _____

16. How would assess your effectiveness in climate change intervention in the coastal communities?

17.What are the major challenges and needs of your network?

Appendix 13. Questionnaire to assess the level of participation of state and non-state actors in building resilience to climate

University of The Gambia

Doctoral Research Program on Climate Change and Education

Farafenni Campus, North Bank Region, The Gambia

Assess the level of participation of state and non-state actors in building coastal resilience to CC **SURVEY QUESTIONAIRE FOR HEAD OF INSTITUTIONS, NETWORKS AND NGOs**

CONSENT LETTER

My name is Bintou Dibba. I am currently studying PhD in climate change and education at the University of the Gambia. I would like to invite you to participate in a research study which aims to assess the awareness and understanding of the risk and adaptation to livelihood stress due to climate and non-climate hazards among coastal communities in The Gambia. The purpose of this interview is to assess the level of participation of state and non-state actors in building coastal resilience to CC. Be assured that your answers will be anonymous and treated with confidentiality. Please understand your participation in this research is on a voluntary basis and you have the right to discontinue participating at any time. Also, if you have question at any time about the interview, you may contact me on tel: 3856350 email: binsdd@gmail.com. Thank you very much for your time.

Interviewer name (optional)	**Date**

17. Name of institution……

18. Type of institution

    a. Government b. NGO c. CSO d. Private e. others (please specify) …….

19. Which of the following options below is your institutions affiliated with?
    i. Environment
    j. Education
    k. Agriculture
    l. Fisheries
    m. Health
    n. Media
    o. Mining
    p. Others (please specify)
    ……

20. How interested is your institution in climate change issues and the impacts on the coastal zone?
b. Very Interested b. interested c. not interested d. I don't know.

21. Does this institution have a climate policy or any other working document on climate change?
    b. Yes b. no c. I don't know

22. What is the scope of climate change issues your institution addresses?
    a. Very wide b. wide c. not wide d. I don't know

23. Does your institution have plans in place to deal with climate-related events (such as a flood and other forms of disaster) along the coastal zone?
    a. Yes b. no c. I don't know

24. How has your institution able to coordinate activities to respond quickly to the impact of natural events along the coast?
    ……
    ……
    ……

25. Did your institution have special funding to deal with climate change issues along the coast?
    a. Yes b. no c. I don't know

26. How well has your institution work with coastal communities in responding to climate situations or problems?
    a. Very good b. good c. not good d. I don't know

27. Please specify below the challenges in working with coastal communities in responding to climate change problems you face if there is any?
    ….....
    .....
    .....
    .....
    .....
    .....

28. How well has your institution led communities through climate adaptation and mitigation activities in the past?
29. Very good b. good c. not good d. I don't know

30. Does your institution have enough capacity to effectively participate in climate change adaptation along the coast?
    a. Yes b. no c. I don't know

31. Do you work with coastal communities in terms of sharing climate related information?
    a. Yes b. no c. I don't know

32. Is your institution is in the position to provide communities with support in terms of resources and or expertise in climate adaptation and mitigation exercises?
    a. Yes b. no c. I don't know

33. Have your institution taken any actions to adapt/cope with climate change along the coastal zone?
    c. yes b. no c. I don't know

    if your answer in question 17 is yes, then answer questions 18 and 19

34. What have you done already to adapt to/deal with/cope with climate change along the coastal zone? [Tick all the apply]
    p. planted mangroves.
    q. planted trees and vegetation along the shoreline.
    r. stopped cutting mangroves.
    s. maintained trees and vegetation.
    t. built/fixed sea walls.
    u. built wells and/or other water resources.
    v. cleaned or helped to maintain public drainage systems from waste.
    w. turn off lights when not in use.
    x. turn off water tap/pipe when you are not using it
    y. built or helped to build green spaces, such as parks or gardens.
    z. stopped taking a car or bus and walk or cycle to school.
    aa. not litter even when bins are not available.
    bb. nothing
    cc. other (Please specify) _____
    dd. I don't know/remember.

35. How would assess your effectiveness in climate change intervention in the coastal communities?
    a. very effective b. effective c. not effective d. I don't know

36. What is your institution currently doing to prepare in case climate disasters happen again?
    w. made property more resistant to threats for coastal communities.
    x. Clear drains
    y. planted mangroves, trees and vegetation along the shoreline.
    z. sensitise coastal communities to stopped cutting mangroves
    aa. maintained trees and vegetation.
    bb. built/fixed sea walls.
    cc. built wells and/or other water resources for communities.
    dd. cleaned or helped to maintain public drainage systems from waste for the communities
    ee. nothing
    ff. I do not know.

gg. other _____

37. What are the major challenges and needs of your network in climate change and adaptation and mitigation along the coast zone?

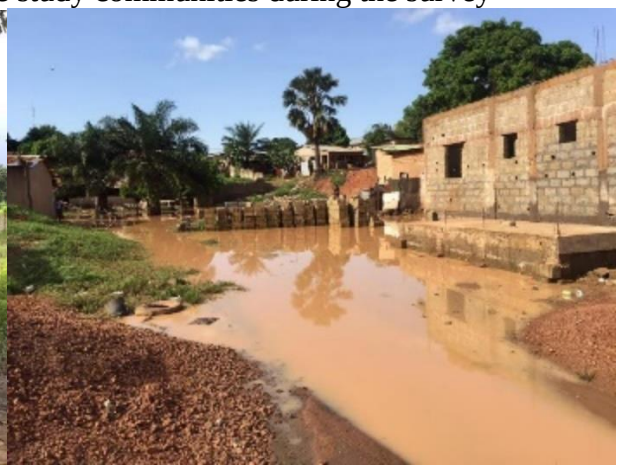
……
……
……
……
……
……
……
……

38. What do you think about the study? And what opinion would you like to advice?

……
……
……
……
……
……
……
……
……
……
……

Thank you very much for taking your valuable time to respond the questionnaire.

Appendix 14. Pictures taken within the study communities during the survey



Appendix 14. Pictures taken during the focus group discussions.