UNIVERSITY OF GHANA, LEGON

ASSESSING THE VULNERABILITY OF COASTAL COMMUNITIES TO THE IMPACTS OF CLIMATE CHANGE: A CASE STUDY OF THE ANLOGA COMMUNITY

BY

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THIS THESIS IS SUBMITTED TO THE UNIVERSITY OF GHANA, LEGON IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE AWARD OF MASTER OF PHILOSOPHY DEGREE IN CLIMATE CHANGE AND SUSTAINABLE DEVELOPMENT

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DECLARATION

This is to certify that this work is the result of research undertaken by Kassim Gawusu under the supervision of Dr. Rosina Kyerematen and Professor Yaa Niamoa-Baidu, towards the award of the Master of Philosophy degree in Climate Change and Sustainable Development under the B4C Project, University of Ghana, Legon.

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DEDICATION

This work is dedicated to my beloved parents, Mr. and Mrs. Kassim who have humanly been my strength throughout my academic journey. God richly bless you for the financial and spiritual support given me throughout these years of education.

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CAW	-	Center for African Wetlands
CCSD	-	Climate Change and Sustainable Development
CCVA	-	Climate Change Vulnerability Assessment
CCVA	-	Climate Change Vulnerability Assessment
CERGIS	-	Centre for Regional Geographical Information System
CPD	-	Committee for Development Policy
FC	-	Forestry Commission
GHG	-	Green House Gas
GIS	-	Geographical Information System
GIS	-	Geographical Information System
GMA	-	Ghana Meteorological Agency
GSNC	-	Ghana Second National communication
GSS	-	Ghana Statistical Services
GSS	-	Ghana Statistical Services
IPCCC	-	Intergovernmental Panel on Climate Change
KeMA	-	Keta Municipal Assembly
MMDP	-	Municipal Medium Term Development Plan
MOFA	-	Ministry of Food and Agriculture
MOFAD	-	Ministry of Fisheries and Aquaculture Development
MOH	-	Ministry of Health
NADMO	-	National Disaster Management Organization
UNEP	-	United Nations Environmental Program
UNFCCC	-	United Nations Framework Convention on Climate Change
UNGA	-	United Nations General Assembly
WD/FC	-	Wild life Division of the Forestry Commission
WLD	-	Wild Life Division
WOTR	-	Watershed Organization Trust

ABSTRACT

In recent years, global warming/climate change has caused many glaciers to melt with the subsequent rising of sea levels. This has put many coastal communities all over the world especially those in developing countries at risk. The vulnerability of these communities to the impacts of climate change depends on many factors including environmental and socio-economic factors.

This study sought to assess the vulnerability of coastal communities in Ghana to the impacts of climate change taking the Anloga community as a case study. To do so, a case study design was adopted and multi-stage sampling involving purposive and simple random techniques was employed for the study. An integrated vulnerability assessment approach was used and vulnerability indicators of exposure, sensitivity and adaptive capacity were analyzed using data collected from both primary and secondary sources.

Results from this study indicated that, the Anloga community is highly exposed to the impacts of climate change due to its geographical location. Coupled with a lack of economic opportunities, the community has a high dependency on farming and fishing as a source of livelihood and that many households have no diversified source of income. The district office of the Ministry of Food and Agriculture (MOFA) mandated to provide agric extension services as well as the National Disaster Management Organization were challenged with low staff numbers and inadequate financial resources and hence could not provide the needed support to the community.

The results also indicated that the community has low awareness about rules and regulations governing the use of the wetland resources, therefore, unpredictable seasonal

patterns on the sea and land together with anthropogenic pressure on the wetland would threaten livelihoods and affect their food security.

CHAPTER ONE

GENERAL INTRODUCTION

1.1 Background

There is a wide academic consensus that global warming and climate change is occurring and every year, more than 190 countries which are signatories to the United Nations Framework Convention on Climate Change (UNFCCC) meet at a Conference of Parties to discuss the essential steps needed to fight climate change. There are many reports on how climate change is impacting our planet. As the fifth assessment report of the Intergovernmental Panel on Climate Change (IPCC) mentioned, the average temperature of the planet has increased due to anthropogenic greenhouse concentrations in the atmosphere (IPCC, 2013). It is noted in the report that each of the last three decades has been successively warmer on the Earth's surface than any preceding decade since 1850. It also indicates that the global atmospheric concentrations of the greenhouse gases which are mainly carbon dioxide (CO^2), methane (CH_4), and nitrous oxide (N_2O) have all increased since 1750 due to human activities. Fossil fuel use is cited to be the main reason behind the rising carbon dioxide concentrations whiles rising levels of methane and nitrous oxide are attributed to the agricultural sector through enteric fermentation of domestic grazing animals, application of synthetic fertilizers, Land use, Land use Change and Forestry (LULUCF). Warming temperatures have led to the melting glaciers and land-based ice sheets of Greenland and Antarctica resulting in sea level rise. IPCC (2013) estimates with high confidence that the rate of sea level rise since the mid-19th century has been higher than the mean rate during the previous two millennia and over the period 1901 to 2010, global mean sea level is estimated to have risen by 0.19m.

Climate change has serious implications on agriculture, coastal systems, human health, biodiversity and on the overall human development (IPCC 2013, Badjeck *et al*., 2010) through long and short term impacts on livelihoods. According to Stern (2006), an increase in temperature by 2^0C is likely to result in the extinction of 15-40% of all species whiles an increase by 3^0C or 4^0C will result in millions of people being displaced by flooding. As a result, vulnerabilities are expected to increase both at regional, national and community levels with increasing poverty and threats on food security. In Ghana, evidence of some extreme weather conditions and climate variability that the country has experienced over the years include; floods, drought, bush fires, unpredictable rainfall patterns, sea level rise along the eastern coast, increased desertification/land degradation, Consistent loss of forest cover and Loss of some biodiversity (Barry, 2013 and GSNC, 2011). The reliance of Ghana' economy on climate-sensitive sectors such as forestry and small-scale agriculture, coupled with the lack of resilience within the energy sector will potentially compound the country's economic challenges. Climate change however does not occur in a vacuum. It is its combined effects with existing problems such as habitat fragmentation that ultimately pose the greatest threat to the natural systems and the people they support (Root and Schneider, 2002).

Globally, efforts to respond to climate change have taken two forms of interventions namely: Mitigation and Adaptation. Decisions with respect to these interventions involve actions or choices at all levels of decision-making, from the most local and community level (including families and individuals) to the broadest international levels, involving national governments (Balbus *et al*., 1998). Until recently, human response to climate change has focused largely on efforts to reduce the GHG emissions that have been the

underlying driver of climate change and global warming. IPCC (2007a) however indicates that, even under the best case scenarios of Green House Gas (GHG) emissions reductions, humans and natural systems will not escape the impending impacts of climate change. According to Glick *et al*. (2011), conservation and natural resource management in an era of climate change will require that they do not only acknowledge and address the environmental problems of the past but also anticipate and prepare for those of the future. This should be through research and investigations designed to find out what effect future changes in climate could have on these systems.

Climate Change Vulnerability Assessment (CCVA) is hence a key step that enables communities to articulate their experiences of how they are being impacted by climatic changes and variability, identify and assess their areas of vulnerability or "development deficits" and provoke them to plan for and undertake adaptive actions to build resilience and reduce vulnerability (WOTR, 2013). This study therefore sought to assess the vulnerability of Ghanaian coastal communities to the potential impacts of climate change, taking Anloga as a case study.

1.2 Justification of the Research

It is clear that, in many parts of the world, climate change will adversely affect socio-economic sectors, including human settlements (IPCC, 2007b). It has also been established that, People who live on arid or semi-arid lands, in low-lying coastal areas, in water-limited or flood-prone areas, or on small islands areas are particularly vulnerable to climate change (Watson *et al*., 1996).The African continent, even though a less contributor to the global Green House Gas Emissions, is most likely to suffer the adverse

impacts of climate change because of the vulnerable social and natural systems, multiple interacting stresses, widespread poverty and low adaptive capacity (USAID, 2011). The fifth Assessment report of the IPCC projects that, agricultural production, including access to food, in many African countries and regions will be severely compromised by climate variability and climate change. The areas suitable for agriculture, the length of growing seasons and yield potential, particularly along the margins of semi-arid and aridareas, are expected to decrease. Additionally, climate variability and change threaten other resources, including water, forests, and fisheries whiles many millions more people are projected to suffer from flooding with a rise in sea-level of up to one meter (1 m) in this century (USAID, 2011 ; IPCC, 2007b). The effect will be exacerbated by increasing human-induced pressures on coastalareas. Also in many developing countries, almost all of the development sectors are sensitive and vulnerable to climate change and climate variability. As a result, climate change does not only affect national development but also derails the successes and efforts to achieve sustainable development.

Key vulnerable sectors to climate change in Ghana like many developing countries are agriculture, energy, water resources, human health and forestry. Indications of climatic changes the country is experiencing are, increasing climatic variability, in the form of unpredictable rains, rises in minimum and maximum temperatures and recurring droughts (Agyemang *et al*. 2008). Coastal erosion and flooding as a result of sea level rise have also been widely experienced (Boko*et al*., 2007). Addo *et al*., (2011), projects a sea level rise in the Dansoman of the Ghana coast of between 21.2 cm–79.7 cm, for worst case scenario and of 14.0 cm–60.3 cm for a best case scenario. These biophysical changes put Ghana under threat of climate change making people in the coastal regions more

vulnerable and exposed to relatively higher levels of poverty than the other parts of the country. According to Armah (2005), 25% of the estimated 22 million population of Ghana live in the four coastal regions, namely the Volta, Greater Accra, Central and Western regions, and depend on coastal resources in diverse ways. Dependency on natural resources that are sensitive to climate change makes the livelihoods of coastal communities susceptible, affecting their lifestyle and their socioeconomic development.

There have been many climate change studies conducted on coastal Ghana like the Short-term Shoreline Evolution Trend Assessment (Addo *et al*., 2012), Assessing Coastal Vulnerability Index to Climate Change (Addo, 2013) and the Spatial Planning in Coastal Regions (Boateng, 2010). Though studies have been conducted to assess climate change vulnerability and adaptation for Ghana as a country (USAID, 2011), further research is needed at the community level in order to identify the local level vulnerability patterns under the threat of climate change. This is because, each community is unique with its own set of capacity and coping strategies to respond to climate change events which will generate different levels of vulnerability. Again, there is a methodology gap in many of the early studies as they did not consider the vulnerability indicators under the umbrella of the IPCC climate change vulnerability components of exposure, sensitivity and adaptive capacity.

This study is aimed at providing better understanding of the climate change vulnerability of the Anloga community and will contribute to policy formulation and adoption. The findings will be used also for developing local adaptation strategies or for mainstreaming climate change adaptation and mitigation into existing district or community plan.

Drawing from the fact that developing countries are particularly vulnerable to climate change because of limited financial resources to deal with its impacts (IPCC, 2007b), the findings of this study will help decision makers, decision implementers, coastal resource managers and adaptation planners in the prioritization and in the efficient allocation of scarce resources to deal with the climate change challenge.

1.3 Research Objectives

The overall objective of this study is to assess the vulnerability of coastal communities to the impacts of climate change using Anloga as a case study.

The specific objectives are as follows:

- To assess community's awareness of climate change and their perception of persisting and emerging threats to their livelihood.
- To assess the socio-economic vulnerability of coastal human populations to the increasing and emerging threats of climate change.
- To assess the vulnerability of the Keta lagoon and associated wetland habitat to the emerging threats of climate change.

1.4 Scope of the Research

This study was carried out solely to assess the community's vulnerability to the impacts of climate change under the umbrella of climate change vulnerability components of exposure, sensitivity and adaptive capacity (IPCC, 2001; 2007b) which have been widely used and recognized in recent studies of climate change (Turner, 2003; Perez *et al*., 2010). This will involve an integrated approach of vulnerability assessment comprising of both bottom up and a top down approaches. This is to help capture not only the

vulnerability of human populations but that of the wetland habitat which supports the livelihoods of the people.

1.5 Organization of the Report

The research has been organized into six chapters. Chapter One introduces the research, identifies the key problem and presents a justification for the topic under investigation. It also states the specific objectives for the research and defines the scope.

The second chapter presents definition of related terms, a review of relevant literature on major marine and coastal ecosystems, climatic and non-climatic hazards impacting on marine and coastal ecosystems, attributes of vulnerability and methodologies and frameworks for integrated vulnerability assessments. It presents also a review of coastal adaptation options and challenges. This chapter provides the theoretical and historical information needed to define methodologies for the research.

Chapter Three gives a brief background of Anloga and presents the conceptual framework for this research. It presents also the sampling technique, the data collection methods, sources of data and tools employed, and a framework for data analysis and reporting.

In chapter four, and five data collected from the field were analyzed and discussed respectively. The analysis and discussions were done in terms of the exposure of communities to climatic hazards, their resilience as well as their adaptive capacity. These are very important chapters in the research because they provide answers to the research questions and form the basis for recommendations to improve the adaptive capacity of coastal communities.

Chapter five constitutes the key findings of the study and a set of recommendations and a general conclusion for the study. This is very relevant to the study because it discloses information which hitherto was unknown and hence adds to the existing knowledge.

CHAPTER TWO

LITERATURE REVIEW AND CONCEPTUAL FRAMEWORK

2.1 Definition of Relevant Terms

2.1.1 Climate Change

Climate change according to IPCC (2012), refers to a statistically significant variation in either the mean state of the Climate or in its variability persisting for an extended period (typically decades or longer). Climate change is defined in Article 1 of the United Nations Framework Convention on Climate Change (UNFCCC) as, a change of climate which is attributed directly or indirectly to human activities that alter the composition of the global atmosphere and which are in addition to natural climate variability observed over comparable time periods." The UNFCCC thus makes a distinction between climate change attributable to human activities altering the atmospheric composition, and climate variability attributable to natural causes.

2.1.2 Climate Variability

Climate variability refers to variations in the mean state and other statistics (such as standard deviations, the occurrence of extremes, etc.) of the climate on all temporal and spatial scales beyond that of individual weather events (IPCC, 2012).Variability may be due to natural internal processes within the climate system (internal variability), or to variations in natural or anthropogenic external forcing (external variability).

2.1.3 Sensitivity

The sensitivity of a species, habitat, or an ecosystem to climate change reflects to the degree to which that system is or is likely to be affected either adversely or beneficially to those changes (IPCC, 2007b). According to Adger, (1999), sensitivity is the capacity to

absorb and adjust to the hazards. In social context, sensitivity is the degree to which a community is negatively affected by changes in climate (Wongbsarakumandloper, 2011). It is largely determined by the relationship of individuals, households, or a community to resources impacted by climate events, and by the degree of dependency on those resources (Wongbsarakumandloper, 2011).

Glick *et al*., (2011) indicates that, Sensitivity may depend on innate physiological or biological variables. For example, a species that is already living at the upper end of its biological temperature range may not be able to tolerate increases in the average temperature in its habitat due to climate change Glick *et al*., (2011). That species is therefore considered to be sensitive to higher average temperatures. Conversely, a population already living in hot conditions may have adapted evolutionarily to high temperatures and may be less vulnerable to warming than other populations of that species adapted to cooler conditions.

2.1.4 Exposure

Exposure is the nature and degree to which a system is exposed to the significant climatic variations (IPCC, 2012). Specifically, this includes areas of residency and resource-use exposed to different climate events and impacts (Wongbsarakumandloper, 2011). Adding to the IPCC definition, Glick *et al*., (2011) also explains that, exposure is not only to the physical climate changes such as temperature and precipitation but also to related factors such as altered fire regimes, shifts in vegetation types, increased salinity due to sea level rise, location of the species or system on landscape etc. For example, communities along the coast may have high exposure to rising sea levels, salt-water intrusion and inundation than inland communities (Glick *et al*., 2011).

2.1.5 Adaptive capacity

Adaptive capacity is the ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences (IPCC, 2012). In the contribution of working group II to the third assessment report, the IPCC summarizes the determinants of adaptive capacity as economic resources, technology, information and skills, infrastructure, institutions, and equity in the use of natural resources (Smith*et al*., 2001).

Broadly, adaptive capacity may be considered a factor of particular internal traits such as the ability of a species to physically move in search of more favorable habitat conditions, adapt evolutionarily or modify its behavior as climate changes. Adaptive capacity of a species may also be a factor of external conditions such as the existence of structural barrier such as urban areas, seawalls or dikes that may limit the ability of that species to move away from climatic stresses (Glick *et al*., 2011).

For a human system, Wongbsarakum and Loper, (2011) explain that, adaptive capacity may be influenced strongly by a few key characteristics, or by a wide range of social characteristics. These characteristics includes but not limited to social cohesion, education, access to technology, and past experience with hazard events (Adger, 1999;Kundzwiez, 2002;Verheyen, 2002; Smit and Pilifosova 2003). For example, a well-informed village with a strong traditional leader who is able to develop good plans and make decisions that help and involve all members of the community will likely show high adaptive capacity. A household that has diversified sources of income and supplementary livelihood options will likely have higher adaptive capacity to impacts of climate change than those that do not (Wongbsarakum and Loper, 2011).

2.1.6 Adaptation

Adaptation is the adjustment in natural or human systems to a new or changing environment. Adaptation to climate change refers to Adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities (IPCC, 2007b). Various types of adaptation can be distinguished and this includes, anticipatory (Adaptation that takes place before impacts of climate change are observed), reactive adaptation, private and public adaptation, and autonomous (Adaptation that does not constitute a conscious response to climatic stimuli but is triggered by ecological changes in natural systems and by market or welfare changes in human systems) and planned adaptation (Adaptation that is the result of a deliberate policy decision, based on an awareness that conditions have changed or are about to change and that action is required to return to, maintain, or achieve a desired state) (Tol *et al.* 1998, Klein *et al.* 1999, Smit *et al.* 1999, Verheyen 2002).

2.1.7 Mitigation

In the context of disaster risk and disaster management, Mitigation refers to the lessening of the potential adverse impacts of physical hazards (including those that are human-induced) through actions that reduce hazard, exposure, and vulnerability. In the context of climate change however, Mitigation refers to an anthropogenic intervention to reduce the sources or enhance the sinks of greenhouse gases (IPCC, 2007). The forestry sector is known to have huge potential to contribute to the mitigation of the global climate change through carbon sequestration (Malhi*et al.*, 2008) and often have a cost advantage over other mitigation strategies (Patosaari, 2007).

2.1.8 Resilience

The term Resilience was first coined by ecologist Holling (1973), and it is defined as the natural capacity of an ecological system to buffer change (i.e., absorb impacts and recover from some pre-disturbed state) (Folke *et al.* 1996).This term has been adopted by climate change researchers in considering the capacity of an individual, community, state, or nation to buffer climate change impacts (Adger 1999; Klein and Nicholls, 1999; Barnett, 2001). While absorbing disturbances, a resilient system should be able to retain the same basic structure and ways of functioning, the capacity for self-Organization, and the capacity to adapt to stress and change (IPCC, 2007; Tobin, 1999; Folke *et al.*, 2002).

2.1.9 Vulnerability

The term vulnerability has been defined in many different ways by various scholarly communities (Fussel, 2005). The ordinary use of the word 'vulnerability' refers to the capacity to be wounded, i.e., the degree to which a system is likely to experience harm due to exposure to a hazard (Turner *et al*., 2003). The scientific use of 'vulnerability' has its roots in geography and natural hazards research but this term is now a central concept in a variety of research contexts such as natural hazards and disaster management, ecology, poverty and development, secure livelihoods and famine, sustainability science, land change, and climate impacts and adaptation (Fussel, 2005).

In the context of climate change, vulnerability is defined by the working group II in their contribution to the fourth assessment report to the IPCC, as the degree to which a system is susceptible to, and unable to cope with adverse effects of climate change, including climate variability and extremes. In other words, vulnerability is a function of exposure, sensitivity and adaptive capacity (IPCC, 2007b) (Figure 2.1).

Research on vulnerability can be characterized in three distinct ways. First, vulnerability can be determined by the potential exposure to a physical hazard (Handmer, 2003). This view is based on the premise of 'environmental determinism', whereby humans are controlled by and dependent upon the surrounding physical environment (Burton *et al.*, 1978). Second, vulnerability can be viewed as a social construct, whereby social, political and economic conditions (e.g., unequal distribution of wealth and power) contribute to vulnerability, rather than environmental conditions (e.g., floods, droughts) (Watts and Bohle, 1993). Third, vulnerability can be viewed as an integrated concept that encompasses biophysical exposure to hazards and the social responses, constraints, and impacts of these events (Cutter *et al.*, 2000). This third approach uses elements from the first two in a more integrated way and gives the assessment process a geographical domain (e.g., community), allowing for site-specific assessments.

2.2 Characterizing Vulnerability

Table 1 and Figure 1 present attributes of vulnerability that will be elaborated upon in chapter five to illustrate their applicability to the Anloga community. There are however many studies that have previously applied some of these attributes. These include, but are not limited to, the integrated vulnerability assessments conducted by Cutter *et al.* (2000), Lorenzoni *et al.* (2000a, 2000b), Shaw *et al.* (2001), Wu *et al.* (2002), and Mendis *et al.* (2003).

Table 1: Attributes of vulnerability derived from existing Literature.

Category	Attribute	Relation to Vulnerability	Source(s)
Geographic	Location	Isolation and remoteness can present challenges of transportation and communication, in emergency situation	Armstrong and Read 2002, Dolan and Walker in press
	Geophysical	Can increase rate of erosion and accretion	Shaw *et al.* 2001
	Exposure	Can increase proneness to flooding, erosion, and storminess	Burton *et al.* 1978, Barnett 2001, Sidle *et al.* 2004
Social	Age and Experience	Older people are often taken as one of the most vulnerable demographic groups Experience can strengthen preparedness	Dolan and Walker in press Wongbusarakum and Loper, 2011
	Population size and stability	Small population may create economic disadvantages; high population density may increase difficulty in evacuation	Townsend *et al.* 1988, Cutter *et al.* 2000, Tapsell *et al.* 2002, Wu *et al.* 2002
	Education	A determinant of income that can increase the ability to adjust to economic changes; fosters greater awareness of hazards	Tobin 1999, Holman and Nicol 2004
	Health	Limited access to health care facilities; potential impacts to healthcare centers; current state of health	Wisner 1998, Shaw *et al.* 2001, Leichenko and O'Brien 2002, Tapsell *et al.* 2002
	Social	Large families may be difficult to	Watts and Bohle 1993,

	relations	track in emergency situations; strong social ties may strengthen community support; the ability of people to work together	Bohle*et al.* 1994, Clark *et al.* 1998
	Access to services	Greater distance to emergency services may increase vulnerability	Clark *et al.* 1998, Wisner 1998
	Culture	Strength of the local culture; human interactions with the environment	Yamada *et al.* 1995, Magistro and Roncoli 2001
Economic	Employment and income	Greater income allows spending on prevention planning; poverty is directly related to vulnerability	Clark *et al.* 1998, Wisner 1998, King 2001, Tapsell *et al.* 2002, Kundzwiez 2002, Yohe and Tol 2002
	Livelihood dependency	Dependence on natural resources can increase vulnerability; supply and demand and the international level	Barnett 2003, Dolan and Walker in press
	Economic development	Economic base for employment increases income levels; growing economic sector can strengthen adaptation options	Lorenzoni *et al.* 2000a, Barnett 2003, Sidle *et al.* 2004
Political	Governance and leadership	Communities with strong, institutions and infrastructure will be more able to adapt.	Wongbusarakum and Loper, 2011
	Planning	Strong emergency planning can increase adaptive capacity to Potential impacts.	Tapsell *et al.* 2002, Sidle *et al.* 2004

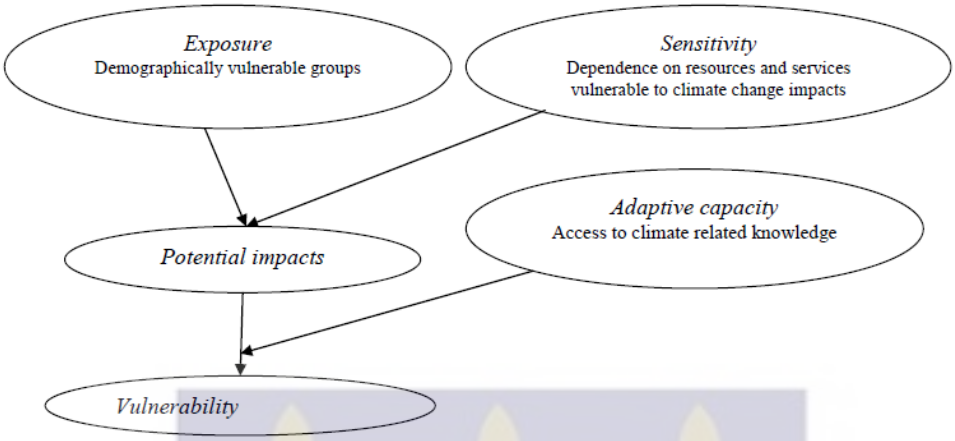

Figure 1: Climate change social vulnerability framework

(Adopted from Wongbusarakum and Loper, 2011)

2.3 Methodologies and Frameworks for Integrated Vulnerability Assessments

Over time three primary research frameworks emerged from the understandings of vulnerability, as characterized by Fussel (2005). The first of which is the risk-hazard approach, used most often in technical research (Fussel, 2005). This approach assesses the level of risk to the system being considered as a result of exposure to a hazard (Fussel, 2005). In a risk-hazard approach, the system whose vulnerability is being assessed is usually a physical one (e.g. built infrastructure) (Fussel, 2005). The second research framework is the social constructivist approach, with a focus on who is most vulnerable and why (Fussel, 2005). Vulnerability in this framework is often understood as socio-economic vulnerability (Fussel, 2005). The final, and most currently prevalent, research framework is the hazard-of-place approach (Fussel, 2005). Typically found in the climate change literature, this framework understands vulnerability as an integration of exposure to a natural hazard, and adaptive capacity of the system in question (Fussel, 2005). One example of an integrated vulnerability assessment framework is that produced

by Dolan and Walker (in press) (Figure 2). This framework acknowledges the various scales (individual, community, regional, national, and global) of an integrated vulnerability assessment. It also illustrates that while exposure to climate variability and change may increase local vulnerability, enhancing social adaptive capacity work to decrease vulnerability. This framework also recognizes the inherent linkages between the human and biophysical environment. It also complements current scholarship as it recognizes the importance of investigating and building adaptive capacity through identifying response and adjustment options (Basher, 1999; Burton *et al.*, 2002).

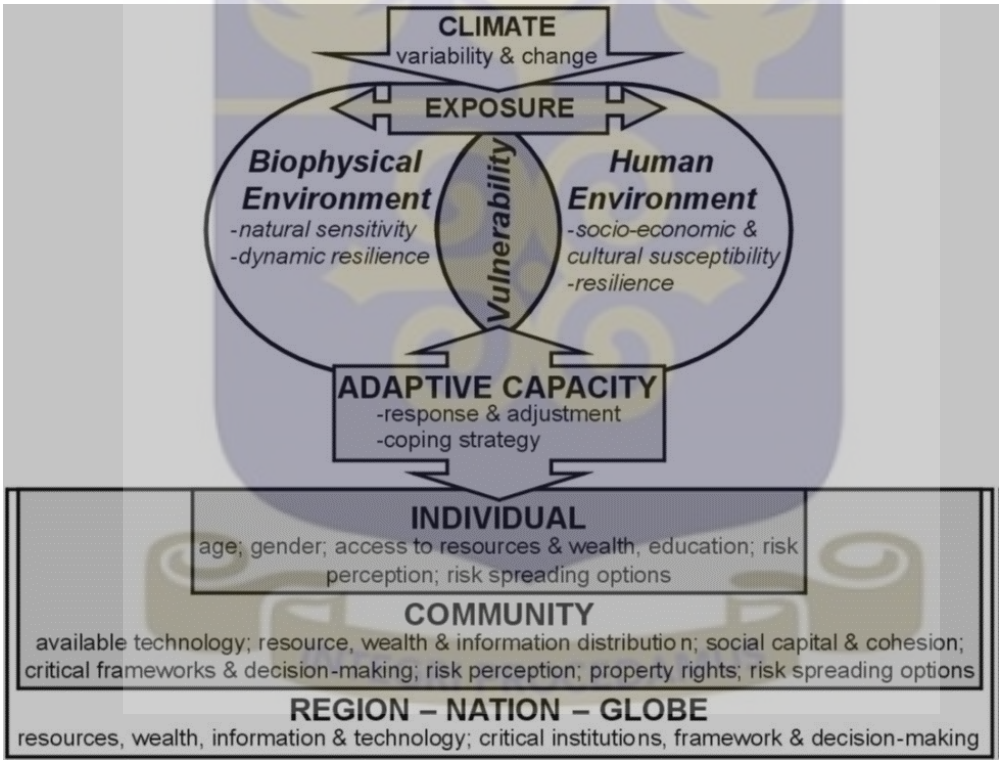

Figure 2: Integrated assessment framework for assessing vulnerability to climate change and accelerated sea-level rise impacts (Dolan and Walker in press).

2.4 Major coastal and marine ecosystems

2.4.1 Mangroves Forest

Mangroves are unique ecosystems of tree or shrub adapted to colonize sheltered tropical and subtropical coastal environments between the high-water and low-water marks (Lorde *et al*., 2013). Much of the coastal population of the tropics and subtropics resides near mangroves. 64% of all the world's mangroves are currently within 25 km of major urban centers having 100,000 people or more (UNEP, 2006). Apart from the timber and non-timber products as well as other livelihood support systems, mangroves sustain diverse flora and fauna species in large proportion and provide many ecosystem services such as coastal protection from storm, reduction of shoreline and riverbank erosion, stabilizing sediments and absorption of pollutants (IUCN, 2003).

They have traditionally been utilized by the local people for a variety of purposes (Choudhry, 1997) which includes; fuel wood for cooking, grounds for game hunting and extracts for medicinal use. Mangrove forests are estimated to provide an annual net benefit of $15 per hectare for medicinal plants, and up to $61 per hectare for medicinal values (UNEP, 2006).

By virtue of being, in general, a relatively undisturbed ecosystems, mangroves provide vital nurseries for fisheries and many commercially important shrimp and crab species throughout the tropics (Macnae., 1974; Dall *et al*., 1990).They also support an abundance of mollusk species that are largely sessile in nature (Ronnback, 1999).

2.4.2 Sea grass beds

Sea grasses are flowering plants that flourish in shallow, sheltered, marine environments, such as lagoons near mangroves or coral reefs or just offshore from beaches. Sea grasses provide habitat for fish and shellfish, and numerous important ecological services to the marine environment (Thayer *et al*., 1978; Canuel *et al*., 1997;Costanza *et al*., 1997; Bianchi *et al*., 2007). They are an important food source for mega herbivores such as green sea turtles, dugongs, and manatees, all of which are threatened, charismatic species of great public interest (Beck*et al*., 2001and Lee, 2007). They provide refuge and nurseries for larvae and juvenile of many fish species, reduce coastal erosion, filter water and trap sediments improving water clarity (McKenzie and Di Carlo, 2011). They also take up carbon dioxide and produce oxygen that other marine creatures use.

Although the recent trends of increasing global temperature, sea-level rise, and CO2 concentrations could result in environments that are potentially more conducive for many sea grass species, they are rather in serious decline or have been totally destroyed due to increasing human population and anthropogenic pressure on coastal zones (Green and Short,2003; Orth *et al*., 2006).

2.4.3 Coastal Wetlands

Wetlands are sites of high biodiversity and productivity (Mitsch and Gosselink, 2000). Coastal lagoons constitute a common coastal environment, occupying 13% of coastal areas worldwide (Kjerfveand Magill, 1989). Depending on local climatic conditions, wetlands exhibit salinities which range from completely fresh to hyper saline (More and Slinn, 1984; Kjerfve and Magill, 1989; Knoppers *et al*., 1991). They provide essential services, such as maintenance of atmospheric composition, providing key habitats for

migratory bird species, and important nursery areas for some fish species (Basset and Abbiati, 2004). In general, coastal lagoons trap inorganic sediment and organic matter, and thus serve as material sinks or material filters (Kjerfve, 1994). They often exhibit very high primary and secondary production rates and are valuable for fisheries and aquaculture, and sometimes for salt extraction. Wetlands can play a role in reducing the frequency and intensity of floods by acting as natural buffers, soaking up and storing a significant amount of floodwater (Kjerfve, 1994). Aliaume *et al*., (2007) indicates that wetlands act as spawning grounds for marine fish and invertebrates, and provide resting areas for many species of migratory birds. For example, Migrating waterfowl rely on wetlands for resting, eating and breeding leading to increased populations. Healthy lagoons produce food for birds and fish, and provide for several human extractive activities and significant food resources (aquaculture, fishing, hunting, etc.) (Sylaios and Theocharis, 2002). Wetlands are pleasant places for recreational activities like fishing. They may provide a place of natural beauty and solitude that can be enjoyed by persons of all ages who may seldom be exposed to nature. Among aquatic ecosystems, coastal wetlands have been subject to massive environmental degradation and habitat destruction worldwide (Goudie, 1990). For example, Jones, (2001) observed that more than 50% of the original area of coastal wetlands that existed in 1900 have been lost in most countries of Western Europe. Aliaume *et al*., (2007) also observed that, modification of extensive natural areas by human action, such as desiccation, urbanization, hydrologic modification and isolation of areas previously connected, has led to a reduction or disappearance of large areas of wetlands and coastal lagoons.

2.4.4 Beaches

Beaches are deposits of sand between the high and low tide marks, transported to shore and molded by waves. Beaches are dynamic, the sand being constantly subjected to deposition (accretion) or loss (erosion). Beaches are widely known for their importance to tourism and in addition to their economic importance in attracting overseas visitors (Watson *et al*., 1997).

Beaches and dunes serve as one of the world's major sources of construction aggregate. They are important habitats for sea turtles, which nest in the zone above the high-tide mark. However, beaches could provide income, community employment, and educational opportunities through well-managed ecotourism (Lorde *et al*., 2013).

A number of threats linked to human activities are causing beach erosion and polluting coastal waters, compromising the ability of beaches to continue providing ecosystem services. Unregulated sand mining, for example, causes loss of sand and prevents the natural replenishment of other beaches through material being carried around the coast by tides and currents (Lorde *et al*., 2013).

Another key threat stems from the tourism industry itself, despite its reliance on beaches to attract visitors. Many poorly-planned developments are too close to the edge of the sea. Lorde *et al*., (2013) observed that, coastal tourism industries often lack adequate waste-disposal facilities resulting in contamination with sewage and other effluents, causing a health hazard and badly diminishing the aesthetic value of beaches.

2.5 Socio-Economic Importance of Marine and coastal Ecosystem

2.5.1 Fisheries

The rich diverse ecosystem of coastal zones has attracted a large number of human populations to the coast of many countries (Watson *et al*. 1997). Coastal areas form the food basket of the region as offshore and inshore areas, as well as estuaries and lagoons, support artisanal and industrial fisheries. Fisheries have always been a source of livelihood and sustenance for the people living along the coast, contributing towards food security, poverty alleviation, employment, foreign-exchange earnings, recreation, and tourism (Lorde *et al*., 2013). The sector is dominated by small, artisanal boats constructed of wood and may be powered by outboard engines, oars, or sails, or a combination of all three whiles hook and lines, gillnets, and traps are the main types of gear used (FAO, 2011).

In terms of employment, the fisheries sector provides stable, full-time and part-time (boat-building, net making), direct employment (as fishers) to more than 200,000 people, and jobs for an estimated additional 100,000 in processing and marketing (Agard and Cropper, 2007). Some 200 million people and their dependents worldwide, most of them in developing countries, live by fishing and aquaculture. In Ghana, the fisheries sector alone contributes about 4.5% to the national GDP (GSS, 2008 and USAID, 2011) and it forms about 60 percent of all animal protein for human consumption nationwide, particularly among poor and vulnerable members of society (Agyemang *et al*., 2008). People engaged in fishing often have low levels of formal education, limited access to capital, and limited occupational and geographical mobility (Agard and Cropper, 2007).

2.5.2 Tourism and Recreation

Among the cultural services provided by the coastal and marine ecosystems are tourism and recreation. Global tourism has been deemed the world's most profitable industry, and fastest growing sector and despite multiple international crisis, international tourism has grown by 4-5% in the past decade (UNEP, 2006).Natural amenities are highly valued by people and contribute to human welfare, thus providing significant economic value. Stretches of beach, rocky cliffs, estuarine and coastal marine waterways, and coral reefs provide numerous recreational and scenic opportunities. Boating, fishing, swimming, walking, beachcombing, scuba diving, and sunbathing are among the numerous leisure activities that people enjoy worldwide and thus represent significant economic value (UNEP, 2006).Throughout Africa, rural coastal fishing communities, which are directly dependent on the services provided by these coastal and marine ecosystems are often poor and therefore tourism provides a window of opportunity as it generates revenue for development (Boisrobert and Virdin, 2008).

Tourism development without proper planning and management standards and guidelines however poses a threat to biodiversity. This is compounded by the fact that environmental impacts are often not clearly visible until their cumulative effects have destroyed or severely degraded the natural resources that attract tourists in the first place(UNEP, 2006 ; Lorde *et al*., 2011).

2.6 Climatic Hazards Impacting on Marine and Coastal Ecosystem

Coastal marine systems are among the most ecologically and socio-economically vital on the planet. Given their global importance, coastal marine environments are a major focus of concern regarding the potential impacts of anthropogenic climate change (IPCC,

2007b). People living in the coastal zone are often poor and landless, with limited access to services, and hence vulnerable to impacts of climate change on natural resources (UNEP, 2006). There is a strong scientific consensus that coastal marine ecosystems, along with the goods and services they provide, are threatened by anthropogenic global climate change (IPCC 2001). Bindoff *et al*., (2007) observed a number of important climate change-related effects relevant to coastal zones.

Two climate risks namely; rising sea levels and increasing temperatures are considered to be of particular importance to the coastal and marine sector

2.6.1 Sea Level Rise

Global sea levels rose at 1.7 ± 0.5 mm/yr through the 20th century (Bindoff*et al*., 2007) and with great confidence, IPCC (2013) projects an increase experience of adverse impacts such as submergence, coastal flooding and coastal erosion on coastal systems and low-lying areas. When compared to other climate factors, it is fairly certain that global sea level rise will continue beyond the twenty-first century, irrespective of future greenhouse gas emissions (Nicholls and Lowe, 2004). This will likely damage or destroy many coastal ecosystems such as mangroves and salt marshes, which are essential to maintaining wild fish stocks, as well as supplying seed to aquaculture. Higher sea levels may lead to salinization of groundwater, which is detrimental to freshwater fisheries, aquaculture and agriculture and limits industrial and domestic water uses (World Fish Center, 2007). Along with the negative consequences, this however presents benefits in the form of increased areas suitable for brackish water culture of such high-value species as shrimp and mud crab and hence highlights the importance of maintaining people's

capacity to recognize and take advantage of opportunities and how aquaculture can play an important role in diversifying livelihoods (World Fish Center, 2007).

Although many coasts are experiencing erosion and ecosystem losses around the world, few studies have unambiguously quantified the relationships between observed coastal land loss and the rate of sea-level rise (Zhang *et al*., 2004; Gibbons and Nicholls, 2006).Vermeer and Rahmstorf, (2009) however observed that most of the observed current climate-related rise in global sea level over the past century could be attributed to the expansion of the oceans as they warm but it is anticipated however that, the melting of land-based ice may become the dominant contributor to global sea level rise in the future.

2.6.2 Increasing Coastal Sea Temperatures

Sea temperature plays a dominant role in shaping marine ecosystems. Global mean sea surface temperatures have risen about 0.6°C since 1950, with associated atmospheric warming in coastal areas (Bindoff *et al*., 2007). Sea temperatures influence organism survival and growth, egg and larval development, and spawning and feeding behavior (Lorde *et al*., 2013). UNEP,(2006) observed that, changing sea temperature and current flows will likely bring shifts in the distribution of marine fish stocks, with some areas benefiting while others lose . Brander *et al*., (2003) also observed that as the coastal sea temperature increases, it is projected to cause range of suitable habitat for many commercially-important fish and shellfish species to shift northward. When sea temperatures rise, ecosystems become vulnerable to shell fish diseases, harmful algae blooms, and the proliferation of exotic species that force indigenous species to compete for resources, including dissolved oxygen (Kurihara *et al*., 2008).

Two-thirds of all reefs are in developing countries, and 500 million people in the tropics depend heavily on reefs for food, livelihoods, protection from natural disasters and other basic needs (World Fish Center, 2007). Higher sea temperature is a major cause of coral bleaching and damage to reef ecosystems around the globe with studies suggesting that 60% of coral reefs could be lost by 2030 due to increased acidification of oceans from higher levels of atmospheric carbon dioxide (World Fish Center, 2007).

2.7 Non-Climatic Hazards Impacting on Marine and Coastal Ecosystems

Non-climate stressors impacting the various coastal components of the coastal and marine ecosystems are associated with human consumption of natural resources and land use practices (Lorde *et al*., 2011).

2.7.1 Pollution

Eutrophication, or nutrient pollution, has become a driver of change for coastal and marine ecosystems (UNEP, 2006). Sewage discharges and contaminated storm water runoff from developed and agricultural areas cause pollution and pathogenic outbreaks that can lead to the closure of near shore fisheries (Lorde *et al*., 2011). In addition to stresses related to water quality, fish stocks, as well as other marine ecosystem components, may be affected by harvesting practices, diseases that are not necessarily climate-related, and normal population dynamics, such as predation, competition, and recruitment variability (Lorde *et al*., 2011). Overfishing and destructive fishing methods such as trawling (for example, use of heavy gear on sensitive substrates), dredging, and the use of explosives and poisons such as cyanide impact negatively on the marine ecosystem by changing the community structure and altering trophic and other

interactions between ecosystem components and by physically modifying the habitats (UNEP, 2006)

2.7.2 Land Use Change

Intense development along the coast increases both vulnerability to inundation and the demand for groundwater, which could lead to drawdown of aquifers and increased saltwater intrusion (Lorde *et al*., 2013).UNEP, (2006) observed that mangroves conversion to allow for coastal zone development, aquaculture, and agriculture, including grazing and stall feeding of cattle and camels is the second most serious threat to mangrove ecosystems. Removal of trees for fuel wood and construction material, removal of invertebrates for use as bait, changes to hydrology in both catchment basins or near shore coastal areas, and excessive pollution all have serious implication on the integrity of the marine and coastal ecosystems (UNEP, 2006).Such changes, produced by urbanization and other forms of human land-use, can lead to habitat fragmentation causing increase vulnerability to pathogens, insect pests, and invasive species (Lorde *et al*., 2011). Nicholls and Tol, (2006) observed that coastal infrastructure inhibits natural geographic migration of wetlands.

2.7.3 Invasive species

Invasive species are those species that are not native to a country's ecosystems and cause harm to the economy, environment, or human health (Lorde *et al*., 2011). They have been recognized as a major driver of ecosystem change and are expected to grow in importance contributing to species extinction and the deterioration of ecosystem services (UNEP, 2006). Increases in global commerce and human travel, have led to increasing rates of species invasion that show no signs of slowing down in the future (Tatem, 2009).

The economic impacts of invasive species can be as profound as the ecological impacts (Lorde *et al*., 2013) posing serious economic threats to coastal sectors industries such as, fishing, tourism and recreation.

2.8 Critical Vulnerability of Marine and Coastal Sector

2.8.1 Fresh water resources

Globally, freshwater supply problems due to climate change are most likely in developing countries with a high proportion of coastal lowland, arid and semi-arid coasts and coastal megacities reflecting both natural and socio-economic factors that enhance the levels of risks (Alcamo and Henrichs, 2002; Ragab and Prudhomme, 2002). The direct influences of sea-level rise on freshwater resources come principally from seawater intrusion into surface waters and coastal aquifers (Hay and Mimura, 2005). Essink, (2001) observed that, many coastal aquifers, especially shallow ones, experience saltwater intrusion caused by natural and human-induced factors, and this is exacerbated by sea-level rise.

The scale of saltwater intrusion is dependent on aquifer dimensions, geological factors, groundwater withdrawals, surface water recharge, submarine groundwater discharges and precipitation (Nicholls *et al*., 2007). Coastal areas experiencing increases in precipitation and run-off due to climate change, including floods, may therefore benefit from groundwater recharge, especially on some arid coasts (Khiyami *et al*., 2005).

2.8.2 Human settlements and Infrastructure

Climate change and sea-level rise affect coastal settlements and infrastructure in several ways. Even, moderate sea level rise could have surprisingly large impacts, especially for

low-lying coastal zones and deltas (Nicholls and Casenave, 2010). While saltwater intrusion may threaten water supplies, the degradation of natural coastal systems due to climate change, such as wetlands, beaches and barrier islands, removes the natural defenses of coastal communities against extreme water levels during storms (Nicholls *et al*., 2007). Changes in natural systems, such as flooding, for instance, can damage coastal infrastructure, ports and industry, the built environment, and agricultural areas, and, in the worst case, lead to significant mortality. Erosion can lead to loss of beachfront/cliff-top buildings and related infrastructure (Lorde *et al*., 2011). IPCC, (2007), observed that, population exposed to flooding by storm surges will increase over the 21st century with Africa likely to see a substantially increased exposure.

Even though there is now a better understanding of flooding as a natural hazard, and how climate change and other factors are likely to influence coastal flooding in the future (Hunt, 2002), the prediction of precise locations for increased flood risk resulting from climate change is difficult, as flood risk dynamics have multiple social, technical and environmental drivers (Few *et al*., 2004).

2.8.3 Human health

Other indirect impacts of climate change can include adverse effects on human health. For example, Nicholls *et al*., (2007) observed that, Coastal communities, particularly in low income countries, are vulnerable to a range of health effects due to climate variability and climate change particularly, extreme weather and climate events such as cyclones, floods and droughts. Coastal communities that rely on marine resources for food, in terms of both supply and maintaining food quality (food safety), are vulnerable to climate-related impacts, in both health and economic terms (Nicholls *et al*., 2007). Marine

ecological processes linked to temperature changes also play a role in determining human health risks, such as from cholera, and other enteric pathogens (Vibrio parahaemolyticus), Harmful Algal Blooms (HABs), and shellfish and reef fish poisoning (Pascual *et al*., 2002; McLaughlin *et al*., 2006). Extreme climatic events cause a direct impact through loss of life and injury (McLeman and Smit, 2006).

Despite the role of climate change in determining human health risk, Kovats and Haines, (2005) observed that convincing evidence of the impacts of observed climate change on coastal disease patterns is absent. The projection of health impacts of climate change is still difficult and uncertain (Ebi and Gamble, 2005; Kovats *et al*., 2005), and socio-economic factors may be more critical than climate.

2.8.4 Agriculture, forestry and fisheries

Climate change is expected to have impacts on agriculture and, to a lesser extent, on forestry (Easterling, 2003). Although non climatic factors, such as overfishing and habitat loss and degradation, are already responsible for reducing fish stock, climate variability and change also impacts fisheries in coastal and estuarine waters (Daufresne *et al*., 2003; Genner *et al*., 2004).

Globally an increased agricultural production potential due to climate change and CO2 fertilization should in principle add to food security, but Nicholls *et al*., (2006) observed that, the impacts on the coastal areas may differ regionally and locally. More frequent extreme climate events during specific crop development stages, together with higher rainfall intensity and longer dry spells, may impact negatively on crop yields (Olesen *et al*., 2006). Rising sea level has negative impacts on coastal agriculture whiles detailed

modeling of inundation implies significant changes to the number of rice crops possible in the Mekong delta under 20-40 cm of relative sea-level rise (Wassmann *et al*., 2004).

Coastal forestry is little studied, but forests are easily affected by climatic perturbations, and severe storms can cause extensive losses (Nicholls *et al*., 2006). Salinity and greater frequency of flooding due to sea-level rise reduces the ability of trees to generate, including mangroves which will also experience other changes (IUCN, 2003). Mangroves and other coastal vegetation buffer the shore from storm surges that can damage fish ponds and other coastal infrastructure and may become more frequent and intense under climate change (UNEP, 2006).

The biotic communities and productivity of coastal lagoons may experience a variety of changes, depending on the changes in wetland area, freshwater flows and salt intrusion which affect species (Nicholls *et al*., 2006).

2.8.5 Vulnerability of Coastal Wetlands

Global climate change is recognized as a threat not only to coastal human populations but also to species survival and the health of natural systems (IPCC, 2007b). Wetland systems are vulnerable to changes in quantity and quality of their water supply, and it is expected that, climate change will have a pronounced effect on wetlands through alterations in hydrological regimes with great global variability (Erwin, 2009). Many wetlands and species are already under immense pressure with high level of loss and degradation globally through biological responses to changes in temperature, rainfall, water regimes, and salinity (Erwin, 2009).

Throughout much of the world, the rate of reduction in the area of wetland and associated ecosystem services increased rapidly during the period following the industrial revolution as intensive agriculture spread through the landscape (Biebighauser, 2007).Pressure on wetlands remains high today despite increasing interest in preserving habitats, and the degradation and loss of wetlands is currently more rapid than that of other ecosystems (MEA, 2005). In Asia during the Green Revolution, the need to produce greater quantities of food led to extensive useof fertilisers and pesticides which in turn led to the degradation of some wetland ecosystems (Ponting, 2007).

Current evidence indicates that the degradation of the Muni Pomadze wetland in Ghana could be largely attributable to neglect and unsustainable human activities (e.g. bushfire setting, hunting, farming, fuelwood harvesting, estate development, etc.) over the years (Ntiamoa-Baidu and Gordon, 1991; Ryan and Ntiamoa-Baidu, 1998).

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Study Area

3.1.1 Location

The town Anloga in the Keta Municipality was selected as the study area for this research (Figure 3). The Keta municipality is one of the 18 Administrative Districts of the Volta Region and shares common borders with Akatsi District to the north, Ketu North and South Districts to the east, Tongu District to the west and gulf of Guinea to the south. It has a total surface area of 1,086km^2 of which 30% (362 km^2) is covered by water bodies. The largest among these water bodies is the Keta Lagoon and because of its importance as a breeding and nesting site for migratory and resident water birds, insects, and terrestrial vertebrates (Ryan and Attuquayefio, 2000), it has been designated under the Ramsar convention as a Wetland of International Importance. It is about 12 km at its widest section and 32 km in length (MMTDP, 2010). The Municipality is a low-lying coastal plain with the highest point at 53 metres above sea level and the lowest between 1-3.5 metres below sea level, thereby making it vulnerable to tidal waves and sea erosion (MMTDP, 2010).

3.1.2 Ethnic Composition

The Municipality is highly homogeneous regarding ethnicity and religion (PHC, 2000). There has not been any significant change in the ethnic and religious composition of the population since 1996. In 1996, Ewes formed about 98.8% of the Municipal population with 1.2% accounting for other ethnic groups. In the 2000 Population and Housing Census Report, Ewes still dominated the Municipal population with about 91.8% while

the other tribes which include the Akans, Ga-Dangme, Guan, Mole Dagbani, Grusi, Mande and Guma shared the remaining 8.2% (MMTDP, 2010).

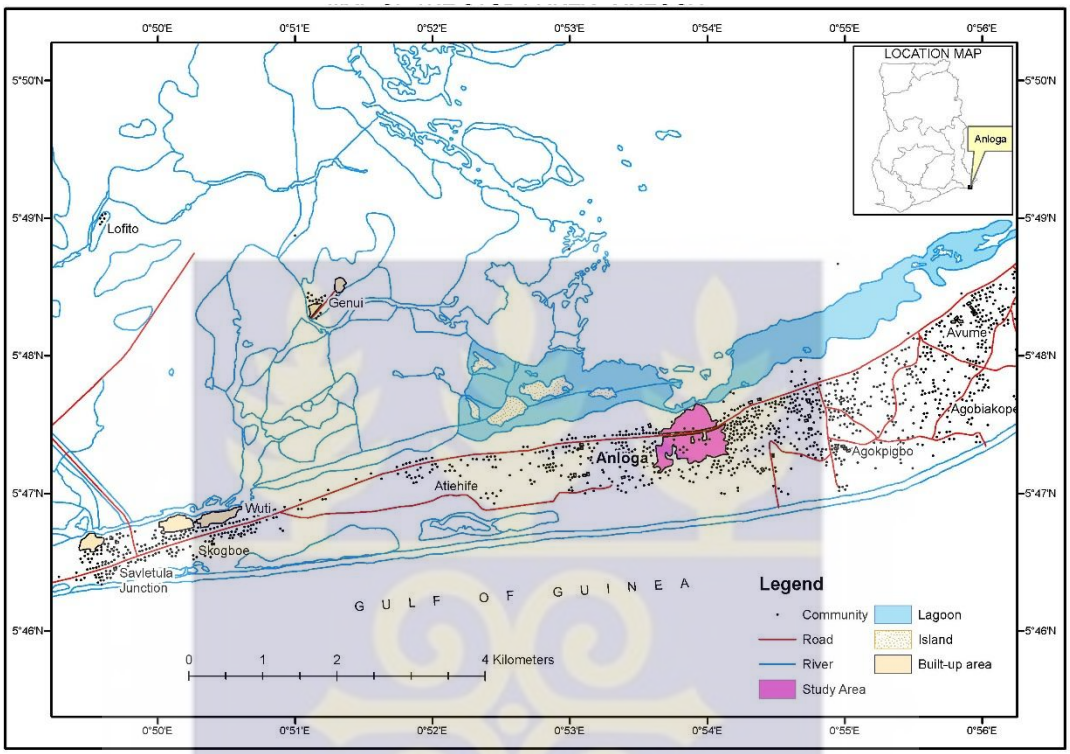

Figure 3: Map showing the study area

3.1.3 Socio-Economic Conditions

The population of the Keta Municipality has been growing at a relatively low rate of 0.5 per cent since 1970. From a total population of 104,100 in 1970, it reached about 111,700 in 1984 and 133,661 in 2000 (2000 Population and Housing Census). The 2010 Population and Housing Census however put the total population of Anloga at 23,301 with 5,296 households and 4.4 household size. The low population growth rate of the Municipality is attributed to a very high out-migration (281/1000 per year) of the potential labour force. The main factor of the low population growth rate seems to be the lack of employment opportunities (MMTDP, 2010). This is evidenced by a relatively high unemployment rate of 38 per cent as against the estimated 28 per cent nationwide.

Other factors contributing to out- migration are the dwindling of fish catch, low crop yields, low land per capita, limited market for industrial produce and intensive sea erosion, among others (MMTDP, 2010).

Based on an economically active population of fifteen (15) years and above, a total of 53,397, constituting 40% of the total population in 2000 were employed. The Private Sector employed 94.6% of the economically active population while the Public Sector accounted for only 5.4% (MMTDP, 2010). The Municipality has mainly an agrarian economy, with the majority of the population engaged in crop farming, livestock keeping, fishing and other related trading activities.

3.1.4 Climate

The Municipality falls within the dry Coastal Equatorial Climate with annual average rainfall of less than 1000mm (MMTDP, 2010). The major rainy season is between March and July while minor season begins from September and ends in November. The average temperature is about 30^0C with low relative humidity (MMTDP, 2010). The Municipality is thus one of the driest along the coast of Ghana. The Municipality experiences a double maximum rainfall pattern.

3.1.5 Vegetation

The entire Municipality falls within the coastal savanna zone and has been classified into four vegetational zones namely:

- Tall grasses interspersed with medium sized trees of relatively higher density in the northern part of the Municipality.

- Short grasses with short trees and occasional occurrence of "Pamira" palm and baobab trees in the mid-section of the Municipality.
- Mangrove plants and tall grasses along the Volta estuary in the South-western parts.
- Short grasses and many neem trees in the South-eastern part along the coast from Whuti.

3.2 Conceptual Framework

The United Nation Framework Convention on Climate Change (McCarthy, 2001) mentions two types of vulnerability assessment framework namely; Top down and Bottom up approaches (Figure 4).

Top-down approaches usually refer to scenario-driven assessments that apply global or regional climate projections or modeling (e.g. by using General Circulation Models, GCM) to assess potential impacts on physical or natural exposure units, such as watersheds, infrastructure, or agricultural production systems (Bünner, 2013). These approaches are usually more costly than bottom-up approaches (Bünner, 2013). With this approach, outsiders enter a community with a list of indicators for assessment, without involving communities in the early stages of the process (e.g., project planning, and defining of indicators).

With the bottom-up approaches, the unit of analysis is typically smaller and more localised, such as communities (Bünner, 2013). The emphasis is more on current and short-term time scales, where vulnerability to current climate variability serves as a starting point for understanding vulnerability to future climate conditions (Bünner, 2013).

Bottom-up approaches typically therefore, but not necessarily, use other sources of data, for instance, from participatory processes.

In order to capture the advantages and benefits of the different approaches, this research applied a combination of both approaches referred to as an integrated approach. This approach seemed the most appropriate for a given location (Bünner, 2013). Experience has shown that, such an approach also increases the acceptance of the results (Bünner, 2013).

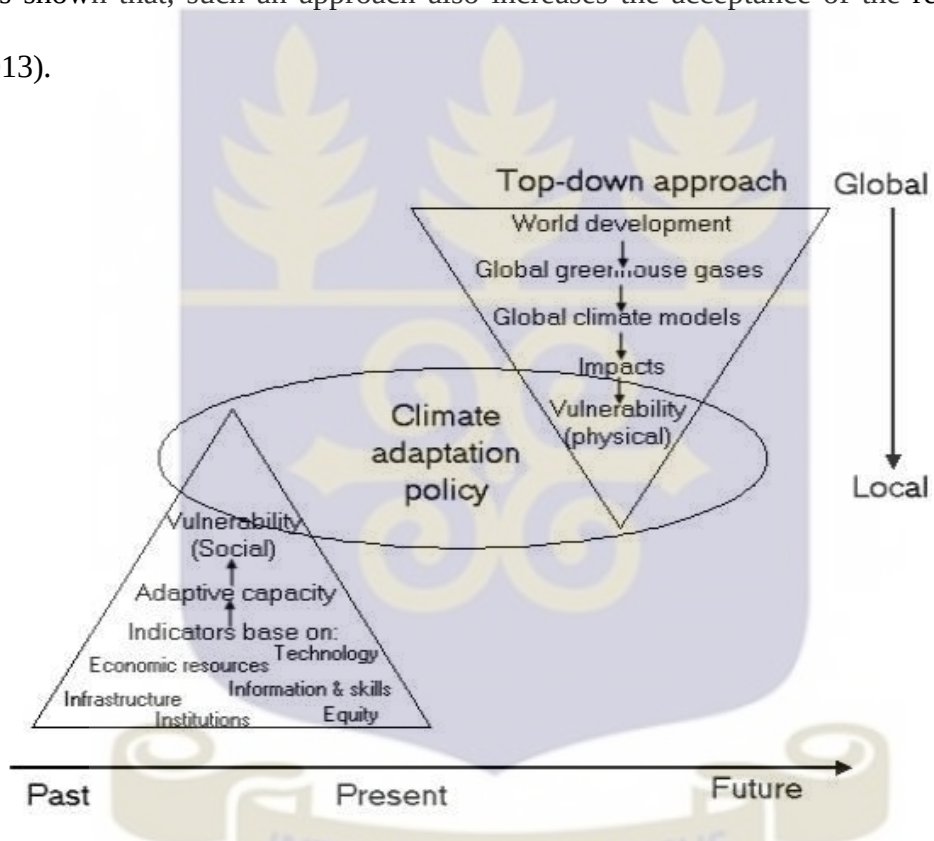

Figure 4: Framework approach by UNFCCC

3.3 Sampling Technique

The purposive sampling technique was used to select the Anloga community for this research based on the fact that (i) it is a coastal community, predisposed to the impacts of climate change (Erwin, 2009); (ii) the predominant livelihood activities carried out were fishing and farming (MMTDP, 2010) and (iii) the members of the community have direct

or indirect interactions with the Keta lagoon which has been shown to be sensitive to the potential impacts of climate change (Erwin, 2009).

The Keta Municipal Assembly, (KEMA), The Center for Regional and Geographical Information systems (CERGIS), The Ghana Statistical Service (GSS), The Ghana Wildlife Division of the Forestry Commission (WD/FC) and the Ghana Meteorological Agency (GMET) were purposively selected because they are known to have the data relevant for this study.

For the purpose of this research, all households within the community were divided into four strata considering that the cross variation creates heterogeneity in the livelihoods of the local people, especially on the factors related to climatic variation. Stratified Random Sampling is often used when the population characteristics are heterogonous and this sampling technique gives a better cross-section of the population so as to gain a higher degree of relative precision (Weiss and Hassett, 1982).

3.4 Sample Size

In selecting the sample from the population, Miller and Brewer (2003) formula for calculating sample size was adopted for the study.

The formula is specified as;

$$n = \frac{N}{1 + N(\alpha)^2}$$

Where n = sample size N = Total population of the study community (23,301) α^2 = is the marginal error (8%)

Therefore; $n = \frac{23,301}{1+23,301\ (0.08\ )^2} = 155.34 \approx 155$

Per the above calculation the minimum respondents that can be selected from the sample size was 155 but for more representation of the sampled community a sample size of 200 was used.

3.5 Data Collection Methods

The data for this study were collected from May 2014 to September 2014 and involved three main phases. Phase I (May 2014) involved a review of relevant literature on vulnerability assessment and a preliminary visit to the community to gather information relevant for the development of the questionnaires and interview guide needed for this research. Phase II (June, 2104) involved a second visit to the case study community to conduct a community pilot study using the survey questions and interview guides. Phase III, involved the review and adjustment of the questionnaires and interview guide followed by the main field data collection (July 2014 – September 2014) which comprised key informant interviews, household surveys and focus group discussions. In all three phases, data were collected from both primary and secondary sources whiles participant observation was used as a supplementary data collection tool.

To ensure consent and voluntary participation in the household surveys, the interviewees were required to sign a participation form. The confidentiality of the research was also assured as the surveyed population was not asked to provide any personal identifying information such as name, address and Identification cards (ID) cards.

3.6 Primary Data

3.6.1 Reconnaissance survey

A reconnaissance survey was carried out to get the general understanding of the study area before starting the detailed work. This was done by first introducing myself and describing the nature of the project to the community leaders through appropriate community entry procedures. The support of a community liaison officer was necessary to help me familiarize myself with the study area.

3.6.2 Household Survey

Surveys are an effective way to obtain data focused on a particular topic (Hoggart *et al.* 2002). The household survey was conducted with the help of two research assistants who were trained to develop their understanding of the research goals and objectives. Stratified random sampling was used to select the 200 households for interviews. Using the semi-structured questionnaires (Appendix 1), interviews were conducted incorporating different aspects of climate change, exposure, resilience and adaptive capacity. Information on disasters, water resources, agricultural production, living conditions, livelihoods, vulnerability, awareness of wetland conservation and environmental issues were obtained whiles other key socio-economic parameters such as income, expenditure, and landholding were also considered for the household survey. Though household heads were the ones targeted for the interviews, other elderly people within the household were considered in the absence of the household heads (Plate 1).

Plate 1: Household Survey

3.6.3 Focus Group Discussion

Focus group discussion (FGDs) are discussions characterized as informal discussions among selected individuals about specific topics (Beck, 1986), where issues for discussion receive contribution from all group members. For the purpose of this study, a focus group discussion was conducted (Plate 2) to understand the perspective of the community members and their concerns on climate change and current vulnerability issues. The major stakeholders involved in the FGDs included: Representatives of farmers, fisher men, women and youth. Using an interview guide (Appendix 2), several research questions pertaining to climate change and perception of its impacts on local livelihood, gender differences in the utilization of the local resources, population and migration trends, food security and on local adaptation measures were raised for discussions.

Focus groups discussions are commonly criticized because individual voices may become silenced when an individual's view runs contrary to the majority and may feel embarrassed and to prevent this, moderation of the FGDs were carefully done to seek the personal perspective of all FGDs members on issues, especially from quieter members of the group.

Plate 2: Focus Group Discussion with community members

3.6.4 Key Informants Interview

To document community vulnerability and institutional capacity in addressing climate change, informal interviews with key informants were carried out and with the aid of an interview guide (Appendix 3), questions about the climate change and agricultural change pattern, natural resource management, disaster risk and emergency response, and human health protection were asked. Where possible and with the permission of the interviewee,

audio recordings accompanied the interviews allowing focus of the interviewee's responses rather than being engaged with extensive and distracting note taking.

Key institutions considered for these interviews included: The District offices of the Wild life Division of the Forestry Commission (WD/FC), the National Disaster Management Organization (NADMO), the Ministry of health (MOH), the Ministry of Food and Agriculture (MOFA) and the Ministry of Fisheries and Aquaculture Development (MOFAD).

3.6.5 Field observation

Field observations were carried out a number of times. During field visits, observations of possible hazards that might be aggravated by changing weather patterns were made. Photographs of the area were taken and important observations noted. Questions were also noted during the field observation and were incorporated into the focus group discussions, key informant interviews, as well as in the household surveys questionnaires.

3.7 Secondary Data

3.7.1 Climatic data

With the closure of the Meteorological Agency station in Keta, climatic data for the nearest coastal town, Ada with features similar to Anloga were used for this study. Monthly maximum and minimum temperatures as well as rainfall data from 1961 to 2010 (Appendix 4) were obtained for the analysis in the trends of climatic changes.

3.7.2 Socio economic and other data

Data published by the Ghana Statistical Services as well as various data published in the medium term development plan of the Keta Municipality were used for the analysis of the socioeconomic status of the study area.

3.7.3 Time Series Data on land cover change of the wetland

A Geographical Information System (GIS) time series data including maps on land cover and land use change of the Keta Lagoon and its environs were obtained from the Center for Regional and Geographical Information Systems (CERGIS). The time period for the analysis of the GIS data were between 1990, 2000 and 2010. Image processing and GIS software such as ArcGIS were used in the data reclassification and in laying out land-use change maps for land use change analysis. Table 2 below indicates the key data sources of the study.

Table 2: Key Data Sources

Data Source	Data Required	Method of Data Collection
KEMA, GSS	Population size, No. of households and No. of houses	Interview guide
Household	Socio-demographic data, Information on living conditions, Livelihoods, vulnerability and adaptive capacity, Awareness of wetland conservation and environmental issues and coping and adaptive strategies	Questionnaire Administration and Focal group discussion
GMet	Climatic data on temperature and rainfall	Request through a letter
CERGIS	A GIS time series data including maps on land cover and land use change of the keta lagoon	Request through a letter
WLD/FC (Site manager)	Information available on previous intervention based projects at the selected site specifically those on Coastal Wetlands Management Projects and challenges faced by the institution in their operations.	Interview guide
MOFA (District director)	Information on food security and interventions and challenges to address climate change challenges in the district.	Interview guide
NADMO (District coordinator)	Information on frequent hazards and emergency response capabilities and challenges faced by the institution	Interview guide
Health Directorate (District director)	Information on the state of health of the community, the trend of diseases and challenges faced by the institution in the provision of healthcare services.	Interview guide
MOFAD	Information on fish resources, current programs and activities to promote the fishing industry and challenges in regulating the activities of fisher men in the community	Interview guide

3.8 Data processing, analysis and interpretation

Data obtained through different sources were processed, analyzed and interpreted using version 20 of the IBM SPSS statistical tool. Tables, graphs and charts were generated for the analysis. Maps were also prepared using appropriate GIS software.

6.2 Limitations of the Research

The study had some limitations regarding data collection. These limitations emanated from the respondents and their personal biases and institutional inefficiencies which affected the study in diverse ways as listed below:

1. In the first place, some individuals were suspicious of the interviewers and were therefore reluctant to co-operate for fear of landing themselves into trouble. Others were reluctant because they reported past experience with researchers and NGOs who had promised to come back to support them and never came back.

2. Some others felt uncomfortable about disclosing information on their household waste and sewage disposal as well as access to toilet facilities especially among those who used the coast as a place of convenience.

3. Obtaining secondary data such as the recent community level population statistics and downscaled climate information from models and projections that suit the needs of the study area was also a challenge.

Appropriate steps were taken to minimize the impacts of the anticipated constraints. This included detailed explanation of the objectives of the research to the respondents and identifying and using appropriate channels to facilitate easy access to secondary

data. The data was properly coded and interpreted to help reduce the overall impact of the limitations on the research outcome.

CHAPTER FOUR

RESULTS

4.1 Socio-Demographic Information

The survey involved a total of 200 persons; of this, 83% of the respondents were males whiles 17% were females (Table 3). 193 representing 96.5% of the respondents were natives of the study area with just 7 representing 3.5% being non-natives of the area.

It was also observed from the survey that majority of the respondents were quadragenarians as 87 respondents representing about 44% were between the ages of 41 and 50 years (Table 3). Only 13% of the respondents were between the ages of 21 to 30 years. In terms of education, 9.5% of the respondents had tertiary education, 18% had vocational or senior high education whiles 21.5% had primary and junior high education respectively. 29.5% of the respondents however had no education at all (Table 3).

Table 3: Sex, Age and educational level of respondents

Sex of respondents	**Frequency**	**Percentage (%)**
Male	166	83
Female	34	17
Age of respondents	**Frequency**	**Percentage (%)**
21-30	26	13.0
31-40	40	20.0
41-50	87	43.5
50 and above	47	23.5
Educational level of	**Frequency**	**Percentage**
Primary	43	21.5
JHS	43	21.5
SHS / Vocational	36	18.0
Tertiary	19	9.5
None	59	29.5
Native status of respondents		
Natives	193	96.5
Non Natives	7	3.5

4.1.1 Occupation of respondents

The district planning officer indicated in a key informant interview that, the Anloga area has an agrarian economy and this was evident from the household survey where 45.5% of the respondents were into farming which was their primary occupation. 29.5% were

salaried workers whiles 7% were fishmongers (Figure 5). In the case of secondary occupation, the trend is not too different as over 50% of the respondents were into both farming and fishing (Fig 6).

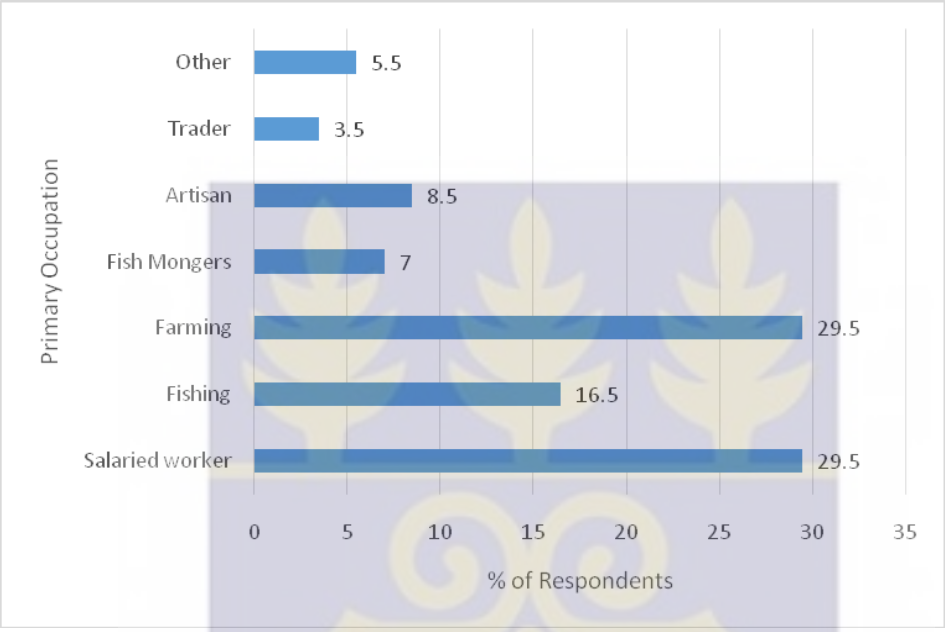

Figure 5: Primary Occupation of respondents

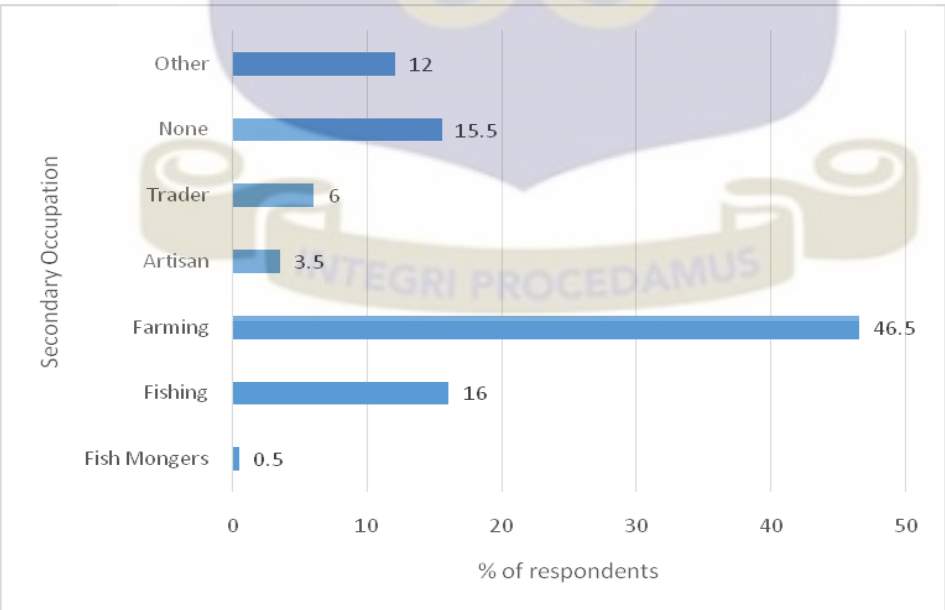

Figure 6: Secondary occupation of respondents

4.1.2 Relationship between Primary and Secondary Occupation

The relationship between primary and secondary occupation of respondents is shown in table 4. Generally it was observed that most of the respondents engage in farming as their secondary occupation.

Table 4: Relationship between primary and secondary occupation

Primary occupation	What is your Secondary Occupation							Total
	Fish Monging	Fishing	Farming	Artisan	Trader	None	Other	
Salaried worker	0	1	54	1	1	1	1	59
	0.0%	1.7%	91.5%	1.7%	1.7%	1.7%	1.7%	100.0%
Fishing	0	1	14	2	0	15	1	33
	0.0%	3.0%	42.4%	6.1%	0.0%	45.5%	3.0%	100.0%
Farming	0	26	0	4	3	5	21	59
	0.0%	44.1%	0.0%	6.8%	5.1%	8.5%	35.6%	100.0%
Fish monging	0	0	0	0	8	5	1	14
	0.0%	0.0%	0.0%	0.0%	57.1%	35.7%	7.1%	100.0%
Artisan	0	1	16	0	0	0	0	17
	0.0%	5.9%	94.1%	0.0%	0.0%	0.0%	0.0%	100.0%
Trader	0	0	3	0	0	4	0	7
	0.0%	0.0%	42.9%	0.0%	0.0%	57.1%	0.0%	100.0%
Other	1	3	6	0	0	1	0	11
	9.1%	27.3%	54.5%	0.0%	0.0%	9.1%	0.0%	100.0%
Total	1	32	93	7	12	31	24	200
	0.5%	16.0%	46.5%	3.5%	6.0%	15.5%	12.0%	100.0%

Out of the 59 respondents who were salaried workers, 54 representing 91.5% were engaged in farming as a secondary occupation with just one person engaged in fishing as

a secondary occupation. One person each was engaged in art work and trading. With regards to respondents who were engaged in fishing as their primary occupation, about 42% of them were into farming as their alternate source of livelihood whiles about 45% of them were not engaged in any activity as an alternate source of livelihood. Only three of them were engaged in art work as a secondary occupation. For the respondents who were however into farming as their primary occupation, 44.1% of them were into fishing as an alternate source of livelihood with only 6.8% of them engaged in art work as an alternate source of livelihood. 35.5% of them were engaged in other occupation other than fishing, fish monging, art work and trading with only 8.5% of them engaged in no activity as a secondary occupation. 57.1% of the fish mongers were engaged in farming as a secondary occupation with 35.7% of them engaged in trading as a secondary occupation. None of the fish mongers was engaged in fishing as a secondary occupation. All the artisans in this survey were engaged in either fishing or farming as their alternate source of livelihood. 94.1% of them were engaged in farming as a secondary occupation whiles the rest were into farming. For the traders, 42.9% of them were engaged in farming whiles the rest, 57.1% were not into any activity as an alternate source of livelihood.

4.1.3 Number of children per household (Fertility)

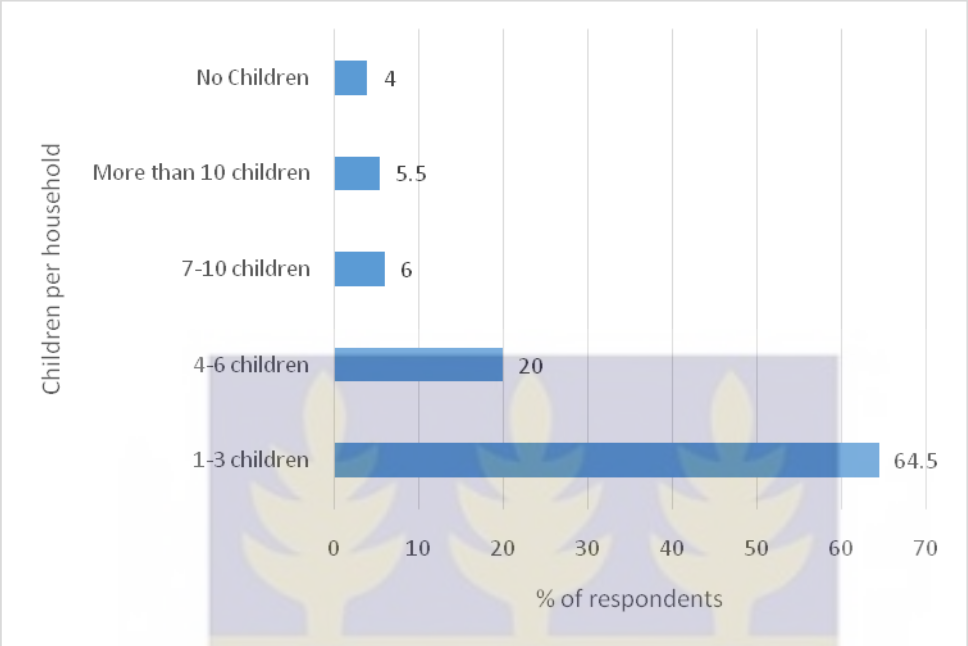

Figure 7: Number of children in a household

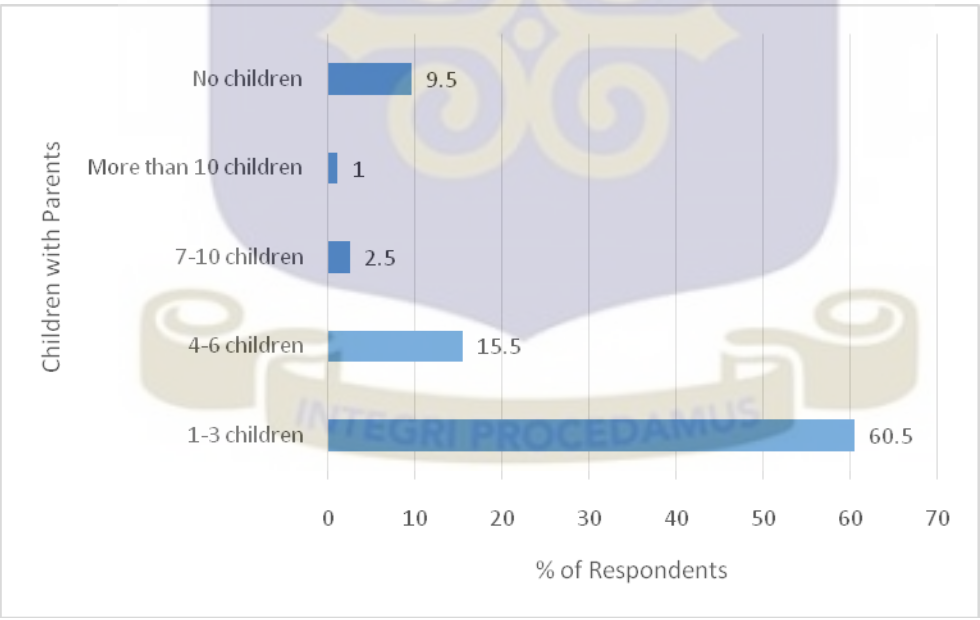

Figure 8: Children living with parents

Even though nationally, the average household size for rural areas is 5.2, it was observed from this survey that, 129 of the respondents representing 64.5% had between 1-3

children out of which 60.5% of them had their children living with them (Figures 7 and 8). 40 respondents representing 20% had between 4-6 children and out of which 15.5% had their children living with them, whiles 12 respondents had between 7-10 children out of which 2.5% had the children living with them. Only 11 respondents representing 5.5% had children numbering more than 10 and out of which 1% had the children living with their parents and with just 8 respondents without children.

4.2 Living Conditions, Livelihoods and Adaptive Capacity

4.2.1 Type of houses used by respondents

The type of houses the respondents in this survey live in include: detached houses, semi-detached houses, compound houses, apartments and tents. It was observed that, 38% of the respondents live in detached houses whiles 33.5% live in compound houses. 16% of them live in semi-detached houses, 9% live in flats or apartments with 3.5% living in tents (Figure 9).

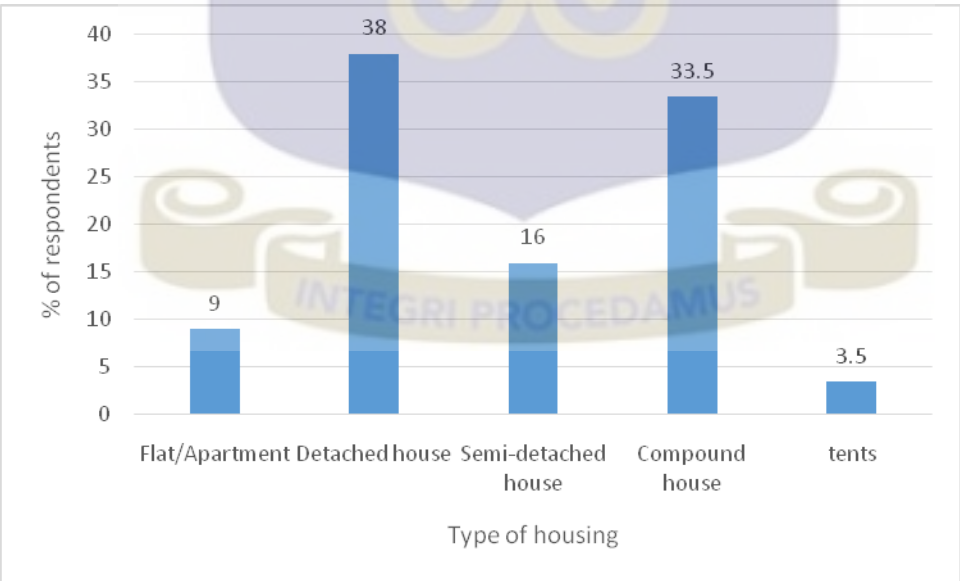

Figure 9: Type of housing used by respondents

4.2.2 Construction material for the wall and material for Roofing for houses of respondents

The study identified, mud, wood, metal sheets, sand crate blocks and land crate blocks as the main materials used in building the walls of houses in the studied area. However, almost all the households were constructed with cement or sand crate blocks with majority roofed with aluminium roofing sheet (Figures 10 and 11). This was confirmed in a key informant interview with the district planning officer who disclosed that, majority of houses within the district were constructed with cement or sand crate blocks with aluminium, asbestos or zinc roofing sheets. As high as 93% of the households had their houses constructed with cement or sand crate blocks with just 5% of them having the walls of their houses constructed with wood, bamboo or raffia. Only 1% of the households had their houses constructed with land crate with 0.5% of them having their houses constructed with mud. Another 0.5% had the house constructed with metal sheets (Figure 10).

For roofing, it was observed that, for almost all the households, aluminium sheets were used for roofing (Figure 11).

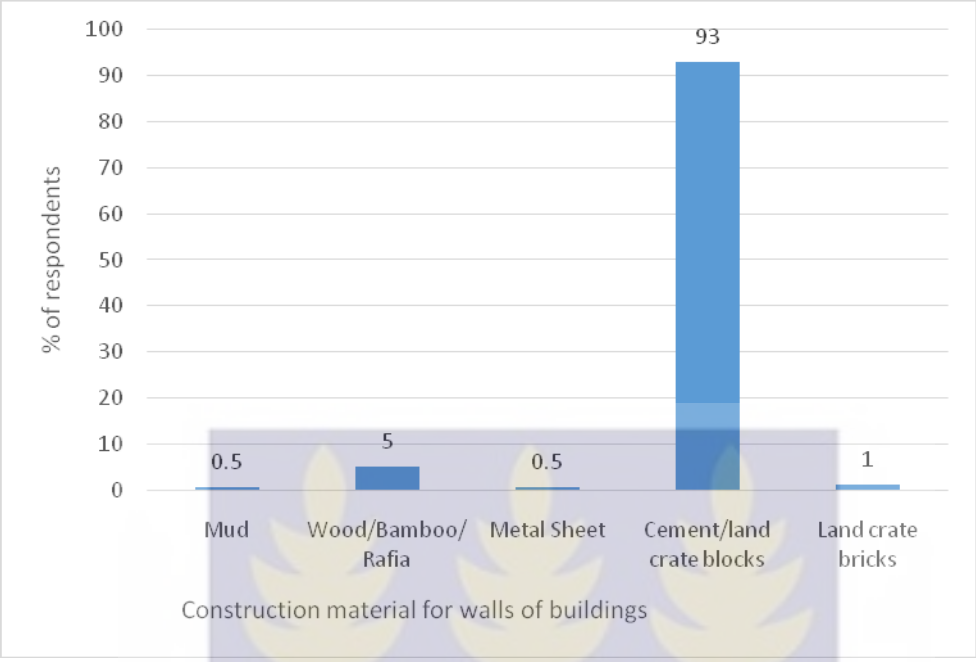

Figure 10: Construction material for walls

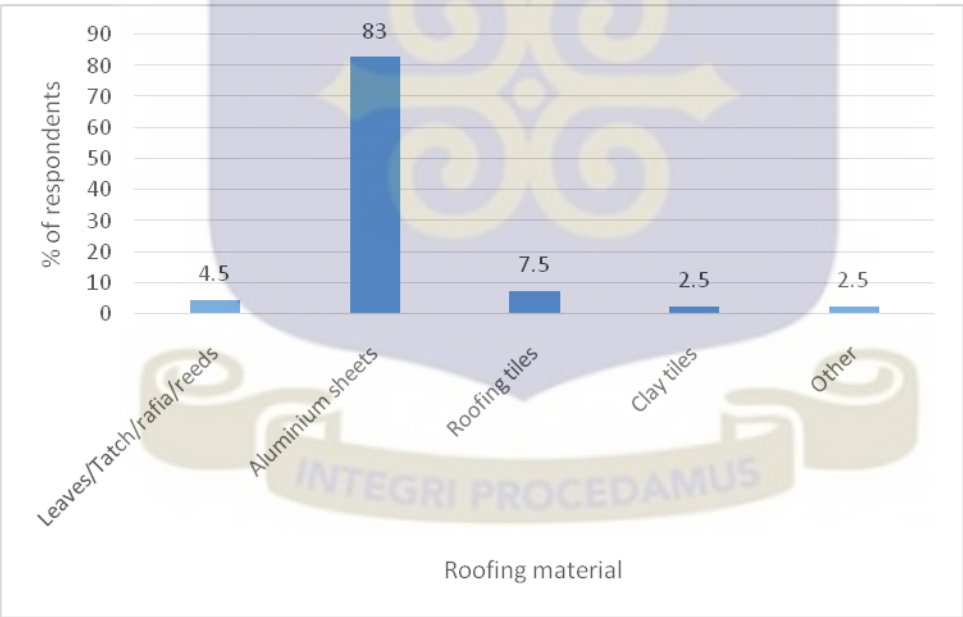

Figure 11: Material for roofing

83% of the respondents had their houses roofed with aluminium sheets with just 7.5% having their households roofed with roofing tiles. Only 4.5% of households had their

houses roofed with thatch, leaves and raffia whiles 2.5% had their households roofed with clay tiles with another 2.5% households having their houses roofed with other materials other than aluminium, tiles, thatch, leaves and raffia.

4.2.3 Type of toilet facility used by respondents

92 households representing 46% of the total households in this study used household latrines whereas 52 houses representing 26% used the communal KVIP with 16 households representing 8% using the flush toilet facility. 40 households representing 20% however used the open space on the beach or coast as their place of convenience (Figure 12).

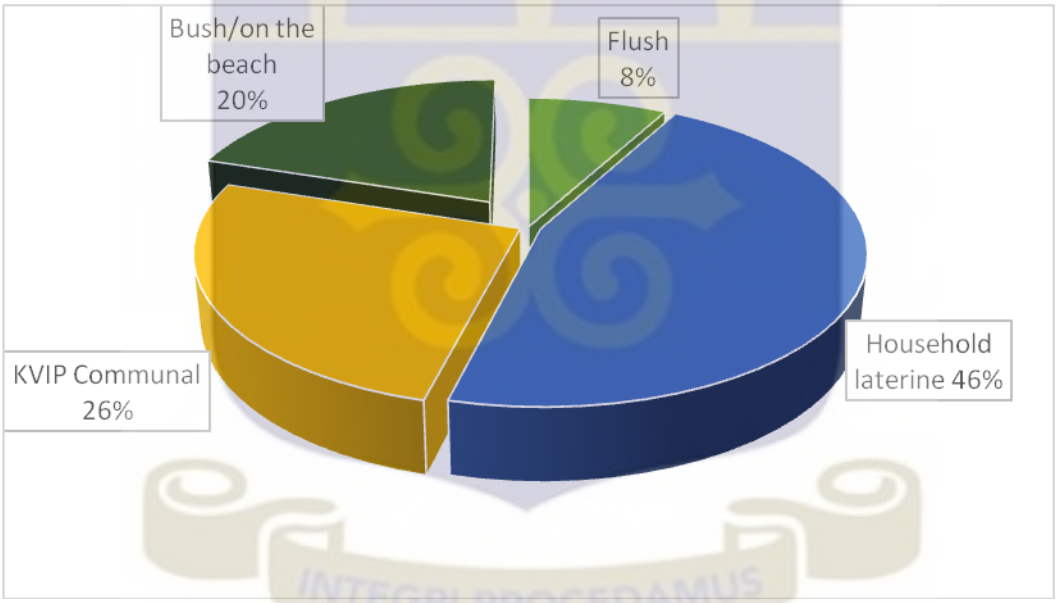

Figure 12: Type of toilet facility used by respondents

4.2.4 Method of household refuse disposal

One of the problems identified by the Medium Term Development Plan (MTDP) for the Keta Municipality is the indiscriminate disposal of liquid and solid waste which was also evident in this study. It was observed that, half of the households in this study dumped

their refuse on the beach, coast or open space within the wetland with just 5 households representing 10% engaging the services of waste management companies. 54 households representing 27% however dumped their refuse in dug pits with 26 households representing 13% using the communal refuse dump (Figure 13).

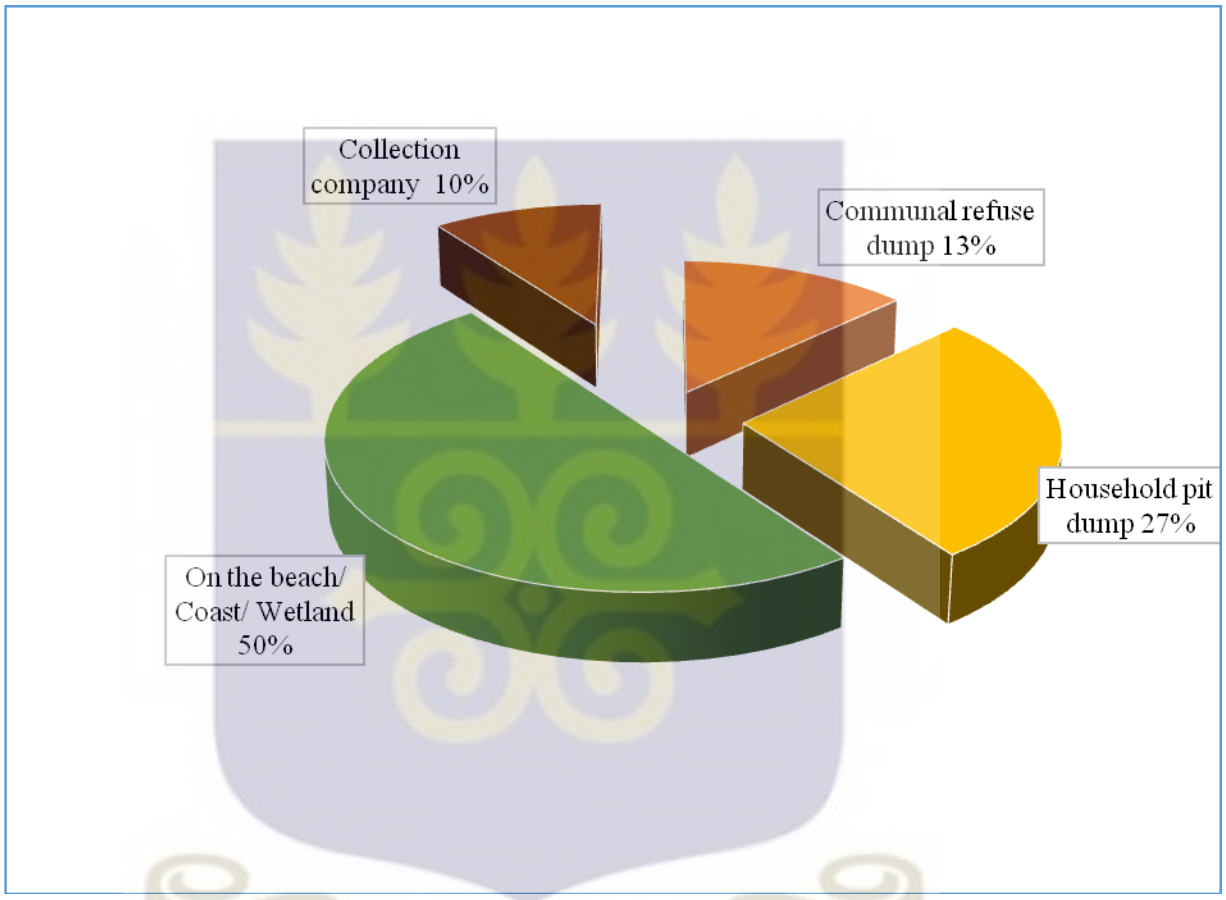

Figure 13: Method of disposal of household refuse dump

4.2.5 Sources of water for domestic use

Participants in the focus group discussion indicated that, the major sources of drinking water in the study area were pipe borne water from Ghana Water Company Limited (GWCL), boreholes with hand pumps, traditional hand dug wells and rain water harvesting.

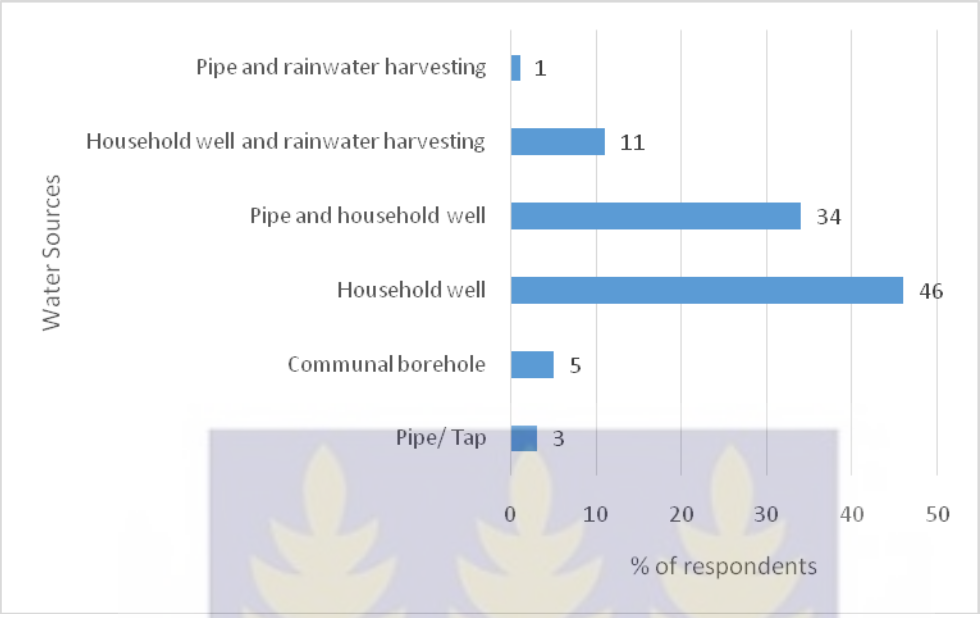

Figure 14: Sources of water for domestic use

From the household survey, it was observed that 92 households representing 46% of the respondents had traditional hand dug wells as the only source of drinking water with only six households representing 3% having only pipe borne water as the only source of their drinking water. 10 households representing 5% however used communal boreholes as their only source of drinking water. 68 households representing 34% had both pipe and traditional hand dug wells as their source of water whiles 22 representing 11% had both traditional hand dug wells and rain water (harvesting) as their source of drinking water. Only two households representing 1% used both pipe and rain water as their source of drinking water (Figure 14).

4.2.6 Type and source of fuel used by households

Almost all households in this survey made use of charcoal or fuel wood for cooking and for other energy needs (Figure 15). In total, 62% of the households make use of either charcoal or fuel wood. The use of Liquefied Petroleum Gas (LPG) for cooking was also

very common among the households as a total of 100 households representing 50% made use of it.

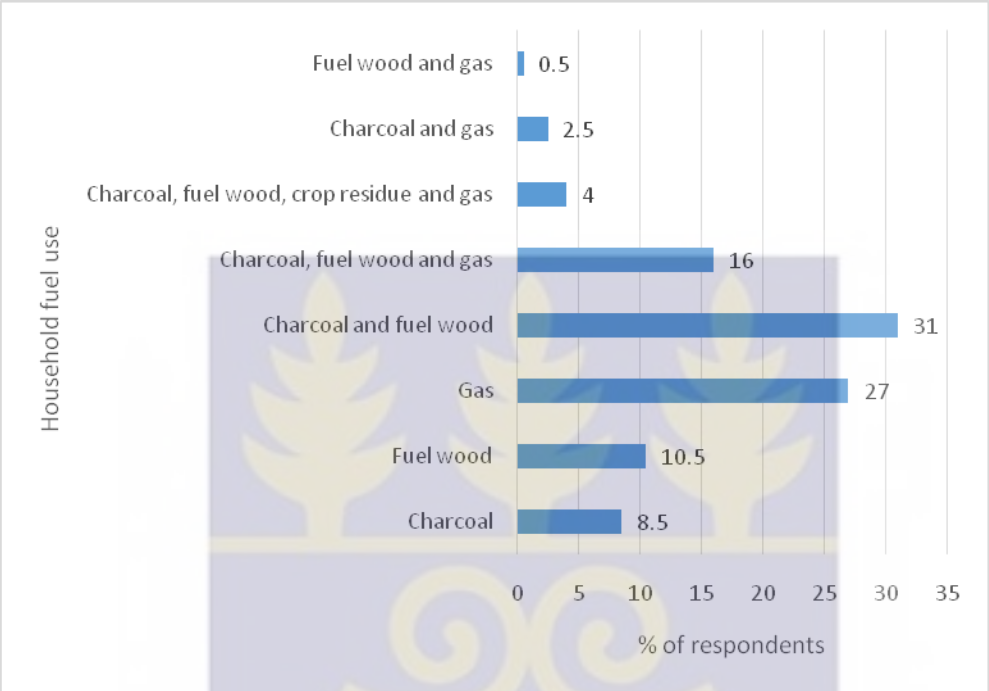

Figure 15: Type of fuel used by households

Out of the 200 households, 66 representing 23% made use of LPG together with other fuel types such as charcoal, fuel wood and crop residues with 27% using no other fuel apart from the LPG.

Out of the households that made use of either charcoal or fuel wood or both for their energy needs, it was observed that 31 of them representing 15.5% obtained them from the wetland. Two households representing 1% did not know the source whiles 115 representing 58% bought them from the market.

4.3 Awareness of Wetland Conservation and Climate change

4.3.1 Knowledge of respondents about wetland and Ramsar site

156 respondents representing 78% in this survey had various understandings about wetlands with the remaining 44 respondents representing 22% having no idea about what a wetland is. Table 5 shows the description given by various respondents for a wetland. Out of the 156 respondents 131 representing 65.5% said they had no knowledge about the protection of the wetland whiles the remaining 25 respondents representing 12.5% said they were aware that the wetland was under a kind of protection. With regards to the knowledge of respondents about a Ramsar site, 18 out the total 200 respondents said they were aware of the existence of a Ramsar site in the area with the remaining 182 respondents representing 91% saying they had no idea of what a Ramsar site is (Table 5).

Table 5: Respondents knowledge about wetlands

Knowledge about the Wetland	**Frequency**	**Percentage**
It is a land that is wet	32	16.0
It is a land that is flooded with water	70	35.0
It is the lagoon	25	12.5
It is a place we do fishing	29	14.5
I don't know	44	22.0
Knowledge about what a Ramsar Site is	**Frequency**	**Percentages**
A prohibited site for bird hunting	11	5.5
Habitat for birds	5	2.5
Not sure	3	1.5

Among the 18 respondents who said they were aware of the existence of a Ramsar site in the area, 11 of them representing 5.5% said it is a site where bird hunting is not allowed. 5 of them said it is a habitat for birds whiles the remaining 3 said they were not sure what it is.

4.3.2 Benefits Respondents derive from the Wetland

With regards to benefits obtained from wetland, 95 respondents representing 47.5% said the wetland provides them with a fertile land for farming as well serving as alternate grounds for fishing. 82 of the respondents representing 41% said the wetland only provide them with grounds for fishing purposes whiles seven respondents representing 3.5% said the wetland only serves as fertile grounds for farming. Three respondents representing 1.5% said they obtain Non Timber Forest Products (NTFPs) whiles six respondents representing 3% said they obtain fuel wood from the wetland (Table 6)

Table 6: Benefits respondents derive from the wetland

Benefit obtained from wetland	**Frequency**	**Percentage**
Source of fuel wood	6	3.0
Fertile land for farming	7	3.5
Fishing	82	41.0
Source of NFTPs	3	1.5
Fishing and flood control	7	3.5
Fishing and fertile land for farming	95	47.5
Total	200	100.0

4.3.3 Awareness of governments' rules and taboos governing the use of wetland

Just like the case of awareness about the existence of a Ramsar site in the study area, awareness about government rules and regulations governing the use of the wetland was very poor as 179 respondents representing 89.5% did not think there are government rules and regulations governing the use of the wetland whiles 21 respondents representing 10.5% thought there are government rules and regulations governing the use of the wetland.

In the case of awareness about traditional beliefs and taboos governing the use of the wetland, almost all the respondents were not aware of the existence of such beliefs and taboos in the area. This was confirmed by the focus group discussion and key informant interviews where participants also indicated that there are no taboos or beliefs governing the use of the wetland. They however disclosed that, in spite of this, some fishing communities within the municipality had set aside certain days of the week for rest but were not bound by any government rule or traditional beliefs and taboos. Only 28 respondents representing 14% said there was the existence of traditional beliefs and taboos in the area governing the use of the wetland. Table 7 shows the traditional beliefs and taboos mentioned by these respondents.

Table 7: Traditional Beliefs and taboos governing use of wetland

Traditional beliefs and taboos	**Frequency**	**Percentage**
No fishing on Sundays	12	6.0
No fishing on Thursdays	2	1.0
No fishing on certain days of the week	14	7.0

Among the 14% of respondents who recognized the existence of traditional beliefs and taboos governing the use of the wetland, 6% explained that, fishing on Sundays is prohibited, 1% explained that fishing on Thursdays was prohibited whiles the remaining 7% explained that fishing was prohibited on certain days of the week but were not very sure of the days.

4.3.4 Perception of respondents on key threats to the wetland

Even though the respondents in this survey had varying perception on key threats to the wetland, it was observed that almost all the respondents perceived irregular rains, droughts and bush burning as key threats to the wetland (Table 8). For the case of deforestation, 48 respondents representing 24% thought it was a key threat to the wetland. Many of the respondents however did not perceive soil erosion, waste disposal, algal bloom, farm encroachment, salt mining, housing and infrastructure as well as overgrowth of weeds as key threats to the wetland.

Table 8: Perception of respondents on key threats to the wetland

Key Threats	Frequency	Percentage
deforestation	48	24.0
Farm encroachment	34	17
Irregular rains	186	93
Bush burning	199	99.5
Soil erosion	15	7.5
Salt mining	5	2.5
Overgrowth of weeds	5	2.5
Algal bloom	1	0.5
Droughts	198	99.0
Waste disposal	13	6.5
Development encroachment	2	1.0
Housing/Infrastructure	9	4.5

4.3.5 Respondents Perception on key threat that have persisted over the past 10 years

Among the perceived threats to the wetland, almost all the respondents in this survey perceived droughts and irregular rains as threats that have persisted for more than 10 years whiles 64% and 20.5% of the respondents perceived farm encroachment and deforestation respectively as key threats that had persisted for more than 10 years (Table 9).

Table 9: Respondents' perception on key threats that have persisted over the 10 years

Key threats	Frequency	Percentage
Droughts	194	97
Irregular rains	191	95.5
Farm encroachment	128	64
Deforestation	41	20.5

4.3.6 Respondents Perception of key threats that have persisted for the past 5 years

For perception on key threats to the wetland that have persisted for the past five years, 176 respondents representing 88% mentioned application of fertilizer and other agro chemicals whiles 22 respondents representing 11% mentioned household waste disposal. Two respondents representing 1% however mentioned soil erosion (Table 10).

Table 10: Respondents Perception of key threats that have persisted for past 5 years

Key threats	Frequency	Percentage
Erosion	2	1.0
Application of fertilizer/Agro chemicals	176	88.0
Household waste disposal	22	11.0

4.3.7 Perception of respondents on land cover change of the wetland

Out of the total respondents in this survey, 179 representing 89.5% perceived that the land cover of the wetland has changed whiles 21 respondents representing 10.5% perceived there had been no changes in the bare surface of the wetland. Among the 179 respondents who perceived changes in the bare surface of the wetland, 157 of them said

the bare surface had increased whiles 22 respondents said the bare surface had decreased (Table 11).

Table 11: Perception of respondents on change in the bare surface of the wetland

Changes in bare surface of the wetland	**If Yes has it increased or decreased**			**Total**
	Increased	Decreased	Not applicable	
Yes	157	22	0	179
	87.7%	12.3%	0.0%	100.0%
No	0	0	21	21
	0.0%	0.0%	100.0%	100.0%

4.3.8 Perception of respondents on the causes of land cover change of the wetland

Most of the respondents in this survey had attributed farm encroachment and household pollution due to waste disposal as the causes of the changes in the land cover of the wetland. 143 respondents representing 71.5% perceived farm encroachment to be the cause of the land cover change whiles 101 representing 50.5% perceived household pollution due to waste disposal as the cause of the land cover change of the wetland (Table 12). Perception of respondents on increased invasive species, sediment load, increased infrastructure as well as use of agro chemicals as the causes of land cover change of the wetland was however very low.

Table 12: Perception of respondents on the causes of land cover change of the wetland

Perception on cause of land cover change	Frequency	Percentage
Farm encroachment	143	71.5
Household pollution due to waste disposal	101	50.5
Increased cash crop farming	3	1.5
Increased housing	17	8.5
Increased infrastructure	44	22
Sediment load	7	3.5
Increased invasive/ alien species	20	10.0
Use of agro chemicals	3	1.5

4.3.9 Climate change awareness

Climate change awareness among respondents in this survey was very high as out of the 200 respondents, 144 representing 72% had heard about climate change with just 56 respondents representing 28% having no idea about climate change (Table 13). With regards to the relationship between educational level of respondents and their awareness about climate change, it was observed that all the respondents who had education up to the tertiary level education had heard about climate change whiles out of the 59 respondents who had no formal education only 12 had heard about climate change. The respondents in this survey who said they had heard about climate change however had varying understanding. Table 14 illustrates what they understood by climate change.

Table 13: Formal education of respondents and climate change awareness

	Have you ever heard about climate change		**Total**
Level of education	**Yes**	**No**	
Primary	35	8	43
JHS	43	0	43
SHS / Vocational	35	1	36
Tertiary	19	0	19
None	12	47	59
Total	144	56	200

Table 14: Knowledge of respondents about climate change

What is climate change	**Frequency**
It is the changes in the rainfall	7
it is Low rains	33
it is irregular rains	18
High temperatures	13
Droughts	1
Changes in the weather conditions	36
Changes in seasons	24
No idea	8
It is caused by eclipse	1
Changes in environment	1
Changes in atmospheric condition	2
Total	144

4.3.10 Available Source of climate change information

Among the respondents who had heard about climate change in this survey, a total of 141 representing 70.5% of them received climate change information from either radio or television (Table 15). Only one respondent said he received climate change information from the wildlife extension officers' whiles only two respondents received such information from family and friends. Meanwhile, the Wildlife Division of the Forestry Commission (WD/FC) and the Agricultural extension office whom as part of their mandate is to promote environmental awareness in the area in a key informant interview however mentioned the lack of adequate staffing and low allocation of budget as key challenges faced by the institutions. The WD/FC however indicated that, although the ATIDEV initiative and the Netherland Development Organization (SNV) had no offices in the study area, these two NGOs are currently carrying out projects in the area. Incidentally, none of the respondents mentioned that, they received climate change information from NGOs and this is consistent with the information provided by participants in the focus group discussion that, there are no environmental NGOs in the area.

Table 15: Available source of climate change information

Source of climate change Info.	Frequency	Percent
TV	1	0.5
Radio	34	17.0
Wild life extension officers	1	0.5
Family	1	0.5
Both TV and radio	106	53.0
Both family and friends	1	0.5
Total	144	72.0

4.3.11: Respondents observation on changes in climatic conditions over the past the 20 years

The respondents in this survey had various observations about changes in climatic conditions. In total, it was observed that, 190 respondents representing 95% had observed low rains whiles 134 respondents representing 68.5% had observed prolonged droughts. 64 respondents representing 32% had also observed high temperatures with only three respondents representing 1.5% having observed low temperatures. Just two respondents representing 1% had observed changes in timing of rains (Table 16).

Table 16: Observed changes in climatic conditions over the past 20 years

Observed changes climatic conditions	Frequency	Percentage
Low rains	58	29.0
Changes in timing of rainfall	2	1.0
Low temperatures	3	1.5
Both low rains and prolonged droughts	68	34.0
Low rains, high temperatures and prolonged droughts	64	32.0
Heavy rains and prolonged droughts	5	2.5
Total	200	100.0

4.3.12 Traditional weather predictions and its effectiveness

Almost all respondents in this survey use clouds formation to predict rains. Other weather prediction index used by respondents to predict rains includes high temperatures, strong winds as well as lightning and thunder storms.

For the effectiveness of the traditional weather predictions, 51 respondents representing 25.5% said it was not effective. 110 respondents representing 55% said it was almost effective whiles 22 respondents representing 11% said it was effective. Nine respondents representing 5% however said it was very effective whiles seven respondents representing 3.5% said it was extremely effective (Table 17).

Table 17: Traditional weather predictions and its effectiveness

Weather prediction Index	Rank assigned by respondents for effectiveness as a predictor of weather patterns on the scale of (1)Not effective – (5)Most effective					Total
	Not effective	Almost effective	Effective	Very Effective	Extremely effective	
Clouds formation for rains	51	106	17	7	7	188
	27.1%	56.4%	9.0%	3.7%	3.7%	100.0%
Strong winds for rains	0	0	1	0	0	1
	0.0%	0.0%	100.0%	0.0%	0.0%	100.0%
High temperatures for rains	0	1	0	0	0	1
	0.0%	100.0%	0.0%	0.0%	0.0%	100.0%
Both clouds formation and strong winds for rain	0	3	3	3	0	8
	0.0%	37.5%	37.5.0%	25.0%	0.0%	100.0%
Lightning and thunder storm	0	0	1	0	0	1
	0.0%	0.0%	100.0%	0.0%	0.0%	100.0%
None	0	0	0	0	0	1
	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%
Total	51	110	22	10	7	200
	25.5%	55.0%	11.0%	5%	3.5%	100.0%

4.4 Exposure, perceived effects and vulnerability to climate change related events

4.4.1 Perception of respondents on the causes of changing climatic conditions

Respondents in this survey had varying perceptions on the causes of changing climatic conditions. 134 out of the 200 respondents perceive deforestation as the cause whiles 87 out of the 200 perceived the burning of fossil fuel as the cause. 83 respondents perceived the use of agro chemicals as the cause whiles 158 respondents cited the proliferation of boreholes and irrigation farming in the area as the cause. 72 respondents however perceived enraged gods as the cause of the changing climatic conditions with only 40 respondents having the perception that, the changing climatic condition is natural. 69 respondents however perceived it was caused by both natural phenomena and human activities (Table 18).

Table 18: Perception of respondents on the causes of changing climatic conditions

Perceived Cause of changing climatic condition	**Frequency of respondents**
Deforestation	134
Burning of fossil fuel	87
Enraged gods	72
Proliferation of boreholes and irrigation farming	158
Use of agro chemicals	83
Industrialization	84
Natural causes	40
Both human and Natural causes	69

4.4.2 Perception on household exposure to key climatic hazards

All households in this survey perceived they had been exposed to one climatic hazard or the other as illustrated in Table 19 above. Of the total respondents, 55.4% said they had

been exposed to sea level rise, 35.7% of them said they had been exposed to coastal erosion whiles 37.5% said they had experienced salt water intrusion into their gardens. Salt water intrusion into wells was said to have been experienced by 58.6% of the respondents whiles changes in rainy season leading to changes in planting season are said to have been experienced by 40.8% of the respondents. As high as 89.9% of the respondents said they had experienced droughts with just 24.8% of the respondents saying they had been exposed to flooding.

Table 19: Households exposure to key climatic hazards

Climatic Hazards	**Frequency**	**Percentages**
Sea level Rise	87	55.4
Coastal erosion	56	35.7
Salt water intrusion into gardens	59	37.5
Salt water intrusion into wells	92	58.6
Changes in rainy season leading to changes in planting season	64	40.8
Droughts	140	89.2
Floods	39	24.8

4.4.3 Perception on household vulnerability to key climatic hazards

The perceived level of vulnerability to key climatic hazards that the respondents in this survey are exposed to is illustrated in Table 20 above. Most of the respondents who are exposed to sea level rise, droughts and salt water intrusion into gardens perceived they were highly vulnerable. In the same way, almost all respondents who had experienced

reduced crop yield and dwindled fish catch also perceive their vulnerability to be high. This was confirmed in the focus group discussion where participants in the discussion explained that, they had no alternate livelihood outside fishing and farming and hence their high vulnerability.

Table 20: Perception on household vulnerability to key climatic hazards

Household vulnerability to key climatic hazards	**Level of vulnerability**			**Total**
	Low	**Medium**	**High**	
Perception on vulnerability to sea level rise	30	20	37	87
	34.5%	23%	42.5	100%
Perception on vulnerability to coastal erosion	19	19	18	56
	34%	34%	32%	100%
Perception on vulnerability to salt water intrusion into gardens	8	23	28	59
	13.6%	39%	47.4%	100%
Perception on vulnerability to salt water intrusion into wells	54	18	20	92
	58.7%	19.6%	21.7	100%
Perception on vulnerability to droughts	6	23	111	140
	4.3%	16.4%	79.3%	100%
Perception on vulnerability to floods	20	14	5	39
	51.2%	35.8%	12.8%	100%
Perception on vulnerability to dwindled fish catch	19	8	126	153
	12.4%	5.2%	82.4%	100%
Perception on vulnerability to Reduced crop yield	2	32	93%	127
	1.6%	25.2%	73.2%	100%

More than 50% of the respondents who said they were exposed to salt water intrusion and flooding however perceived their vulnerability to those hazards to be low. With regards to the vulnerability to coastal erosion, there was a split as 34% of the respondents who were exposed to this hazard said their vulnerability was low with 32% of them saying their vulnerability was high (Table 20).

4.4.4 Perception of respondents on the impacts of climatic hazards on Relevant Sectors

All the respondents in this survey agreed that, climatic hazards have had negative impacts on either Agriculture, human health or on livelihoods. With regards to agriculture, 63.5% of the respondents said they had experienced reduced crop yield, 76% said they had experienced dwindled fish catch whiles 11% said they had experienced increased death of livestock. 27% of them however said they had experienced increased pest and diseases (Table 21). With regards to human health, 55% of the respondents indicated they had experienced increased mosquitoes in their homes. 38% of the respondents indicated they had experienced a reduction of NTF

Table 21: Respondents perception on the impacts of climatic hazards on Relevant Sectors

Agriculture	**Frequency**	**Percentage (%)**
Reduced crop yield	127	63.5
Dwindled fish catch	152	76.0
Increased death of livestock	22	11.0
Increased pests and diseases	54	27.0
Human Health and livelihood		
Increased mosquitoes	110	55.0
Reduced Non Timber Forest Products (NTFP)	76	38.0

4.5. Coping strategies and Adaptation Capacity

4.5.1 Access and Available source of early warning system

124 respondents representing 62% in this survey had access to early warning systems with the rest having no access to such systems. The available source of climate change information in the study area is dominated by the radio and the two radio stations accessible to the community are Radio Jubilee and Hogbe radio. It was observed that, out of the 124 respondents, 107 said they obtained climate change information from the radio with only eight respondents saying they obtained such information from the TV. Four respondents used personal observation whiles only one respondent said he obtained such information from his religious leader (Table 22)

Table 22: Access and available source of early warning system

Access to early warning system	**Frequency**	**Percentage (%)**
Yes	124	62.0
No	76	38.0
Available Source of early warning Info.	**Frequency**	**Percentage (%)**
Radio	107	53.5
Television	8	4.0
Friends	4	2.0
Religious leader	1	0.5
personal observation	4	2.0

4.5.2 Coping strategies against potential climatic hazards

Table 23: coping strategies against climatic hazards

Protection of economic sectors from potential climatic hazards	Frequency	Percentage
Proper timing in Agriculture, fishing and salt mining	115	57.5
New improved seeds, agrochemicals and agricultural practices	58	29.0
Irrigation farming	58	29.0
Increasing farm sizes	5	2.5
Identifying alternative water sources for livestock	18	9.0
Identifying new fishing grounds	31	15.5
Diversifying income sources	36	18.0
Doing nothing special	80	40.0

Table 23 above indicates the coping strategies adopted by respondents in this survey against potential climatic hazards. 57% of the respondents who included farmers, fishermen and salt miners said they practiced proper timing of weather with planting crops, going for fishing and engaging in mining activities respectively. 29% of the respondents said they used new improved seeds and agrochemicals which were readily available in agro shops on the market as well as engaging in improved agricultural practices such as mixed cropping and crop rotation to minimize the risk of disease and pest infestation. Only 2.5% of the respondents resorted to increasing the sizes of their farms as a coping strategy. 28% of the respondents who do fishing said they searched for new fishing grounds as a coping strategy. From the focus group discussions, it was disclosed that, fishermen traveled to far places especially during severe droughts to

identify new fishing grounds. 18% of the respondents were into diversification of income sources as a coping strategy, whiles 40% did nothing special to cope with the potential climatic hazards.

4.5.3 Views of respondents on community's plans to deal with climatic hazards

With regards to the community's plan or readiness to deal with climatic hazards, a total of 70.5% of the respondents said they did not think the community had such plans in place and out of this, 11% were in strong disagreement. Only a total of 22.5% of the respondents had the view that the community had plans in place to deal with climatic hazards (Figure 16).

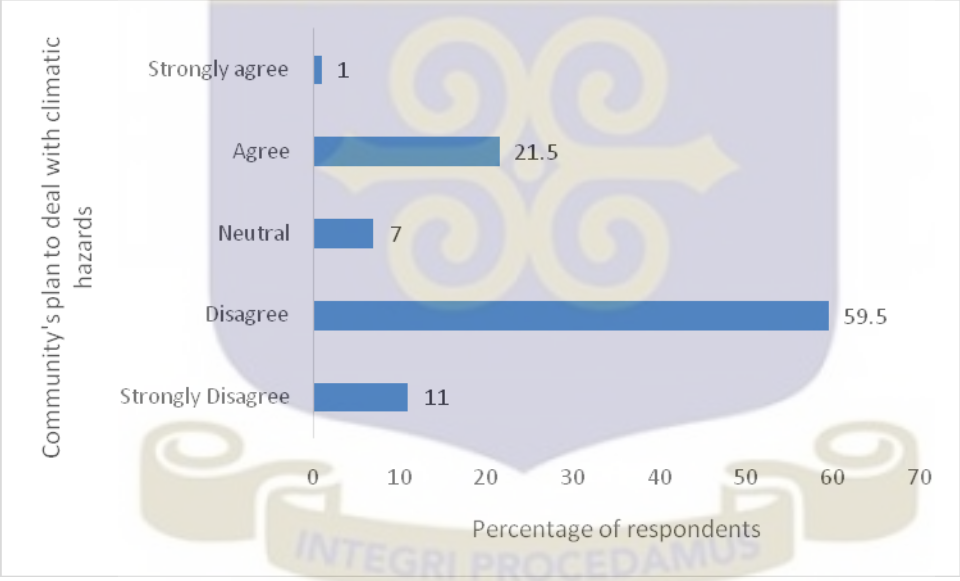

Figure 16: Available plans by community to deal with climatic hazards

4.5.4 Views of respondents on community's ability to reorganize to respond to new situations

A total of 76% of the respondents had the view that, the community did not have the ability to reorganize itself to respond to new situations resulting from climatic hazards

with only 6.5% of the respondents having the view that the community has the ability to reorganize to respond to new situations (Figure 17).

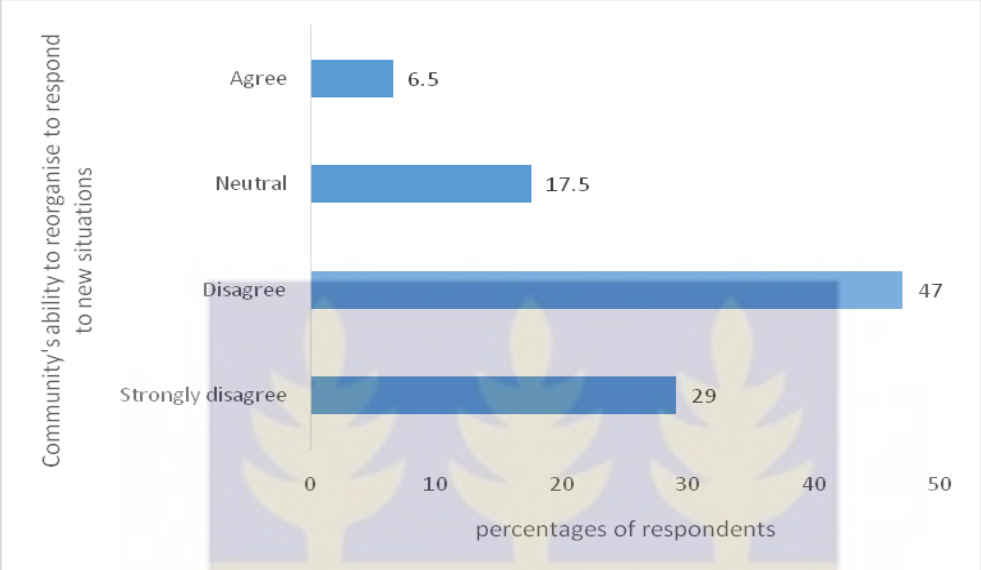

Figure 17: Community's ability to reorganize to respond to new situations

4.5.5 Views of respondents on community's access to institutional support to reorganize to cope with new situations or problems

A total of 73.5% of the respondents did not think the community had access to institutional support to reorganize to respond to new situations with only 15.5% with the view that the community had access to institutional support. The high percentage of respondents who disagreed was confirmed in a key informant interview with the National Disaster Management Organization (NADMO) who disclosed that, the institution did not have a car allocated for its activities within the district. The organization also cited inadequate relief items and logistics as major challenges (Figure 18).

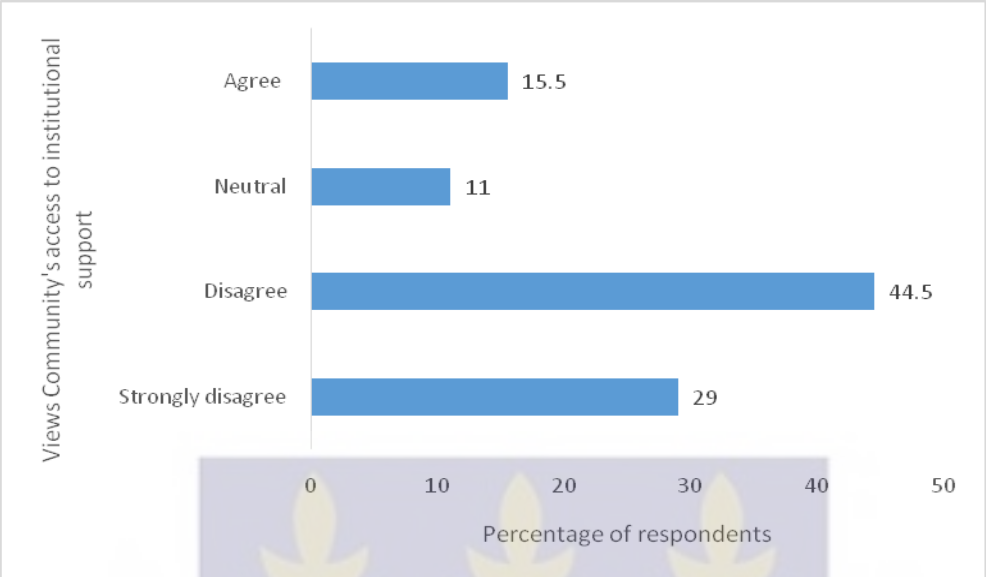

Figure 18: Views on community's access to institutional support

4.5.6 Ability of community members to work well with each other

On the ability of the community members to work well with one another, a total of 56% of the respondents thought the community members did not work well with each other whiles 37.5% of the respondents were of the view that, members of the community work well with each other (Figure 19).

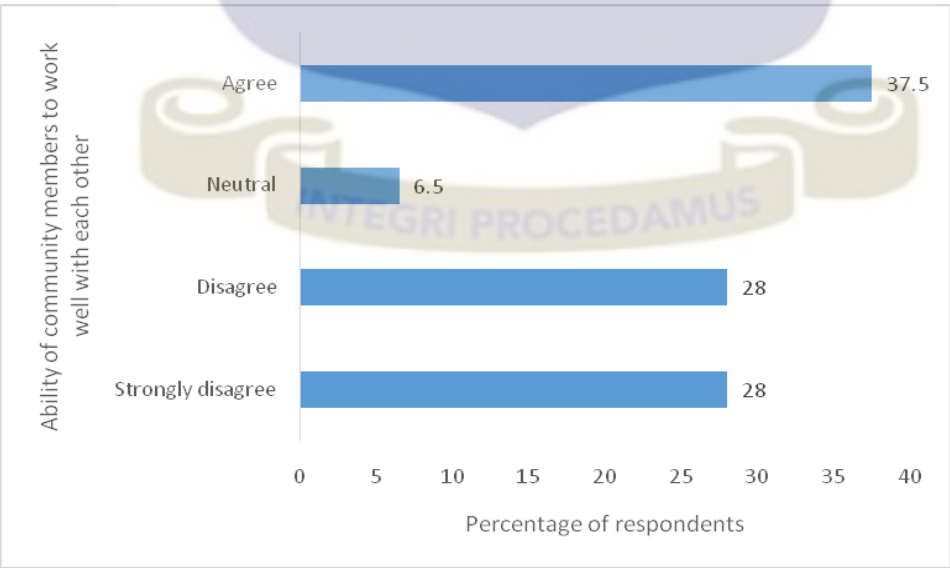

Figure 19: Views of Community's ability to work well with one another

4.5.7 Views on the community's ability to access outside support when needed

A total of 79.5% of the respondents said they did not think the community had access to outside support when needed with only 12.5% of the respondents having the view that the community had access to outside support when needed (Figure 20).

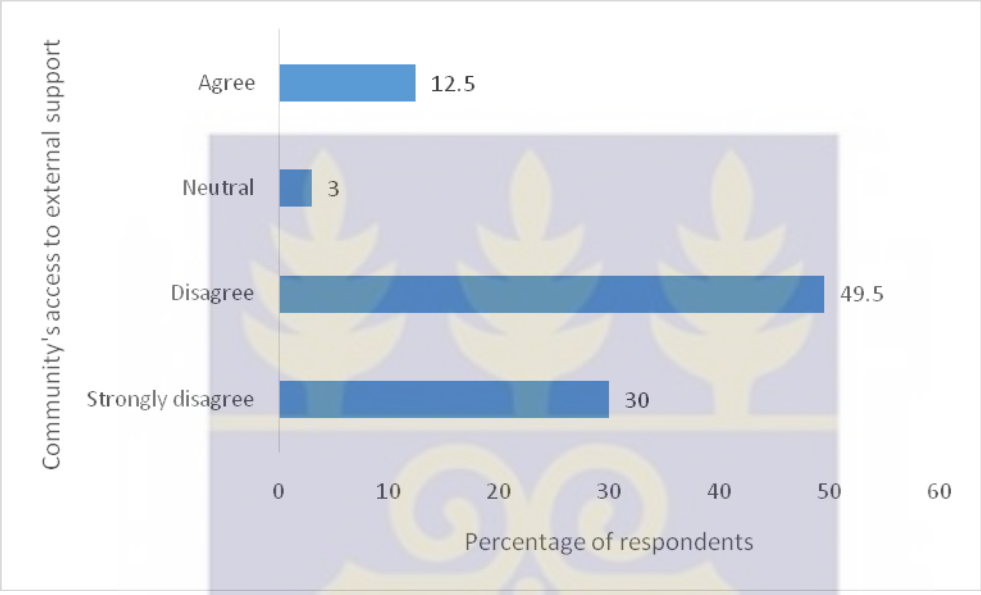

Figure 20: Community's ability to work well with one another

4.6 Secondary Data

4.6.1 Rainfall pattern of the study area from 1961-2010

The weather station closest to the study area was the Ada sub-station of the Ghana Meteorological Agency (GMet). Thus, proxy climatic data used for the work was that of Ada rainfall data from 1961 to 2010.

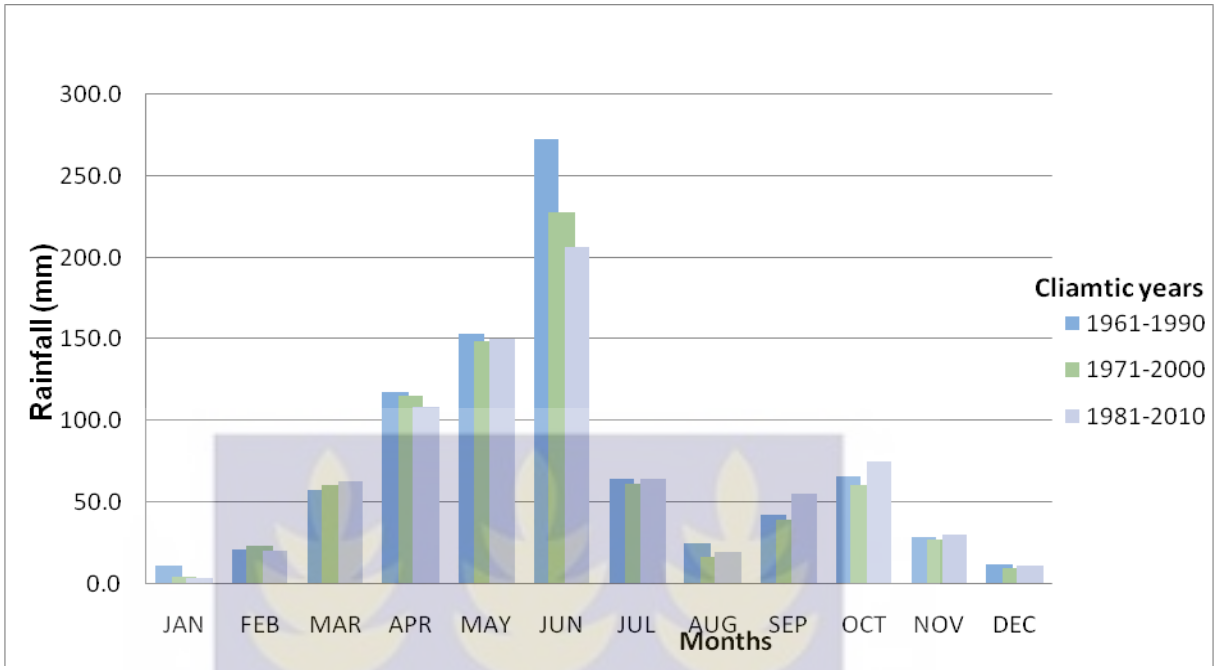

Figure 21: Proxy rainfall data from 1961-2010 obtained from the Ada weather station (source: Ghana Meteorological Agency

The rainfall regime of the area is bi-modal that is, it has double rainfall maxima, reaching its first peak in June and the second in October (Figure 21). December, January and February constituted dry periods with less moisture whiles rainfall began to decline from July and reached its lowest in August which is referred to as the 'little dry season.' It then began to rise in from September reaching another maximum referred to as the 'lean season' in October. From this point the amount of rainfall fell from November to February reaching its driest in January.

Record keeping began in this station in 1961. Three climatic seasons were therefore derived, 61-90, 71-2000 and 81-2010 (which is the WMO's standard period to represent present climate) (Warburton and Schulze, 2006). From the Figure, it is seen that, there is little significant changes in rainfall pattern over the period and a careful observation of

the graph shows that the last climatic season, 1981-2010, rainfall levels in the main season had been reducing while the lean season rains had been increasing. Thus, it can be inferred that it rains heavily now in the lean season as compared to the two previous climatic seasons.

4.6.2. Temperature records of the Study area from 1961-2010

The hottest month in the area is March, where average temperature reaches its maximum, and the coldest months are August. This is evident in all the three climatic seasons. It then began to rise sharply from August to November where another peak was reached and began to fall from November through to January during the harmattan.

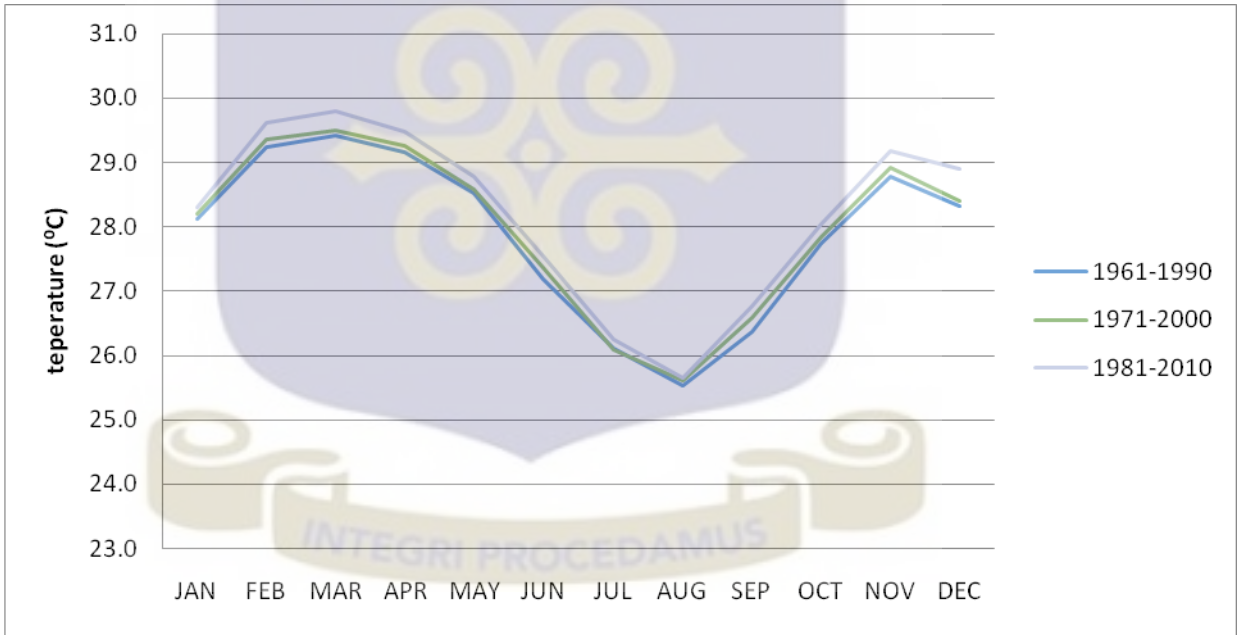

Figure 22: Proxy temperature data from 1961-2010 obtained from the Ada weather station (source: Ghana Meteorological Agency)

4.6.3 Land cover changes of the Wetland

From the time series data on the land cover change of the keta lagoon (Tables 24 and Figure 23), the dense very active bushes which covered 31.3% of the total wetland in 1990 decreased to 23.9% in 2000 and to 18.2% in 2010 with a total decrease of 12,100.3 hectares representing 13.16% of the total land cover of the wetland from 1990 to 2010. In the same way, the shrub or herbaceous cover which was 15.1% of the total wetland in 1990 however decreased to 13.4% in 2000 and to 7.6% in 2010 with a total decrease from 1990 to 2010 of 6,949.71 hectares representing 7.56% of the total land cover of the wetland. The grass cover which however occupied 8.6% of the wetland in 1990 increased to 14.8% in 2000 and to 17.2% in 2010 with a total increase from 1990 to 2010 of 7884 hectares representing 8.57% of the total land cover of the wetland.

Table 24: Land cover of the wetland from 1990-2010

Habitat type	**1990**	**1990 (%)**	**2000**	**2000 (%)**	**2010**	**2010 (%)**
Dense very active bushes	28819.53	31.34	21952.26	23.87	16719.21	18.18
Shrub/herbaceous/grass	13952.34	15.17	12323.79	13.40	7002.63	7.61
Grass cover	7947.63	8.64	13632.48	14.82	15831.63	17.21
Bare surface/built up area	6641.73	7.22	8334.72	9.06	15963.93	17.36
Water Body	34594.32	37.62	35712.3	38.83	36438.15	39.62
Total	91955.55	100	91955.55	100	91955.55	100

The bare surface or built up area increased from 7.2% in 1990 to 9% in 2000 and then to 17.4% in 2010. The total increase from 1990 to 2010 was 9322.2 hectares representing 10.14% of the total land cover of the wetland. There was also an increase in the land cover of the water body from 37.6% in 1990 to 38.8% in 2000 and then to 39.6% in 2010

with a total increase from 1990 to 2010 of 1843.83 hectares representing 2% of the total land cover of the wetland.

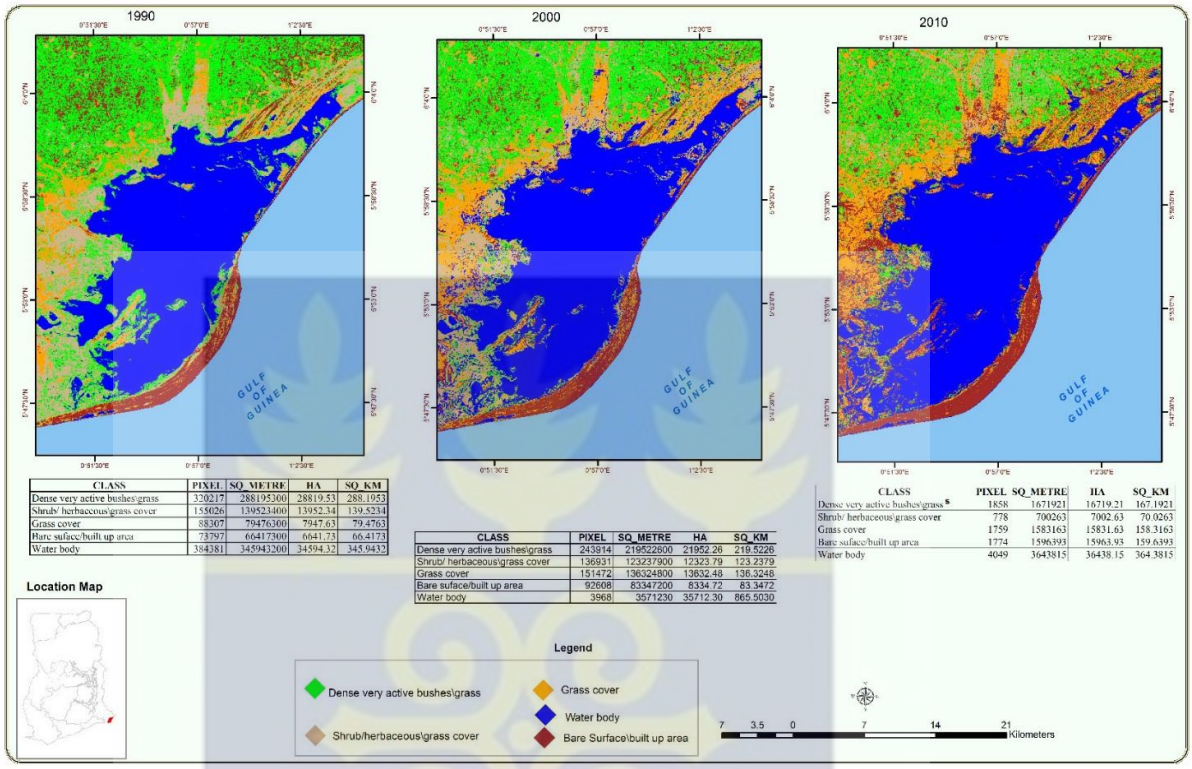

Figure 23: Vegetation cover lagoon using classified satellite images of the Keta lagoon from 1990-2010

Table 25: Changes in vegetation cover of the Wetland from 1990-2010

Habitat type	Changes in habitat type (Ha)		Total changes (Ha and %)	
	1990-2000	2000-2010	1990-2010	Percentage (%)
Dense very active bushes	-867.27	-5233.05	-12100.3	13.16
Shrub/herbaceous/grass	-628.55	-5321.16	-6949.71	7.56
Grass cover	5684.85	2199.15	7884	8.57
Bare surface/built up area	1692.99	7629.21	9322.2	10.14
Water Body	1117.98	725.85	1843.83	2

CHAPTER FIVE

DISCUSSION OF RESULTS

5.1 Awareness of Climate Change and Perception of Threats on Livelihood

Literature recognizes that prior experience and knowledge about climate change can decrease vulnerability by increasing awareness of potential impacts. This awareness often spurs greater planning and preparedness for climate changes and sea-level rise impacts (Burton *et al.*, 1978; Barnett 2001; Smit and Pilifosova 2003; Dolan and Walker in press). From this study, it became obvious that, community members were aware of climate change even though their understanding about it falls short of the technical definition by the UNFCCC and the IPCC (section 4.3.8). They understood climate change as changes in climatic conditions such as rainfall, temperature and seasonal changes. The high level of awareness about climate change may have been due to their geographical location and hence their past experiences about climatic hazards such as sea level rise and coastal erosion might have helped to get them informed about it.

Most of the respondents representing a total of 70.5% had their source of knowledge about climate change from either radio or television (Table 4.14). This indicates generally that the community members have access to information. Only one respondent said he received his climate change information from the Wildlife extension officers indicating that, not much is being done by the institution and other institutions like the Ministry of Food and Agriculture, the National Disaster Management Organization as well as environmental NGOs in the area of climate change and disaster risk awareness creation among community members. This might be due to the low number of staff and financial constraints faced by these institutions. It might also be due to the low presence of NGOs

in the community as only two environmental NGOs namely ATIDEV initiative and the Netherland Development Agency (SNV), are known to be working closely with the WD/FC in projects such as Ecosystem Restoration and the promotion of Efficient Cooking Stoves respectively. Because these NGOs are operating from outside the community, it is also likely that, the planning and implementation of their projects take the top down approach without much involvement of the community members and hence reducing the impacts of their projects.

Through Focus Group discussions and household surveys, community members mentioned, threats of reduced crop yield and dwindled fish resources, increased death of livestock and increased pest and diseases as persisting and emerging threats of climate change on their livelihood and this is confirmed by (Daufresne *et al*., 2003; Genner *et al*., 2004; Olesen *et al*., 2006). They also mentioned increased malaria incidences as a result of increased prevalence of mosquitoes and in confirmation to this, a report from the Municipal Health Directorate indicates malaria is ranked number one among the top ten diseases in the municipality. According to the report, there has been an increase in malaria incidence from 6.8% in 2012 to 11.9% in 2013. The increasing trend of incidence of malaria may be as a result of increased number of hand dug wells meant for irrigation which in most cases are left uncovered hence serving as breeding grounds for mosquitoes. Contrary to the perception of the community members on increase in malaria incidence as an impact of climate change, Kovats and Haines, (2005) observed that, there is no convincing evidence of the impacts of observed climate change on coastal disease patterns.

5.2 Geophysical Vulnerability of the Anloga Community

5.2.1 Remoteness

From literature, remoteness and isolation location of communities may contribute to their vulnerability. This is largely attributed to the accessibility of services such as health care, availability of supplies and services in emergency situations such as food, electricity and emergency response capabilities such as emergency planning (Armstrong and Read 2002, Dolan and Walker in press). For the case of Anloga community, there is a supply of electricity, pipe borne water and also the availability of emergency planning and response institutions such as the National Disaster Management Organization, the National Fire Service as well as the National Ambulance Services. Even though the activities of emergency planning and response institutions is to reduce the vulnerability of the community, they are however faced with challenges such as lack of logistics and relief items, lack of technical staff as well as financial challenges as indicated in key informant interviews These might affect the ability of these institutions to respond to emergency situations and also to provide relief to disaster victims.

5.2.2 Geographical Sensitivity and Exposure

The physical environment of the Anloga community is identified as being 'highly sensitive' and exposed to climatic hazards due to its geographical location (IPCC, 2013). A large part of the community is covered by the lagoon and the sea (Figure 3) with many households living close to these water bodies hence predisposing settlements in this area to natural hazards. According to Stern (2006), an increase in temperature by 3^0C or 4^0C will result in millions of people being displaced by flooding whiles IPCC (2013) projects an increased incidence of adverse impacts such as submergence, coastal flooding and

coastal erosion on coastal systems and low-lying areas. Nevertheless, conditions of housing in the study area show that, most of the houses are constructed of cement with aluminium roofing sheets. This enhances the community's resilience to potential climatic hazards such as coastal flooding and wind storm.

While it was this geographical sensitivity that initially drew the research to this area, other attributes related to environmental "sensitivity" such as severe droughts and salt water intrusion into gardens and wells were also mentioned in the household survey and focus group discussion. This was confirmed by the World Fish Center, (2007) where they observed that, higher sea levels may lead to salinization of groundwater, which is detrimental to freshwater fisheries, aquaculture and agriculture and limits industrial and domestic water uses. Along with the negative consequences, the World Fish Center (2007) also indicates that benefits in the form of increased areas suitable for brackish water culture of high-value species such as shrimp and mud crab will be obtained. Building people's capacity to recognize and take advantage of such opportunities can play an important role in maintaining household livelihoods.

The community members also mentioned, they had observed changes in planting season due to changes in the rainy season and these claims were confirmed by the rainfall data which indicated an increased rain in the lean season in recent climatic years (1961 to 2010) than in the previous climatic years.

5.3 Socio-Economic Vulnerability and adaptive capacity of the Anloga community

5.3.1 Social Capital

Social capital can be a measure of formal networks such as, communication between governing bodies, and informal networks such as support systems, kinship relations and community groups (Watts and Bohle 1993, Yohe and Tol 2002, Adger 2003a, Mendis*et al.* 2003). In many societies, formal and informal networks contribute greatly to preparedness, response, and recovery. Knowing the availability and quality of these networks could help gauge a community's adaptive capacity, as these networks will provide security during times of change (shelter during disasters, financial support, and basic social support during difficult times).

Through the household survey and the focus group discussion, it was observed that community members were not aware of any existing NGOs or support groups within the community. Through the key informant interview it was also observed that, the only existing committee was the turtle watchdog committee which is to monitor and help reprimand people who engage in the illegal hunting of turtles. This committee was not active as they do not receive any outside support. To assess the adaptive capacity of respondents, it was observed through household surveys that, 70% of the respondents believed the community had no plans in place to deal with climatic hazards whiles 76% of the respondents also believed that the community did not have the ability to reorganize itself to respond to new situations resulting from climatic hazards. With regards to the community's access to institutional support, 73.5% of the respondents believed the community did not have such support whiles another 79.5% of the respondents believed the community members did not have access to outside support when needed. All this

translates into low adaptive capacity as explained by Watts and Bohle 1993; Tobin 1999; Yohe and Tol 2002; Adger 2003a; Mendis*et al.* 2003 and Dolan and Walker in press that, associations and partnerships help to strengthen adaptive capacity through better community planning and cohesion. There was however the existence of strong cultural and social relations among community members and as observed in the survey, 56% of the respondents believed the community members were able to pull together in times of need.

5.3.2 Experience with Hazards and change

Literature indicates that, prior experience with hazards can decrease vulnerability by increasing awareness of potential impacts (Wongbusarakum and Loper, 2011). Even though, older people are often taken as one of the most vulnerable demographic groups, they may have lived through climate hazards and hence would have developed coping mechanisms that give them more resilience than other age groups.

Through the household survey, it was observed that 67% of the respondents were above the ages of 41 years. Contrary to literature, the dynamics of the respondents in this survey does not necessarily translate into experience and development of coping strategies as 40% of the respondents in this survey said they did nothing special to cope with climatic hazards whiles 57.5% said they practice proper timing in their agricultural and fishing activities.

5.3.3 Population Trend and Equity in the use of Resources

According to Townsend *et al.,* 1988; Cutter *et al*., 2000; Tapsell *et al.,* 2002; Wu *et al.,* 2002, small populations may create economic disadvantages whiles high population

density may increase difficulty in evacuation. Wongbusarakum and Loper, (2011) also indicates that high equity in the use of resources translates into high adaptive capacity and hence decreases vulnerability.

Respondents in the household survey and focus group discussions observed an increase in population of the community which was confirmed by the data from the Ghana Statistical Service. The respondents also observed that the increase in population had resulted in increased pressure on fish resources within the community. This had resulted in an increase in the use of illegal fishing methods and a decrease in access to farmland coupled with cumbersome procedures to land acquisition. The Ministry of Fisheries and Aquaculture indicated that, the high pressure on the fish resources might have resulted in the local extinction of fish species such as grouper, barracuda,*Caranyx sp* and the yellow finned tuna. It was also observed from the focus group discussions and the key informant interviews that there was no gender difference in the use of resources. There was also no difference in the way people from different religions as well as natives and non-natives used the wetland resources.

5.3.4 Education

Education is assumed to be an element that strengthens both individual and community adaptive capacity, as education can be an important determinant of risk awareness and employment and income, which can increase one's ability to adjust to economic changes (Blanchard-Boehm and Cook, 2004; Holman and Nicol, 2004;Degg and Homan, 2005).

From the household survey and the key informant interviews, it was observed generally that the educational level of respondents was low as only a total of 27.5% of them had

attained Senior High (SHS) and Tertiary level of education. A total of 43% had primary education and Junior High level with 29% of the respondents having no formal education at all. The low level of formal education among community members may be either due to financial reasons or due to low academic performance. Apart from the low level of formal education, it also became evident from the focus group discussions that, the informal skills set within the community were very low which may also have reduced their adaptive capacity.

5.3.5 Health

Limited health care services points to a lower health status, which may contribute to local vulnerability (Armstrong and Read, 2002; Herring, 1995). Wisner 1998, Shaw *et al.*,2001, Leichenko and O'Brien, 2002; Tapsell *et al.*,2002 also indicates that, the potential impacts to health care centers and the current state of health also translate into vulnerability.

Residents of Anloga community had access to both a private clinic and a Public Health Care Centre for health care services. The operations of the National Health Insurance Scheme (NHIS) in these clinics and the district hospital had enabled community members to have access to affordable healthcare services. Even though there was no established relation between increased malaria incidence and climate change, the increasing number of hand dug wells within the community to help farmers adapt to severe droughts could spiral malaria incidences within the community and hence continuing to be the number one threat to the community.

5.3.6 Social Relations

Social relations was identified as an attribute of vulnerability as large families may be difficult to track in emergency situations whiles strong social ties may strengthen community support and the ability of people to work together (Watts and Bohle 1993; Bohle*et al.*,1994; Clark *et al.*,1998). It was evident from the household survey that, the community had generally a low family size as only 19% of the respondents had four or more children living with them. It was also observed that, the community members had strong social ties and were able to work well with each other. The low family size decreases the vulnerability of the population to natural disasters while the ability of the community members to work well with each other helps to increase the adaptive capacity of the community.

5.3.7 Employment and Livelihood dependencies

Employment rates and income are viewed as indicators of vulnerability, as with greater income comes greater adaptation choices (Clark *et al.*,1998; Wisner, 1998;Kundzwiez, 2002;Tapsell*et al.*,2002;Yohe and Tol, 2002). Referring to the employment status of the Keta Municipality based on economically active population of fifteen (15) years and above, a total of 53,397 constituting 40% of the total population in 2000 were employed (MMTDP, 2010). From the household survey however, it was observed that most of the respondents worked in the informal sector with only 29.5% as salaried workers. Among the respondents who work in the non-formal sector, it was observed that majority of them were into farming and fishing as their primary occupation. It was also evident that those who were into other occupations such as arts, trading, fish monging as well as salaried work were also engaged in farming or fishing as their secondary occupation. Barnett,

(2003) indicates that, communities that are highly dependent on natural resources such as fisheries, agriculture and forestry are believed to be more vulnerable to the impacts of climate change.

Through the survey, it was observed that, the willingness to diversify income sources was very low as 40% percent of respondents did nothing special to cope with climate change with only 18% of the respondents diversifying their sources of income. As indicated by Wongbusarakum and Loper (2011), households that rely on a single economic sector for their livelihood such as tourism or fisheries are more vulnerable to climate impacts than those that have a more diversified economy, especially if they are highly dependent on sensitive resources.

5.3.8 Governance and Leadership

As indicated by Wongbusarakum and Loper, (2011), communities with strong, institutions and infrastructure will be more able to adapt to the impacts of climate change. Good policies can strengthen the ability of people to make use of their assets effectively so that they can deal with seasonal changes, cope with shocks and adapt to trends.

From the key informant interview with the MOFA, the WD/FC, NADMO, Health Directorate and the MOFAD which are institutions that have climate change as part of their agenda, it was observed that these institutions are faced with challenges which includes low number of staff, lack of logistics and low allocation of budget to execute their activities within the Keta Municipality. Even though it was noted that there were the existence of committees at the community levels to monitor and report illegal activities such as sand wining and turtle hunting, these committees were not active as there was a

general apathy among members with low remuneration from the institutions their activities support.

5.4 Vulnerability of the Wetland Habitat

From the household survey, it was evident that the community's dependence on the wetland for their livelihood is very high as a total of 88% of the respondents said the wetland serves as grounds for fishing or provides fertile land for farming. It was also identified that 29% of the respondents use agro chemicals such as fertilizers and pesticides as a coping strategy against climate change impacts. The use of these chemicals could cause eutrophication, or nutrient pollution and could eventually lead to the degradation of the wetland ecosystems (UNEP, 2006; Ponting, 2007). From the key informant interviews and the focus group discussions, it was identified that, overfishing and the use of unauthorised fishing nets is very common among fishermen especially those who do fishing on the lagoon and this can be attributed to lack of monitoring and regulations from the Fisheries Ministry and other relevant institutions. UNEP, 2006 indicates that, this could change the community structure, altering trophic and other interactions between ecosystem components and by physically modifying the wetland habitats.

It was also evident from the survey that respondent's perception on deforestation as a key threat to the wetland (20.5%) is very low and this could mean that, either there is a high forest cover in the community and therefore respondents could not relate deforestation to wetland degradation or there is a high rate of deforestation because the respondents think those actions are not a threat to the wetland. From field observations however, it was identified that, the forest cover in the study area is very low compared to Salo, a

community located about 17km from the study area. The low mangrove cover could have resulted in the reduced fish resources in the study area as by virtue of being, in general, a relatively undisturbed ecosystem, mangroves provide vital nurseries for fisheries and many commercially important shrimp and crab species (Macnae, 1974; Dall*et al*., 1990). They also support an abundance of mollusk species that are largely sessile in nature (Ronnback, 1999).

The Keta lagoon has been designated as a wetland of international importance, and by virtue of this, it should be conserved and sustainably utilized recognizing the fundamental ecological functions and its economic, cultural, scientific, and recreational value. This will require consented efforts from all stake holders including community members who have direct interaction with the lagoon. From the household survey however, it was observed that, 91% of the respondents had not heard about a Ramsar Site and did not know if one existed in the community. Among these respondents however, some were aware of some aspects of Ramsar Site regulations such as prohibition of birds and turtle hunting. It was also observed from the survey that 89.5% of the respondents did not think there were government rules governing the use of the wetland. The low level of awareness about Ramsar Sites among respondents may be due to low awareness creation from relevant institutions such as the WD/FC. It may also be due to the low existence of environmental NGOs in the community whose work would have complemented the work of the WD/FC. Low awareness among members of the community about the wetland and its ecological benefits could lead to increasing anthropogenic pressure on the wetland.

Through the household surveys, it was observed that, 78.5% of the respondents perceive an increase in the land cover and a decrease of the land covered by the water body.

Contrary to this, a time series data of the land cover change of the wetland indicates an increase of 2% of the land covered by the water body from 1990 to 2010. This might be as a result of climate change as indicated by Erwin (2009). The time series data also indicated an increase in the built up area as well as the grass cover whiles there was a decrease in the dense very active bushes and herbaceous grasses. Most of the respondents in the survey perceived farm encroachment and household pollution due to waste disposal as the causes of these changes. This perception is confirmed by Ntiamoa-Baidu and Gordon, (1991) and Ryan and Ntiamoa-Baidu (1998) who indicated that, degradation of wetlands could be largely attributable to neglect and unsustainable human activities such as farming hunting and bushfires.

CHAPTER SIX

CONCLUSION AND RECOMMENDATION

6.1 Conclusion

Climate change is already affecting the planet. The devastating effect of climate change can be seen mostly in geographically vulnerable regions including sub-Sahara Africa. In Ghana, there has been evidence of some extreme weather conditions and climate variability that the country has experienced over the years which include; floods, drought, bush fires, unpredictable rainfall patterns, sea level rise along the eastern coast, increased desertification/land degradation, consistent loss of forest cover and loss of some biodiversity.

Communities living along the Eastern coastal region of Ghana have suffered severe environmental hazards including coastal erosion, hindering their current livelihood options and socio-economic development. Even though there are ongoing sea defense projects to safeguard coastal communities from inundation, it is however important to recognize that vulnerability is not just a variable of environmental factors such as agents of disaster, but also a variable of the socio-economic conditions of the communities.

The Anloga community is sandwiched between the sea and the Keta lagoon, therefore indicating high exposure to climatic hazards posing serious threats to development in this area. The lack of economic opportunities in coastal areas is also making this community already vulnerable.

This study identified a high dependency of the community on natural resources as most of the community members had their occupation being fishing and farming. These

fishermen and farmers could be seriously affected by unpredictable climate change patterns as in many households they are the only earning members and often they do not have any other livelihood options.

It was clearly identified that the houses in the community will be relatively resilient to potential climatic hazards as most of them are built with cement with aluminium roofing. Awareness about climate change as well as access to early warning system among respondents were high, however other indicators showed a low adaptive capacity as there was low institutional and outside support to the community.

It was clearly identified that members of the community had high interactions with the wetland either through farming or fishing. It was also identified that the community members were not aware about government regulations governing the use of the wetland with regards to the institutional capacity. It was observed that, lack of technical staff, lack of logistics and low allocation of budget to relevant institutions like MOFA, NADMO, MOFAD the WD/FC was hindering their performance in providing extension and emergency services to the community.

6.2 Recommendations

The following recommendations have been made to help build the resilience and increase the adaptive capacity of the Anloga community to the impacts of climate change

- Institutional and technical capacities of the District office of the Wildlife Division of the Forestry Commission and other relevant institutions in natural resource management and in emergency preparedness and response should be strengthened. This can be done by increasing the number of technical staff posted

to these institutions while posting more national service personnel to serve as supporting staff. In addition, the government through the Municipal Assembly should increase budget allocation to these institutions and provide them with adequate logistics needed to improve their efficiency.

- NGOs and other relevant institutions should have more programs and projects tailored towards raising the community's awareness about climate change and other environmental issues and in addition provide community members with the support to develop alternate livelihood activities that are resilient to climatic hazards. Through these programs, Government's rules and regulations governing the use of the wetland and marine resources should be well communicated.

- There should be improved collaboration between the community, NGO's and relevant government institutions for effective participation in management of natural resources to ensure ownership, security and benefit sharing of these resources. This can be done by establishing more watch-dog committees and providing them with the necessary support to ensure they are fully engaged in monitoring and reporting members of the community whose activities are detrimental to the wetland habitat.

- Government through the Municipal Assembly and with the support of NGOs should help in the dissemination of technologies for climate smart agriculture and sustainable fisheries among farmers and fishermen respectively. There should be support to upscale the adoption of aquaculture technologies among fishermen.

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APPENDICES

Appendix I: Questionnaire for Household Surveys

B4C/GHANA WILDLIFE SOCIETY/CENTRE FOR AFRICAN WETLANDS

SCHOOL OF BIOLOGICAL SCIENCE

UNIVERSITY OF GHANA:

Topic: Assessing The Vulnerability of Coastal Communities to the Potential Impacts of Climate Change; A case study of the Anloga Community

The objective of this study is to assess the current threats including climate related threats of coastal habitats and livelihoods in selected Coastal Ramsar sites. This study is part of the University of Ghana led project *Building Capacity to meet the Climate Change Challenge (B4C)–Ghana*. Questions on this survey and further information on the project may be addressed to Prof. YaaNtiamoa-Baidu (0244769081), Louisa Sawyerr (0543394454) University of Ghana.

Questionnaire No.	Locality.	Date.
Name of Interviewer		

A. SOCIO-DEMOGRAPHIC INFORMATION

1. Sex

1. Male [ ]	2. Female [ ]

2. Age ..... years

3. Educational Level

1. Primary [ ]	4. Tertiary [ ]
2. JHS [ ]	5. None [ ]
3. SHS /Vocational [ ]	

4. Primary Occupation

1. Salaried worker [ ]	5. Salt winning [ ]
2. Fishing [ ]	6. Artisan [ ]
3. Farming [ ]	7. Trader [ ]
4. Fish Monging [ ]	8. Other (name) .....

5. Secondary Occupation

1. Fish monging [ ]	5. Artisan [ ]
2. Fishing [ ]	6. Trader [ ]
3. Farming [ ]	7. None [ ]
4. Salt winning [ ]	8. Other (name) .....

6. Are you or any of your parents a native of this area/district?

1. Yes [ ]	2. No [ ]

7. Which of the following coastal services do you depend on?

1. Tourism and Recreation [ ]	3. Wood for building [ ]
2. Cultural value and services [ ]	4. Wood for charcoal [ ]

8. Do you own a land in this area?

1. Yes [ ]	2. No [ ]

9. Marital Status

1. Married [ ]	4. Separated [ ]
2. Divorced [ ]	5. Single [ ]
3. Widowed [ ]	

10. Sex of household head

1. Male [ ]	2. Female [ ]

11. How many children do you have?

a. Male .....

b. Female .....

c. Total .....

d. Not applicable [ ]

12. How many of your children are living with you? .....

13. Which of the following describes the main reason why you live at this place?

1. Native [ ]	3. Living with family [ ]
2. Marital [ ]	4. Occupational [ ]

14. What religion do you belong to?

1. Traditional African Religion[ ]	3. No religious affiliation [ ]
2. Non-traditional African religion[ ]	

B. LIVING CONDITIONS, LIVELIHOODS, VULNERABILITY AND ADAPTIVE CAPACITY

1. What type of housing do you live in?

1. Flat/Apartment [ ]	4. Compound house [ ]
2. Detached house [ ]	5. Tents [ ]
3. Semi-detached house [ ]	6. Other (specify).....

2. What is the main construction material used for the walls?

1. Mud [ ]	6. Burnt bricks [ ]
2. Wood/bamboo/raffia [ ]	7. Cement/sandcrate blocks [ ]
3. Metal sheet [ ]	8. Landcrate bricks [ ]
4. Stone [ ]	9. Other (specify).....
5. Slate/asbestos	

3. What is the main material used for the roofing?

1. Leaves/thatch/raffia/reeds [ ]	4. Bamboo [ ]
2. Aluminium sheets [ ]	5. Clay tiles [ ]
3. Roofing tiles [ ]	6. Other (specify).....

4. How long have you lived in this community?.....

5. Do you own the house you are living in?

1. Yes [ ]	2. No [ ]

6. What kind of toilet does the household use?

1. Flush [ ]	4. Bush/on the beach [ ]
2. Household latrine/KVIP [ ]	5. Other (specify).....
3. KVIP communal [ ]	

7. Where do you dispose of household refuse?

1. Communal refuse dump	[ ]
2. Household pit dump	[ ]
3. On the beach/coast	[ ]
4. Open spaces within wetland	[ ]
5. Collection company [ ] (name of company).....	
6. Other (Specify)	

8. What are the sources of water used by your household?

1. Piped/tap	[ ]	4. Rainwater harvesting	[ ]
2. Communal borehole	[ ]		
3. Household well	[ ]	5. Other (specify)	[ ]

9. What kind of fuel does the household use for cooking and other dosmetic activities?

1. Charcoal	[ ]	4. Electricity	[ ]
2. Fuel wood	[ ]	5. Gas	[ ]
3. Crop residue	[ ]	6. Others (specify).....	

10. If you chose 1,2 and/or 3, what is your source?

1. From wetland	[ ]
2. Other sources (specify).....	
3. Do not know	[ ]

11. Which of the following household items/services do you own/have?

1. Car [ ]	7. Sewing machine [ ]
2. Refrigerator [ ]	8. Motorbike [ ]
3. Mobile phone [ ]	9. A parcel of land [ ]
4. TV [ ]	10. Fishing net [ ]
5. Radio [ ]	11. Canoe [ ]
6. Bicycle [ ]	12. Others (specify) .....

12. Do you own livestock?

1. Yes [ ]	2. No [ ]

13. If yes, indicate type and how many?

1. Goat	4. Pig .....
2. Sheep	5. Poultry.....
3. Cattle	6. Other (specity).....

C. AWARENESS OF WETLAND CONSERVATION AND ENVIRONMENTAL ISSUES

1. If I use the term/word "wetland", what is your understanding of it?

2. Based on your understanding are you aware of any wetland in this area?

1.Yes [ ]	2. No [ ]

3. If yes mention them

1.	4.
2.	5.
3.	6.

4. Do you know if any of the wetland you mentioned is protected?

1.Yes [ ]	2.No [ ]

5. If yes, which ones do you think are protected: name them

1.	4.
2.	5.
3.	6.

6. If yes, who is responsible for managing/protecting the wetland?

1.	4.
2.	5.
3.	6.

7. Have you heard of the Ramsar Site?

1. Yes [ ]	2. No [ ]
b. If yes, what is it	

8. a. Are you aware of any formal/government rules and regulations governing the use of the wetlands?

1. Yes [ ]	2. No [ ]
b. If yes, specify	

9. Do you respect these rules and regulations?

1. Yes [ ]	2. No [ ]
b. Please explain your Yes or No.....	
.....	
c. If No, why?	
i. Christianity [ ]	
ii. Education and enlightenment [ ]	
iii. No reason [ ]	

10. Are you aware of any traditional beliefs or taboos concerning the use of the wetland?

1. Yes [ ]	2. No [ ]
b. If yes, specify	

11. Do you respect or obey these traditional beliefs and taboos?

1. Yes [ ]	2. No [ ]
b. Please explain your Yes or No..... ..... c. If No, why? i. Christianity [ ] ii. Education and enlightenment [ ] iii. No reason [ ]	

12. Who do you think should lead the management and enforcement of wetland use regulations

1) Responsible government agency (Wildlife Division) [ ]
2) Traditional Authorities who own the wetland area [ ]
3) Collaboration between government agency and traditional authority [ ]
4) Private company [ ]
5) PPP: Public-Private-Partnership [ ]
6) Fetish Priest [ ]
7) DCE/Assembly-person [ ]
8) Other (specify) [ ]

13. What would you consider to be key threats to the wetland?

1. Tree cutting/deforestation [ ]	9. Drought [ ]
2. Farm encroachments [ ]	10. Soil degradation [ ]
3. Irregular rains [ ]	11. Waste disposal(+ sewage) [ ]
4. Bush burning [ ]	12. Development encroachment
5. Erosion (including coastal) [ ]	(industrial) [ ]
6. Salt mining [ ]	13. Housing/infrastructure [ ]
7. Overgrowth of weeds/vegetation[ ]	14. Herbicide/Insecticide or chemicals
8. Algal bloom [ ]	[ ]
	15. Others (specify).....

14. Which of the stated threats do think have persisted over the past 10 years?

Please state:

1.
2.
3.

15. Which of the above threats do you think emerged the past 5 years? Please state:

1.
2.
3.

16. Which of the threats do you consider as most harmful to resources related to local livelihoods? Please state hazard(s) as well as the threatened resource(s)

Hazard/risk/threats	Threatened wetland resource
1.	
2.	
3.	
4	

17. Do you think the extent of land cover (vegetation) in the wetland area has changed over the years?

1. Yes [ ]	2. No [ ]

18. If yes, has it increased or decreased?

1. Increased [ ]	2. Decreased [ ]

19. If yes, what do you think are the causes of the change?

1. Increased subsistence farm encroachment	[ ]
2. Increased cash crop farm encroachment	[ ]
3. Household pollution due waste disposal	[ ]
4. Industrial waste	[ ]

5. Housing[ ]	
6. Infrastucture[ ]	
7. Sediment load	[ ]
8. Increased invasive alien species	[ ]
9. Use of agro-chemicals	[ ]
10. Others (specify)	[ ]

20. Do you think the quantity ofwater in the wetland area has changed?

1. Yes [ ]	2. No [ ]

21. If yes, has it increased or decreased?

1. Increased [ ]	2. Decreased [ ]

22. If yes, what do you think are the causes of the change?

1. Increased subsistence farm encroachment	[ ]
2. Increased cash crop farm encroachment	[ ]
3. Pollution due waste disposal	[ ]
4. Housing/infrastucture	[ ]
5. Sediment load	[ ]
6. Increased invasive alien species	[ ]
7. Others (specify)	[ ]

23. Do you think the quality ofwater in the wetland area has changed?

1. Yes [ ]	2. No [ ]

24. If yes, is the change:

1. For the better [ ] 2. For worse [ ]	3. Not sure [ ]

25. Have you ever heard of climate change?

1. Yes [ ]	2. No [ ]

26. If yes, what do you think it is?

27. Where did you get your information on climate change from?

1. TV [ ]	6. Friends [ ]
2. Radio [ ]	7. Social media/ Whats app [ ]
3. Wildlife/Extension Officers [ ]	8. Internet [ ]
4. At School [ ]	9. Others (specify).....
5. Family [ ]	

28. What changes in climatic conditions have youobserved in your area (changes in temp and rainfall patterns)?

1. Low rains [ ]	6. Heavy rains [ ]
2. High temperatures [ ]	7. Frequent flooding [ ]
3. Changes in the timing of rains [ ]	8. Prolonged dry seasons [ ]
4. Low temperatures [ ]	9. Others [ ]
5. More intense winds [ ]	

29. What do you think is the main cause of the changing climatic conditions in the area? Pick your top 2

1. Cutting of trees (deforestation) [ ]
2. Burning of fossil fuel (vehicles and factories) [ ]
3. Enraged gods [ ]
4. Too many borehole [ ]
5. Irrigation [ ]
6. Agro-chemicals [ ]
7. Industrialization [ ]
8. Mostly natural changes [ ]
9. Both human and natural changes [ ]

30. If you have observed any changes in climatic conditions in your area, how does this impact on your household?

Climate hazards and impacts	Which of the following climate events has your household experienced in the past 50 years? (Check all that apply)	A: How would you rate the frequency of this occurrence? 3= high, 2 = medium, 1= low	B: How would you rate the severity of this hazard? 3= high, 2 = medium, 1= low	C: How would you rate the degree of negative impact on your household by this hazard? 3 = high, 2 = medium, 1= low	D: How would you rate the difficulty of coping with this hazard, for your household? 3 = high, 2 = medium, 1 = low	Total vulnerability rating (sum of columns A through D)
Sea level Rise						
Coastal / Beach erosion						
Salt water intrusion in to gardens						
Salt water intrusion into wells						
Changes in rainy and						

dry seasons, leading to changes in planting seasons,						
Drought						
Flood						
Reduced crop yield						
Low fish catch						
Increased bush burning						
Too many mosquitoes						
Increased pest and disease						
Reduced NFTPs						
Death of livestock						
Other Specify _____						

31. What traditional weather prediction systems are available in your area?

1. 2. 3.

32. What is the effectiveness(traditional weather prediction) in predicting weather patterns on a scale of 1(not effective – 5 extremely effective)

1. 1[ ]	4. 4[ ]
2. 2[ ]	5. 5[ ]
3. 3[ ]	

D. COPING AND ADAPTATION STRATEGIES

1. Do you have access to early warning information on the climate hazard in your area?

1. Yes [ ]	2. No [ ]

2. If yes, please list available sources of early warning information

1. Radio [ ]	10. Personal observations [ ]
2. District weather station [ ]	11. Traditional indicators (specify)....
3. Agric extension [ ]	12. Other(specify).....
4. Fetish priests [ ]	
5. Internet [ ]	
6. Social media [ ]	
7. Family [ ]	
8. Friends [ ]	
9. Religious leader/ Community leaders[ ]	

3. Do climatic hazards affect your livelihood in anyway?

1. Yes [ ]	2. No [ ]

4. If yes, elaborate on how:

5. How do you protect your agricultural/fishing/salt mining practices from potential climatic hazards

1. Proper timing taking into account changing trends [ ]
2. New improved technologies (specify) e.g. improved seed variety; irrigation, use of agro-chemicals.....
3. Doing other works during lean seasons [ ]
4. Fish farming [ ]
5. Green housing [ ]
6. Alternative water sources for livestock and crops [ ]
7. New fishing grounds [ ]
8. Other(specify).....

6. What strategies/measures are you putting in place to cope with climate change?

1. Saving money [ ]	4. Putting more effort into fishing [ ]
2. Diversifying income sources [ ] (specify).....	5. Training to better cope with changing trend [ ]
3. Increasing farm sizes [ ]	6. None: nothing special [ ]

7. Do you think the wetland serves any purpose during climatic shocks?

1. Yes [ ]	2. No [ ]
b. If yes, specify	

8. What values or benefits do you think the wetland provides

1. Source of fuel wood[ ]	6. Salt
2. Bushmeat [ ]	7. Flood control[ ]
3. Fertile land for farming[ ]	8. Source of building material[ ]
4. Fishing [ ]	9. Cultural values[ ]
5. Source of other NTFPs[ ]	10. Other(specify).....

9. On a scale of agreement from 1 to 5 (1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, and 5 = strongly agree), please rate the following:

1. Our community has plans in place to deal with climate-related events (such as a coral bleaching response plan) _____
2. Our community is able to coordinate activities to respond quickly to the impacts of a natural event/hazard _____
3. Our community is able to reorganize to respond to a new situation _____
4. Our community has institutions that support us when we need to reorganize to cope with new situations or problems _____
5. Our community members work well with each other_____

6. Our community is able to access outside support when needed_____

Appendix II:Interview Guide for Focus Group Discussion

Title

Focus Group Discussing Guide

1. On Climate Change

    - Those of you who have lived here for more than 10 years , would you say the climate or weather pattern is changing? If so elaborate on what you see as features or signs of this change:
    - [probe] More specifically, what are the changes you have observed regarding
    - Rainfall in the area
    - Changes to the wetlands
    - Changes to rivers and watersheds
    - Changes to the forest lands and landscape itself
    - Changes to vegetation cover
    - Changes to temperature
    - Changes in the seasons
    - Changes to soil fertility
    - Would you say the climate is changing for the better or worse ? elaborate:
    - 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].

    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

2. Migration and Climate Change Adaption

    - Would you say the population in this area is increasing or decreasing within 5 years or so? Please elaborate:
    - What would you are the factors behind the observed population change [probe : issues of migration, high or low fertility, high or low mortality]

- Would you say the number of immigrants [those moving out of this area]has been increasing ,decreasing, or remained about the same ,over the past 5 years or so ? please elaborate:
- Do you think the nature of migration[emigration and immigration] in this area has anything at all to do with climate change? Elaborate on your answer:

3. Gender biodiversity and Climate Change

- Do you think there are differences between the ways men and women make a living off the land and water bodies? If so, what are the different ways in which men and women here make a living off the land and water bodies?
- What are the gender differences , in ay, in the ways agriculture is done in this area (talk about the different ways men and women approach the production and the sale of agricultural products such as cash crops and foodstuffs for example; would you say more women or more men of this are engaged in the sale of foodstuffs, for example?
- What are the gender differences in the fishing industry: in the catching, processing, wholesale and retailing of fish?
- Do you see any gender difference in the extent to which people are concerned about, or take care of land and water resources, including wetlands, in this are? Please elaborate on your answer.

4. Gender, Food security, and Climate Change

- To be food-secured, families or households have to strategize in many ways (e.g. planting different mix of crops, storing, selling and buying different types of food). What are some of the strategies used by households in this community to enhance their food-security?
- Do men and women use different strategies to help their families/households to be food-secured? Elaborate on any gender differences in food-security strategies in this area, if any.
- Has the food-security status in this are-i.e., the extent to which most people are food-secured, changed in recent years? Do you think it is becoming easier or more difficult to be food-secured in recent years?
- Do you think the perceived or real change in the food security status of people here (that you have just described) has anything to do with the climate change? Elaborate
- If you believe the climate has indeed changed in the last five years or so, to what extent has this change affected food-security in this area?
- Do you think the strategies deployed by families to be food-secured have changed over the years (say over the last five years or so?) Please elaborate.
- Would you say, if a household is going to be food-secure or not depends mostly on the men or the women (or both) in the family? Elaborate

Appendix III: Interview Guide for Key Informant Interviews

A. For community leaders, District planning officer, Traditional leader etc.

1. What are the formal and informal environmental related networks or NGOs in this community?
2. What are their supporting roles in climate change adaptation and hazards mitigation?
3. For how long have they been supporting climate change adaptation and mitigation activities in the community?
4. How effective are their efforts?
5. Can you please share your perspective on how well the community is able to reorganize in working collectively to confront the consequences of climate hazards, how it coordinates and collaborates, and the nature of shared goals and responsibilities among the leaders and members?
6. Which community leaders are engaged in climate change, which sectors they represent (private sector, environment, technology, grassroots organizing, etc) and how effective are they?

B. For Heads Institutions, Networks And NGOs

1. What is the name of your Institution/Network/NGO?
2. What is your staff strength?
3. How many members of the community are members of this network?
4. What is the scope of climate change issues your network addresses
5. What are the major challenges and needs of your network?

Appendix IV: proxy climatic data For Ada

Year	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1961	21.8	2.5	34.8	199.5	131.5	473.6	5.0	0.0	80.3	71.0	24.2	0.0
1962	27.2	0.5	18.5	43.8	144.2	800.6	142.4	2.9	8.2	156.4	78.4	68.3
1963	21.1	21.1	21.1	145.3	192.7	308.5	68.9	54.4	36.9	20.6	45.6	56.7
1964	0.5	3.8	66.0	132.9	133.7	242.4	0.3	2.8	2.0	10.2	2.8	0.5
1965	95.3	23.4	19.1	223.1	149.3	207.8	50.6	11.4	17.7	20.5	19.1	0.8
1966	40.4	25.4	75.2	136.4	112.5	217.9	129.4	16.4	10.5	48.3	4.6	2.0
1967	5.1	0.0	153.2	71.0	193.6	474.1	65.3	1.5	16.8	16.9	30.0	30.0
1968	0.0	33.5	54.0	178.1	100.1	306.1	473.5	278.6	93.8	93.5	76.8	8.4
1969	8.9	38.9	65.5	84.9	112.0	116.9	73.6	10.3	22.1	60.9	25.9	0.0
1970	4.3	16.6	53.6	145.1	370.7	236.0	2.1	0.0	8.3	116.2	12.3	0.0
1971	5.6	69.8	60.9	53.2	104.7	387.4	118.3	31.5	15.8	4.8	17.4	17.8
1972	0.5	21.6	61.9	219.6	33.8	477.9	3.6	7.8	15.2	4.6	30.0	1.3
1973	0.0	20.8	43.0	129.3	160.3	473.8	46.3	41.0	63.3	119.6	5.3	15.5
1974	10.2	0.5	26.5	63.9	247.8	829.9	59.7	6.4	56.7	21.9	0.8	6.1
1975	0.0	97.6	65.9	124.4	108.1	416.0	75.2	0.3	0.0	22.2	19.6	17.8
1976	0.0	44.6	65.0	148.4	116.2	77.4	0.3	26.2	1.8	43.1	0.5	11.2
1977	13.0	0.0	5.9	111.0	100.5	31.0	1.1	1.3	5.2	75.7	28.4	0.0
1978	54.6	37.1	44.4	182.3	198.2	52.9	0.3		10.4	21.5		0.0
1979	2.5	0.0	42.5	78.3	163.4		13.2	17.1	24.2	183.2	50.0	0.0
1980	0.0	36.6	24.7	114.6	183.8	112.3	4.9	34.7	33.5	67.2	49.6	11.2
1981	1.1	19.3	63.7	27.3	216.4	174.2	219.6	30.2	56.1	74.4	14.8	2.3
1982	0.0	28.0	126.4	141.2	269.6	457.3	131.2	0.6	0.0	93.2	0.0	0.0
1983	0.0	0.0	0.0	68.5	163.7	183.2	1.6	0.0	26.2	0.5	75.3	20.7
1984	0.0	0.0	51.1	210.3	203.6	51.4	13.0	17.6	125.6	30.0	9.4	14.9
1985	22.6	0.5	86.4	89.4	206.8	112.6	20.4	2.0	26.5	45.5	52.9	0.0
1986	0.4	27.8	83.0	58.2	75.3	127.6	2.6	0.0	8.0	76.7	36.2	0.0
1987	0.0	0.0	55.3	18.3	35.6	148.7	19.9	160.6	339.9	135.7	7.6	9.4
1988	0.0	40.2	98.8	39.0	107.2	143.2	96.0	0.4	117.7	48.2	107.6	0.0
1989	0.0	0.0	116.0	163.0	141.3	213.8	44.2	1.7	25.3	200.8	43.6	0.2

1990	7.2	17.6	40.2	131.7	125.0	55.2	53.0	0.0	38.0	110.3	0.0	77.7
1991	0.0	11.2	26.0	324.7	197.0	198.2	443.5	0.0	40.0	35.5	22.0	0.0
1992	0.0	0.0	22.8	66.3	176.5	55.5	2.3	0.9	9.5	11.6	11.3	2.5
1993	0.0	86.4	96.9	129.4	82.0	64.5	132.3	10.8	65.3	36.7	48.8	6.2
1994	11.2	37.6	87.2	48.8	207.9	164.7	3.1	1.8	33.9	67.3	37.7	0.0
1995	0.0	3.4	181.1	93.9	88.3	321.1	32.2	30.8	4.6	16.6	56.8	30.4
1996	0.0	57.5	58.4	141.2	265.0	283.8	151.4	15.4	9.2	1.3	8.9	0.0
1997	0.0	3.6	123.7	86.7	115.2	598.3	40.3	17.6	4.6	181.0	14.4	5.8
1998	0.0	0.0	0.3	118.7	183.6	74.3	1.2	15.4	6.0	12.8	53.3	18.8
1999	4.4	36.1	27.7	197.0	89.6	223.6	56.6	13.6	2.8	39.9	11.1	13.6
2000	0.0	0.0	44.6	78.5	100.1	60.5	56.5	10.8	8.8	32.9	0.0	1.6
2001	0.0	19.2	39.7	189.4	162.0	144.9	21.6	3.3	160.5	25.8	3.2	9.6
2002	8.8	0.7	49.0	130.8	134.4	315.3	42.2	9.2	22.0	65.2	65.0	0.0
2003	3.5	34.1	24.2	185.9	34.5	446.4	12.8	9.1	46.4	210.9	26.5	27.6
2004	9.2	96.3	4.8	25.6	146.7	47.0	6.9	58.1	105.3	147.3	51.2	0.0
2005	0.0	2.1	136.7	78.4	134.9	157.3	55.0	60.7	2.1	138.9	24.1	0.6
2006	22.0	0.0	20.3	65.1	202.4	146.7	51.3	1.3	93.4	134.6	0.1	8.8
2007	0.0	0.3	48.0	46.1	99.1	232.0	127.8	65.5	45.2	167.2	0.9	65.0
2008	3.9	0.0	39.2	39.9	213.2	203.1	50.8	15.9	76.1	38.5	71.1	15.6
2009	7.7	86.0	26.4	167.3	206.8	477.3	54.5	28.9	12.2	2.5	0.2	0.2
2010	0.0	15.3	112.7	83.9	134.5	224.3	3.1	15.0	175.9	104.1	73.1	15.5
2011	0.0	96.3	0.1	80.5	145.7	285.7	65.6	15.2	48.8	154.1	1.5	0.0
2012	31.3	107.9	1.6	81.5	142.8	88.4	34.3	12.6	60.9	98.4	9.5	0.5
2013	1.9	0.0	21.3	155.7	211.7	172.8	37.0	0.0	14.9	7.9	12.3	0.0

Appendix V: Prevailing Diseases within the Keta Municipal Assembly

Top Ten Cause of Outpatient Attendance in 2009

Rank	Disease
1	MALARIA
2	ARI
3	HYPERTENSION
4	SKIN DISEASES andULCER
5	DIRRHOEA DISEASES
6	ANAEMIA
7	INTESTINE WORM
8	RHEUMATISM and JOINT PAINS
9	TYPHOID FEVER
10	HOME/OCCUPATIONAL ACCIDENTS

Source: Municipal Health Management Unit, 2009

Top Ten Cause of Admission in 2009

Rank	Disease
1	SEVERE MALARIA
2	HYPERTENSION
3	ANAEMIA
4	ENTERIC FEVER TYPHOID
5	CVA
6	ROAD TRAFFIC ACCIDENT
7	GASTROENTERITIS URTI
8	INCOMPLETE ABORTION
9	PID
10	ASTHMA

Source: Municipal Health Management Unit, 2009

Top Ten Cause of Death in 2009

Rank	Disease
1	MALARIA
2	CVA
3	SEPTICAEMIA
4	HIV/AIDS
5	PULMONARY TUBERCULOSIS
6	PNEUMONIA
7	HYPERTENSION IS
8	ANEAMIA
9	CARDIAC FAILURE
10	NEONATAL SEPSIS

Source: Municipal Health Management Unit, 2009