

UNIVERSITY OF GHANA



**ASSESSING ECOSYSTEM SERVICES AND THE RESILIENCE OF
HUMAN LIVELIHOODS IN THE FACE OF CLIMATE VARIABILITY
IN GHANA: A CASE STUDY OF COMMUNITIES LIVING AROUND
THE SONGOR LAGOON**

BY

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DEGREE**

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DECLARATION

I, Roland Akuka Apambilla hereby irrevocably declare that, apart from the references cited in this work which have been dually acknowledged, this thesis has been my own original research conceptualization and conducted under the supervision of my supervisors indicated below, and that this work has neither in part nor in full been presented for the award of any kind of degree or certificate before to any University here in Ghana or elsewhere in the world.

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DEDICATION

This thesis is dedicated to my parents, siblings, teachers, friends and love ones who have contributed in one way or the other to enable me come this far. All your prayers, support, encouragement, constructive criticism and positive influence over the years are worthwhile and may the almighty God replenish and abundantly increase you all.



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LIST OF ABBREVIATIONS AND ACRONYMS

CBD	Convention on Biological Diversity
EPA	Environmental Protection Agency
GMET	Ghana Meteorological Agency
IPCC	Intergovernmental Panel on Climate Change
MEA	Millennium Ecosystem Assessment
NWCS	National Wetlands Conservation Strategy
OECD	Organisation for Economic Co-operation and Development
SSP	Songor Salt Project
SDG	Sustainable Development Goals
UNDP	United Nations Development Program
UNEP	United Nations Environment Programme
UN	United Nations
UNFCCC	United Nations Framework Convention on Climate Change
WRI	World Resources Institute

ABSTRACT

Climate Change has been globally recognized as a multi-scalar socio-economic and environmental problem. Its effects are multidimensional and affect ecosystems, rain-fed agriculture, forestry resources, water, and health. Developing countries, particularly those whose livelihoods are tied to climate-sensitive sectors coupled with low resilience and high vulnerability, will suffer the worst of this menace. Despite these daunting realities confronting developing countries and local communities, research in understanding the gravity of the situation and strategies for effective adaptation remain scarce. It is against this background that this study was undertaken with the objectives of (i) assessing the key ecosystem services associated with the Songor lagoon and the potential beneficiaries; (ii) assessing the changing trend of ecosystem services and the impacts of climatic variability on these services; (iii) evaluating the peoples' level of awareness, perceptions, knowledge, and understanding of climate variability and its impact on ecosystem services and their livelihoods; (iv) to identify the alternative livelihood and coping strategies of the communities in response to changes of ecosystem services for localized adaptation. In order to achieve these objectives, the study adopted mixed method approaches with the use of semi-structured questionnaire, interviews, and documentations. Both secondary and primary data on climatic variability (temperature and rainfall) were collected for analyses. For the purposes of analysis, a binary logistic model was used to model the determinants on the resilience of ecosystem services and human livelihoods. A multiple linear regression model was also employed to assess the impacts of climatic variability on ecosystem services (salt yield). Overall, the results have shown that, among the other regulating, cultural and supporting ecosystem services obtained from the lagoon, the dominant one is the provisioning services (salt production). Results from the analyses confirmed that ecosystem services have declined considerably over the years and this has affected respondents' livelihoods. Climate variability was also observed to occur in the study area with increasing temperature and decreasing rainfall patterns over the past 30 years. The variability in temperature and rainfall were therefore noted to have both negative and positive implications on ecosystem services, particularly salt yield. A 1^oC increase in temperature was noted to result in a decrease of 0.488 Mt of salt and increasing that of rainfall by 1mm was also noted to result in a 0.142 Mt of salt increase yield. From the study, both temperature and rainfall changes were shown to affect salt yield by 51.4 %, leaving the rest of the influence to other confounding factors ($R^2 = 0.514$; $P < 0.05$). Respondents demonstrated an appreciable level of awareness, knowledge and understanding about the meaning, causes, evidence of and the strategies for mitigating climate change although their perceptions were not empirically ascertained and may raise concerns. Several strategies were identified by the respondents for adaptation to climate change impacts and changes in key ecosystem services. These included rainwater harvesting, diversification of livelihoods sources, shifting planting times to adjust to seasonal variations of rainfall availability and adoption of drought and heat tolerant crop varieties by farmers for improved crop yield. These findings suggest that, for the sustainability of the salt industry of the Songor Lagoon and its continued support for livelihoods and resilience of the communities, the government must take an interest in the sector and invest massively in infrastructure and expertise development. This will help boost production and handle the challenges as well as harness the opportunities that climate change presents to the sector. It is also recommended that continual monitoring and assessment of these services be carried out for improvement to build on the lessons learned and this calls for further research. These must, however, be coupled with the engagement of all the relevant stakeholders and taking into consideration the social, cultural and demographical specificities of the people.

Key Words: Climate Change, Ecosystem Services, Human Livelihoods, Songor Lagoon, Resilience. L



CHAPTER ONE

GENERAL INTRODUCTION

1.1 Introduction

This chapter comprises a general introduction to the study which give the background of the study, the objectives, justification and research scope. Also, it provides information on the approach adopted in conducting this study and how the whole thesis has been organized.

1.2 Background

1.2.1 The Climate Change Science, Causes and Its Evidence

The fifth report of the Intergovernmental Panel on Climate Change (IPCC) has concluded that climate change is unequivocal and that it is due to the influence of anthropogenic activities (IPCC, 2013). The international community has now recognized climate change as one of the greatest environmental, social, and economic threats that are confronting the world today (UNDP, 2009; UNFCCC, 2009; OECD,2008, IPCC 2013). What are climate change and climate variability? Different scholars have made attempts to distinguish the difference between the two concepts and indicate the thin line that separates the two. Climate change is defined as the statistically significant variation in mean climate variability or both over an extended period of time, usually decades (IPCC, 2013). It is explained by the United Nations Framework Convention on Climate Change (UNFCCC) as the change of the climate that is attributed directly or indirectly to human activity that alters the composition of the global atmosphere in addition to natural climate variability observed over comparable time periods. (UNFCCC, 1992). Furthermore, based on the data gathered over the years, the scientific community has concluded that rising temperatures, sea level rise, decrease in rainfall patterns in most parts of the world, melting of snow and widespread

decline in glaciers coupled with extreme weather events such as floods, heat waves, storm surges, among others, are the clear manifestations of climate change.

On the global scale, the averaged combined land and ocean surface temperature has shown a warming trend of 0.85°C over the period of 1880-2012 and is projected to rise contingent on emissions scenarios (IPCC, 2013). The report further indicated that a global mean sea level rise by 0.19m from 0.17-0.21m over a period of 1901-2010 has occurred. There has also been a loss of masses of the Greenland as well as Antarctic ice sheets and glaciers shrinkages averaging 226 Gt/yr over a period of 1971-2009. These are noted to correlate with increasing concentrations of greenhouse gases, the major drivers of climate change in the atmosphere in recent times as compared to pre-industrial levels and records. The IPCC (2013) noted that model simulations together with observations have shown that the concentrations of the major greenhouse gases such as carbon dioxide, methane, and nitrous oxide, have increased substantially above pre-industrial levels contributing significantly to the causes of climate change. The increase in concentration of these gases are consequences of anthropogenic activities, including the burning of fossil fuels, deforestation, land use and land use changes, intensification of agricultural production, use of refrigerators and industrial process as well as poor waste management. The attendant implications of climate change impacts will have far more reaching effects on climate-sensitive sectors such as rain-fed agriculture, forest resources and biodiversity, water resources, fisheries, health and energy sustainability, thereby making climate change to be regarded as a multi-scalar environmental and socio-economic problem of our time (Ahenkan *et al.*, 2012).

1.2.2 Ecosystem and Ecosystem Services

The ecosystem is defined to be a dynamic complex of plants, animals, and microorganism communities and non-living environment interacting as a functional unit. It, therefore, implies that humans are an integral part of the ecosystem (CBD, 2009). The Millennium

Ecosystem Assessment (MEA, 2005) defined ecosystem services as the benefits that people obtain from ecosystems. The provisions of these goods and beneficial services for humans are contingent upon the type, health, structure, and function of ecosystems. The first ever assessment of ecosystem services and their implications for human well-being to be conducted, known as Millennium Ecosystem Assessment, has categorized ecosystems services under four broad categories. These include the provisioning services (food, water, fuel wood), regulating services (carbon sequestration, pollination, flood control, water/air purification, disease control) cultural services (recreational, spiritual and religious enrichment) and supporting services (soil formation, nutrient cycling, seed dispersal).

The impacts of climate change coupled with non-climatic and anthropogenic activities such as pollution, degradation and over-exploitation of resources are seen to affect the structure and health of ecosystems, thereby affecting the delivery of these essential services for human livelihoods. As observed by Nahuelhual *et al.*, (2017), the impacts of these multiple pressures can impair the structure and functions of ecosystems which in turn can affect the delivery of ecosystem services with serious implications on the livelihoods of the people who depend on them.

1.2.3 Human Livelihoods and their Resilience to Impacts of Climate Change

Chambers and Conway (1992) defined livelihoods as the capabilities, assets, and activities required for supporting the means of living. Ecosystem services are at the centre of enhancing human essential assets in the form of goods and benefits that enable or support their well-being. The authors further noted that livelihoods are about how actors can mobilize their capital and capabilities to achieve their well-being. In a more encompassing perspective of livelihoods, others argued that livelihoods involve a whole complex of factors that allow families to sustain themselves materially, emotionally, spiritually and socially (WRI, 2005, Ahenkan *et al.*, 2012). This definition is partially consistent with the MEA

categories of ecosystem services that support humans' livelihoods via the provisioning services, emotionally, spiritually, and socially by the cultural services and failed to capture the regulating and supporting ecosystem services which are equally important in enhancing the other ecosystem services especially the supporting services. A clear limitation of these studies is the fact that they do not capture the implications of climate change on the resilience and sustainability of these livelihoods sources which is the focus of this study.

What then is the resilience of these livelihoods? It has been noted that livelihoods resilience implies the ability of those livelihoods to thrive or recover from internal or external shocks and stressors (Chambers & Conway, 1992). It can also be defined as the ability of a system to regain its original state after perturbation (MEA, 2005). Climate variability and change present yet another external stressor that can alter natural ecological processes and resources (goods or assets) with the potential of exacerbating the susceptibility and further worsening of the vulnerability of communities. Therefore, in order to assess the resilience of the communities' livelihoods to the impacts of climate change, it is prudent to, first of all, identify the areas and the factors that can enhance such resilience. These include but are not limited to the presence of the following: institutional capacities, infrastructural development, technological systems, availability and accessibility of external supports and relief services in cases of extreme events. In the absence of these factors, it means that communities are liable to high vulnerability rather than being resilient in the face of climate variability and change (MEA, 2005; IPCC, 2013).

Ecosystem services' resilience and their implications on human livelihoods assessment is, therefore, an important area of research which can help to ensure sustainable goods and services supply for sustainable livelihoods and human well-being particularly among the rural poor and vulnerable groups in society.

This study therefore recognizes that ecosystems play a crucial role in providing ecosystem goods and services that enhance human livelihoods in many different ways. Ecosystem services' resilience and long-term sustainability could be seen as a great priority, especially by developing countries where the majority of their human populations depend on these resources for their livelihoods. The interaction between biodiversity and ecosystems to deliver ecosystem services for human livelihoods has however been an area of increased research interest to many, although establishing a clear linkage has not been arrived at (Milner-Gulland, 2012). The inability to establish such clear linkages may be due to the difficulty in decoupling climate change impacts from other anthropogenic drivers and influences on ecosystem services. Nonetheless, human livelihoods sustenance and sustainable well-being have been noted to face several challenges that may exacerbate the vulnerabilities of rural communities and existing social differentiation and inequalities (Egoh *et al.*, 2012). These authors contended among other things that climate change, rapid urbanization and the reoccurrences of land grabbing in developing countries are the major threats to human livelihoods resilience. These challenges will impede efforts aimed at safeguarding ecosystem services delivery and harnessing the associated benefits for human livelihoods and building their resilience in a changing climate.

It has been argued that climate change is projected to affect the delivery of ecosystem services and invariably the livelihoods of people that depend on them, particularly rural communities (IPCC, 2013, Boafo *et al.*, 2016). Climate-induced changes to availability of resources can fundamentally affect the viability of livelihoods of the rural poor by affecting their assets base and limiting their adaptive strategies (Badjeck *et al.*, 2009). Therefore, urgent measures are imperative to safeguarding the livelihoods of human societies and communities that are intricately linked to ecosystems and the resources that they produce. These measures and initiatives are feasible if sound information and evidence are available

to guide effective decision-making and programme design, upon which the motivation of this study was anchored.

1.3 Research Problem and the Guiding Principles

According to the Millennium Ecosystem Assessment report (2005), it has been noted that about 60-70% of the world's ecosystem services are deteriorating with dramatic implications and consequences on the communities that depend on them for their livelihoods. Ahenkan *et al* (2012) also highlighted that this is particularly severe for rural communities in developing countries whose livelihoods are linked to forestry and coastal water resources. Several other authors have asserted that climate change has been noted and is projected to be the dominant cause of biodiversity loss and changes in ecosystem structure, thereby affecting the delivery of ecosystem services (MEA, 2005, IPCC, 2013, Hernandez-Delgado (2015). This, therefore, will further exacerbate and deepen the already existing vulnerabilities of the local communities as a result of poverty, gender inequality, and low adaptive capacity as well as the over-reliance of communities on natural resources for their subsistence (Fatma, 2002, WRI, 2005 Pg 16).

The major limitation of these assessments is the fact that they tend to be more general without specific locally based data. As a result, they do not clearly reflect local conditions and their specific needs. Local comprehensive studies are needed urgently to assess the impacts of climate change and climate variability on ecosystem services and how these, in turn, affect the livelihoods of local communities that rely on these resources for their livelihoods.

The Songor lagoon is a wetland of international importance recognized as a biosphere reserve area that provides enormous resources and services to communities living around it over the years (Ramsar Information Sheet, 2016). The communities living around the lagoon

depend on its resources for their livelihoods and survival. Thus, the need for this study to investigate what are the likely impacts of anthropogenic climate change and climate variability on the Lagoon's ecosystem services are and their implications of these changes on the livelihoods in the surrounding communities. The study was to further identify traditional or local strategies that are already adopted and have been practised in response to these impacts and evaluate the general awareness and perceptions of the community dwellers about climate change. These findings are relevant in designing appropriate adaptation strategies to cope with the adverse impacts of climate change at the local level. Local communities' awareness and perceptions about climate change play a more crucial role in climate change adaptation and therefore were evaluated in this study to serve as entry points for localized adaptation. This is particularly more important because communities' knowledge, perceptions, and coping strategies tend to be context specific and must be adapted to suit local adaptation needs. Badjeck *et al.*, (2009) also emphasized that using traditional knowledge in the design and implementation of adaptation strategies is a key determinant for communities to build their capacities and abilities to respond effectively to the impacts of climate variability.

This study was therefore based on building the principles of inclusiveness, focusing on local community participation and engagement in exploring solutions and ways by which the impacts of climate change and climate variability can be addressed to better the lives of the same.

1.4 Objectives of the Study

1.4.1 General Objective

1. To assess the ecosystem services and human livelihoods resilience of communities living around the Songor lagoon in the face of climate change.

1.4.2 Specific Objectives

1. To identify the key ecosystem services associated with the Songor Lagoon and the potential beneficiaries.
2. To assess the trend of changes in ecosystem services and the effects of climatic variability on these services.
3. To evaluate the level of awareness, perceptions, knowledge, and understanding about climate variability and its impacts on ecosystem services and local livelihoods.
4. To identify the alternative livelihood and coping strategies of communities in response to changes in ecosystem services for localized adaptation.

1.5 Research Questions

As an exploratory study in order to analyze trends, linkages of ecosystem services and human livelihoods, this study seeks to answer the following important questions. Based on the stated objectives of the study above, the following critical questions are to be examined;

1. What are the key ecosystem services (goods and services) that the communities around Songor lagoon derive from the Lagoon
2. Who are the potential beneficiaries of these ecosystems services?
3. Are there changes in the provision of these services and if there are, what are the trends/changes of the ecosystem services over the years?
4. What drivers influence such changes?
5. What is the general level of knowledge, awareness, and perceptions of the local people about climate variability and its impacts on the resilience of ecosystem services and livelihoods?
6. What are the possible coping strategies that are adopted in response to the changes in ecosystem service change and climatic variability?

1.6 Justification of the Study

The function of ecosystems in the face of climate change in providing goods and services for the communities around them is central to their survival. This is because of the key role ecosystems play in providing conditions and resources essential for life on earth such as food, water, quality air, disease control, flood control among others.

However, it has been noted that the ability of ecosystems to sustain agricultural production and improve incomes and food security, especially for the rural poor, is increasingly constrained in developing countries due to climate change (Berbes-Blazquez, 2012). This is further challenged by the fact that there is limited information on the monitoring of most ecosystems and their services delivery in rural communities. This will undoubtedly affect the vulnerable groups in society whose livelihoods are tied to the natural resources from ecosystems. This may be due to over-reliance leading to the depletion of these resources in the long run. With reference to the Millennium Ecosystem Assessment (2005), the information available for assessing the consequences of changes in ecosystem services for human well-being is limited, particularly in developing countries. The inability of people to adapt to the changes in resources that may also result from climate change is further threatened by their low level of awareness and understanding of the climate system, including how it impacts on their livelihoods (Ahenkan et al, 2012). All these may pose serious implications for resources sustainability and human subsistence in the face of climate change. Following the projection made by the Millennium Ecosystem Assessment report, it is asserted that by the end of this century climate change and its impacts will become the dominant direct driver of biodiversity loss and changes in ecosystem services globally under different greenhouse gases emission scenarios (MEA, 2005). This further raises concerns for proactive measures to be adopted in order to prevent or adapt to the impacts projected on human livelihoods and society in general in the coming years.

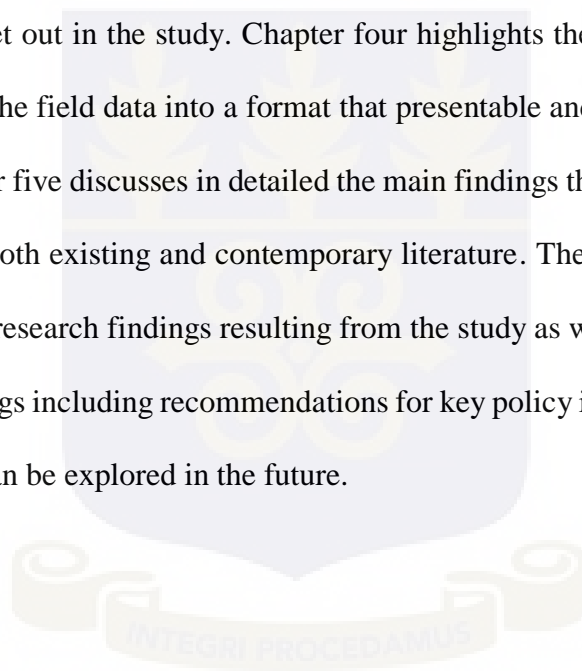
The Songor lagoon is a wetland of international importance recognized as a biosphere reserve area that provides enormous resources and services to communities living around it over the years (Ramsar Information Sheet) . The communities living around the lagoon depend on its resources for their livelihoods and survival. Thus, the need for this study to investigate what are the likely impacts of anthropogenic climate change and climate variability on the Lagoon's ecosystem services are and their implications of these changes on the livelihoods in the surrounding communities. The study was to further identify traditional or local strategies that are already adopted and have been practised in response to these impacts and evaluate the general awareness and perceptions of the community dwellers about climate change. The findings will serve as useful entry points for localized adaptation measures to climate change in the communities and to enable them to respond resiliently to the unprecedented impacts. The findings also serve as source of information for informed decision and policy design in addressing climate change adaptation. Recognizing that the key priority of many African leaders is to improve the livelihoods of their citizens (Egoh *et al.*, 2012), this work aimed to provide useful indicators for evidence-based and sound policy formulation to ensure equitable investments in nature and ecosystem conservation for ecosystem services delivery in a future drying climate.

1.7 Ethical Consideration

In order to ensure the integrity of this research work, the ethical principles of informed consent of study respondents, confidentiality of information, respect and protection for study respondents among others were duly followed. Community consultation with community leaders was also done to gain access and permission to collect data within the study area.

1.8 Thesis Organisation

This thesis is organized into six main chapters. Chapter one is the general introduction and background of the study including the problem statement, its theoretical framework underpinning the study design. Chapter two deals with the literature review which explores the existing literature in relation to the study problem together with the Conceptual Framework which serves as a guide to the investigation of the research problem. In chapter three, the methodology and the research techniques that were employed in the study are described. It also explores the processing and analyses of the data in order to answer the research questions set out in the study. Chapter four highlights the findings or results that were obtained from the field data into a format that presentable and readily understandable to the reader. Chapter five discusses in detailed the main findings that are obtained from the study in relation to both existing and contemporary literature. The final chapter presents a summary of the key research findings resulting from the study as well as conclusions made from the study findings including recommendations for key policy interventions and further research areas that can be explored in the future.



CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter is a review of current scholarly works on climate change impacts on ecosystem services and the implications for the sustainability of human livelihoods. It highlights both the main findings of these scholarly work and their limitations. The chapter is organized under various thematic areas such as an overview of the climate profile in Ghana and its future projections. It also explores the climate change and ecosystem services nexus as well the anthropogenic and non-climatic drivers of ecosystem services deterioration. Finally, the state of knowledge, awareness and perceptions within the local population on climate change and its impacts on their livelihoods were explored. The concluding part of this chapter highlighted the capacity of the adapted conceptual framework to ensure a comprehensive investigation of the research problem.

2.2 Overview of the Interaction Between Climate Change and Ecosystem Services

2.2.1 Climate and Ecosystem Services

Although the ecosystem services science is a relatively new concept, several scholars have made attempts to explore the linkages between climate change and ecosystem services and the implications on human livelihoods. Interest in this area has increased widely in recent times (Costanza, 1997, MEA, 2005, Egoh *et al.*, 2012., Bennett *et al.*, 2015). An overview of these scholarly works and a critic on the major limitations are presented.

The first ever global ecosystem assessment was the Millennium Ecosystem Assessment conducted from 2001-2005 with the primary objective of assessing the consequence of ecosystem change for human well-being and the scientific basis for action needed to enhance the conservation and sustainable use of those systems and their contribution to

human well-being (MEA, 2005). This assessment emerged with four key findings which are relevant to this current study and therefore worth teasing out. These findings include the following;

The first findings of the MEA indicated that,

“over the past 50 years, humans have changed ecosystems more rapidly and extensively than in any comparable period of time in human history, largely to meet rapidly growing demands for food, fresh water, timber, fiber, and fuel. This has resulted in a substantial and largely irreversible loss in the diversity of life on earth” (Pg. 2).

This suggests and consolidates the fact that indeed humans are intrinsically linked to the ecosystem concept and ever increasing population growth places more pressure on ecosystems and alters this natural ecosystem structure and resilience to benefit themselves hence the increasing deterioration in both abundance and diversity of life on the earth.

Also, they found out that,

“the changes that have been made to ecosystems have contributed to substantial net gains in human well-being and economic development, but these gains have been achieved at growing costs in the form of the degradation of ecosystem services, increase risks of nonlinear changes and the exacerbation of poverty for some groups of people. These problems unless addressed will substantially diminish the benefits that future generations obtain from ecosystems” (Pg. 5).

This finding suggests that population and economic growth are coupled with ecosystem degradation. Thus, increasing population with significant improvement in economic gains implies more pressure exerted on ecosystems and ecosystem services to meet the increasing population demands, hence the recent ecosystem deterioration. This kind of economic growth is however unsustainable in the medium to long term. Therefore, there is the need for pragmatic steps and policy formulation based on sound evidence that can ensure

environmental sustainability and ecosystem resilience whilst at the same time creating opportunities for economic prospects and improving the living standard of the ever increasing population.

The study further indicated that, *“the degradation of ecosystem services could grow significantly worse during the first half of this century and is a barrier to achieving the Millennium Development Goals”* (Pg. 14) which have been rebranded as the Sustainable Development Goals (SDGs). This means a lot to developing countries already wrangling with poverty, inequality, conflict, and discrimination. The decline in ecosystem services in the coming decades will further deepen these challenges and their impacts may be irrevocable. This, therefore, calls for drastic measures to be put in place in order to ensure sustainable management of ecosystems and their resources to ensure continual services delivery that will meet societal needs such as food, water, and fiber among others.

The last but not the least equally important findings of this assessment is the recognition that,

“the challenge of reversing the degradation of ecosystems while meeting increasing demands for services can be partially met under some scenarios considered by the report but will involve significant changes in policies, institutions, and practices that are not currently under way, many options exist to conserve or enhance specific ecosystem services in ways that reduce negative trade-offs or that provide positive synergies with other ecosystem services” (Pg. 18).

Overall, these findings by the Millennium Ecosystem Assessment underscored the value of the earth diverse ecosystems and the implications for human well-being and sustainable development. The increasing threats and degradations of these ecosystems are invariably threats to sustainable human well-being and therefore the need for more pragmatic measures to be put in place and policies that can be translated into actions geared towards reversing

current trends, avoiding future alarming and damaging projections and enhancing resilience of ecosystems and ecosystem service delivery and sustainability for both present and future generations. However, the major limitation of this assessment is the fact that it was done on the global scale and does not necessarily capture situations in the local context. The global perspectives portrayed and the nature of this assessment makes it difficult and inadequate to apply to the local scenarios and situations to address local needs and challenges.

In addressing this gap, Ahenkan *et al.*, (2012) attempted with a study in Ghana, titled “*assessing the impacts of climate change on ecosystem services and livelihoods in Ghana. Case studies of communities around Sui forest reserve*”.

The objectives of this study were among others to investigate and analyze the impact of climate change on the ecosystem goods, services and livelihoods of the communities, to identify the main drivers of the change as well as evaluate the mitigating and coping strategies practised by the people around the reserve. The study revealed that climate change has negatively affected ecosystem goods and services, particularly agriculture production (cocoa and food crop production), biodiversity and water resources, thereby affecting the livelihoods of communities around the forest reserve. For instance, it was shown that climatic data on rainfall pattern indicated a decline with a consistent and significant reduction in cocoa yield within the study area from 118 tons of cocoa to 62 tons in 1990 and 2000 respectively. The study further indicated that, due to less precipitation, prolonged drought and deforestation, most rivers that are sources of water for about 70%, communities without pipe borne water are dried up during the year in the dry season compelling them to resort to low quality and contaminated water sources increasing their risks of water-borne diseases. The authors argued that high temperatures coupled with prolonged droughts have led to frequent and increased bushfires causing habitat destruction and loss of biodiversity, the effect of which is the decline in ecosystem services delivery.

The findings from this study were undoubtedly aimed at enhancing ecosystem services provision and improving livelihoods of the communities. The study showcased the reality of the impacts of climate change on ecosystem services and livelihoods in the local case scenario making it clear that the impacts associated with climate change tend to be context specific due to differences in location, adaptive capacity and vulnerability indicators as well as knowledge and cultural circumstances. Adaptation needs, therefore, need to be designed in such a way that will suit local needs and situations in order to address the challenges of climate change. The authors have not however been able to decouple the other anthropogenic drivers from climate change that affect biodiversity, water resources, and agriculture and ecosystem services.

Bennett *et al.*, (2015) in their study titled; *linking biodiversity, ecosystem services and human well-being; challenges for designing research for sustainability* criticized and argued that although several works have been done on ecosystem services over the years, they have not fully addressed our understanding on their ecological foundation, their impacts on human well-being and how we can regulate and manage these services. This current study will seek to address this limitation by looking at these linkages at the Ghanaian coastal landscape and the rural communities' livelihoods who live around the Songor lagoon site.

2.3 Ghana's Climate Profile: Past, Present and the Future Projection

2.3.1 Past and Present Climate

Ghana is among the least emitters of greenhouse gasses globally although the emission in recent times seems to rise and yet the country is among the countries identified as highly vulnerable to the adverse impacts of climate change (EPA, 2015). This is due to the country's geographical location, dependence on rain-fed agriculture, the low adaptive

capacity of the human population characterized by high gender inequality, poverty, and discrimination.

Evidence exists to show that across the major ecological zones of Ghana, the climate has changed in recent times. For example, data from the Ghana Meteorological Agency from 1990 - 2000 has shown that there has been a marginal rise in temperature with a sharp decline in rainfall (**Ahenkan *et al.*, 2012**) in Ghana. Ghana's climate is tropical and mostly under the influence of the West African monsoon winds and generally warm with variable temperatures. Mostly two seasons of rainfall pattern exist in the southern part of the country usually from April to July and from September to November but one rainfall season occurs in the northern part of the country which usually begins in May till late September. However, these seasons are now not predictable and highly uncertain. It is noted through models ensembles that the country has since 1960 experienced an average of 1.0 °C temperature increase with a rate of 0.21°C per decade (EPA, 2015).

Therefore, this indicates that the country is highly vulnerable to the impacts of climate change. The country's vulnerability to the impacts of climate change is exacerbated by the fact that the majority of the population depends on climate-sensitive sectors for their livelihoods and survival. These include agriculture, forestry, fisheries and water resources. The high poverty levels and low adaptive capacity due to weak institutional and infrastructural facilities further increase the country's vulnerability to the adverse impacts of climate change. Adaptation strategies and interventions aimed at reducing these vulnerabilities and enhancing the resilience of individuals, communities and the country as a whole are therefore imperative to ensuring medium to long term prospects and sustainable development of the country.

2.3.2.1 The Future Climatic Projections in Ghana

According to the EPA (2015) report, the mean temperature for Ghana is projected to increase from 1.0 to 3.0 °C by 2060 and 1.5 to 5.2 °C by 2090 with much of the warming occurring in the northern part of the country. Rainfall projections have been highly uncertain; this is because whilst most models predicted an increase in rainfall across the agro-ecological zones, several others predicted a decrease as a result of the highly variable nature of rainfall in terms of interannual and interdecadal time scales. The models projected a decline in rainfall pattern of 2.8%, 10.9% and 18.9% by 2020, 2050 and 2080 respectively as presented in figure 1.

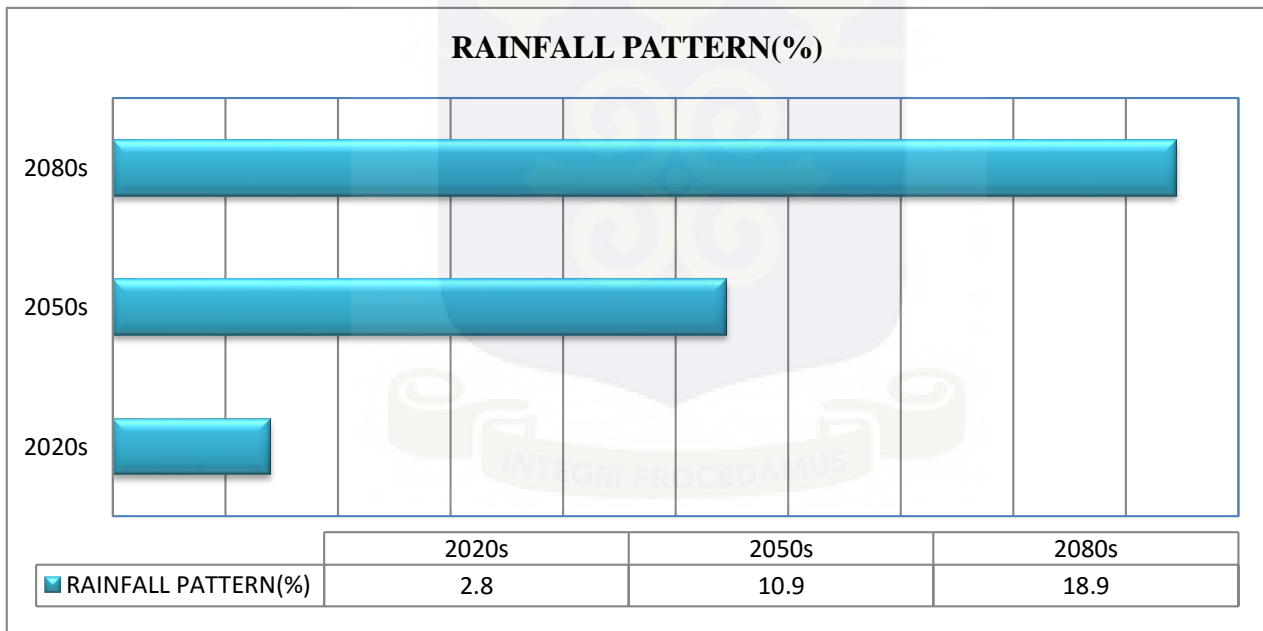


Figure 1 Projections on the Declining Trend in Rainfall in Ghana

Source; EPA, 2015

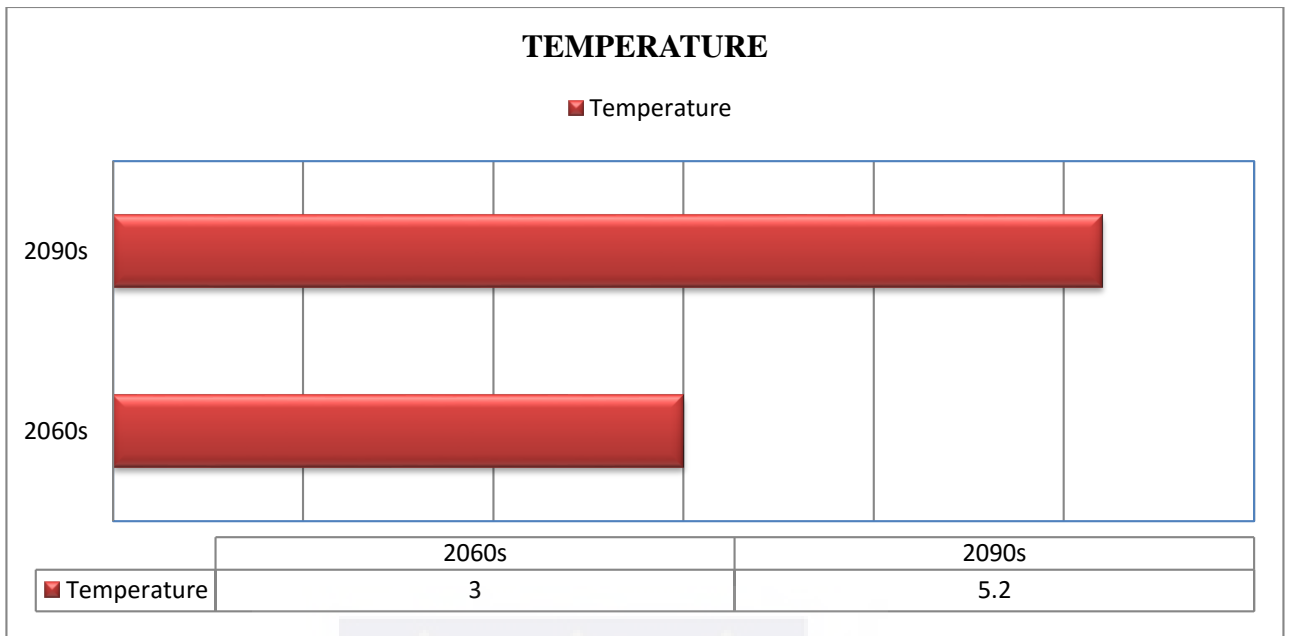


Figure 2. Projection of the Increasing Trends of Temperature in Ghana

Source; EPA, 2015

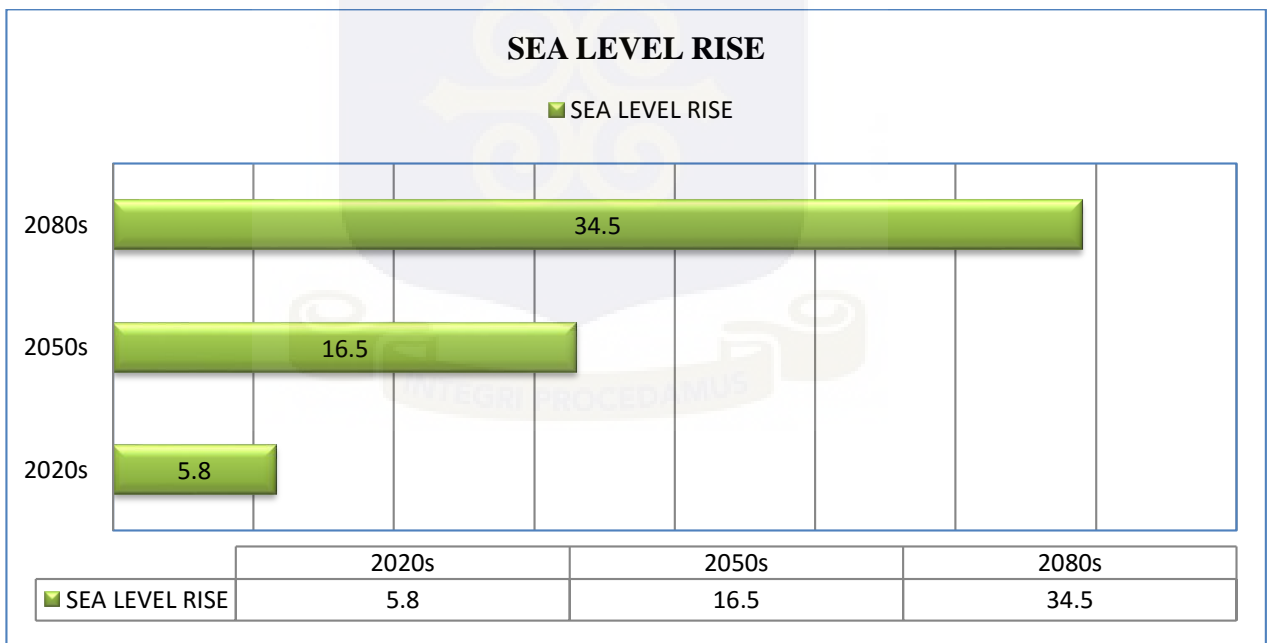


Figure 3. Projection on the Increasing Trend of Sea Level Rise in Ghana

Source; EPA, 2015

2.4 The Implications of Climate Change Projection in Ghana

These projections further pose many challenges for coastal dwellers, rural farmers among other stakeholders who depend on climate-sensitive resources for their livelihoods and survival. The projected decline in rainfall will have severe implications for the agriculture sector and food security in the coming years posing a major setback for rural livelihoods sustainability and poverty eradication.

Increasing sea level rise implies coastal inundation that increases the risks of flooding of coastal communities, seawater intrusion into freshwater bodies and destructions of crop and vegetable production in those areas are likely to increase in the coming years, posing severe threats to rural communities and livelihoods.

2.5 Climate Change Knowledge, Perceptions and Level of Awareness within the Local Context

The review of the literature has indicated that generally the current state of the awareness of many Ghanaians about climate change has been described as low and widely perceived differently across various stakeholders of the population (Ahenkan *et al.*, 2012). This the authors noted is attributed to the fact that, the climate change concept has no place in the local Ghanaian language, making it difficult to explain in clear terms especially among the rural farmers and fisher folks. In their study, they found out that the respondents perceived a reduction in rainfall, drought as signals of climate variability and climate change although they do not understand the causes of such phenomena.

The overall implication of the low level of understanding and perceptions means that there is more to be done to raise the level of awareness, knowledge and understanding on the causes, signs, and effects of climate change on their livelihoods. This is more relevant

because these areas are critical in gathering public support and boosting the momentum in the fight against climate change impacts.

2.6 Wetlands in Ghana and their Ecological Characteristics

Wetlands are areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salty, including areas of marine water the depth of which does not exceed six meters at low tide (Ramsar Convention, 1971). Wetlands have been noted to be productive and unique ecosystems that play critical roles in maintaining many natural cycles and supporting a wide range of biodiversity.

Wetlands inter alia ensure water purification and recharge, provision of fish and other food resources, flood regulation, erosion control and sediment transport and nutrient cycling which are important for human livelihoods and survival (MEA, 2005). In Ghana, wetlands constitute about ten percent of the total land surface area (National Wetlands Conservation Strategy, 1999). There are six main wetlands of international significance which include the Songor lagoon, the Sakumono Lagoon, Densu Delta, Keta Lagoon and Muni-Pomadze (Wiegand, 2016).

2.7 Wetland Ecosystems and Ecosystem Services

According to the Millennium Ecosystem Assessment (MEA, 2005), an ecosystem is a dynamic complex of plants, animals and microorganism communities and the non-living environment interacting as a functional unit of which human beings are an integral component.

The structure and ecological health of an ecosystem are central to its function and in the providing ecosystem services. Ecosystem services refer to the benefits people derive from ecosystems. These include provisioning, regulating, supporting and cultural services that are essential to enhancing and sustaining human livelihoods and survival of particularly the

rural poor. It has been acknowledged that these four categories of ecosystem services overlap in some cases and are essential in enhancing human livelihoods.

2.7.1 Provisioning Services

These are the products and material benefits that people obtain directly from ecosystems and include food resources, fiber, water, fuel wood, biochemical and genetic resources

2.7.2 Regulating Services

These are the benefits obtained from the regulation and control processes of the ecosystem. Some of the regulating processes and services include climate regulation, disease control, flood control, water purification, and pollination.

2.7.3 Cultural Services

The cultural services refer to the non-material benefits obtained from ecosystems and may include recreational and ecotourism services, educational values, spiritual and religious benefits, inspirational and aesthetic value and cultural heritage associated with a particular ecosystem type.

2.7.4 Supporting Services

These are services with indirect and long-term impacts on people. They differ from the other three categories in that they offer services that are needed for the production of the other ecosystem services. Examples of supporting service include; soil formation, nutrient cycling, and primary production.

2.8 Linking Climate Change, Ecosystem and Ecosystem Services

The interaction between biodiversity, ecosystems and ecosystem services has been well established in many studies (Ahenkan *et al.*, 2012, Cardinale *et al.* (2012). Climate Change involves several stressors that impact on ecosystem structure and function and therefore the

provision of ecosystem services. These stressors include temperature, rainfall, carbon dioxide concentration, floods, droughts, sea level rise, acidification of water bodies, etc. Drawing clear linkages of climate variability to ecosystem services and human livelihoods remain scarce as many studies contend the difficulty of decoupling the impacts of climate change from other non-climatic stressors. From the report by the Millennium Ecosystem Assessment (2005), about 60 to 70% of the world's ecosystems services are deteriorating with dramatic consequence on the communities that depend on them for their livelihoods (MEA, 2005). Clearly, their survival is increasingly threatened. This is because biodiversity underpins the functioning of ecosystems on which people depend on for food, water, health and recreation (CBD, 2010) and are affected globally with many species suffering from extinction and several others threatened. Ecosystem services such as food resources cannot be guaranteed under such rapid biodiversity decline which will adversely affect human livelihoods. Climate change will further deepen these concerns and exacerbate their implications. It has also been widely noted that rising temperature will lower water quality in freshwater ecosystems through the fall in hypolimnetic oxygen concentration, the release of phosphorus from sediments and altering of mixing regimes (Fischlin *et al.*, 2007). It recognized again the fact that increase or decrease in freshwater flows as a result of a decrease in rainfall will affect coastal wetlands by altering the salinity, sediment inputs and nutrient loading (Fischlin *et al.*, 2007). The same authors have emphasized that small increases in variability of precipitation regimes have the potential to significantly affect wetland plants and animal species at different stages of their developmental cycles (Fischlin *et al.*, 2007).

These studies, however, failed to link the implications of these changes in ecosystem services to the livelihoods of people that depend on them, particularly in developing

countries where the majority of the human folks rely on these resources for their livelihoods, a gap this current study attempts to address.

2.9 Anthropogenic and Non-Climatic Drivers on Ecosystem Changes and

Deterioration

Climate change has been cited as one of the dominant threats to biodiversity and ecosystems and their effective services delivery (MEA, 2005, Ahenkan *et al.*, 2012, IPCC, 2013). In most studies, they stressed that climate change adds to the mix of drivers and reinforces their negative effects on ecosystems. These effects manifest in many ways including altering the abiotic habitat condition such as water balance, shifts in species phenology and distribution all of which can affect ecosystem structure and functions and the services they deliver for humans (Rannow & Forster, 2014).

However, despite the overwhelming evidence, others lamented the difficulty of decoupling other drivers of biodiversity loss from the influences driven by climate change (Maarten *et al.*, 1999, CBD, 2010). But consensus has been built and many tend to agree on the fact that climate change tends to exacerbate the existing anthropogenic pressures such as pollution, land use and land use changes, over-exploitation, habitat fragmentation, invasive species thereby accelerating their effects on biodiversity loss, altering ecological processes and functions, and limiting their associated ecosystem services delivery (Fischlin *et al.*, 2007; CBD, 2010).

2.10 Local Livelihoods and Adaptation Strategies to Past Climate Variability and Change

The effective functioning of ecosystems help in providing a wide range of ecosystem services to human societies and their deterioration threatened by climate change and other interacting factors has been noted to have severe implications for human well-being

especially the rural poor (MEA, 2005) and future generations (Chambers & Conway 1992). Interestingly, it has been recognized that local strategies have been in practiced since time immemorial to coping and adapting to harsh conditions to ensure sustenance and resilience by the local people (Ahenkan *et al.*, 2012). Increasing climate variability however, places a greater concern about such practice and their sustainability with climate change in the midst of existing socio-economic challenges such as poverty, high illiteracy rates and gender inequalities that often characterized rural communities in developing countries. Sound scientific evidence that will guide the design and implementation of effective adaptation strategies are therefore imperative to enhancing local adaptation in the face of rapid climate change and its attendant effects on vulnerable communities and their livelihoods.

2.11 Research Gaps in the Literature

Although increasing interest and efforts have been directed towards research on climate change and its impacts on ecosystems and their resources, several research and knowledge gaps still exist that are crucial for designing effective management and conservation strategies for protecting ecosystems and their valuable resources. This position is consistent with the argument of Bennett *et al.*, (2015) who also noted that although several efforts have been directed towards addressing the knowledge and research needs in relation to ecosystem services in the face of rapid anthropogenic climate change, yet several gaps that are critical to ecosystems management and their conservation in providing essential ecosystem services in the face of rapid anthropogenic climate change still persist. In developing countries, for instance, there are studies that have attempted to address the knowledge gaps in the ecosystem services science and their sustainability to enhancing livelihoods and poverty reduction in recent times but important knowledge gaps for comprehensively tackling the ecosystem deterioration and ecosystem services decline remain arguably a daunting challenge (Ahenkan *et al.*, 2012; MEA, 2005).

These reviews clearly indicated that one of most important necessities and areas identified for research to promote sustainable management of ecosystem services is in regards to economic valuation of ecosystem services, thus putting a monetary value on the benefits that people derived from ecosystems and the services. It remains difficult to quantify the value of most ecosystem services, particularly the non-provisioning and regulating ecosystem services in monetary terms although emerging frameworks are being developed and are undergoing various testing and evaluations. This gap possessed a major conservation and management challenge to ecosystem services since people are unable to appreciate the value of these services as compared to other marketable goods and services.

In the Ghanaian studies, most of the work has been done in the northern part of the country focusing on climate impacts on agriculture whilst little attention has been given to southern part especially along the coastal zones where many people are located (Adiku et al., 2011). Assessments of the impacts of climate change on ecosystems and their implications on human livelihoods and sustainability are scarce yet critical for sustainable management and conservation as they play important roles in enhancing human subsistence and survival.

2.12 Conceptual Framework

In order to simplify and ensure a balanced understanding of the complex link existing between climate change and ecosystem services and human livelihoods, this study seeks to adopt a human ecology approach as used in other studies (MEA, 2005, Ahenkan et al., 2012).

Human Ecology is defined as the study of the dynamic interrelationships between human populations and the physical, biotic and social characteristics of their environment and the biosphere (Ahenkan *et al.*, 2012). This means the ecosystems provide benefits for humans and humans can, in turn, affect ecosystems in myriad ways. They noted that human ecology

as an interdisciplinary subject integrates concepts across different disciplines and holistically solves problems and enhances the understanding of the complex interaction between human beings and their environment. The complex and multifaceted nature of climate change and ecosystem services and the implications on livelihoods options demands a broader approach to effectively examine the issues rather than a single discipline. Therefore Ahenkan *et al.*, (2012) pointed out that knowledge of ecology, forestry, sociology, geography, economics will be useful in enhancing the understanding of this complex issue. As observed in other studies, the assessment of the conditions of ecosystem and the provision of essential services requires such an integrated approach that will enhance the decision making process as to determine which services or set of services are valued most and how we can design approaches for their sustainable management (Petheram & Campbell, 2010).

2.12.1 Brief Description of the Conceptual Framework

This is the conceptual framework developed for assessing the linkages of ecosystem services to enhancing human livelihoods and how climate variability can impact these services causing the human dependents to employ alternative coping strategies in response to climate. The premises of this conceptual framework is based on the fact that various ecosystem services are provided by the wetland ecosystems (lagoons, peatlands, rivers, etc) that can enhance human livelihoods but can, however, be impacted by climate variability of rainfall and temperature, hence causing people to look for alternative livelihood and coping strategies to build their resilience and enhancing their capacities for adaptation to the impacts of climate change and climate variability. The conceptual framework of the study is illustrated in **(Figure 4.)**

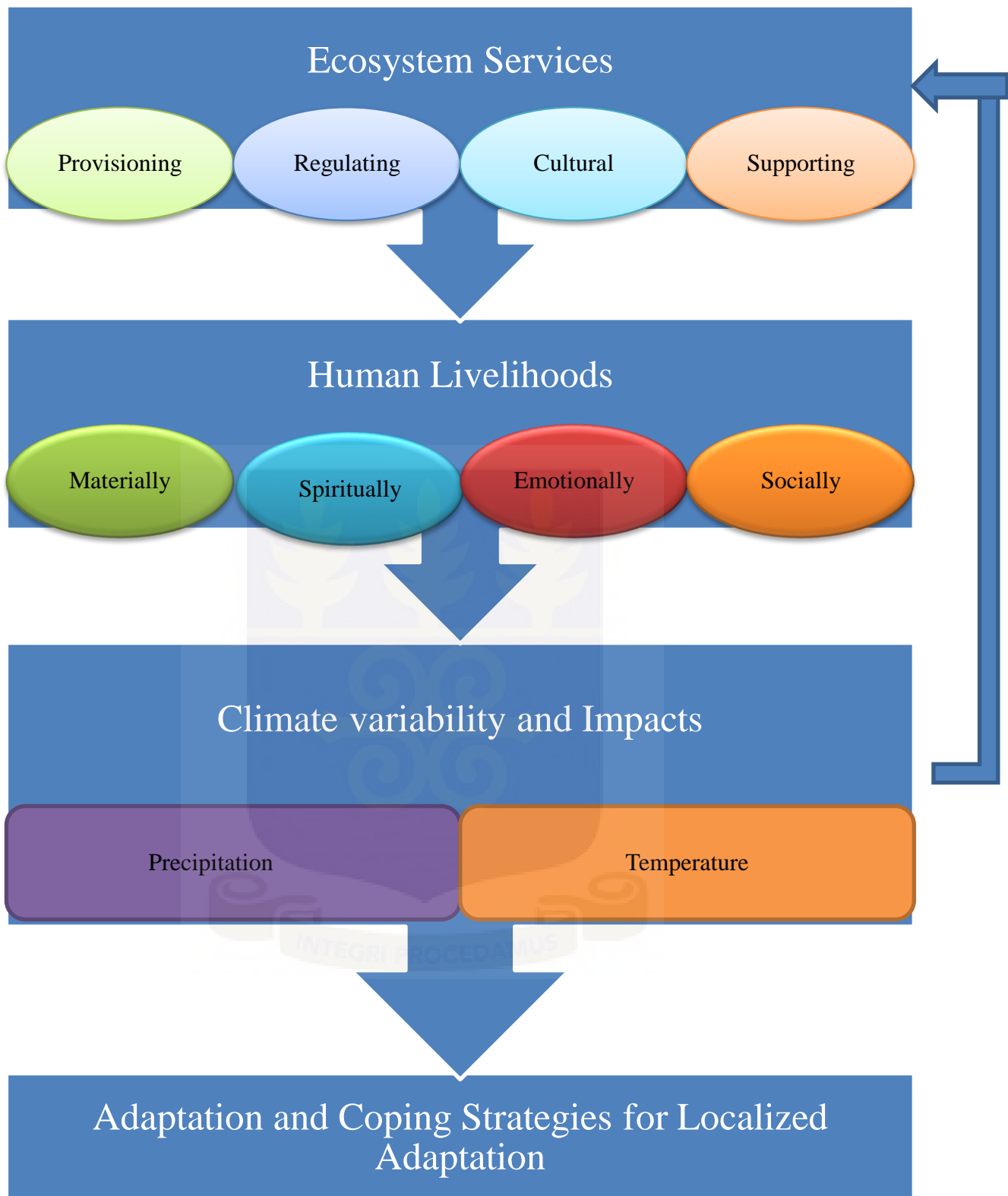
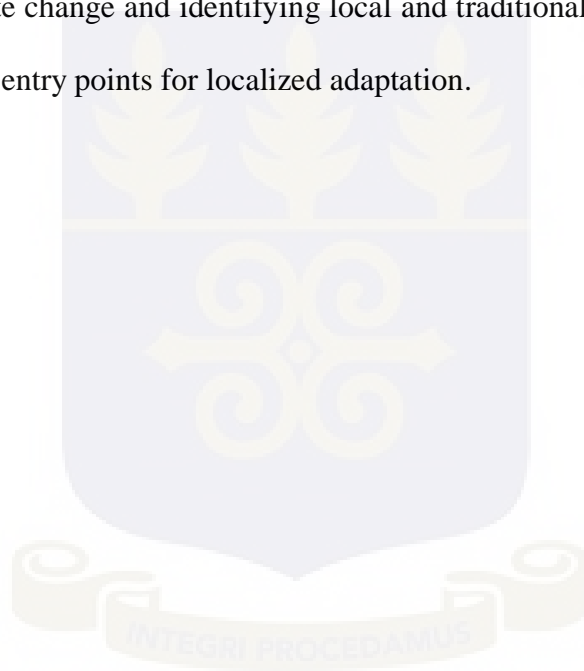


Figure 4. Conceptual framework for assessing the linkages of ecosystem services to enhancing human livelihoods and how climate variability can impact these services causing the human dependents to employ alternative coping strategies in response to climate. Source: Adapted from Ahenkan et al., (2012)

2.13 Chapter's Conclusion

It has been widely recognized that there are severe implications of climate change on ecosystem services. This is, however, contingent on other non-climatic drivers making the linkages increasingly difficult. Also recognized by related literature is the fact that climate change awareness and perception among Ghanaians particularly farmers has been low exacerbating the gap that exists in the communication of climate-related issues among the Ghanaians especially the rural poor which is a necessary tool for effective adaptation. This research sought to contribute to closing the awareness gap among the rural communities on the impacts of climate change and identifying local and traditional climate change coping strategies to serve as entry points for localized adaptation.



CHAPTER THREE

MATERIALS AND METHODS

3.1 Introduction

This chapter describes the research paradigm upon which the methods of inquiry are based. It also indicates the research methods/design used and the unit of analysis. These include the description of the study area, sources of data, the research methods for collecting data, sampling techniques used in sampling data, target population under consideration and its size, and general data collection procedures that were used.

3.2 Research Paradigm and Theoretical Perspective

This study is anchored on the pragmatic philosophical world view. The pragmatic philosophical paradigm is concerned with the application of what works and offering of solutions to problems using different approaches. Creswell (2003) noted that the pragmatists view the problem to be solved more important rather than the methods and therefore researchers use all kinds of approaches to better understand the problem under investigation in order to arrive at a solution, hence its philosophical underpinning for mixed methods studies. The assumption underlining this approach is that the collection of the diverse type of data sets using various methods and approaches will best provide an understanding of the research problem being investigated. This is particularly important because of the limitations that are inherent in the individual methods.

In relation to this study, the functions of ecosystem services and change can be impacted by several drivers other than anthropogenic climate variability only and may have severe implications on the beneficiaries in different ways. This, therefore, means that using a single method or approach will not provide sufficient information for better understanding of the problem. This, therefore, has influenced and is the reason for adopting mixed methods

approach which opens the door for multiple methods, different assumptions as well as different forms of data collection techniques and analysis (Creswell, 2003). The pragmatists agree that research always occurs in social, historical, political and other contexts and therefore adopting mixed methods studies will provide postmodern turn with a theoretical lens that is more reflective of social justices and political aims (Creswell, 2003).

This study will therefore begin with a broad survey to generate the results that can be generalised to the population under investigation and then focus on the second phase, detailed qualitative in-depth interviews and focus group discussions to collect views from respondents about the ecosystem services and how their livelihoods are enhanced and their perceptions, knowledge on climate variability and climate change.

3.3 Approach and Conceptual Framework

In order to facilitate and ensure a balanced and broader understanding of the complex linkages that exist between climate change and ecosystem services and human livelihoods, this study adopted the human ecology approach which forms part of the ecosystem approach used widely in many studies (MEA, 2005, Ahenkan *et al.*, 2012). Human ecology has been defined as the study of the dynamic interrelationships between human populations and the physical, biotic and social characteristics of their environment and the biosphere (Ahenkan *et al.*, 2012). Human ecology as an interdisciplinary subject integrates concepts across different disciplines to holistically solve problems and enhance the understanding of complex interactions that exist between human beings and their environment. The complex and multifaceted nature of climate change and ecosystem services and livelihoods demand such a much broader approach to effectively examine these linkages rather than a single discipline. Therefore knowledge of ecology, forestry, sociology, geography, and economics will be essential in enhancing the understanding of these complex issues (Ahenkan *et al.*, 2012).

3.4 Research/Study Design

This study adopted the mixed methods design of inquiry which combines both quantitative methods and qualitative approaches to explore data on the variations in climate variables such as temperature and rainfall patterns over a 30 year period and the implications on human livelihoods that are linked to the key ecosystem services.

The quantitative methods involved the use of a survey where semi-structured questionnaires were administered to the population sample. Field observations on the ecosystem structure and essential ecosystem services were explored coupled with the use of climatic data on temperature and rainfall patterns over a 30 year period to ascertain changes and variability.

For the purpose of in-depth analysis of the results from the quantitative analysis, a further approach called the qualitative methods which include interviews and focus group discussions were conducted to provide a platform for assessing convergence of both data sets. According to Innes and Booher (2010), qualitative methods offer a grounded form of knowledge which can address the full complex of a situation and also allow solutions to be tailored to unique circumstances.

The rationale for using a mixed methods design is underscored by the recognition that there are inherent limitations that are associated with using just a single approach, hence the need for different methods which will allow for triangulation of data and to seek for convergence of evidence and validity of information from both qualitative and quantitative data (Creswell 2003). For instance, qualitative methods allow important dimensions to emerge from the analysis of cases under study without supposing in advance what those dimensions will be. Teye (2012) thus noted that the basic underlying assumption about mixed methods research is the fact that it provides a broader and more credible understanding of the research problem than a dichotomous qualitative/quantitative approach. Its usage can help cross-validate

findings emerging from both qualitative and quantitative approaches. The other advantage is that the results obtained from one method could also be used to inform the design of the other method to further gain a deeper understanding of the problem under investigation.

The use of quantitative approaches in research is often preferred due to its usefulness in making predictions and generalization as well as the higher level of objectivity that is often associated with it, however, researchers have criticized this approach on the grounds that it is not good for explaining behaviors and perceptions (Teye, 2012). Others also argued that measurements in quantitative research tend to detach findings from real-world contexts (Moghaddam, Walker & Harre, 2003, Teye, 2012) hence it fails to reflect the ground situation of peoples' experiences and perceptions of the problem under investigation.

On the other hand, it is worth noting that qualitative methods in research do not escape criticism by scholars and therefore have been severally criticized for being too subjective (Plano Clark, Huddleson, Churchill, Green and Garrett 2008, Teye, 2012) and therefore cannot be used for generalizations and predictions.

In addressing the strengths and weakness associated with both qualitative and quantitative methods, the use of mixed methods offers an important catalyst and tool for dissolving complex problems. It is therefore against this backdrop that combining both quantitative and qualitative approaches are important tools to employ in investigating the current situation of ecosystem services and human livelihoods resilience in the face of anthropogenic climate variability as well as the perceptions and awareness of the people on this global phenomenon.

Although several benefits can be obtained through mixed method approaches, these methods are also noted to be confronted with many challenges which should be handled carefully. These challenges include increased cost of research, time constraints, the problem

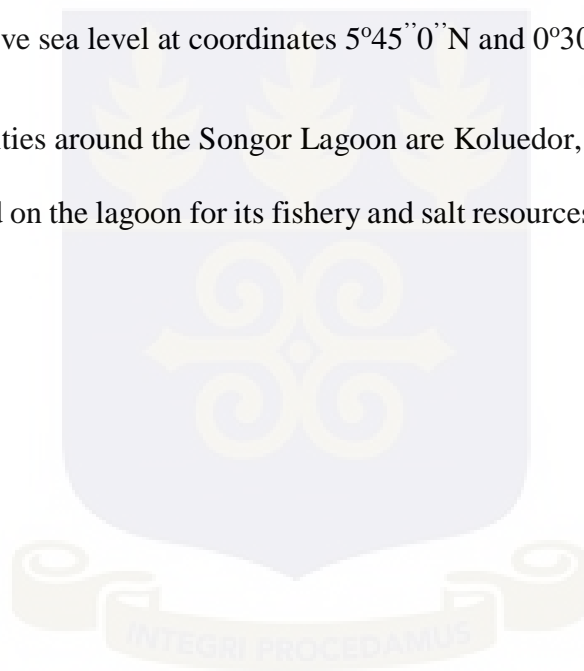
of integrating findings across methods, conflicts in data interpretation as well as adapting to the dynamism of positionalities (Teye, 2012).

3.5 Description of Study Area

3.5.1 Study Location

The study was conducted at the Songor Ramsar site and surrounding communities. The Songor Lagoon is located in the Ada East District of the Greater Accra Region of Ghana as indicated in (Figure 5.). It is a coastal wetland designated as a Ramsar site, and is therefore of international ecological importance. It covers an area of about 51,133.33 hectares at an elevation of 69m above sea level at coordinates 5°45'0''N and 0°30'0'' E.

Among the communities around the Songor Lagoon are Koluedor, Toflokpo and Songorya which largely depend on the lagoon for its fishery and salt resources and a source of income and livelihoods.



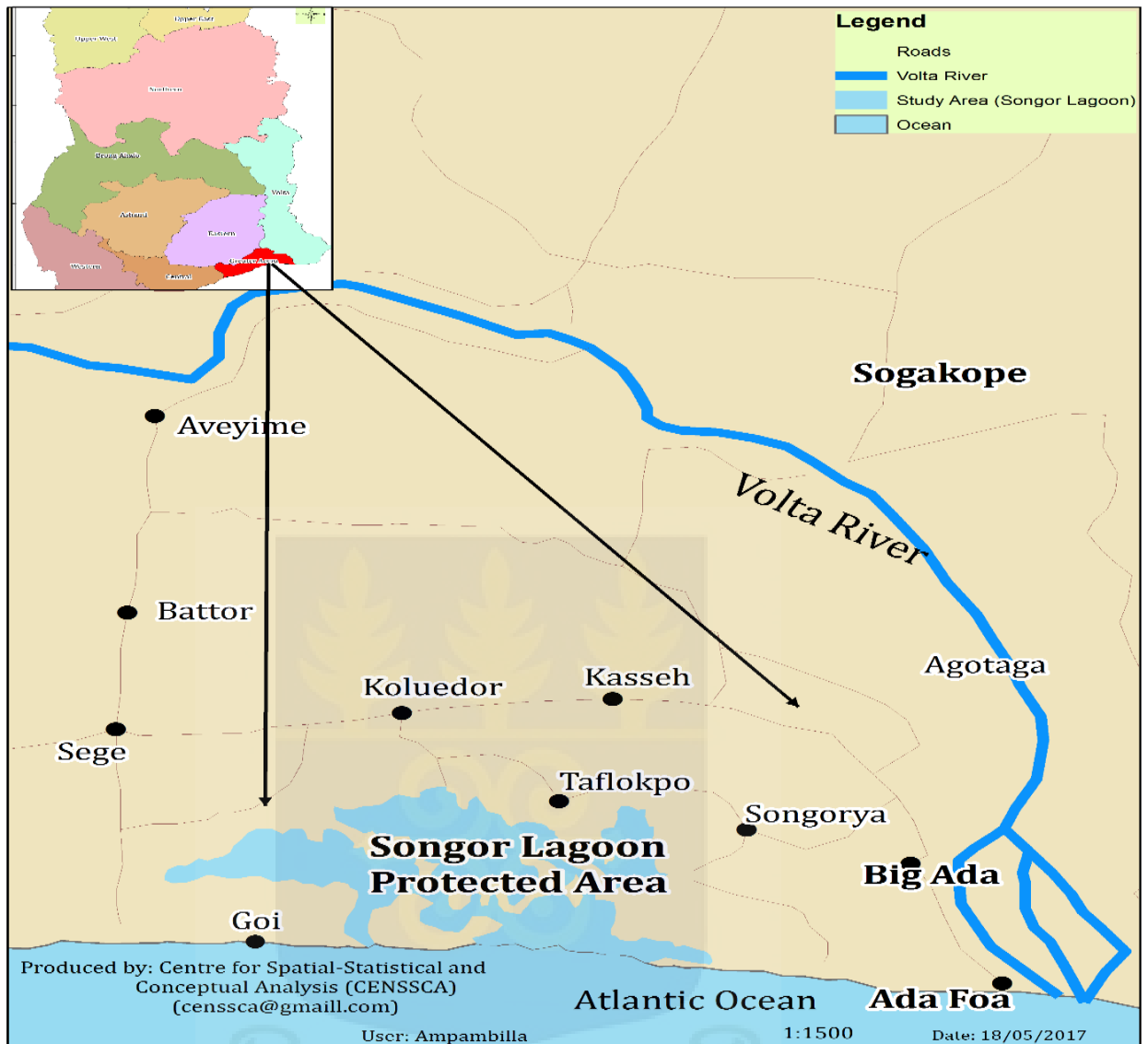


Figure 1. Map of the Study Area with the Communities around it

Source; CENSSCA (2016)

3.5.2 Biological Characteristics

The Songor Lagoon is a habitat for many living organisms such as aquatic birds, including egrets, herons, avocet, stilt waders, and terns; and marine turtles including, leatherback turtles and olive ridley turtles. These are commonly found along the shores and serve as a major means of attraction to tourists.

The vegetation of the area comprises of a mix/mosaic of saline marshes, waterlogged grasslands, scattered thickets of shrubs, climbers, riverine woodland, stunted mangroves along the lagoon margins are also predominant. Some common flora species include *Paspalum vaginatum*, *Cyperus articulatus*, *Sesuvium portulacastrum* and *Elocharis mutata* that are dominant along the floodplains of the Ramsar site (Ramsar Site Information Sheet, 2016).

3.5.3 Socio-economic Characteristics

The Ada East District has a population of about 71,671 of which 47.5% are males and 52.5% are females. Out of this figure, the higher proportions of about 70% of the people are living in rural communities (Ghana Statistical Service, 2010).

The main economic activities and sources of the people in the area include farming, intensive salt extraction, fishing and trading. Agricultural, fishing and salt mining sectors are all noted to be climate sensitive. Climate variability, therefore, presents a major threat to the sustainability of these sectors and overall implication on the livelihoods of the communities that rely on these resources. The communities are also said to benefit economically from neighboring countries like Togo, Benin, Ivory Coast and Nigeria who patronize in the salt produce for exportation into their local markets. This trade generate foreign exchange and taxes for the communities and the District Assembly of the study area.

3.6 Types and Sources of Data

The main types of data sets used for the study were both primary and secondary data. The primary data were collected through the administration of questionnaires to the respondents. The aim here was to facilitate the understanding of the respondents' recognition of essential ecosystem services obtained from the Songor Lagoon. It also sought to understand better whether there have been declines and changes in these services over the years and the

people's level of awareness, and perceptions on climate variability. Their livelihoods and coping strategies in response to the perceived impacts of climate change were also assessed through this survey.

The secondary data was obtained from the Ghana Meteorological Agency for the periods of 1980 to 2010. The data included climatic variables such as temperature and rainfall patterns. These were used to determine the trend of climatic variability within the study area and the implications on ecosystems structure, functions, the essential services they provide and how these, in turn, affect the livelihoods of the communities. The yearly production figures of salt by the Songor Salt Project since 1996 to 2010 were also obtained for to assessing the impacts of temperature and rainfall variability on the production of salt over the years.

3.7 Target Population and Sampling Techniques

The target group for the study was sampled from a range of stakeholders who are directly or indirectly affected by the provision of ecosystem services by the Songor Lagoon. These include permanent residents and stakeholders living around the study area such as farmers, fishermen, herdsman, and hunters. The sampled individuals were above 30 years. The age limits were to ensure that those who understood and have historical perspectives of the study area with regard to climate change were considered. A purposive sampling technique was therefore employed in sampling about 180 respondents from three different communities around the lagoon for the survey. Individuals however after purposively targeted, were taken randomly to participate in the study.

3.7.1 Sample Size

To ensure true representation of the sample, a more rigorous and scientific technique was employed to obtain the sample size. This sampling technique was derived from the sampling method by Miller and Brewer (2003) and which is calculated as follows;

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

(a)

Where;

n = Sample size *N* = population size *a* = marginal error of 8% or 0.08

$$\text{Hence } n = \frac{71,671}{1+71,671(0.08)^2} = 156.24 \approx 156$$

This methodology gave a minimum sample of about 156 participants that could be recruited for the study but for the purpose of representativeness of the population, a sample size of about 180 respondents was selected from the three communities studied to reduce errors.

3.8 Data Collection Procedures

In order to ensure a comprehensive analysis of the research problem under investigation, the study adopted an integrated framework that helped to guide the data collection on the major sections of the research problem whilst relying on a wide review of scientific literature available on the research problem. Both primary and secondary data were collected in addressing the research questions set forth to answer within the scope of the study.

Secondary data on climate variability and change for a period of 30 years from 1980-2010 were collected from the Ghana Meteorological Agency (GMET). The data was used to ascertain the trend and changes in rainfall and temperature variability patterns in the study area over the specified period. This was further useful in exploring the implications on ecosystem services changes, stability or decline as a consequence.

To be able to ascertain this link, that is the interaction between the ecosystem services, particularly salt production which is largely the main commodity obtained from the Songor lagoon and the climate conditions, data on the production of key ecosystem services (salt production) was collected from the Songor Salt Project (SSP). It is a government of Ghana Liability initiative for the production of salt to feed both the local and the international markets. The data was collected for the period between 1996 and 2010. A multiple regression analysis was used to analyse the impacts of climatic variables such as rainfall and temperature on salt production at the study area. The salt production was the dependent variable while the temperature and rainfall variability were the independent variables.

An individual field survey was also conducted to give a broader understanding of the research problem through the administration of semi-structured questionnaires to the sampled respondents. The purpose of the survey was to explore the respondents' views on the key ecosystem services that are obtained from the Songor Lagoon, their knowledge and understanding, their level of awareness about climate change and climate variability and the implications of these changes on their livelihoods resilience. Other participatory and exploratory research methods including three key informant interviews and two focus group discussions were conducted in the data collection regarding the communities knowledge and experiences about ecosystem services, the level of awareness of climate change and its impacts on their livelihoods as well as coping and adaptation strategies. Due to time and financial constraints, the focus groups discussions were however held in only one community (Koluedor).

Prior to administering the questionnaire, a representative sample of the target population mostly farmers, fisher folks, traders, hunters among others living around the study site and are directly or indirectly affected by the Songor lagoon was selected through the use of purposive sampling technique. The selected communities respondent were Koluedor,

Toflokpo, and Songorya. Only community members under the target population who were 30 years and above were purposively selected for participation in the study. This was based on the assumption that the younger people have less experience on climate change and its trends but older people tend to have deeper understanding and therefore are able to give historical perspectives on the trends and changes of climate variability such as temperature and rainfall patterns and the implications on their food produce, livestock production in the communities over the years (Ahenkan et al., 2012).

In all, 180 questionnaires were administered to the sampled respondents in the three selected communities and the response rate was about 97%. The other participatory methods such as three key informant interviews and two focus group discussions were conducted to validate the findings obtained from the survey and the field observations. These techniques were very significant in that they tended to facilitate open dialogue and co-learning among the researcher and the study participants as depicted in Plate 1. They tend also to provide more qualitative data on key areas that might not have been tackled or covered in the survey.

The final part of the data set that was collected on salt production data from the Songor Salt Project for a 10 year period. The data was standardized and analyzed (see chapter 4). The data was used to ascertain the implications and impacts of climate variability on the extent of production. It has however acknowledged the fact that other confounding variables that may influence such outcomes which could not be accounted for in this paper.

The data obtained through all these approaches were stored and managed for processing and subsequent analysed as outlined in section 3.9



Plate 1: Interactive Meeting with Some Respondents during Focus Group Discussion Session

Source; Field Photo Author

3.9 Data Management and Analysis

3.9.1 Data Processing

The data obtained from the survey were coded and appropriately entered into a Statistical Package Called the Social Package for Social Sciences (SPSS) software version 22 using proper coding techniques and procedures to facilitate further analysis.

The data from key informant and focus group discussions (FGDs) were transcribed into a format that can help to explain and give more in-depth evidence for the individual survey

The secondary data obtained from GMET were also processed into annual average and interdecadal temperature and rainfall and presented in the form of charts. The data on the annual salt production obtained from the Songor Salt Project were also processed for analysis to draw the link between the climatic variability in temperature and rainfall against the extent of salt production over the period specified.

Statistical Analysis

Two main analyses were done to understand and draw the appropriate inferences from the data obtained from the field. These included descriptive and inferential statistical analyses. Prior to running the statistical analysis on the climatic variables such as the data sets on rainfall and temperature records, normality tests were carried out to see if the climatic data sets for both temperature and rainfall were normally distributed. This was to choose the appropriate statistical test using either a parametric or non-parametric method to test for the significant difference on the changes in rainfall and temperature patterns recorded over the years. This is critical in ascertaining the threshold levels of both variables and their implications on the present and future livelihoods of the communities in the study area.

Descriptive Statistics

Firstly, a comprehensive descriptive statistics were run on all the variables investigated in the form of means, percentages, and standard deviations among others to get a clear representation and distribution of the respondents' responses on the various variables being investigated. The results of this analysis were tabulated or where appropriate put in form of charts based on the category of variable examined to achieve the objectives of the study.

Inferential Statistical Analysis

On the other hand, four different statistical analyses were run for the data gathered from the field. These included the Pearson-Chi Square Test which sought to establish the relationship and the significance between the respondents' educational level and gender, and the respondents' location and their climate change perspectives. These independent variables (age, gender, education, location, religion, and occupation) were thus tested against the dependable variable (climate change perception and understanding) to determine if significance relationship exists between these variables.

The second statistical test used was the Pearson correlation Chi –Square test which was also employed basically as a tool to test the relationship and significance of the respondents’ current state of livelihood activities compared to the past 20 years ago.

Thirdly, in order to ascertain the factors that determine the resilience of the respondents in the three communities to the perceived current and future climate impacts, a binary logistic model was employed. This statistic is a proxy way of assessing each of the community’s resilience to the impacts of climate change both now and in the near future depending upon two dichotomous variables such as the presence or absence of the resilience indicators such as institutional capacity, infrastructure, early warning systems, external support and financing among others.

The Model is specified as follows;

$$\text{Logit} (Y_i) = \ln \left(\frac{P_i}{1-P_i} \right) = \beta_0 + \sum (\beta_i X_i + \dots \dots \dots \beta_n X_n) + \mu_o \dots \dots \dots$$

(b)

Where

Y_i = a dependent dummy variable for Resilience which is equal to one (1) if the respondents’ livelihood is resilient and zero (0) if not resilient

X_i = the independent factor under investigation that can influence Resilience

β_i = regression coefficient to be estimated

β_0 = intercept of the regression coefficient

P_i = the Probability of being Resilient μ_o = error margin

By expansion, the logit equation can be written as follows where the various independent indicators influencing resilience are incorporated:

$$\mathbf{Logit (Y_i) = In \left(\frac{P_i}{1-P_i} \right) = \beta_0 + \beta_1 Instc + \beta_2 Ppm + \beta_3 Infra + \beta_4 Techc + \beta_5 Ears} \\ \mathbf{+ \beta_6 Acces + \beta_7 Relsa + \mu_o \dots\dots\dots (c)}$$

For the purpose of clarity and precision, the determining factors of resilience among the three different communities investigated are summarized in Table 1. below



Table 1. Determinant/Factors of Resilience of the Communities investigated in the Study

<i>Variable</i>	<i>Description</i>	<i>Mode of measurement</i>	<i>Expected sign (-+)</i>
<i>Y_i</i>	<i>Resilience</i>	<i>Dummied variable Resilient=1 Not Resilient =0</i>	-+
<i>Pp_m</i>	<i>Proper planning Mechanisms</i>	<i>Dummied variable Yes =1 No=0</i>	-+
<i>Instc</i>	<i>Institutional Capacity</i>	<i>Dummied variable Yes=1 No=0</i>	-+
<i>Inf_c</i>	<i>Infrastructural Capacity</i>	<i>Dummied variables Yes=1 No=0</i>	-+
<i>Ear_s</i>	<i>Early warning systems availability and accessibility</i>	<i>Dummied variables Yes=1 No=0</i>	-+
<i>Tech_c</i>	<i>Technological capacity</i>	<i>Dummied Variable Yes =1 No =0</i>	-+
<i>Acce_s</i>	<i>Access to external support</i>	<i>Dummied variable Yes=1 No=0</i>	-+
<i>Reli_s</i>	<i>Relief services availability and accessibility</i>	<i>Dummied variable Yes=1 No=0</i>	-+
<i>Rain_p</i>	<i>Rainfall Perception</i>	<i>Dummied variable Increase= 1 Decrease=0</i>	-+
<i>Tem_p</i>	<i>Temperature Perception</i>	<i>Dummied variable Increase= 1 Decrease=0</i>	-+

Source: Authors own Construction

Finally, the fourth statistical tool was the multiple linear regression model which sought to established the linkages between variability in temperature and rainfall and the impacts on salt production.

3.10 Modeling the Impacts of Climate Variability on Ecosystem Services

The tool used was a linear multiple regression model employed to assess the impact of climatic variables such as temperature and rainfall variability on salt production in the Songor Lagoon. This test was useful because it provided both the coefficient of determination which describes the relationship between the level of salt production (dependable variable) with variations in temperature and rainfall (independent variables) and the significance of any relationship. Thus, it helps to quantify the impacts of temperature and rainfall on the quantity of salt produced at a time.

The Linear Multiple regression model is represented by the equation as follows:

$$Y = a_0 + \beta_1 X_1 + \beta_2 X_2 + \mu_0 \dots\dots\dots (c)$$

Where;

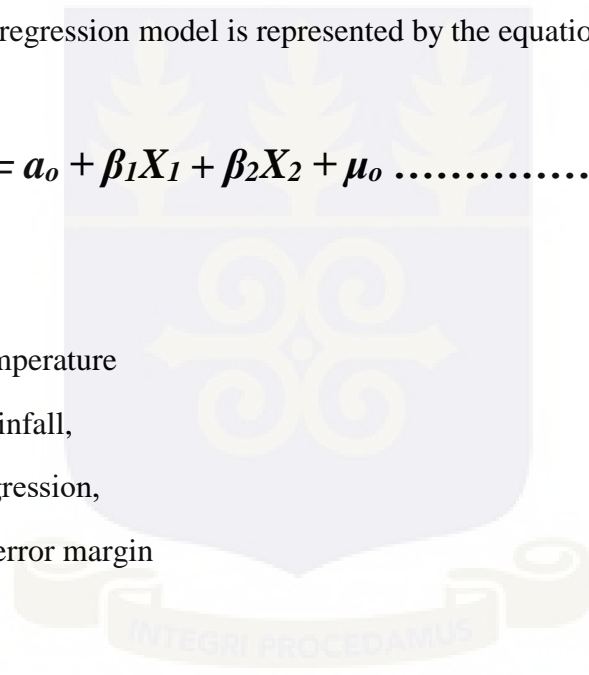
Y = Salt Production,

X₁ = Variation in Temperature

X₂ = Variation in Rainfall,

β = coefficient of regression,

a₀ = constant and μ₀ error margin



CHAPTER FOUR

RESULTS

4.1 Introduction

In this chapter, a summary of the findings of the study based on the various approaches used in gathering and analyzing the data generated is presented. Although brief descriptions are added to the results, the comprehensive and detailed discussions of these findings are given full attention in chapter five.

The first part of this chapter presents the demographic information on the study respondents and their distribution according to the various variables examined in the study. The second aspect includes data obtained from the GMET on temperature and rainfall pattern variability. The third part focuses on the survey that was conducted with the help of semi-structured questionnaire for gathering data on the key ecosystem services that the respondents derived from the site. Their perceptions about, knowledge and understanding of climate change were also analysed. Finally the last part captures the implications of these changes on their livelihoods and resilience and the coping strategies that are adopted in response to these changes to build their resilience.

4.2 Demographic Characteristics and Distribution of Respondents

Out of the total number of 180 respondents that were to be sampled for the study, there was a success response rate of about 97.2% . The non participation of the some targeted respondents was because of personal reasons and the need to conform to the ethical principles of voluntary participation without coercion they were allowed to withdraw.

4.2.1 Respondents' Communities of Residence

Out of the total of 175 respondents sampled from the three communities, namely Koluedor, Toflokpo and Songorya in the Ga East District, about 39.4% (69), 22.9% (40) and 37.7% (66) are from Koluedor, Toflokpo and Songorya respectively (Figure 6). They were sampled because of their proximity to the Songor Lagoon and their accessibility and frequency of engagement with the site for accessing essential ecosystem services, particularly the salt production. Community location had a significant influence on the occupation and livelihood activity of the respondents ($X^2 = 55.18$, $df = 10$, $p < 0.05$). Residents of Songorya close to the lagoon were predominantly salt miners (20) out of 36 salt miners whereas those of Koluedor were mostly farmers (55) out of 84 farmers. The respondents' community of location and whether they had knowledge and understanding of climate change were found not to differ significantly ($X^2 = 1.9$, $df = 2$, $p > 0.05$).

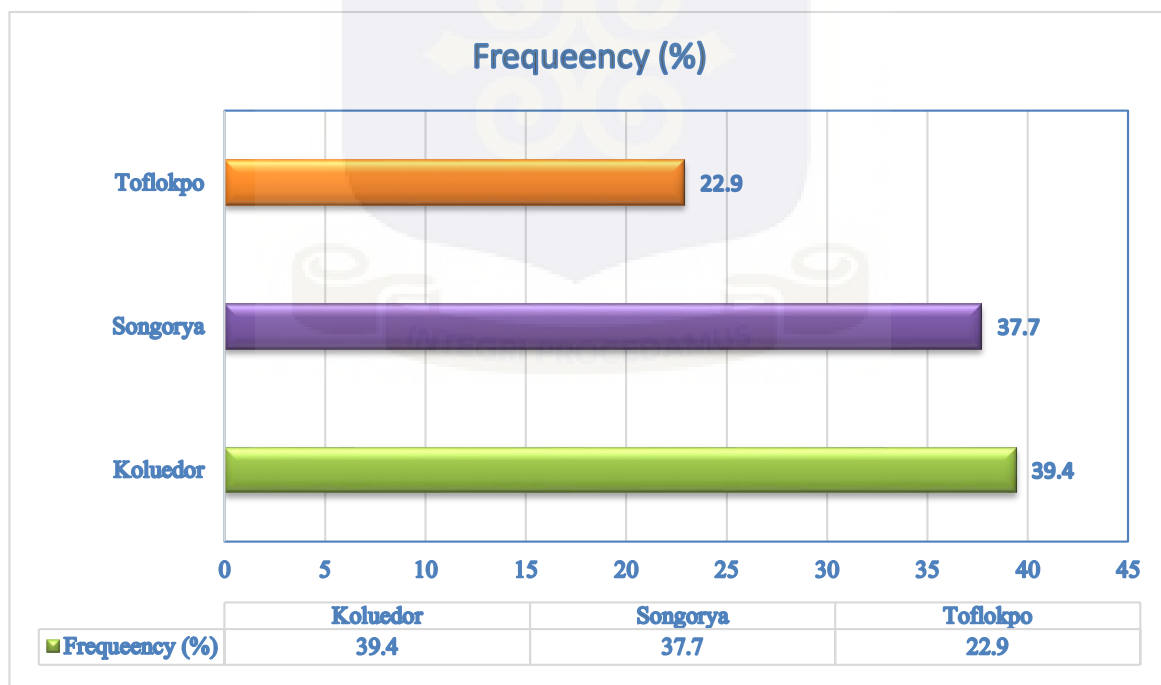


Figure 2. Distribution of Locations of Respondents

Source: Author's Field Data

4.2.2 Gender Distribution of Respondents

The majority of the respondents 52.6% (92) were males whilst 47.4 % (83) were females with dominating respondents being males. Farming and salt mining were the most dominant economic activities in the study area. Out of 84 farmers interviewed, 45 were females and out of 36 salt miners, 20 were females and these were actively engaged in the Songor lagoon for the salt extraction as a source of their daily livelihoods and subsistence. There was however no difference in the respondents' gender and occupational engagement in the different communities ($X^2 = 9.13$, $df= 5$, $p > 0.05$). Similarly, with respect to gender and respondents' knowledge and their understanding of climate change, there was no significant difference ($X^2 = 2.68$, $df= 1$, $p > 0.05$). The gender distribution of the respondents is presented in (Figure 7.)

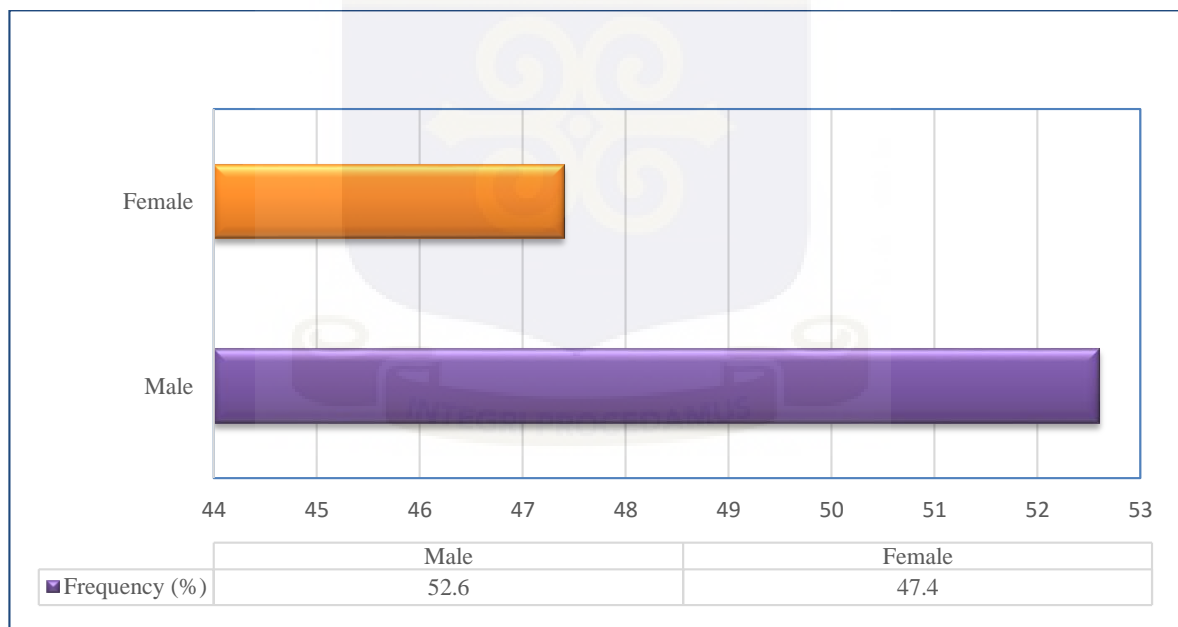


Figure 3. Gender Distribution of Respondents

Source: Author's Field Data

4.2.3 Age Categories of Respondents

Based on the objectives and the design of the study, people below the age of 30 years were excluded from the study since they may be unable to give discernible historical perspectives of the study area in relation to climate change. The survey, therefore, captured respondents' who were resident in the area and were 30 years and above with long-standing historical knowledge about the area especially with regards to temperature and rainfall variation. The age categories of the target sample are represented in Figure 8.

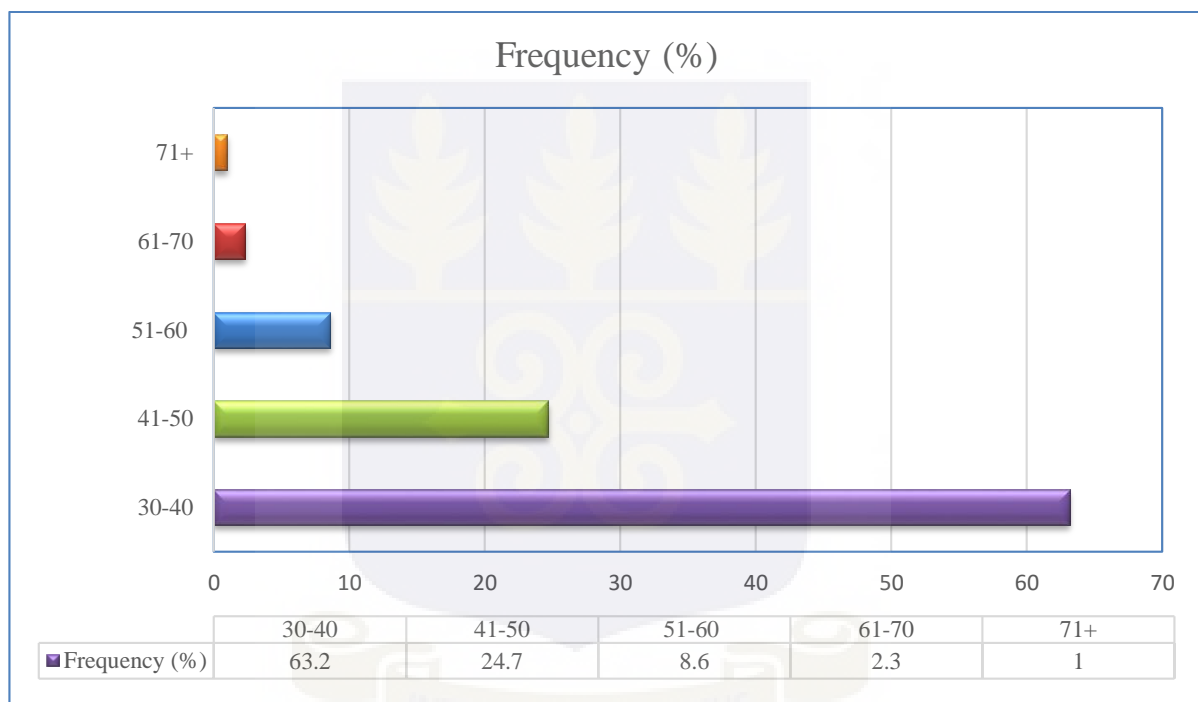


Figure 4. Age Categories of Respondents

Source: Author's Field Data

4.2.4 Religious Affiliation of Respondents

The religious affiliations of study respondents were indicated as follows; about 7.4 % (13) were Traditional worshippers, 88.0% (154) were Christians and 4.6% (8) were Muslims with the dominating religion of the respondents being Christianity (Figure 9). There was however no difference in the respondents' religious affiliations and their knowledge and

understanding about climate change ($X^2 = 2.32$, $df= 3$, $p > 0.05$). This means that one's religious persuasion has no influence on the way they understand climate change and its impacts.

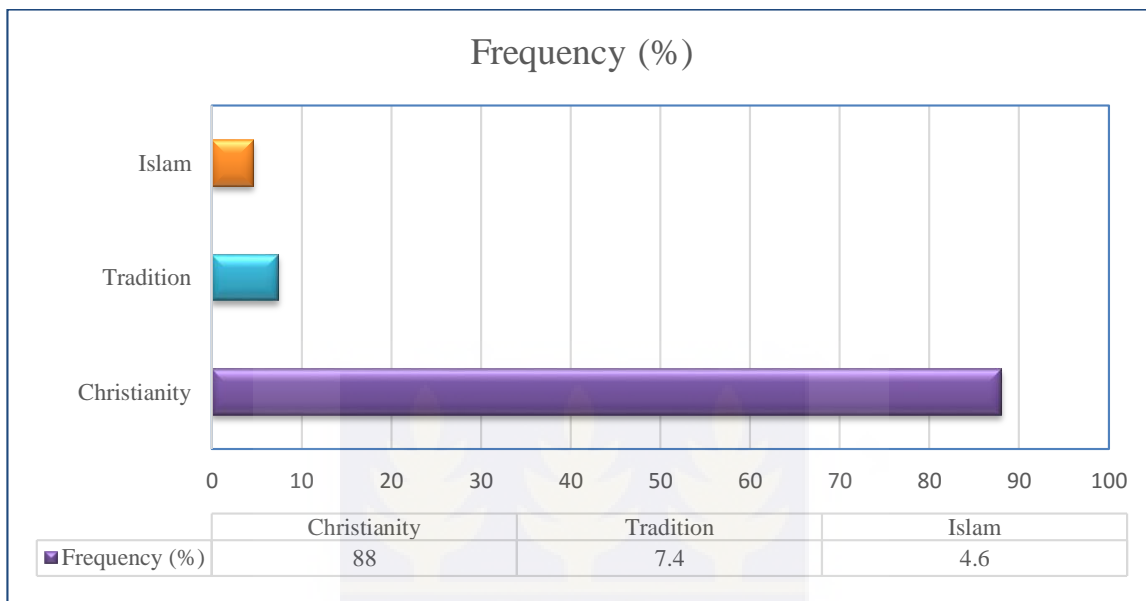


Figure 5. Religious Affiliations of Respondents

Source: Author's Field Data

4.2.5 Major Occupation Characteristic of Respondents

As a purposive sampling of respondents, the major activities and occupations of the respondents were farming, salt mining, cattle rearing and fishermen. The study revealed that 48.0% (84) were farmers, 2.9% (5) were fishermen, and 20.6 % (36) were salt miners, 1.7% (3) as herdsmen and 26.8% (47) engage in both farming and salt mining depending on the season as reflected in the (Figure 10). It is also clear that out of 84 farmers and 36 salt miners, (45) and (20) were women respectively in both activities, suggesting that more women were involved in economic activities than men.

Across the different categories of livelihood activities such as faming, salt mining, animal herding, herdsmen and fishing, respondents asserted that they had experienced decline in

productivity in recent times, there was however no difference in the respondents' perceptions of climate variability and its effect on their livelihood ($X^2 = 12.70$, $df= 10$, $p > 0.05$). Although the respondents demonstrated an appreciable level of knowledge and understanding with regards to climate change and its impacts on their livelihoods, there was no difference in the respondents' occupation and their knowledge and understanding of climate change ($X^2 = 5.70$, $df= 5$, $p > 0.05$).

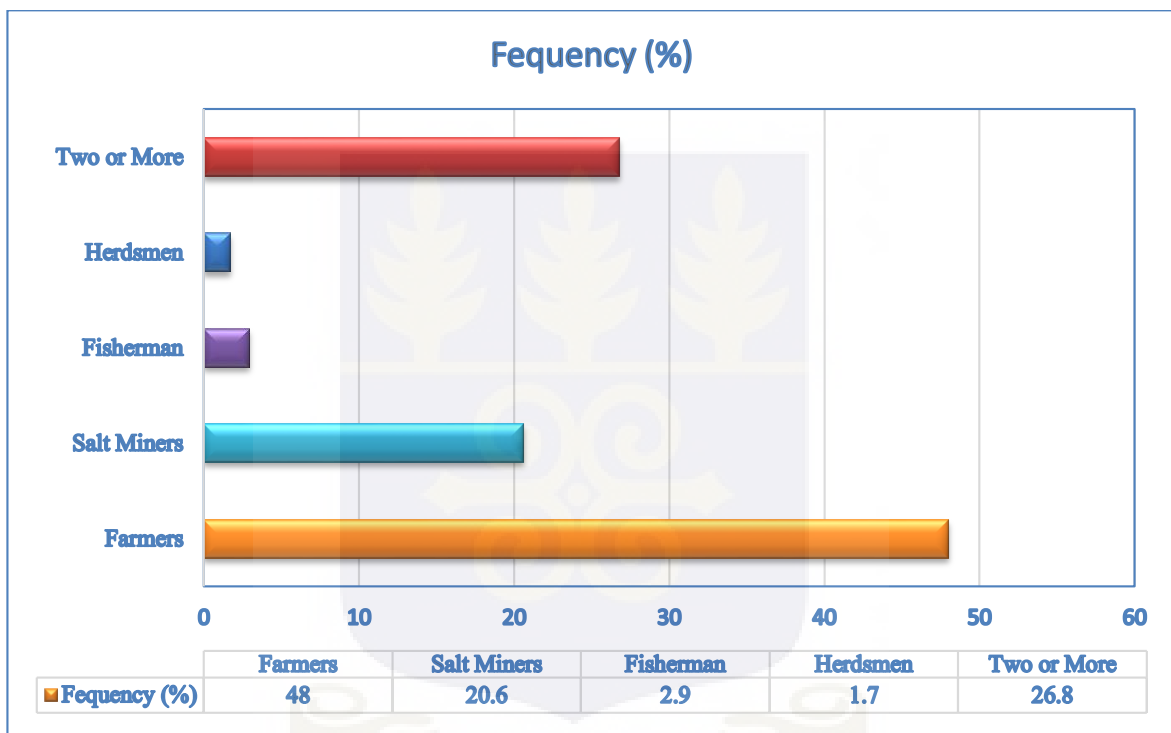


Figure 6. Occupational Distribution of Respondents

Source: Author's Field Data

4.2.6 Level of Education

With regard to educational level, the results of the study indicated that a large percentage 28.6% (50) of the respondents were illiterate with 17.1% (30) receiving primary education, 28.0% (49) Junior High School level, 22.9% (40) senior high school education and only 3.4% (6) attaining tertiary education as shown in Figure 11 . This variation in the educational level could stem from the fact the study focused on those who were 30 years and above and

the fact that education was not a priority until recently when more awareness and sensitization began to change the trend. The results further showed that there was a significant difference in the respondents' educational status with respect to their knowledge and understanding of climate change vis a vis increase in temperature and decrease in rainfall ($X^2 = 31.16$, $df= 12$, $p < 0.05$). It was evident that those who had at least JHS or SHS education had better knowledge and understanding of climate change as compared to those with primary or no formal education at all. This shows the role education can play in enhancing people's understanding of climate change. This is especially useful for gathering momentum to addressing climate change.

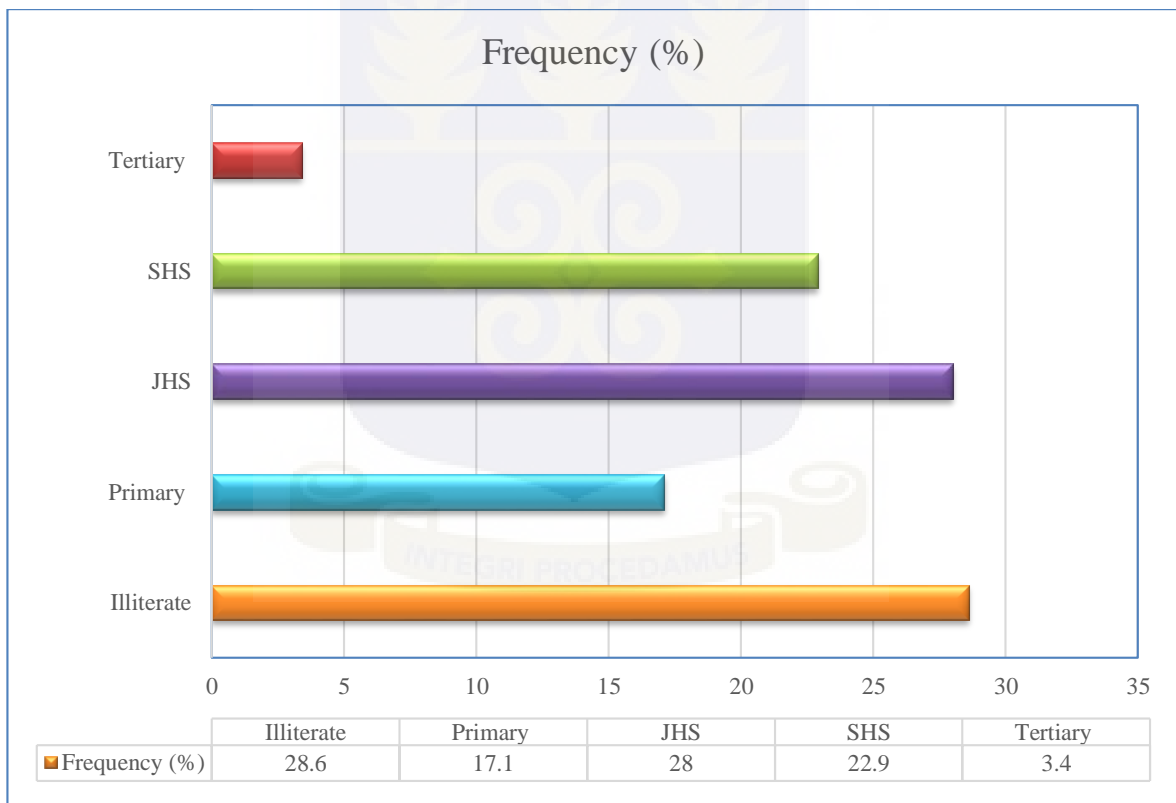


Figure 7. Educational Characteristics of Respondents

Source: Author's Field Data

4.3 Respondents Perceptions on the Key Ecosystem Services from the Songor

Lagoon

The study indicated that the key ecosystem services that are obtained from the Songor lagoon range across the various categories of the Millennium Ecosystem Assessment report including the provisioning, regulating, supporting and cultural and recreational ecosystem services.

Out of the 178 respondents surveyed on each of the essential ecosystem services that they obtained or benefit from the Songor Lagoon, 171 respondents claimed they obtained fish, salt, water resources (Provisioning services) from the lagoon which form a major part of their livelihoods. This was however found not to be significant across the various respondents demographic characteristics and their perceptions on the provisioning ecosystem services such as Gender ($X^2 = 1.01$ df= 2, $p > 0.05$) Education ($X^2 = 6.58$ df= 8, $p > 0.05$) and Location ($X^2 = 2.67$ df= 4, $p > 0.05$).

With regards to the recreational and cultural services, 101 respondents said that the lagoon also serves as a place for recreational and cultural engagements such as tourism and site seeing. Respondents perception and understanding of the these services were also found not be to significant with regards to their Gender ($X^2 = 0.06$ df= 1, $p > 0.05$), Education ($X^2 = 4.88$ df= 4, $p > 0.05$), Occupation ($X^2 = 4.39$ df= 5, $p > 0.05$), and Location ($X^2 = 1.10$ df= 2, $p > 0.05$).

For the regulating services, 130 respondents indicated that the Songor lagoon is a good buffer that safeguards their communities against extreme events such as flooding and windy storms (regulating services). With respect to their demographic characteristics there were no significant difference and their perceptions on about regulating services such as Gender ($X^2 = 3.10$ df= 1, $p > 0.05$), Education ($X^2 = 6.82$ df= 4, $p > 0.05$), Occupation ($X^2 =$

=10.96 df= 5, $p > 0.05$) except respondents' Location ($X^2 = 7.10$ df= 2, $p < 0.05$) that was found to be significant. From the results, it was also clear that 86 respondents asserted to the fact that the birds and insects in the lagoon help provide supporting services such as pollination and means of pest and disease control in their vegetable farms and homes.

These assertions and perceptions were similarly not significant with respect to respondents' Gender ($X^2 = 3.26$ df= 1, $p > 0.05$), Education ($X^2 = 3.59$ df= 4, $p > 0.05$), Occupation ($X^2 = 5.03$ df= 5, $p > 0.05$), and Location ($X^2 = 3.41$ df= 2 $p > 0.05$).

The results further indicated that, due to the importance and benefits of all these essential ecosystem services, the conservation and protection of the Songor lagoon was therefore regarded by the respondents as most important. This is shown whereby 92.2% (163) of the total respondents argued that the lagoon should be protected.

Further analysis indicated that, there was no significant difference with the respondents perceptions on the protection of the lagoon with respect to their Gender ($X^2 = 1.01$ df= 2, $p > 0.05$), Education ($X^2 = 5.10$ df= 4, $p > 0.05$) Occupation ($X^2 = 4.89$ df= 5, $p > 0.05$), but residents' Location ($X^2 = 6.97$ df= 2, $p < 0.05$) was found to be significant. This means those closer to the Lagoon were a concern for the conservation of the site due to the benefits that they obtained from the site. The graphical representation of the respondent's perceptions and understanding on the four categories of ecosystem service is shown in Figure 12.

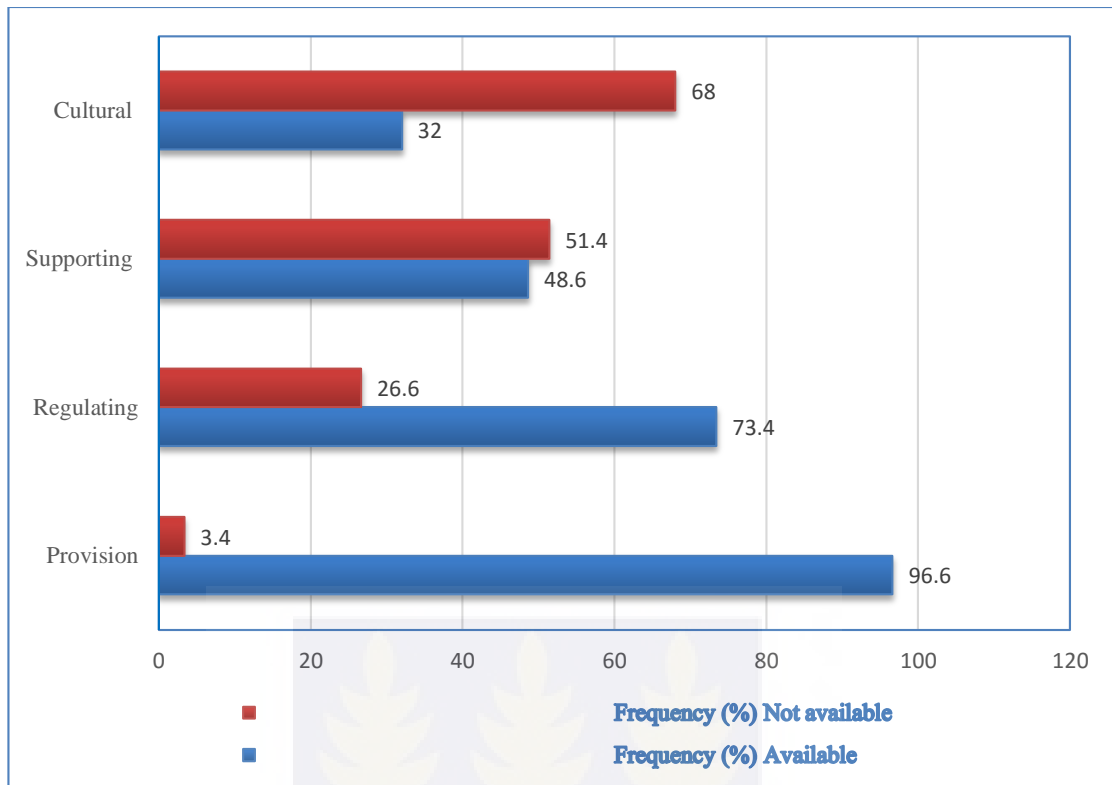


Figure 8. Respondents Perspectives on the key Ecosystem Services from the Songor Lagoon

Source: Author's Field Data

Plate 2. shows some images of the essential ecosystem services that were captured during the field work to illustrate their livelihoods and income sources.





Plate 2: Images of the Salt production from Production to Packaging at the Songor Salt Project Site, Songor Lagoon

Source: Photos by Author

4.4 Climate Change and Variability, Evidence from the Study Area

The climatic data on temperature and rainfall variables collected from the Ghana Meteorological Agency (GMet) for the study area over a thirty year period (1980-2010) were analysed and used to ascertain the extent of climate change and climate variability in the study area. These analysis are useful for cross-validating the perceptions of the people in the study area drawing reasonable conclusions in relation to the research questions.

4.4.1 Temperature Variability

The temperature data from GMET were analyzed into both annual and decadal basis in order to ascertain the trend of variability over the years and that across different decades based on the period specified.

4.4.1. 1 Annual Temperature Variability

For the annual temperature variations, the proxy data by the GMET agency on temperature for the study area from 1980 to 2010 shows an increasing trend in temperature over the years. An average temperature of about 27.8°C was recorded in 1980 and in 2010 an average temperature of about 28.8°C was recorded indicating a marginal increasing trend. Thus, the

data has thus showed a consistent increase in temperature over the years although it fell in some years (Figure. 13).

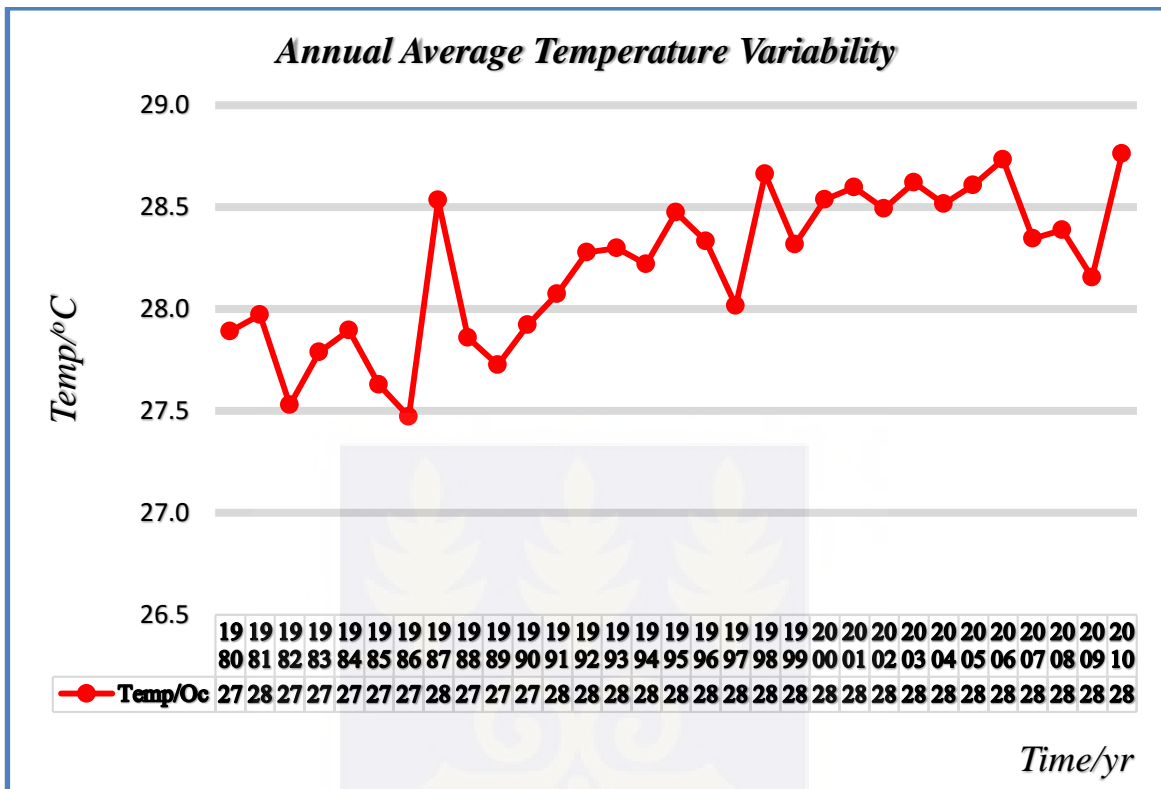


Figure 9. Annual Average Temperature variations of the Study Area from 1980 – 2010
Source: GMET, 2016

4.4.1.2 Decadal Average Temperature Variability

The temperature records were also analysed to ascertain the trends over the past three decades and the findings are presented as indicated Figure 14 . The results indicated that from 1980-1989 the average inter-decadal temperature was 27.7°C whereas from 1990-1999, an average inter-decadal temperature of 28.1°C was recorded which is slightly higher than the previous decade. The last decade (2000-2010) temperature was noted to be higher than the previous two decades with an average temperature of 28.3°C. Clearly, these results show the occurrence of an increasing temperature trend over the last 30 years with the last decade being the warmest among the three decades of temperature records examined.

Subjecting the inter-decadal average temperature variability to statistical analysis indicate that the variability that existed among the decades are however not statistically significant at 95% confidence interval (**F. 2, 33; P > 0.05**). The results are presented in the form of a chart in (Figure 14) showing the inter-decadal temperature variability.

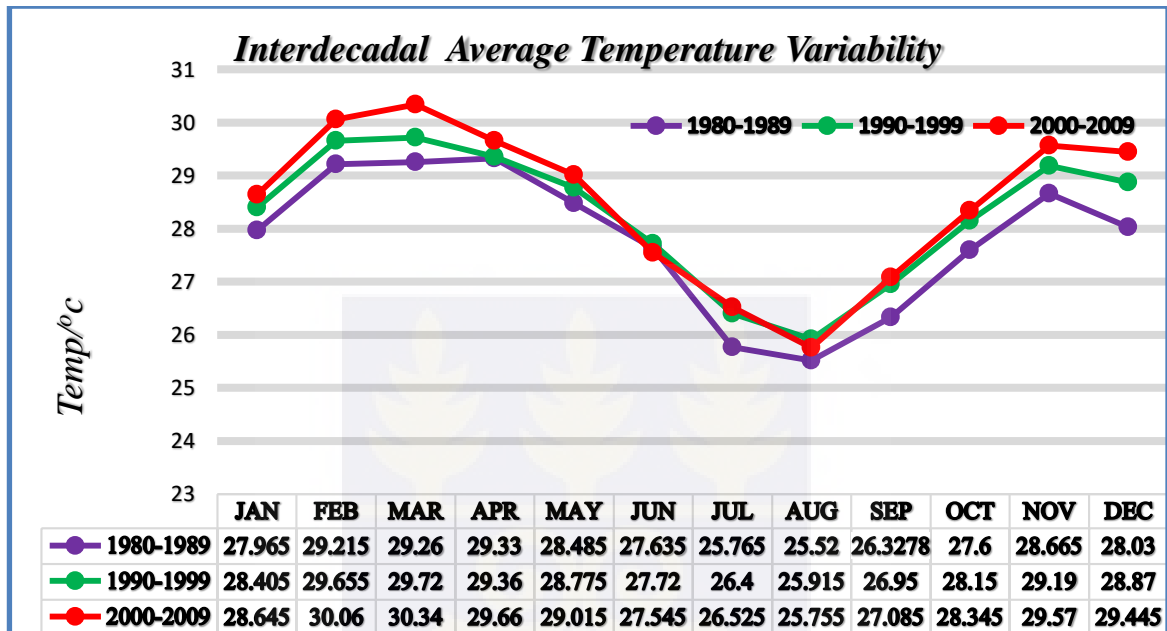


Figure 10 Interdecadal Average Temperature Variability of the Study Area from 1980 – 2010

Source: GMET,2016

4.4.2 Rainfall Variability on the Study Area

Like that of the temperature variation analysis, the rainfall data was also run on both annual and decadal lines to depict clearly the variations between years and across different decades.

4.4.2.1 Annual Rainfall Variability

The data on rainfall variability over the study area between 1980 and 2010 from the GMET shows a decreasing trend unlike the temperature with rather an increasing trend over the same period of time. From the records of the three decades ago, rainfall was recorded as high as 104mm in 1982, 108mm in 1991 and has since declined to 89.2mm and 79.8mm in

2009 and 2010 respectively. Although the rainfall data in most cases appears to be erratic from year to year, the results presented here clearly indicated that annual rainfall patterns over the years continue to decrease in most parts of the years within the past three decades of the study area as depicted in (Figure 15).

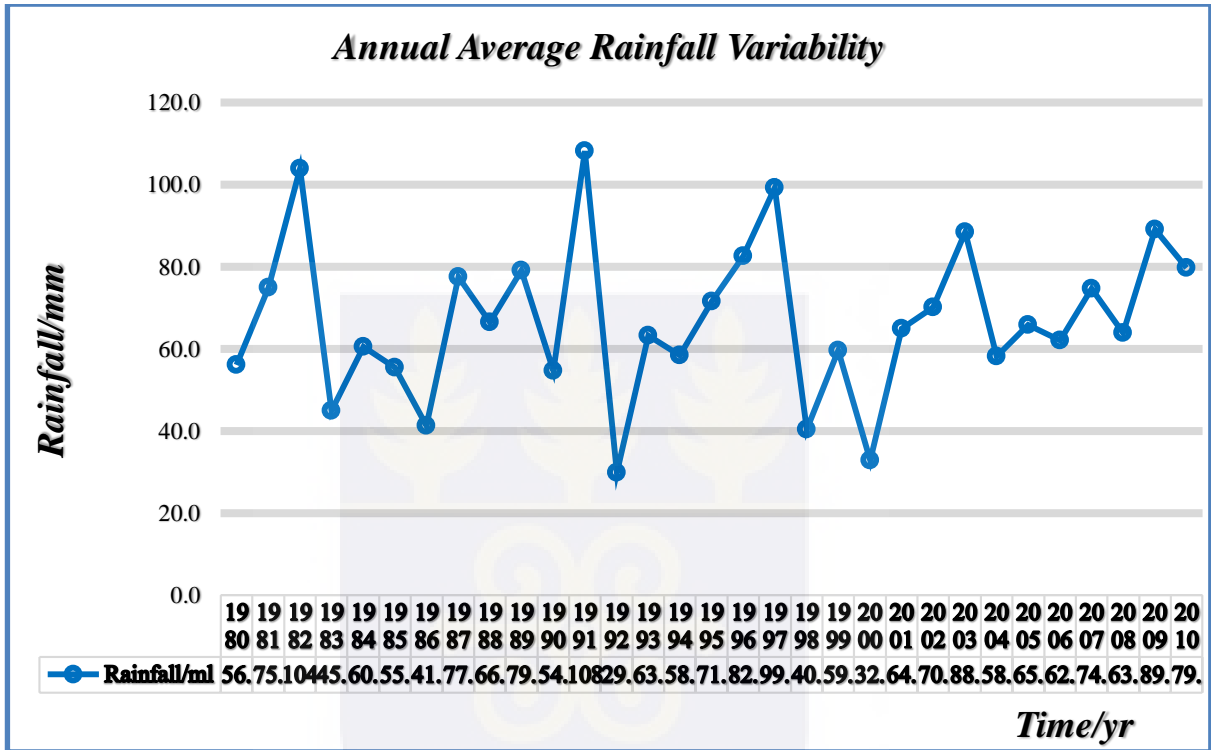


Figure 11. Annual Average Rainfall Variability

Source: GMET, 2016

4.4.2.2 Decadal Rainfall Variability over the Study Area

The results on inter-decadal average rainfall patterns of the study area have shown that an average of 66.1mm was recorded from 1980-1989, 66.8mm recorded from 1990-1999 and 66.7mm from 2000-2010 as shown in (Figure 16). The results show an erratic inter-decadal rainfall variability pattern within the study area. Although a decreasing trend is observed in the different decades of rainfall patterns, these differences were however not statistically significant at 95% confidence interval when subjected to statistical analysis with a

parametric One – Way ANOVA test (F. 2, 33; P > 0.05). This test was used on the assumption that the data set was normally distributed with have unequal variance.

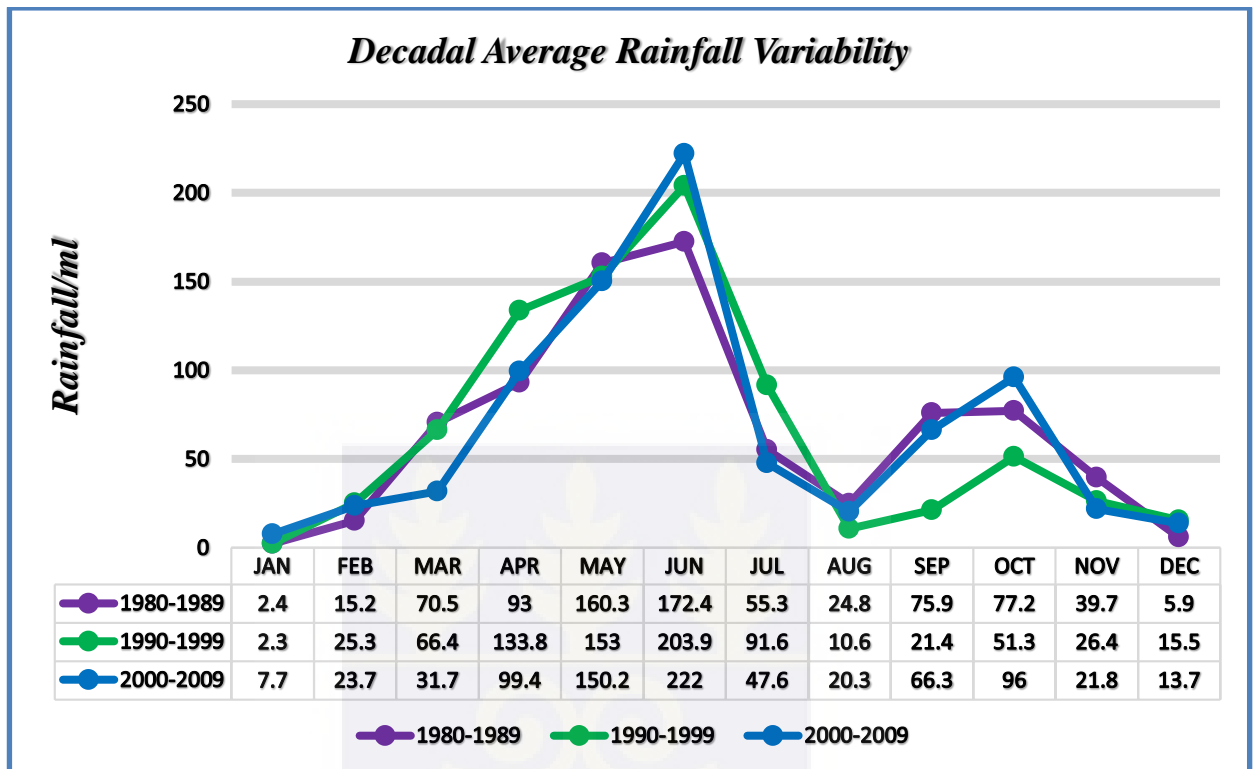


Figure 12. Inter-Decadal Average Rainfall Variability

Source: GMET, 2016

4.5 Respondents’ Perceptions on the Trend of Changes in the Songor Lagoon Area and Essential Ecosystem Services

The study’s respondents were also investigated on their perception and opinions on the changes of the lagoon over the three decades since the year 1980 to 2010 and the factors that may be attributed to the changing trends and the overall impacts of these changes in the resources and livelihoods that they obtained.

Table 2. Respondents Perceptions on the Land Use and Land Cover Changes Associated with The Songor Lagoon over the Three Decades

Year	Lagoon Status	Frequency (%)	Interdecade Changes	significant p-value 0.05
1980-1990	Major	39	1980-1990 & 1990-2000	> 0.001
	improvrment			
	Improvement	51.4	1980-990 & 2000-2010	< 0.001
	Deterioration	0.6		
	Not sure	9.0		
1990-2000	Major	31.1		
	improvrment			
	Improvement	55.6		
	Deterioration	11.3		
	Not sure	1.7		
2000-2010	Major	10.7		
	improvrment			
	Improvement	10.2		
	Deterioration	48.6		
	Not sure	0.6		

Source: Author's Field Data

From (Table 2), out a total of 178 respondents surveyed, 39.0% (69) perceived that from 1980-1990, the area of the lagoon at that period was in a major improvement state, 51.4%

(91) indicating improvement, and 0.6% (1) respondent claimed it has deteriorated with 9.0% (16) respondents who were not sure of the state of the lagoon at the time.

Also, out of the 178 respondents surveyed for the period 1900-1999, 31.1% (55) asserted that the area of the lagoon was in a major improved state, 55.6% (99) indicating improvement, and 11.3% (20) respondents claiming Deterioration with only 1.7% (3) respondents not sure of the state of the lagoon for the same period.

For the current decade, the results indicated a rather opposite trend to that of the first two decades examined in this study, out of the 178 respondents for the period 2000-2010, 10.7% (19) respondents indicated that, the area of the lagoon was in a major improved state, 10.2% (18) indicating improvement, and 48.6% (86) respondents claiming Deterioration of the lagoon area with 29.9% (53) affirming that the lagoon has seen major deterioration within the last decade (2000 -2010), 0.6% (1) respondent not sure of the current state of the lagoon for the same period.

Statistically, between 2000 to 2010 the respondents believed that a significant deterioration of the lagoon area was experienced as compared to between 1980 to 1900 ($X^2 = 71.58$ df= 12, $p < 001$). Similarly, from 2000 to 2010, the respondents perceived that there has been a significant deterioration of the lagoon area as compared to 1900-2000 ($X^2 = 163.26$ df= 12, $p < 0.001$).

These findings demonstrate that the respondents believed that in recent times major changes, therefore, have taken place in the Songor lagoon in its structure and functions which mean it has become a major concern for the local communities. This is because the deterioration of the lagoon over the years have severe implications for the structure and functions (MEA 2005). This will affect the delivery of ecosystem services and the resources that they

obtained from the lagoon, especially the salt production that has been the mainstay of their livelihoods. These are succinctly captured the (Figure 17).

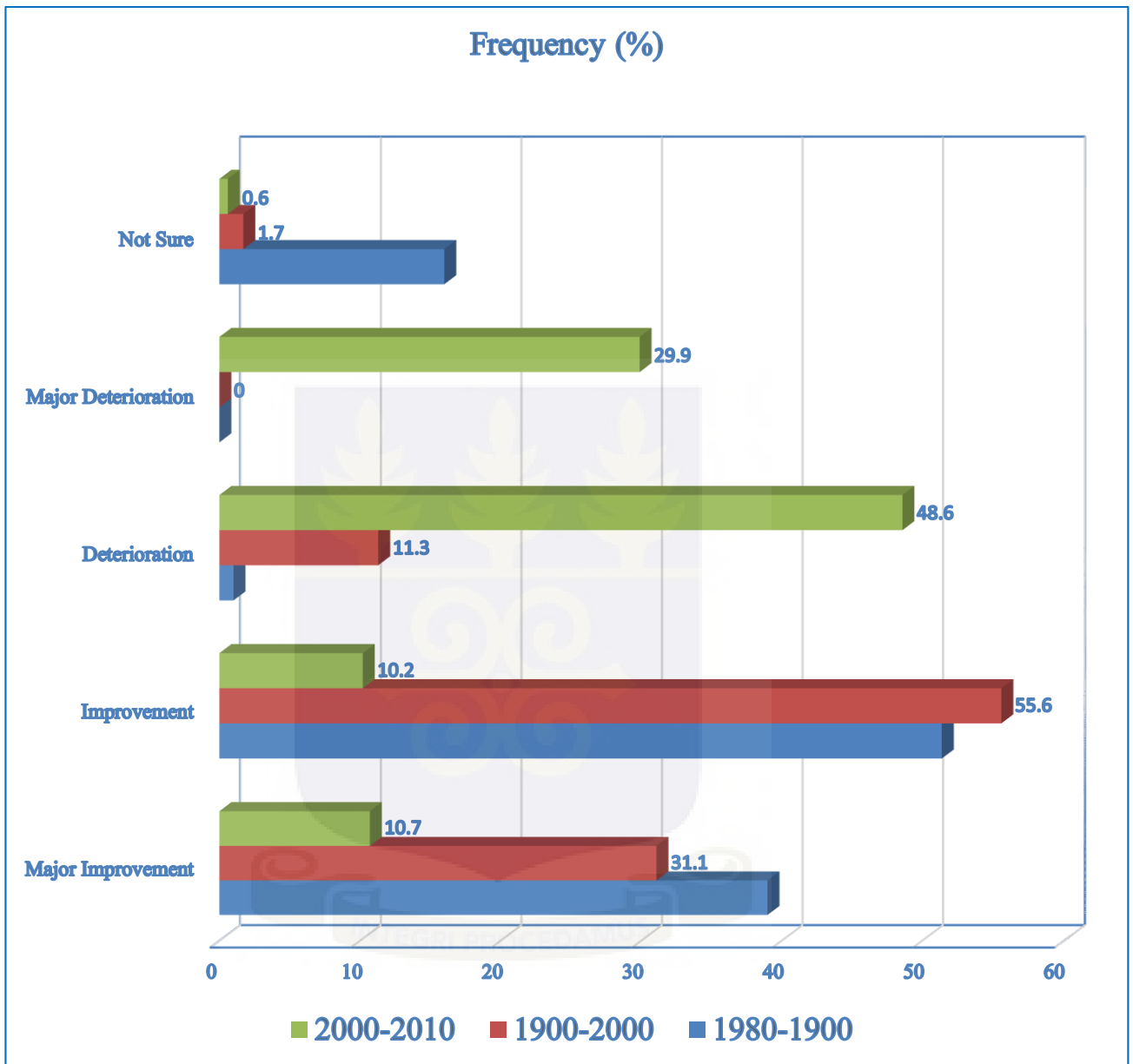


Figure 13. Respondents Perspectives on the Nature of Changes Associated with the Songor Lagoon over the Years.

Source: Author's Data

4.6 Respondents' Perspectives on their Past and Current Livelihoods and Productivity

Status

In order to ascertain the changing trend of productivity and the resilience of these livelihoods within the study area, respondents were asked to indicate their opinions on the level of productivity of their livelihood activities for both current and the past 20 years.

Over the past 20 years, the study indicated that 29.5% (52) respondents claimed that their livelihood activities were very productive, 31.8% (56) indicated theirs were productive, 21.6% (38) indicated theirs were normal as expected per the input they made. 8.0% (14) respondents asserted theirs were not productive and 9.1% (16) were not sure of their level of productivity over the last 20 years. Further analysis of the results revealed that, there was significant difference of respondents perceptions of their livelihoods status over the past years across their different demographic characteristics including Gender ($X^2 = 13.73$ $df = 4$, $p < 0.05$), Occupation ($X^2 = 43.63$ $df = 2$, $p < 0.05$), Education ($X^2 = 41.72$ $df = 16$, $p < 0.05$), and Location ($X^2 = 104.20$ $df = 8$, $p < 0.05$). these result are summarized in (Table 3.)

Table 3. Respondents Perceptions of their Livelihoods Status over the Years

Period	Livelihood status	Demographic feature	Significance at 0.05 level
Past 20 years	Very productive	Gender	$p < 0.05$
	Productive	Occupation	$p < 0.05$
	Unproductive	Education	$p < 0.05$
	Not sure	Location	$p < 0.05$
Current Situation	Very productive	Gender	$p > 0.05$
	Productive	Occupation	$p > 0.05$
	Unproductive	Education	$p > 0.05$
	Not sure	Location	$p < 0.001$

Between Past and Current Status of Repondents Perceptions of Livelihoods; $X^2 = 72.61$,

$df = 16$, $P < 0.001$

Comparing the past and current states of the livelihoods and productivity status of the respondents, the results have shown a downturn of events indicating that productivity has changed drastically over the years. The current state of events as indicated in the data as follows; overall, 5.1% (9) respondents claimed that their livelihoods activities are currently very productive, 8.5% (13) respondents indicated that theirs are productive with 19.9% (35) stated that theirs are in normal level and 65.3% (115) respondents overwhelmingly asserted that their current state of livelihoods productivity have been unproductive with only 1.1% (2) respondents not sure of their current state of activities.

There was however no significant difference with respect to their current state of livelihoods productivity and difference in their Gender ($X^2 = 8.32$ df = 4, $p > 0.05$), Education ($X^2 = 25.15$ df = 16, $p > 0.05$), Occupation ($X^2 = 17.47$ df = 20, $p > 0.05$) except respondents Location ($X^2 = 47.91$ df = 8, $p < 0.001$), that was found to be statistically significant.

Overall, there was a significant difference in the respondent's perspectives on the state of their past and current livelihoods thresholds ($X^2 = 72.61$, df = 16, $P < 0.001$). They perceived that their livelihoods activities have been unproductive in recent times as compared to the past.

Therefore, the assessment of the livelihoods by the respondent implies that in recent times their livelihoods activities which basically are the salt production and production of food resources in their farms are been negatively affected than it was in the past. This may increase the respondents' vulnerability and risks to the sustainability of their livelihoods for survival and existence in the coming years. The findings pose a big dilemma for the local communities who livelihoods are tied to these activities with no guarantee that things will improve in the future rather continuous deterioration under business as usual scenario. The

respondents' perspectives on the past and current states of their livelihoods are presented in the Figure 18.

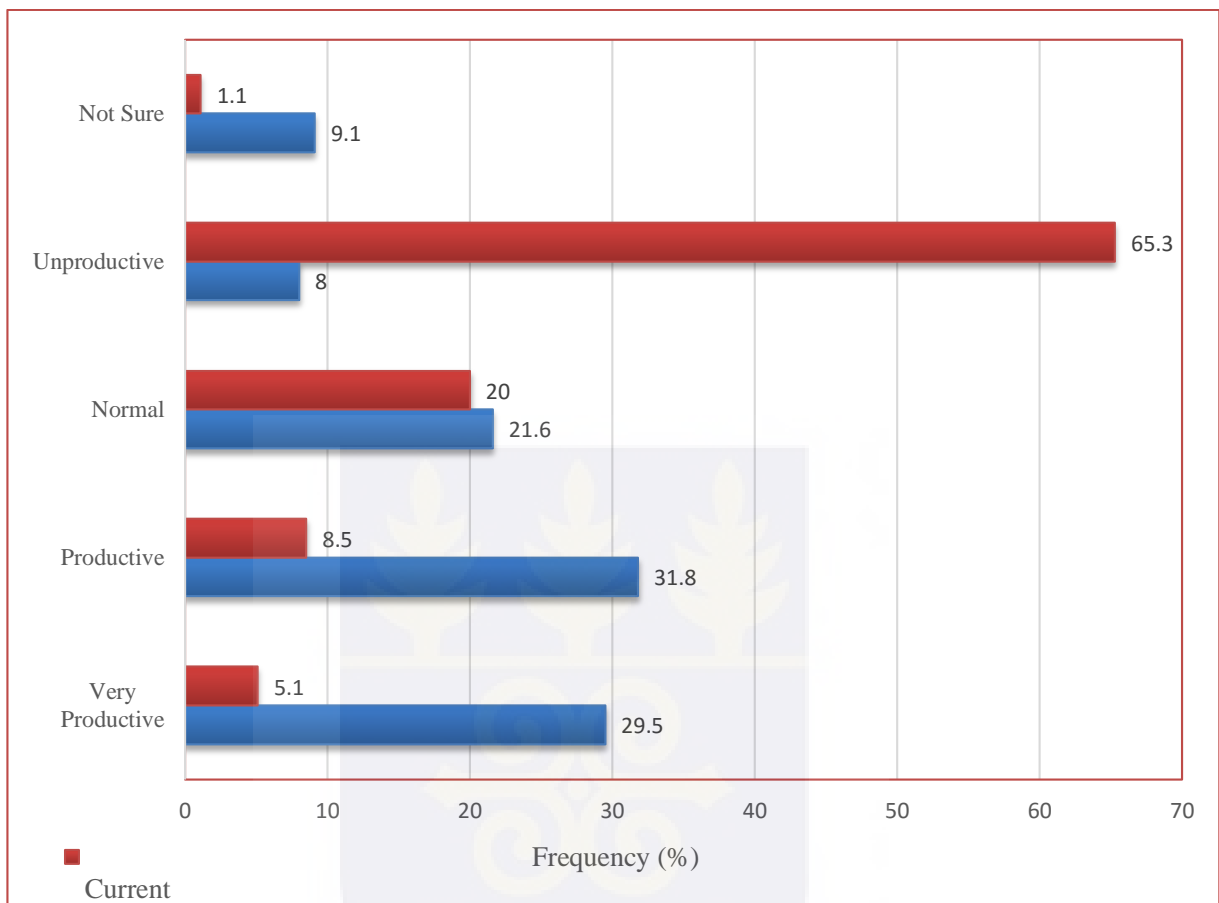


Figure 14. Respondents' Perspectives on the Past and Current State of their Livelihood Activities

Source: Author's Data

4.6.1 Respondents' Livelihood Activities and their Resilience

According to the production manager of the Songor Salt Project, there are about 800 to 1,000 unskilled personnel who work at the site daily to produce salt for the company besides the skilled labour force employed as permanent staff at the Songor salt project such as the accountants, human resource managers, directors, engineers, drivers, security, and production and packaging staff as illustrated in the Table 4. This is beside the large

undocumented number of people who are involved in small-scale extraction of the salt within the Songor lagoon

Table 4. Employee Data at Songor Salt Project

Job Category	Male	Female	Total
Human Resource	12	9	21
Accounts	9	-	9
Engineering Works	16	-	16
Production	9	-	9
Packaging /Iodation	4	-	4
Security	57	5	62
Transport	17	-	17
Total	126	14	140

Source; Songor Salt Project, 2016

4.6.2 Salt Production and the Implications of Climate Variability at the Songor Salt Project

The Songor Salt Project is among the three main salt production centres in Ghana that feed both the local and international markets with an overall production capacity of about 60,000 Metric tons per year. Salt production is facilitated through evaporation facilitated by wind, temperature and rainfall variability over the production area. In view of this, the production data for the Songor salt project was collected over a ten year period to ascertain the impact of these climatic variables on the level of production.

Overall, the findings indicated a declining trend over the years since production commenced in commercial quantities in 1996 to date. The highest production recorded was in 1997 followed by a drastic decline in 1998, and 1999. The highest production levels ever recorded

were in 1997 and 2001, recording 60773.03 and 61,835.25 metric tons respectively which were above the current production capacity. The lowest levels of production since the project inception were also in 2000 and 2008 recording 10,219.25 and 9,527.75 metric tons respectively. In 2001, the project was able to reach its full production capacity. It has however, since not been able to attain the production level but rather continues to be erratic. The yearly level of salt production is presented in the Figure 19.

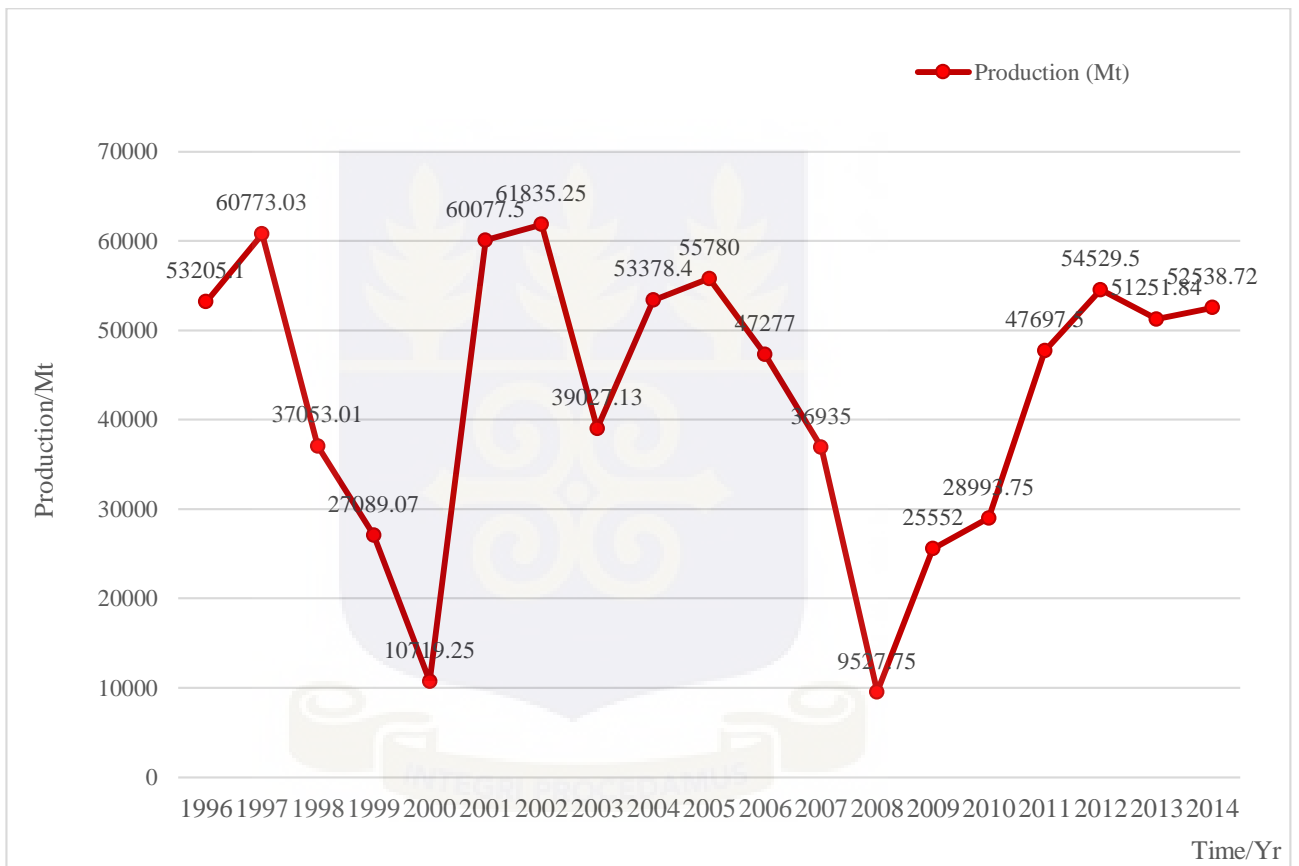


Figure 15. Trends of Yearly Salt Production of the Songor Salt Project

Source: Songor Salt Project, 2016

4.6.3 Impacts of Temperature and Rainfall Variability on Salt production

To ascertain and model the impacts of temperature and rainfall variability on the extent of salt production, a linear multiple regression model was used. In this model, Salt production (dependent variable) was regressed against temperature and rainfall (independent variables).

The results of the model indicate that both temperature and rainfall increase with salt production. Although the impacts of temperature ($P > 0.05$) and rainfall ($P > 0.05$) are not statistically significant, the model reveals that an increase in 1°C temperature will lead to a decrease of **0.488** metric tons of salt production and vice versa. Also, the model predicted that if there is an increase in 1mm of rainfall, it will lead to an increase in **0.142** tons of salt production and vice versa as presented in Table 3. below. These results do not reflect the trends of both rainfall and temperature patterns as it is in the study area. The decrease in salt production in Songor lagoon with the decreasing rainfall trend is a consistent trend unlike that of temperature which indicates a contrary reflection on the background since there continues to be an increase in temperature in the study area.

Table 5 Impacts of Temperature and Rainfall on Salt Production

Salt Production	Standard –error	Regression coefficient	t-value	P-value
Rainfall	116.1	0.142	0.57	0.577
Temperature	-28427.1	-0.488	-1.97	0.073
Constant	827175.4	-	2.05	0.063

$R^2 = 0.514$; *Coefficient of Determination = 51.4%*; *P- value= 0.15 at 95% CI*

Source: Author's Field Data

4.6.4 Implication of Resources Degradation on the Respondents' Livelihoods and Resilience

The findings showed that majority of respondents 81.8 % (144) asserted that their livelihoods activities have been affected due to the changing trend of the Songor Lagoon and resources depletion, only 9.1% (16) indicated that their livelihoods have not been affected and 9.1 % (16) were not sure of their livelihoods status with the changing trend over the years. In comparison with the past state of the lagoon, it was clear that the respondents' perception of the effects on their livelihoods was not significant ($X^2 = 8.44$ df

= 8 $p > 0.05$). With that of the current state, respondents' perception however, on the current state of the lagoon and their livelihoods were found to be significant ($X^2 = 16.78$ $df = 8$ $p < 0.05$). This is reflected in the view that, the majority of the respondents have lamented over the drastic decline in their productivity of the salt commodity and farm produces.

On the implications for different characteristics of the respondents, the results further showed that more men (76) were affected than women (65) in this survey. Also, one's educational status varies with the chances of livelihood being affected, many more illiterates were known to have their livelihoods affected than those who claimed to attain basic to secondary education. It was clear that the farmers (68) and salt miners (57) were the most affected and indicated that their productivity levels have decreased as illustrated in Figure 20. There was however no significant difference in these variations ($X^2 = 0.66$ $df = 2$ $p > 0.05$) for Gender, ($X^2 = 6.40$ $df = 8$ $p > 0.05$) for Education, ($X^2 = 12.69$ $df = 8$ $p > 0.05$) for Occupation). This further suggests to build people resilience, requires an integrated approach that takes into consideration the gender inequalities, education, different occupational roles and where people live are imperative for ensuring better outcomes.

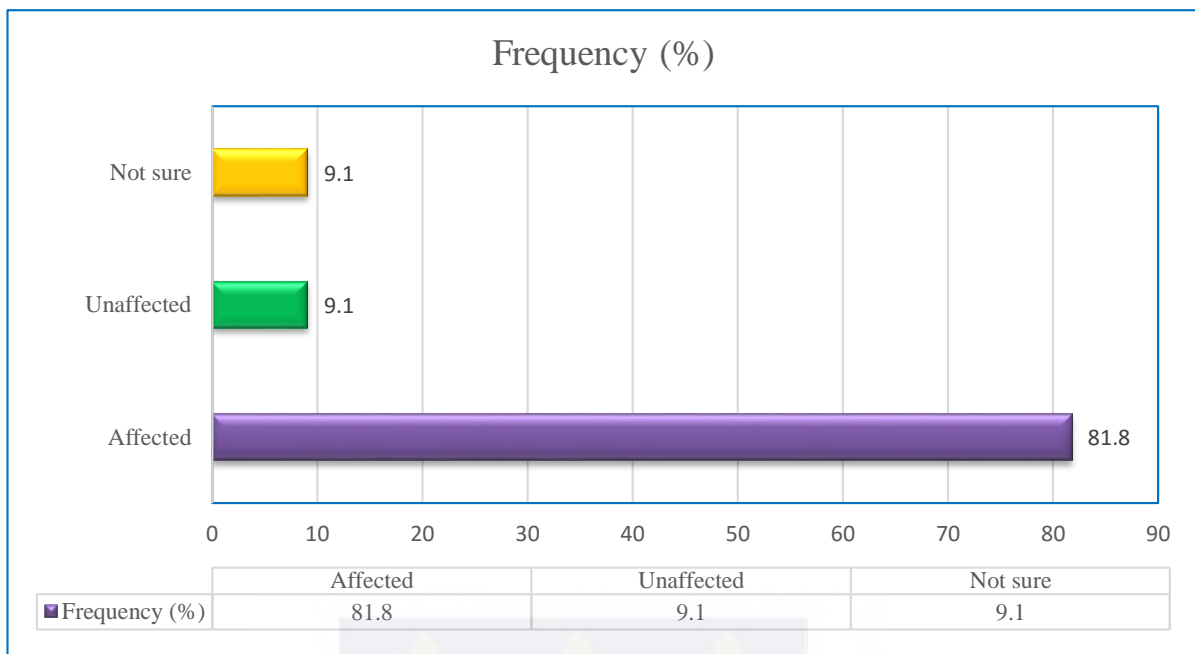


Figure 16. Respondents Perceptions of their Livelihoods Status over the Years

Source: Author's Field Data

4.7 Assessing Respondents Perceptions, Knowledge and Understanding of Climate Change

The perceptions of the people and their knowledge and understanding of climate change play a critical role in the fight against its impacts. This underscores the necessity of assessing these perceptions and general knowledge and understanding for the appropriate design, implementation, monitoring, and evaluations of the needed interventions and programs.

Respondents Perceptions on Temperature and Rainfall Variability

From the study, majority 63.5% (113) of the respondents perceived that over the past 20 years temperatures within the study area have increased considerably and 25.8% (46) respondents had a contrary view with 10.7% (19) respondents claiming they are not sure whether temperature has increased or decreased over the period specified. There was no significant difference with regards to the respondents' occupation ($X^2 = 15.70$, $df = 10$, $p > 0.05$), gender ($X^2 = 0.34$, $df = 2$, $p > 0.05$), and education ($X^2 = 13.56$, $df = 8$, $p > 0.05$)

except respondents' location ($X^2 = 11.80$, $df = 4$, $p < 0.05$) which was noted to be significant in their perceptions of temperature variability over the years.

With respect to the respondents' perceptions about rainfall variability, 36.5% (65) perceived that rainfall has increased over the years whereas 56.2% (100) respondents indicated that rainfall pattern has rather decrease considerably within the study area for the period specified. Also, 6.2% (11) respondents observed that rainfall pattern has been erratic with only 1.1% (2) respondents who were not sure if there has been any changing trend as presented in Table 4. below.

Consistent with their perception on temperature variability, there was no significance difference ($X^2 = 21.10$, $df = 15$, $p > 0.05$), Gender ($X^2 = 2.01$, $df = 3$, $p > 0.05$) Education ($X^2 = 31.20$, $df = 12$, $p < 0.05$). There was however significant difference between respondents location and their perception of rainfall variability ($X^2 = 21.38$, $df = 6$, $p < 0.05$).

Table 6. Respondents' Perspectives about Rainfall and Temperature Variability over the Years

Climatic Variable	Pattern of Variability	Frequency	Percentage (%)
What has been the pattern of temperature for the past 20 years or more	Increases	113	63.5
	Decreases	46	25.8
	Not sure	19	10.7
	Total	178	100
What has been the pattern of rainfall for the past 20 years or more	Increases	65	36.5
	Decrease	100	56.2
		11	6.2
	Erratic		
	Not sure	2	1.1
	Total	178	100

Source: Author's Data

4.7.1 Assessing Respondents General Perceptions, Knowledge and Understanding of Climate Change

In addressing the research question on the level of awareness, knowledge, understanding and the perceptions of the respondents on climate change and climate variability, different views and observations were gathered from the study.

Out of the total respondents of 177, 62.1% (110) respondents strongly agree that human activities are the main causes of climate change in recent times, 32.8% (58) said they agree that human activities are the contributing factor to climate change, 0.6% (1) respondents strongly disagree with the claim that human activities are causing climate change, 3.4% (6) said they also disagree that the climate phenomenon is caused by human activities with 1.1% (2) respondents taking the neutral position that they are not sure if human activities are causing climate change.

About 20.3 % (36) respondents also strongly asserted that they are frightened about the consequences that climate change will present to their livelihoods and survival, 32.8% (58) agree that climate change is something that frightens them, 25.4% (45) strongly disagree and that they do not frighten by climate change, 17.5% (31) disagree they are not frightened by climate change and 4.0% (7) respondents were not whether they are afraid or frighten by climate change.

Also, 51.4% (91) respondent strongly agree that they are convinced and certain that climate change is happening now and 41.8% (74) also agree to that effect whilst 2.8% (5) respondents strongly disagree that climate change is happening now and 1.1% (2) respondents disagree that climate change is happening now and 2.8% (5) respondents not sure about the reality of climate change if it does occur now.

On the perceptions and assertions to addressing climate change to better their livelihoods and ensure sustainability of the essential ecosystem services that they enjoy, many expressed different views which are described as follows; 46.9% (83) respondents strongly agree that we can all do our bit to address the menace of climate change with 31.1% (55) also asserting to that whilst 8.5% (15) strongly disagree that we all have a role to play in addressing the climate change phenomenon and 10.2% (18) also disagreeing with the same position with only 3.4% (6) respondents not sure if we can all do our bit to tackle climate change.

Moreover, 54.2% (96) respondent strongly asserted that the government must first of all play a leading role in addressing the issues of climate change that will charter the course for all to follow with 35.6% (63) equally agreeing to that claim whilst 2.3% (4) respondents strongly disagree with that claim and 7.3% (13) respondents disagree to the claim with only 0.6% (1) respondent who was not sure whether the government should play a leading role or not. These perceptions and general views are captured in Table 7.

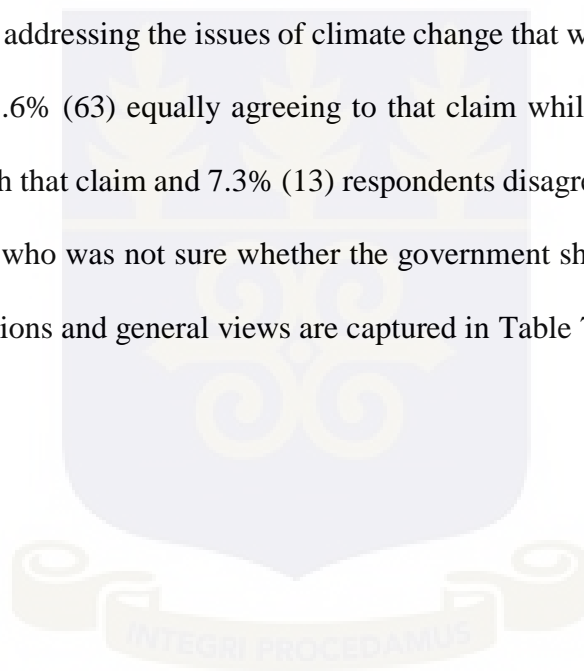


Table 7. Respondents Perceptions about Climate Change

Respondents knowledge and perceptions		Frequency (n)	Percentage (%)
Human Activities are Causing Climate Change	Strongly agree	110	62.1
	Agree	58	32.8
	Strongly disagree	1	0.6
	Disagree	6	3.40
	Not sure	2	1.1
	Total	177	100
I am Certain that Climate Change is Happening now	Strongly agree	91	51.4
	Agree	74	41.8
	Strongly disagree	5	2.8
	Disagree	2	1.1
	Not sure	5	2.8
	Total	177	100
Frightens about Climate Change	Strongly agree	36	20.3
	Agree	58	32.8
	Strongly disagree	45	25.4
	Disagree	31	17.5
	Not sure	7	4.0
	Total	177	100
It is Already too Late to Address Climate Change	Strongly agree	45	25.4
	Agree	24	13.6
	Strongly disagree	61	34.5
	Disagree	43	24.3
	Not sure	4	2.3
	Total	177	100
We can all do our bit to Tackle Climate Change	Strongly agree	83	46.9
	Agree	55	31.1
	Strongly disagree	15	8.5
	Disagree	18	10.2
	Not sure	6	3.4
	Total	177	100
The Government Must Play a Leading Role in Addressing Climate Change	Strongly agree	96	54.2
	Agree	63	35.6
	Strongly disagree	4	2.3
	Disagree	13	7.3
	Not sure	1	0.6
	Total	177	100

Source: Author's Data

4.7.2.1 Respondents' Awareness/Heard about Climate Change

Out of the 175 respondents interviewed, whether they have heard or not about climate change, 77.7% (136) respondents said they have heard of climate change and 22.3% (39) said they have not heard of climate change before as presented in Figure 21 below. Out of

this number, it further reveals that men heard of climate change (76) more than their female counterparts (60). Although men seem to hear of climate change this is not statistically different with that of the females ($\chi^2 = 2.68$, $df = 1$ $p > 0.05$) Thus, although the results suggest that a greater proportion of the respondents have heard of climate change, it does not differ statistically from the gender perspective. The study further indicated that many of the respondents who heard of climate change were those that have attained education up to the JHS (40) and SHS (35) levels with lowest been the illiterate respondents. This was again found not to be statistically significant ($\chi^2 = 6.74$, $df = 4$ $p > 0.05$). Similarly, one's community of residence does not differ in statistical terms with regards to hearing of climate change ($\chi^2 = 1.88$, $df = 2$ $p > 0.05$).

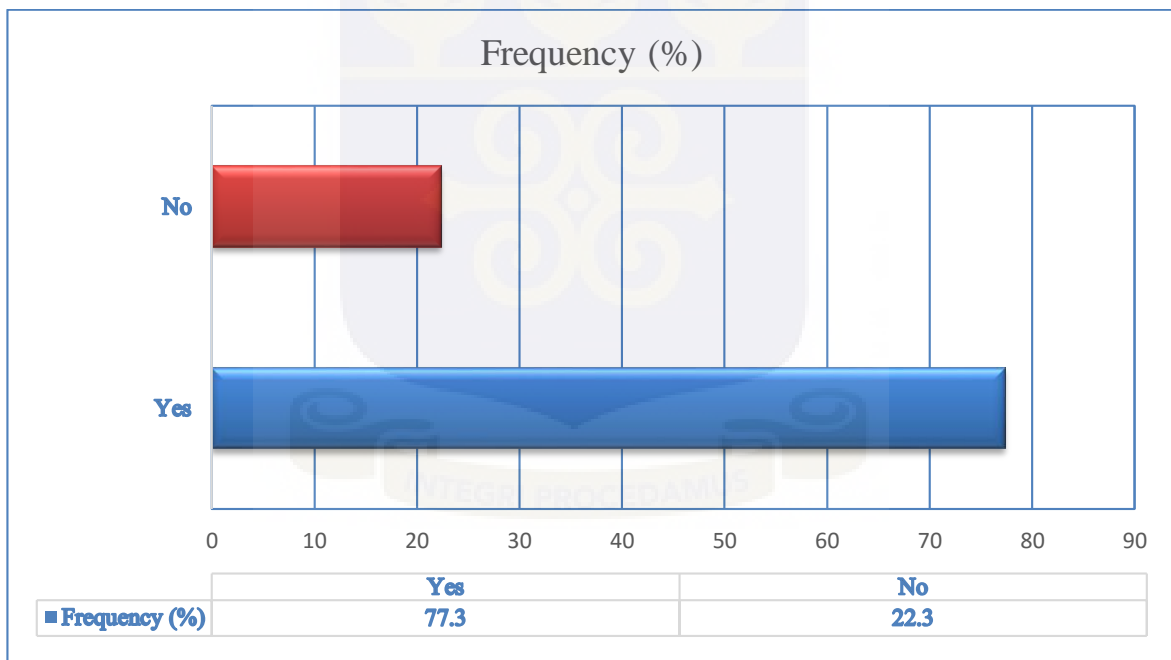


Figure 17. Respondents Level of Awareness about Climate Change in the Study Area

Source: Author's Field Data

4.7.2.2 Respondents Sources of Climate Change Information

Out of 77.7% (139) respondents who claimed that they have heard of climate change were further interrogated to indicate the source(s) of climate information that they have heard the issues of climate change from, it was clear from the results that the respondents have heard climate change information from a variety of sources.

The results indicated that 30% (42) heard of climate change through the radio, 9% (12) through the Television, 56% (78) through both Radio and Television, 1% (2) through Newspapers and 4% (5) through other sources such as Family and Friends as depicted in (Figure 22.) The results imply that Radio and Television are the dominant media platforms through which most respondents had access to information and so were able to hear climate change information as well. This, therefore, means they can be the valuable platform in the climate change advocacy campaigns and communications to intensify the awareness creation of climate change.

From a further analysis of the results, it however indicated there were no significant differences across the various sources of climate change information with respect to respondents' Gender ($X^2 = 0.79$, $df = 4$ $p > 0.05$), Education ($X^2 = 11.71$, $df = 16$ $p > 0.05$), except Occupation ($X^2 = 46.64$, $df = 20$ $p < 0.01$) and Location of their residence ($X^2 = 57.42$, $df = 8$ $p < 0.01$) respectively which were noted to the contrary.

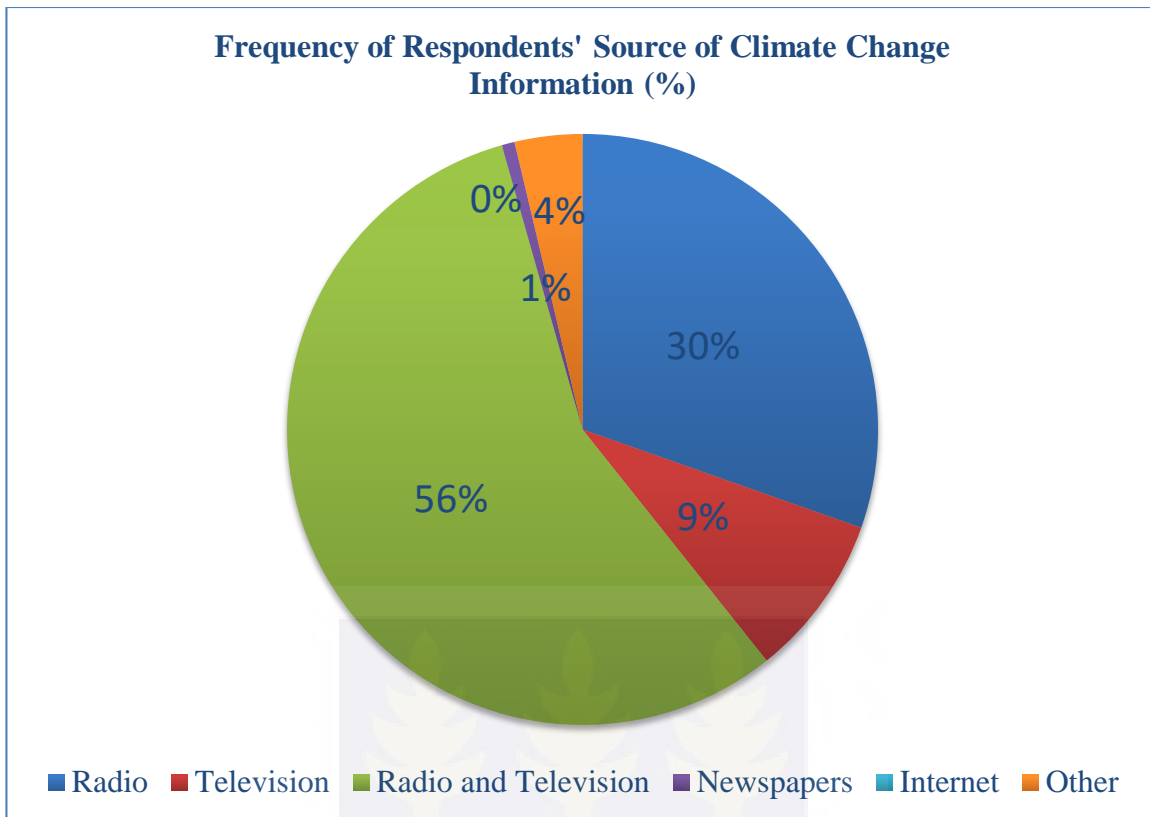


Figure 18. Respondents' Sources of Climate Change Information

Source: Author's Field Data

4.7.2.3 Respondents' Level of Knowledge of Climate Change

The respondents' knowledge on what climate change is all about was also investigated. The findings reveal that although most respondents have heard of climate change, their knowledge and understanding of the phenomenon is however, low as indicated in Figure 23. The result showed that 42% (72) respondents indicated that they know and understand what climate change is, 32% (54) said they do not know nor understand the climate change phenomenon whilst 26% (44) were not even sure about climate change what is. This may be due to the fact that the terminology has no root in the local dialect, for the people are unable to accurately explain it.

There was significant difference in their understanding of climate change with regards to respondents gender ($\chi^2 = 13.30$, $df = 2$ $p < 0.01$), education ($\chi^2 = 32.34$, $df = 8$ $p < 0.001$), occupation ($\chi^2 = 42.02$ $df = 10$ $p < 0.001$), and location of respondents ($\chi^2 = 31.3$, $df = 4$ $p < 0.001$). These views of the respondents are presented in the Figure 23. as indicated below.

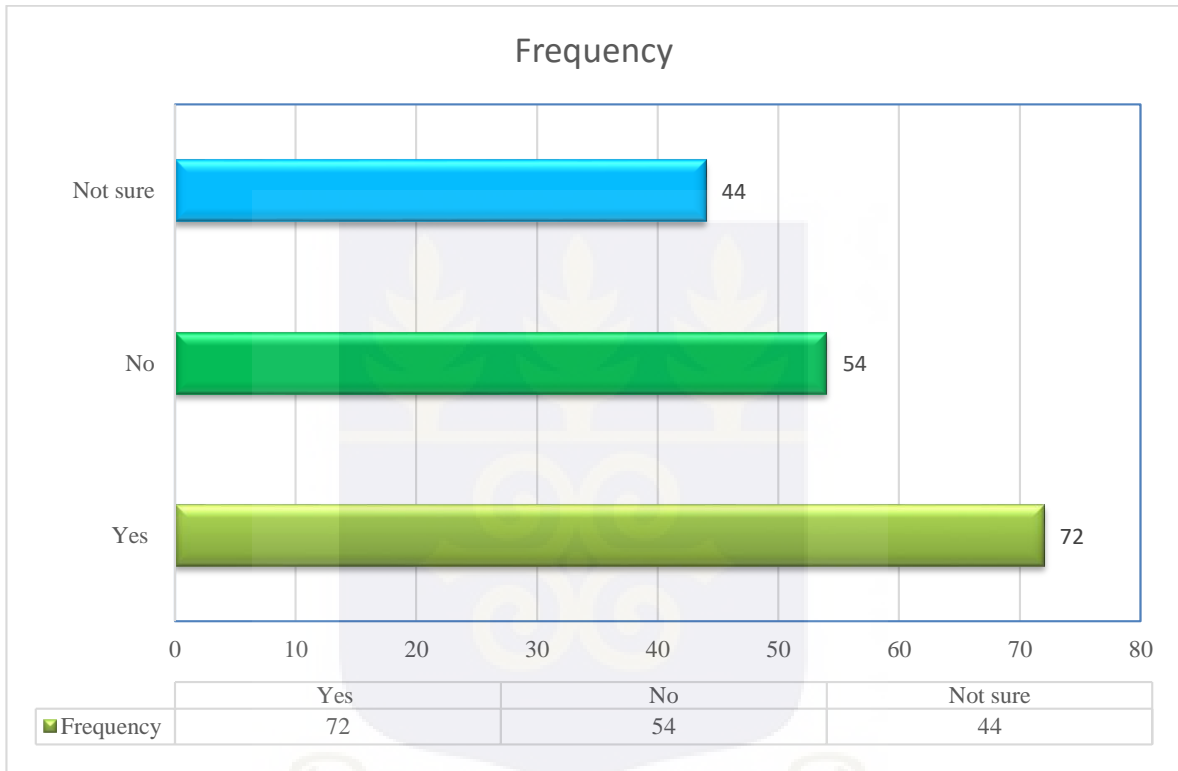


Figure 19. Respondents General Level of Knowledge of Climate Change

Source: Author’s Field Data

4.7.2.4 Respondents’ Understanding of What Climate Change is all About

From the study it was evident that the respondents demonstrated an appreciable level of understanding about what climate change is. 10.8 % respondents stated that climate change is the increase in temperature, 35.1% indicated that climate change is decrease in rainfall whilst 54.1% noted that climate change implies both increase in temperature and decrease in rainfall as indicated in (Figure 24). There was however no significant difference in their

understanding of climate change as increase in temperature and decrease in rainfall with regards to respondents' gender ($X^2 = 4.82$, $df = 2$ $p > 0.05$), education ($X^2 = 13.56$ $df = 8$ $p > 0.05$), occupation ($X^2 = 13.28$ $df = 8$ $p > 0.05$), and location of respondents ($X^2 = 9.03$, $df = 4$ $p > 0.05$).

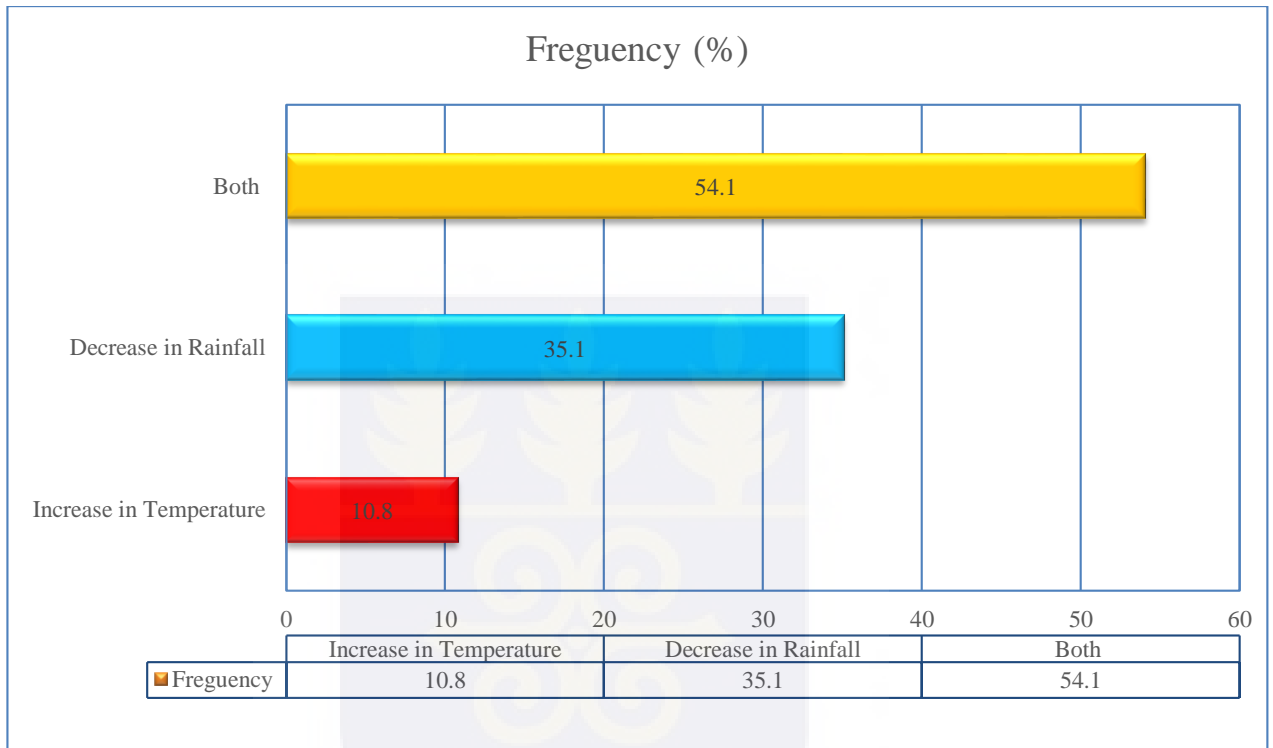


Figure 20. Respondents Understanding and Knowledge about Climate Change

Source: Author's Field Data

4.7.2.5 Respondents Perceptions and Understanding about the Causes of Climate Change

On the causes of climate change, the respondents gave several views. The findings indicated that 16.8% (25) of the respondents argued that climate change is caused by bushfires, 59.1% (88) respondents attributed the cause of climate change to deforestation through logging and firewood harvesting, 17.4% (26) believed climate change is due to the consumption of fossil

fuel by cars and motor cycles and 6.7% (10) respondents saw climate change as punishment from God for our bad human practices (Figure 25).

There was a significant difference in the respondents' educational status and their understanding of the causes of climate change ($X^2 = 27.58$ $df = 12$ $p < 0.001$). Among the farmers, salt miners, herdsmen and fishermen, there was however no significant difference with regards to the respondents' occupational type and their understanding of the causes of climate change ($X^2 = 14.47$ $df = 15$ $p > 0.05$).

These results that suggest much still needs to be done in raising the awareness and educating the people about the causes of climate change and how human activities such as deforestation, bushfires and fuel consumption are linked to emissions of greenhouse gases leading to climate change. This is imperative because the proper understanding of the causes of climate change by the respondents will play a critical role in ways by which climate change mitigation can be achieved.

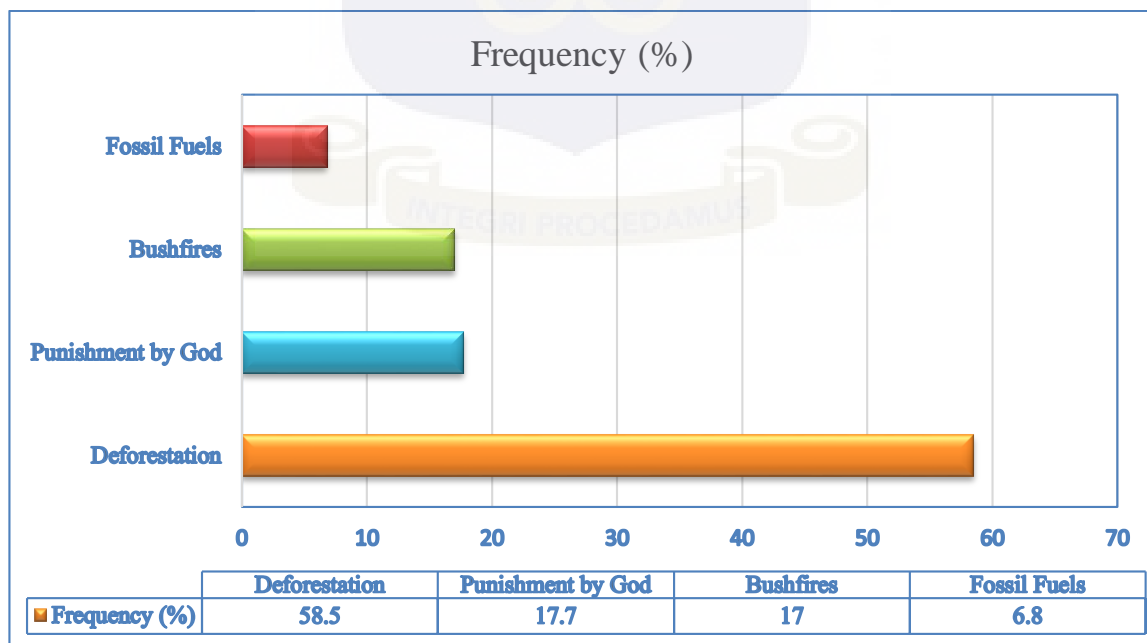


Figure 21. Respondents' Perception about the Causes of Climate Change

Source: Author's Field Data

4.7.2.6 Respondents' Perceived Signs of Climate Change

The effective diagnosis and treatment of disease depends on accurate understanding of the signs and symptoms of that disease through the adoption of appropriate methods for administering treatment. Therefore, to be able to effectively mitigate climate change and its impacts, understanding its various dimensions becomes very imperative. Hence, the respondents were interrogated on the ways by which they perceived are the manifestations of climate change.

Climate change has been perceived differently by different respondents irrespective of their location. The study findings indicated that people have different ways of describing the signs and evidence associated with climate change. The results indicated that 10.1% (14) of the respondents said that flooding in the community is a sign of Climate change, 2.9% (4) indicated that experiencing storms and wind surges are manifestation of climate change, 51.1% (71) respondents claimed that the hotter days and nights due to the increasing temperatures are clear signs of climate change and 36.0 % (50) noted that drought is a clear sign or evidence of climate change in the area as shown in the Figure 26.

Their perceptions on the different signs of climate change were noted to be significant across the demographics characteristics such as education ($X^2 = 28.20$ df = 12 p < 0.05), Occupation $X^2 = 32.86$ df = 15 p < 0.05) and location of respondents ($X^2 = 18.50$ df = 6 p < 0.05) respectively except gender, ($X^2 = 5.1$ df = 3 p > 0.05) that was found to be not significant.

The understanding of the manifestations of climate change as demonstrated in this study will stimulate and help to incentivize momentum for action. This, however, require effective collaboration and engagement with the various relevant stakeholders.

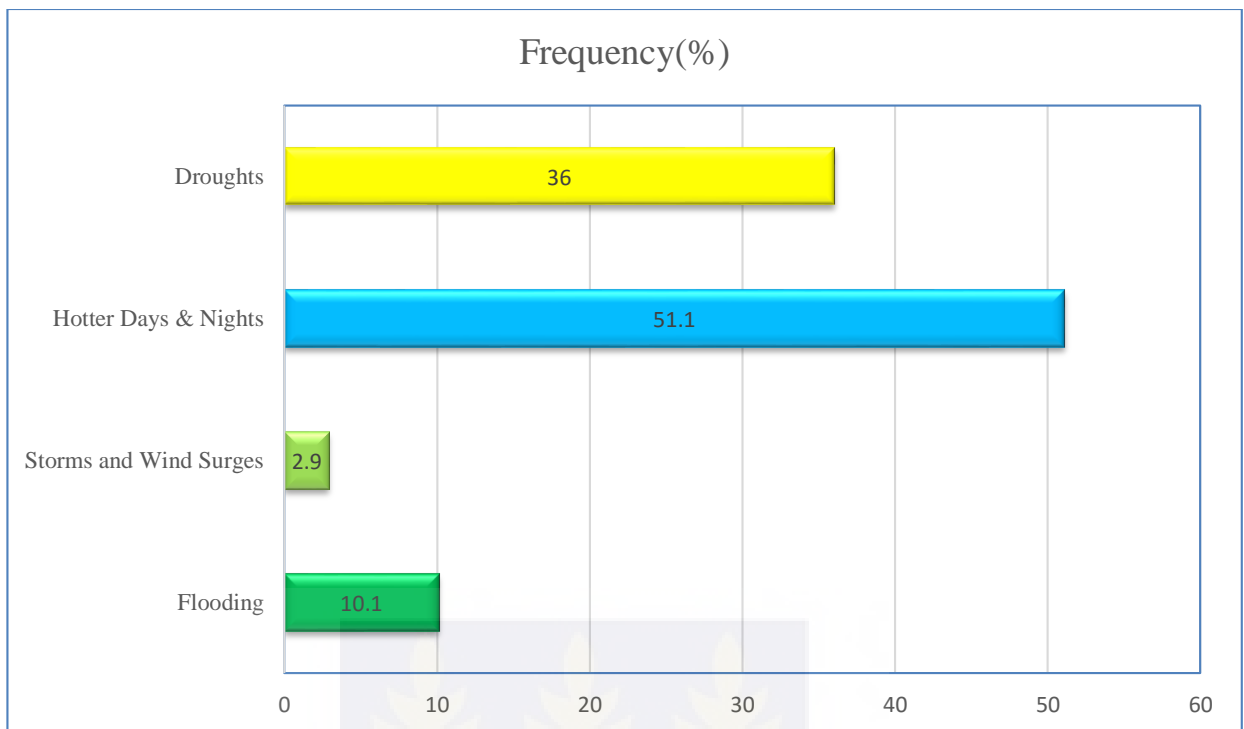


Figure 22. Respondents Perceptions on the Signs of Climate Change

Source: Author's Field Data

4.7.2.7 Respondents' Understanding on the Measures for Mitigating Climate Change

Generally, the respondents seem to have a better perception on the measures and ways of addressing climate change. 43.8 % respondents suggested that planting more trees can help tackle climate change. About 1.1 % indicated that walking and cycling can also help address climate change and 3.4% asserting that patronising the public transport system instead of individuals using their private cars for transportation could also go a long way to address the menace of climate change. With only 1.7% respondents agreeing that the way we use our electrical appliances at home, offices and workplaces can also help to tackle climate change by switching them off particularly when they are not in use. These are illustrated in (Figure 27.) Although it is not clear whether they understand the meaning of these assertions as to how these can mitigate or reduce emissions of greenhouse gases (GHGs) such as carbon dioxide, methane, nitrous oxide, etc. which are the principal cause of climate change.

Although the respondents have demonstrated appreciable level of understanding on the means by which we can address climate change, their perceptions on the different ways of mitigating climate change were not significant across the demographic characteristics such as Gender ($X^2 = 0.83$ df = 3 p > 0.05), Education ($X^2 = 9.22$ df = 12 p > 0.05), Occupation ($X^2 = 13.15$ df = 15 p > 0.05), and Location of respondents ($X^2 = 9.18$ df = 6 p > 0.05) respectively. Therefore, irrespective of one’s demographical settings and characteristics, mitigating climate change is seen as more important and all of them value that as their priority. Thus differences in one’s education, gender, occupation and location of residence do not influence the respondent's perceptions about the strategies we can adopt in tackling and addressing climate change.

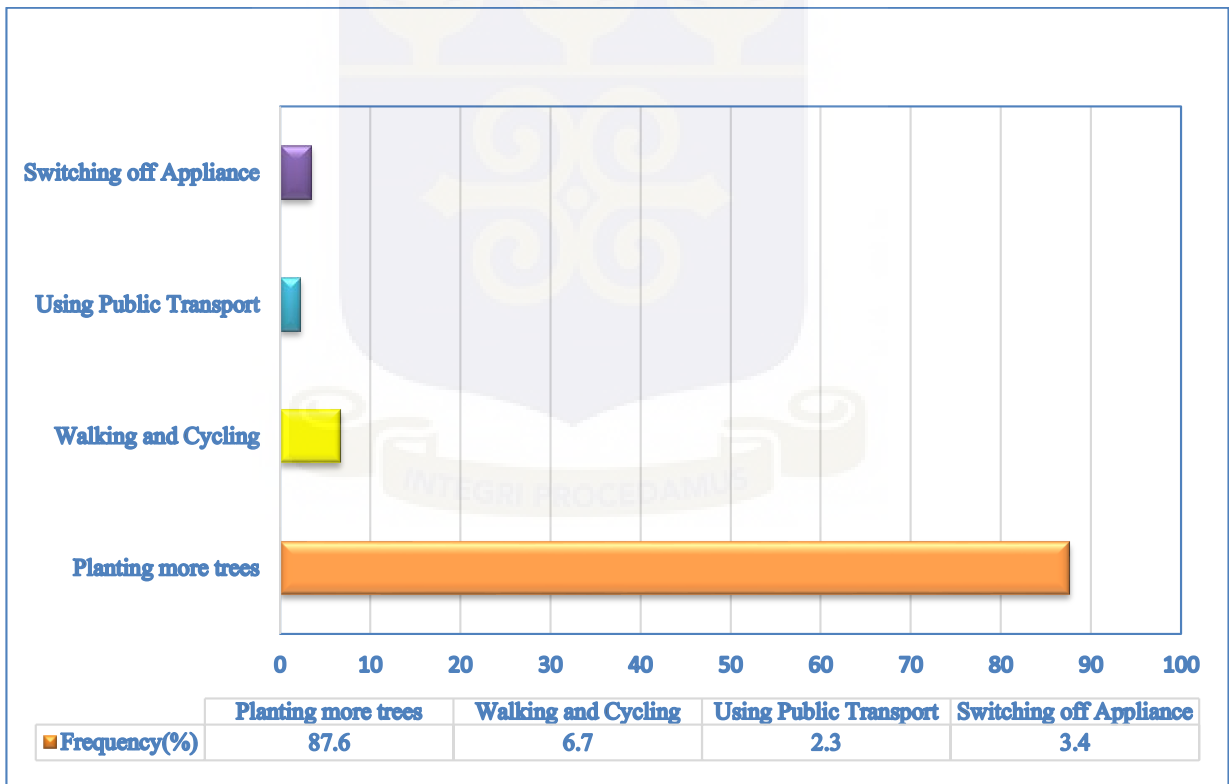


Figure 23. Respondents Perceptions on the Measures of Mitigating Climate Change

Source: Author’s Field Data

4.8 Assessing the Resilience of Respondents' Livelihoods and Sustainability

The key challenge and concern of governments and development agencies in developing countries include devising appropriate strategies for adapting to the impacts of climate change, and how to build resilient communities that are capable of reducing the vulnerability in the communities as well as enhancing their livelihoods sustainably. These have gained increased attention and priority in recent times. This is particularly important against the backdrop that many local communities depend largely on natural resources and ecosystem services that form the backbone of their livelihoods and these are recognized to be linked and sensitive to climate change.

In this study, the resilience of the communities and the sustainability of their livelihoods were investigated in order to ascertain the availability and accessibility of the determinants and factors that can contribute to building this resilience in the communities in the face of climate change in recovery from any extreme climatic shocks and impacts.

4.9 Determinants of the Respondents' Resilience to the Impacts of Climate

Variability

In modelling the resilience of the human livelihoods and ecosystem services that they depend on among the various communities within the study areas, several factors that determine the –resilience if present or vulnerability if absent were investigated and respondents were asked to give credence to the fact these factors are present or not in the community in which they live. A further analysis of modeling the extent to which these factors contribute to resilience was done using the binary logistic regression on the basis of two responses present or absent of the various independent variables of interest.

Proper planning is very important in every situation where proactive measures and strategies are put in place in anticipation to any eventualities in order to be able to respond

appropriately to them. However, in this study, 91.4% (160) out of 175 respondents reported that none of such planning mechanisms exist in all the communities investigated making them not ready to cope nor respond securely should any unfortunate event occur.

From the survey, it was evident that 94.9 (166) respondents asserted there was a lack of adequate institutional support and structures in addressing climate change impacts with only 5.1 % had a contrary view. In terms of the technological capabilities of the various communities investigated, the findings showed that there is a gross lack of technological capacity affirmed by 96.6% (166) out of 172 respondents of the respondents in the communities that can appropriately and promptly respond any climate change extreme shocks or events. The results also indicate that 65.7% (117) respondents claimed that there were no early warning systems to pre-inform residents of the communities of an impending climate change extreme and 34.3 % of respondents asserting that such information does exist through the radio, television although their accuracy and certainty in most times cannot be guaranteed. 96.0% (168) of respondents also lamented of the poor infrastructural development in the area such as poor roads networks that can impede their response to any climate induce extreme events. With regards to relief services especially in the event of any climate change induced events such as drought and possible crops failure, 76.6% (134) respondents have confirmed that such services are hardly available to help victims adapt to the perturbations.

Access to an external support such as loans, government subsidies among others is key means by which people can resort to during emergencies in order to cope with the situation. In this study, 94.9% (166) respondents indicated that there was no external support for them to access making them increasingly vulnerable and unable to cope in the event of any external shocks. The analysis of these responses is tabulated as indicated in Table 8.

Table 8. Respondents' Perceptions on the Determinants of Resilience to the Impacts of Climate Change

Resilience Determinants	Frequency	Present	Per(%)	Present
		Absent		Absent
Institutional support		9		5.1
		166		94.9
Technological capacity		6		3.4
		166		96.6
Early warning systems		59		34.3
		117		65.7
Infrastructure		7		4.0
		168		96.0
Proactive Measures		61		34.7
		115		65.3
Relief service		41		23.4
		134		76.6
Proper Planning Mechanisms		15		8.6
		160		91.4
Cooperation		20		11.4
		155		88.6
Access to external support		9		5.1
		166		94.9

Source: Author's Field Data

4.8.1 Modelling the Resilience of the Determinants of Resilience to the Impacts of Climate Change

Based on the presence or absence of resilient factors such as infrastructure, early warning systems, technological capacity, etc., respondents are likely to recover or cope with shocks hence resilient or unable to cope or recover from external shocks such as climate change

hence vulnerable or not resilient. To achieve this, a binary logistic regression was run where resilience (dependent variable) was regressed against multiple independent variables (Determinants of Resilience) with only binary responses (Present or Absent) as reported by the respondents. The resilience determinants with binary responses results together with the outcome of the model are presented in Table 9. The results clearly demonstrated that, there was clear absence of the various factors that could make the respondents more resilient against climate extreme events implying high vulnerability of these respondents although there was no significant difference among the various factors ($P > 0.23$, $R^2 = 0.645$).



Table 9. Binary Logistic Regression Model Analysis on the Socio-economic Determinants of Respondents' Resilience in the Face of Climate Variability

Resilient factors	Odd ratio	Standard Error	P-value
Early warning system			
Available(RC)	1.00	0.000	0.079
Not available	-0.044	2.077	0.132
Institutional support			
Available(RC)	1.00	0.000	
Not available	0.000	3.535	0.005*
Technological capacity			
Available(RC)	1.00	0.000	
Not available	152.21	7.749	0.517
Access to external support			
Available(RC)	1.00	0.000	
Not available	79.29	7.598	0.565
Good Infrastructure			
Available(RC)	1.00	0.000	
Not available	0.217	3.074	0.619
Cooperation			
Available(RC)	1.00	0.000	
Not available	15.77	2.381	0.247
Relief services			
Available(RC)			
Not available			
Education			
Illiterate (RC)	1.00	0.000	0.36
Primary	0.00	5103.805	0.99
JHS	-0.02	2.069	0.05*
SHS	-0.17	2.012	0.37
Tertiary	-0.01	3.094	0.9
Occupation			
Famer (RC))	1.00	0.000	0.60
Fishermen	13.2	4.121	0.53
Herdsmen	0.00	17707.827	0.99
Salt miners	-0.07	2.604	0.29
Community			
Koluedor ((RC)	0.00	0.00	0.18
Toflokpo	1.101	1.884	0.99
Songorya	-0.018	2.199	0.06

-2log likelihood = 48.108; cox & Snell R square = 0.304; Nagelkerke R square = 0.645; P-value = 0.230, RC = Reference Category

Source: Author's Field Data

4.10 Respondents Adaptation Strategies in Coping with the Perceived Impacts of Climate Change

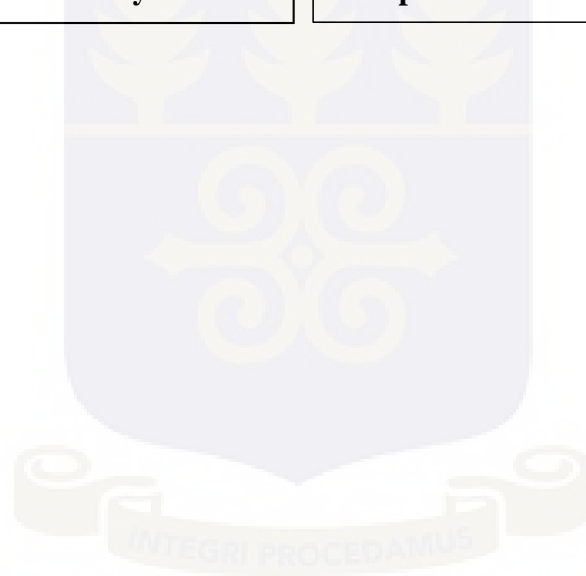
From the study, it indicated that climate change is occurring with grave impacts on the livelihoods and subsistence of the communities. Observations indicated that in response to these perceived impacts that climate change presents to the people, several adaptation strategies have been in place and practiced by the local people in order to cope with increasing temperature and decreasing rainfall pattern as indicated in this study. These adaptation strategies include the following; changing the plating times to suit the changing patterns of rainfall, rainwater harvesting (Plate 2), adopting new and heat tolerant crop varieties that can withstand the drought and heat conditions due to the impacts of climate change. The respondents complain that due to the unpredictable nature of the rainfall, they are often left confused after planting crops only to realize that the rain does not continue leading to crop failure and hugely losses. For the salt miners, during the rainy season, they cover their produced salt with local tusk to prevent the salt from being washed away until the lean season where they can then repackage them for sale at higher and competitive prices (Plate 3). Others switch completely from the salt business to engage in farming during the season and return later in the dry season to resume salt production.



Plate 3: Water Harvesting Technique and Adaptation Strategy adopted by the Respondents in the Study Area



Plate 4: Local Technique in Storing Salt Preservation Produced During Bumper Sea



CHAPTER FIVE

DISCUSSION

5.1 Introduction

In this chapter, a more in-depth analysis and discussions on the findings as presented in the previous chapter are comprehensively dealt with. These also include a comparison of the findings of the present study to that of the existing literature and identifying consistencies or conflicts where possible as well as the implications of these findings to the body of knowledge and research problem being investigated. These encompass discussions on the results from the different approaches and techniques employed in the data collection for the purposes of cross-validation of the results and the identifying of any internal consistency of the results obtained from the different methods of inquiry. For the purpose of clarity and easy comprehension, these discussions are organized under various thematic areas to facilitate easy understanding and orderly presentation of the material.

5.2 The Key Ecosystem Services associated with the Songor lagoon in the Study Area

Ecosystem services which are the goods and services tangible or intangible, that are obtained from ecosystems are noted to be the principal sources of livelihoods and income support systems for local people (MEA, 2005; Zhang *et al.*, 2017). In this study, it became clear that the key ecosystem services that are predominately playing a leading role in enhancing the livelihoods of the surrounding communities in the Songor lagoon are the salt production, although respondents indicated they also obtained fish, water resources from the lagoon in smaller scales. From this study, it was clear that the respondents demonstrated appreciable knowledge and understanding about the value and importance of the Songor lagoon which according to them play a more critical role in their lives. The other intangible services that people benefit from the Songor lagoon is the fact it attracts tourists regularly and which help

provide an avenue for revenue generation for the local assemblies. The Songor lagoon also plays a central role in serving as a buffer zone for the uptake of water during torrential rains in serving as flood prevention and controls point. These essential services are consistent with the findings and categories of the MEA report (2005) on the provision, cultural, supporting and regulating ecosystem services.

These findings mean that the Songor Lagoon, therefore, forms an integral part of the survival of the communities living around it since it serves as the principal source of their income and acts as a major player in providing jobs for the people through the salt production and farming. A respondent who is farmer and teacher over the years as one of the key informant interviewee stressed the fact the Songor lagoon has played significant roles in affecting the lives of the people of the area. He noted that

“ the lagoon has always been our main source of income and food through the salt mining that we engaged in on a daily basis. Through the lagoon water resources, we get salt, fishes to sell and also use in our homes. Not only do people who are resident within Songor area but outsiders were also allow to participate freely in mining the salt although there has been changes in recent years whereby the place is no longer accessible to all but now mined under few people”.

The finding suggests the conservation and protection of the lagoon should therefore be seen as a key concern and priority for the local people by all the relevant stakeholders. However, encroachment and illegal practices such as division of the lagoon land area into pans have been identified as major threats which do not only deny others from benefiting from the salt resources but also risks creating tensions and conflicts in the near future.

Also, from the focus group discussions, it was realised that the major concern now by the people in the Songor area and salt resources is the fact that it is no longer easily accessible to engage in the salt mining business as few people are controlling the resource by creating what is called “Asiakpo” (the division and creation of

plots of lands into pans which the salt water from the sea is drawn into using water pumping machines and then allow to vapourise leaving th salt to be collected, processed, and packaged), and not necessarily climate change although they lamented that there have been increased in temperature and decreased in rainfall affecting their crop yield and production.

These concerns, therefore, call for proactive and radical government interventions in creating the right policy that will help streamline the operations of the Songor lagoon for the salt production that benefits the local indigenes and other stakeholders as a whole.

5.3 Evidence of Climate Change and Climate Variability within the Study Area

From the existing literature within the climate change debate, it is now clear that climate change is real and has serious implications for the entire world although its impacts will vary from place to place (IPCC, 2014). Consistent with these claims is the results from this current study. From this study, it became clear that indeed there have been variations in temperature and rainfall patterns in the study area over the past 30 years examined. The climatic data from the GMET have shown a marginal annual average temperature increase over the years whereas rainfall was observed to decrease. These findings are found to agree with the global scientific body IPCC reports of a rising temperature trend and continue decrease in rainfall especially in the tropics and subtropics regions (IPCC, 2014). In Ghana, it has also been reported that temperatures are rising every year and this is projected to continue in the coming years as predicted by the report of the EPA (2015), Ghana to the UNFCCC in its third communications report. Evidence from the study is considered to affirm these projections.

Since it is important to compare observations with what the real situations on the ground area, the evidence from the respondents' assertions of climate change in the study area over the years became relevant. Therefore, from the survey, the results on the respondents' views

about changes in temperature and rainfall patterns also reflect consistently with trends of the climatic data obtained from GMET. The results indicated that about 63.5% (113) respondents of the total surveyed argued that over the years temperatures within the study area have increased considerably. On the other hand, 56.2% (100) respondents of the total surveyed indicated that rainfall pattern has rather decrease considerably within the study area over the years.

These findings clearly confirm and help cross-validate the recorded data by the GMET on rainfall and temperature variability within the study area. This makes the mixed method of research inquiry a more useful approach than a dichotomous single oriented technique as argued by (Teye, 2012).

Overall, the findings confirm that climate variability is now a reality and will continue in the coming years under the business as usual scenario. Under such a scenario presents serious adaptation challenges for the local people whose livelihoods are tied to the climate sensitive sectors. Therefore, commitment on the parts of governments, agencies, institutions, NGOs and the private sector in designing and implementing effective adaptation strategies are imperative if the future of these communities and local people are at heart of their operations.

5.4 The Impacts of Climate Variability on Ecosystem Services and the Implications on Respondents Livelihoods

From the model results made in this study, it became clear that climate change, that is changes in temperature and rainfall variability have implications on the ecosystem services that are obtained from the Songor lagoon particularly the main commodity which is the salt production. Although the impacts of temperature ($p > 0.05$) and rainfall ($p > 0.05$) appear not to be statistically significant, the model result indicates a relationship that exists between

salt yield and variability in temperature and rainfall. The model indicates that increase in temperature of **1°C** will lead to a decrease in **0.488** metric tons of salt produced per annum. The increase in the rainfall of **1mm** will also lead an increase in **0.142** metric tons of salt produced per annum. Collectively both temperature and rainfall variability from the model results reflected a coefficient of determination **51.4%** impact, which means that the influences of both temperature and rainfall on salt production are **51.4%** with the rest been the influences of other factors (confounding variables) not accounted for in this study ($R^2 = 0.514$). The increase in temperature as observed in the study area suggests the opportunities that exist for the salt production industry and the decrease in rainfall as observed in the study presents a rather contrary reality which will affect the salt production. The findings made from this current study is somewhat consistent with that a similar work by (**Bhat *et al.*, 2015**). In their study, they noted that salt yield was sensitive³ to climatic variability. They observed that increase in temperature has a positive correlation with that of salt yield whereas the increase in rainfall tends to have a negative correlation with salt yield contrary to the findings made in this current study where rainfall rather correlates positively with salt yield.

These findings clearly indicate that the salt production sector is sensitive climate change and the continuing trends of both temperature and rainfall present a mix of both opportunities and challenges for the salt production industry and human livelihoods for which strategies must be employed to harness the inherent opportunities that climate change poses to the salt industry.

Majority 81.8% of 144 respondents have also complained that their livelihoods have been affected in recent times as compared to two decades ago. Several reasons were given for these. Many of them (farmers) attributed this to the unpredictable and changing pattern of rainfall as well as temperature among other factors such as diseases, and soil infertility.

Others (salt miners) lamented that the structural modification coupled with the indiscriminate division of the Songor lagoon into individual pans “Asiakpo” has affected production level and even access to the site.

The situation is not different in other parts of Ghana among especially farmers and other natural ecosystems resources dependent households. In a study by Adiku et al., (2011) they observed that about 89.7% of the total respondents surveyed complained that their production and quantity of crop, harvest and produces have decreased over the years. This was more severe in the Northern, Brong Ahafo, Upper West, Upper East and Volta regions of Ghana many of whom attributed these observations to bad weather conditions. Climate change therefore severe implications on rural livelihoods. This will further deepen their poverty thresholds and risks achieving the United Nation’s Sustainable Development Goals.

In this regard, strategies aimed at harnessing and optimizing the opportunities of climate change whilst minimizing its threats are therefore imperative for governments and all the relevant agencies as well institutions. However, these strategies must take into consideration the social, cultural, economic and the demographic needs of the rural communities which will help protect and sustainably engender rural livelihoods resilience.

5.5 The Respondents’ General Awareness, Perception, Knowledge, and Understanding of Climate Change

The study findings have demonstrated that the respondents had appreciable knowledge and understanding of climate change compared to the scientific findings and explanation discussed in the literature. Contrary to the earlier view` that climate change is a new concept and has no place in the local languages in Ghana by Ahenkan (2012), a significant number of the respondents affirmed that they have heard of climate change which means that the

phenomenon has gained increased awareness in recent times. This may be attributable to the fact that global and local negotiations and campaigns are being held in recent times in a bid to address this global challenge. With regards to gender perspectives, although men seem to hear of climate change this is not statistically different with that of the females ($P > 0.05$) but suggests that a greater proportion of the male respondents have heard of climate change with few not being aware of climate change and this differs from gender dimension. Also from the study, it was clear that many of the respondents who heard of climate change were those that have attained education up to the JHS (40) and SHS (35) levels with lowest being the illiterate respondents although this is not statistically significant ($P > 0.05$). It, however, reflects basically the role education can play in raising awareness and gathering momentum to tackle climate change. This is because the more people are educated, the more they are exposed, become aware and sensitive to the issues that affect their lives thereby increasing their readiness to take action in order to address those issues.

Also, a study by Pandve et al., (2011) observed that the most dominant source of climate information is the television 59.78% radio followed by newspapers and magazines 42.11%, Radio 13.39, the internet (9.23) and others (3.27%). This is somewhat consistent with the present study which showed that the main sources through which climate change information was heard are the radio, television or both although the newspapers, internet information were also sources of climate information these appear to be increasingly difficult means for the rural communities who have no access to these facilities. However, with increasing cell phone penetration across the country internet access to information will see a new trend. Therefore, the sources of climate change information to these respondents are indicative of the possible channels and tools that can be employed in conveying the climate change message. The fact that majority of the respondents heard about climate change either through radio, television or both, predominantly suggests that with the

appropriate educational tools and documentaries on the issues of climate change adaptation and mitigation, we can through these media platforms create and intensify efforts locally and globally to address the climate change menace (Mike et al., 2013).

With respect to their general knowledge and understanding about climate change, the findings suggest that the study respondents seem to know and have a much better understanding of the issues of climate change although their assertions and perceptions cannot be austere ascertained. This reflects in the fact that most respondents rightly noted that climate change is the increase in temperatures and decrease in rainfall which are consistent with the scientific explanation of climate change (IPCC, 2014).

5.5.1 Causes of Climate Change

They further demonstrated their understanding by the fact that many of the respondents noted that the causes of climate change are human-induced factors such as deforestation, bushfires, fossil fuels consumption in our automobiles and cars. However, their understanding of the science of these factors contributing to climate change could not be ascertained in this study.

The respondents perceived droughts, flooding, hotter days and nights as the signals of climatic variability in the study area. They asserted that temperatures have become increasingly hotter these days than before and that rainfall continues to decrease over the years. These have therefore resulted in crop failure affecting their livelihoods.

5.5.2 Mitigation Measures of Respondents

Their understanding of the ways by which climate change can be addressed was also considerably laudable as that of the scientific debate on the mitigation agenda. The respondents believe that planting of more trees will play a major role in mitigating climate change although others argue that it will demand radical behavioral changes in our attitudes

and lifestyles by using public buses, switching off electric gadgets as well as cycling and walking.

Overall, these perspectives of the local communities indicate a positive signal that addressing climate change is not far-fetched but actually lies with our capacity if the efforts and initiatives tailored towards these challenges will be put in place.

5.6 The Resilience of Respondents' Livelihoods and Their Sustainability

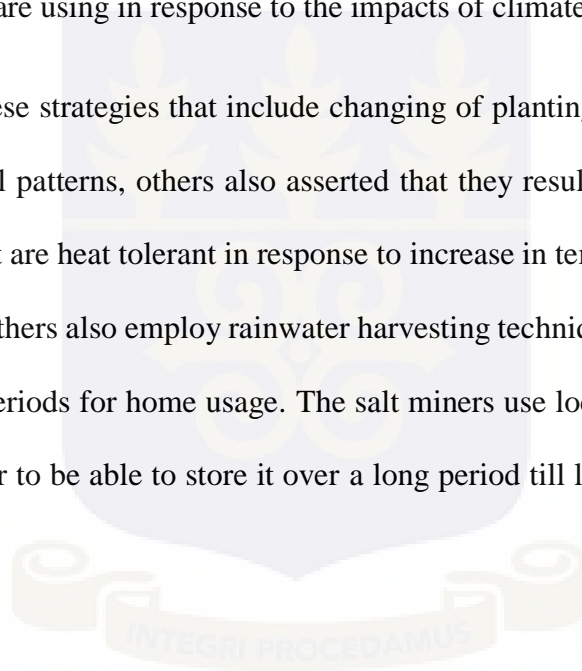
In the findings obtained in this study have shown that apparently in the study communities that were considered are communities that are vulnerable to the impacts of climate change. The binary logistic regression model results on the various determinants of the communities resilience have revealed that indeed these are communities that are highly vulnerable as far as the adaptation to the impacts of climate change is concerned.

Since one's resilience is dependent on the availability of several factors which include; availability of adequate infrastructure, effective institutions, enhanced level of technological capacity availability, access to external support, relief service, proactive early warning systems among others, and the findings in this study, however, revealed a gross lack or inadequate of these essential factors within the communities investigated. These, therefore, means that they are highly vulnerable to the impacts of climate change and therefore may not be able to withstand any extreme shocks nor recover from climate-induced events. These will further exacerbate their poverty and inequalities levels which already characterized the indigenes increasing their vulnerability and compromising their resilience to shocks and extreme events of climate change.

5.7 Adaptation and Coping Strategies in Responding To the Perceived Impacts of Climate Change

There is a clear indication of climate variability in the study area investigated with implications on the ecosystem services and livelihoods of the communities as demonstrated in this study. Therefore in responses to these changing observations and trends, many coping and adaptation strategies are imperative to employ in order to make one resilient and therefore reduce the level of vulnerability to the impacts of climate change and climate variability. This study attempts to discuss some of these coping and adaptation strategies that the respondents are using in response to the impacts of climate change.

In the study area, these strategies that include changing of planting seasons in response to unpredictable rainfall patterns, others also asserted that they result in changing their crop varieties to those that are heat tolerant in response to increase in temperature with the long-standing droughts. Others also employ rainwater harvesting techniques that help them store water during rainy periods for home usage. The salt miners use local tusk to cover the salt they produce in order to be able to store it over a long period till lean season where prices are higher



CHAPTER SIX

CONCLUSIONS AND RECOMMENDATIONS

6.1 Introduction

This chapter is the final chapter of the thesis and in this part of the report are presented the summary of the key findings that were made from the study, the conclusions and inferences that can be drawn from these findings. With the last part, highlights are made on the appropriate recommendations needed for policy considerations and future research directions.

6.2 Summary of Key Findings

This study ended up with certain key findings that sought to answer the research questions that were made earlier in chapter one of this report. Among these findings include the following;

The study has shown that there are key ecosystem services that are obtained from the Songor lagoon by the communities living around the lagoon among which is the salt production, a major provisioning ecosystem service of economic importance to the livelihoods of the communities as well as the government of Ghana through foreign exchange from neighbouring countries such as Togo, Ivory Coast, Benin among others that patronise the salt commodity in Ghana.

The study has also indicated that indeed climate variability within the study area is occurring with increasing temperatures and decreasing rainfall patterns which present severe implications on the ecosystem services that the people depend on and their livelihoods therefore under future threats.

The study demonstrates that the communities living around the Songor lagoon are highly vulnerable to the impacts of climate change considering the fact that their resilience indices were noted to be very low as a result of the apparent lack of infrastructure, strong institutions for the coordination and control of climate change measures for effective adaptation, inadequate early warning systems coupled with inadequate emergency and relief service for any climate-induced upheavals. Their ability to properly adapt to the changing climate or respond to the impacts that these changes have on their livelihoods are therefore uncertain. This implies that their livelihoods and survival situations will be worse in the near future in the face of continuous climate variability if measures and urgent steps are not put in place to address the existing trends observed in this study.

Again, the study has highlighted that the respondents' general awareness, perceptions, knowledge as well as the understanding of climate change and its related impacts on their livelihoods are noted to be appreciable as compare to other studies in the country, although the term climate change is still yet to find its root within the Ghanaian local dialect. Thus the understanding and general awareness of climate change in the study area is laudable although efforts need to continue to increase the current observations.

It was observed that existing local adaptation practices are been used by the communities in responding to the effects of climate change which can be used as key entry points for enhanced localized adaptation to the impacts of climate change. These practices include rainwater harvesting, changes in planting seasons, and diversification of livelihood sources. These practices, if they are locally enhanced, can help build the resilience and thereby reduce the vulnerability of the communities to the impacts of climate change in the study area. Also, building upon these local practices will easily foster the communities' adaptation to the impacts of climate change with the needed support and guidance.

6.3 Conclusions

Based on the findings indicated in this study, the following conclusions are therefore made; first of all, climate variability within the study area is evident with a consistent increase in temperature whilst rainfall pattern continues to decrease over the years. These changes in climate will, therefore, present a big challenge for the local communities' livelihoods that are noted to be climate sensitive sectors such as the rain-fed agriculture and the dominant salt industry in the coming years. This, therefore, calls for proactive measures to be put in place in building the local communities' resilience to adapt to these changes.

In relation to the four specific objectives that were set out to achieve in this study, the conclusions are made in line with these objectives. The first aim of this study was to ascertain the key ecosystem services that are associated and obtained from the Songor lagoon. The results have clearly shown that there are several essential ecosystem services that derived from the lagoon useful for the local communities. The key ecosystem service among others as shown from the study is the salt resources. This forms a major source of livelihoods and income to the indigenes of the surrounding communities of the Songor lagoon and also a boost to the country's economic growth.

Another objective of the study was to assess the changes that are associated with the key ecosystem services identified. It became clear from the results of the study that, the salt project at the Songor lagoon since its inception with the production capacity of about 60,000 Mt of salt per year has over the years not been able to meet this target except only in 1997, 2001 and 2002. The results indicated that the salt production continues to decline drastically over the last decade. Among other confounding factors that may be affecting the level of salt production over the years, it was evident that temperature and rainfall variability account for about **51.4%** to the observed trends of the salt production over the years examined in

this study. Thus, the results showed that climate change has an impact on the extent of salt production in a year.

With regards to the third objective of this study which was to assess the level of awareness, perceptions, knowledge and understanding of climate change of the people in the study area, the results have shown that within the study area, the people have demonstrated an appreciable level of awareness, good perception, knowledge, and understanding of climate change and how its impacts are affecting their livelihoods although much still needs to be done especially the broadening of their understanding of the underlying science and mechanisms of climate change. The observed trends of climate change of the respondents' awareness and understanding are therefore pointers to the fact that the fight against climate change is gaining momentum as many people are becoming increasingly aware of climate change, its impacts on their lives and how it can be mitigated. The result further implies that the appropriate media platforms for the continuous advocacies and campaigns to address climate change noted in this study include the radio and television platforms which have gained increased penetration and usage among the residents of the study area.

The other aspect of the study was to ascertain the level of the communities' resilience to the impacts of climate change and the sustainability of their livelihoods in the face of ecosystem services and resources deterioration. The result from the study has shown that the implications of climate change will continue to have greater impacts on the residents of the communities investigated due to the high level of vulnerability that they are prone to. The lack of proper planning, infrastructure, technological capacity, inadequate early warning systems, inaccessibility to external support among others determinant factors have shown that the resilience of the communities to any climate-induced shocks cannot be guaranteed rather they are highly vulnerable should any climate change induced extreme events to occur. Their livelihoods and ecosystem services have been negatively affected and will

continue to be affected which will further lead to poverty and persistent inequalities in the face of continuous current climate change scenario. As noted by Adger (1999), these call for devising effective strategies to comprehensively tackle the communities' vulnerability and address these challenges holistically which will help them to be better equipped to cope with future uncertainties.

6.4 Recommendations

Based on the findings from the study, the following key recommendations are made for which policy decisions can be made to ensure the design, implementation, monitoring, and evaluations of adaptation strategies, that can help the local communities build their resilience in responding to the adverse impacts of climate change and deterioration of the resources that are currently occurring in the study area.

First of all, it is recommended that the salt industry which is noted in this study to form the bulk of the livelihoods source of the local communities and even contributes to the national gross domestic product, therefore, should be given the due recognition. To this regard, the needed investment by government in the areas of technology, infrastructures such as storage facilities, production tools, and equipment to aid boost the production and storage of the commodity especially during the pumper seasons should be prioritized as such. This will help the salt industry which is sensitive to climate change and will continue to provide and ensure the sustainability of jobs and incomes for the local communities in the coming years.

Again, to effectively address the challenges of climate change, its proper understanding is imperative hence more awareness and intensification of educational campaigns about the causes, signs, and impacts of climate change should be encouraged among local communities. However, these require strategic tools and mechanisms such as crafting a general local dialect, poetry, folktales, documentaries on the climate change with

terminologies that the people can easily understand when communicating to them about the issues of climate change.

Collaboration among all the relevant stakeholders such as government, land owners, salt miners, traditional rulers (chief) through strong community engagement is very essential.



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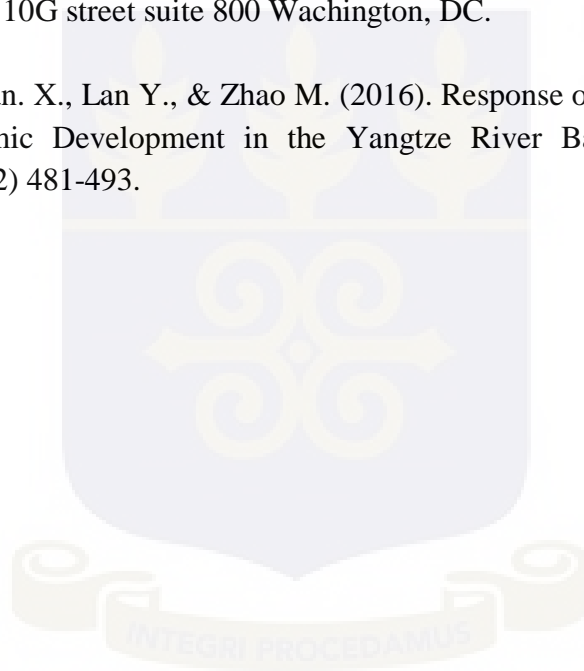
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APPENDIX: QUESTIONNAIRE**1. Data on Mean Annual Temperature and Rainfall Variability of the Study Area**

YEAR	TEMP/°C	RAINFALL/MM
1980	27.90	56.09
1981	28.00	74.95
1982	27.50	103.96
1983	27.80	44.98
1984	27.90	60.58
1985	27.60	55.47
1986	27.50	41.32
1987	28.50	77.58
1988	27.90	66.53
1989	27.70	79.16
1990	27.90	54.66
1991	28.10	108.18
1992	28.30	29.93
1993	28.30	63.28
1994	28.20	58.43
1995	28.50	71.60
1996	28.30	82.68
1997	28.00	99.27
1998	28.70	40.37
1999	28.30	59.67
2000	28.50	32.86
2001	28.60	64.93
2002	28.50	70.22
2003	28.60	88.49
2004	28.50	58.20
2005	28.60	65.90
2006	28.70	62.17
2007	28.30	74.76
2008	28.40	63.94
2009	28.20	89.17
2010	28.80	79.78

2. QUESTIONNAIRE FOR THE SURVEY

Assessing Ecosystem Services and the Resilience of Human Livelihoods in the Face of Climate Variability in Ghana: Case Study of Communities living around the Songor lagoon.

PREAMBLE

The purpose of this survey was to investigate the ecosystem services that are derived from the Songor lagoon and how these contribute to livelihoods enhancement, the level of awareness, the perception of local farmer populations on climate change and its impacts on ecosystem services as well as the effects and implications on their livelihoods and survival. This will undoubtedly provide relevant information necessary as entry points for designing adaptation strategies in local communities to help them effectively adapt to the adverse impacts of climate change.

Please, your participation in this exercise is therefore voluntary and you are at liberty should you decide to decline from responding to this survey without any penalty. All information provided will be kept under strict confidentiality in compliance with research ethics and good practice. This research is under the supervision of Dr. Erasmus H. Owusu and Dr. Rosina Kyerematen under the framework of **Building Capacity** to Meet the **Climate Change Challenge (B-4C)** Project at the University of Ghana.

3. Please, indicate tangible and intangible ecosystem services that obtained from the songor wetland by ticking one option. The Songor lagoon provides the following goods and services

Goods & Services	Yes =1	No =2
The lagoon can provide food, fuel wood, medicine and salt production		
The lagoon can protect the surrounding communities against environmental hazards e.g. floods, storms etc		
The lagoon can be used for recreational and spiritual purposes		
The lagoon serves as sources of income generation		
The lagoon provides a mean of Pest control and pollination		
Protecting the lagoon is very important		

4. The Songor wetland provides several benefits (goods & services) to people in different ways, indicate your view on the following ecosystem services/goods obtained from the wetland?

	Strongly agree=1	Agree=2	Strongly Disagree =3	Disagree = 4	Not sure= 5
Crops produces					
Firewood					
Sense of place					
Honey					
Fish					
Attracting tourists					

Floods control					
Relaxation & recreation					
Water					
Fish					
Medicinal plants					
Pest control and pollination					
Spiritual value					

5. (a). Identify the nature of changes associated with the wetland ecosystem as indicated above (b). what do you think are the major drivers of such change(s)

	Improvement =1	Deterioration =2	b. Driver(s) (you may choose more than one option)
Changes in wetland area			<input type="checkbox"/> Land conversion to industrial area <input type="checkbox"/> Land conversion to urban areas <input type="checkbox"/> Land conversion to tourist development <input type="checkbox"/> Conversion into agricultural land <input type="checkbox"/> Creation of intensive fish farms <input type="checkbox"/> Land conversion to industrial areas <input type="checkbox"/> Climate variability
Changes in water regime			<input type="checkbox"/> Dams <input type="checkbox"/> River Extraction <input type="checkbox"/> Groundwater extraction <input type="checkbox"/> Drainage <input type="checkbox"/> Channelization <input type="checkbox"/> Land reclamation

			<input type="checkbox"/> Irrigation <input type="checkbox"/> Climate variability
Changes in water quality			<input type="checkbox"/> Nutrient enrichment <input type="checkbox"/> Pesticide/Herbicide runoff <input type="checkbox"/> Salinization <input type="checkbox"/> Changes in land use <input type="checkbox"/> Industrial discharges
Exploitation of wetland resources			<input type="checkbox"/> Over-fishing <input type="checkbox"/> Over-hunting <input type="checkbox"/> Over-grazing
Management of wetlands resources			<input type="checkbox"/> Vegetation management <input type="checkbox"/> Vegetation restoration <input type="checkbox"/> Management of hunting <input type="checkbox"/> Management of fishing

What have been the major changes of the Songor lagoon for the past 30 years?

Dates	Major improvement =1	Improvement =2	Deterioration =3	Major deterioration =4	Not sure =5
1980-1990					
1990-2000					
2000 - 2010					

6. What do you think is/are the cause(s) of the changes noted above? (*you may choose more than one option*)

- Land conversion to salt extraction area
- Land conversion to urban areas
- Land conversion to tourist development

- Conversion into agricultural land
- Creation of intensive fish farms
- Land conversion to industrial areas
- Climate hazards disruptions

PART C

KNOWLEDGE, AWARENESS, AND PERCEPTIONS ABOUT CLIMATE CHANGE AND CLIMATE VARIABILITY

7. Select at least the most important environmental problems that are of concerned to you
(you may choose more than one option)

- Air pollution
- Water pollution
- Diseases outbreaks
- Climate change
- Poor sanitation or waste management

8. Have you heard about climate change?

- Yes
- No
- Not sure

9. Where have you heard about climate change? *(you may choose more than one option)*

- Newspaper
- Radio
- Television
- Internet
- other.....

10. Do you know what climate change is?

- Yes
- No
- not sure

11. If yes, what is climate change all about? *(you may choose more than one option)*

- Increase in temperature
- Decline in rainfall
- Not sure

12. What do you think are the causes of climate change? *(you may choose more than one option)*

- Bush fires
- Burning of fossil fuels
- Trees logging
- Deforestation
- Punishment by God
- Industrialization

13. What are likely signs of climate change? (*you may choose more than one option*)

- flooding storms hotter days hotter nights drought

14. In what ways is climate change important to you?

.....

.....

15. Do you think anything can be done to tackle climate change?

- Yes No Not sure

16. If yes, what are some of the measures that can be done to tackle climate change? (*you may choose more than one option*)

- Planting more trees
- Walking and cycling
- Using the public transport
- Switching off electric appliance, not in use

17. Please indicate how you agree or disagree with the following statement about climate change by ticking one option to a statement

Statement	Strongly agree = 1	Agree= 2	Strongly Disagree =3	Disagree=4	Not sure =5
It is already too late to address climate change					
Human activities have significant impact on					

the climate change					
Climate change is something that frightens me					
I am really certain that climate change is happening now					
The effect of climate change is going to be catastrophic					
Recent flooding in the community is due to climate change					
The decline in rainfall pattern over the years is due to climate change					

We can all do our bit to address the challenge of climate change					
The government must play a leading role in tackling climate change					

18. What is your understanding of climate change impacts? (*you may choose more than one option*)

- Increase in temperature Decrease in precipitation or rainfall
 Sea level rise Flooding Storms

19. What has been the pattern of rainfall in this community for the past 20 years?

- Increases Decreases Erratic Not sure

20. What has been the pattern of temperature especially for the past 20 years?

- Hotter Cold Not sure

PART D

LIVELIHOODS OPTIONS BY THE COMMUNITIES ASSOCIATED WITH THE SONGOR WETLAND IN THE FACE OF CLIMATIC VARIABILITY

21. What type of activity do you engage in the Songor wetland (*you may choose more than one option*)

- Farming Hunting
 Salt extraction firewood gathering

- Fishing other (.....)
- Honey keeping

22. How was the state of your activity about 30 years ago

- Very productive Productive Normal
- Unproductive Not sure

23. If very productive or productive can you identify what is the cause?

.....
.....

24. What is the current state of your activity

- Very productive Productive Normal
- Unproductive Not sure

25. If unproductive can you identify the possible cause? (*you may choose more than one option*)

- Decrease rainfall
- Increase rainfall
- Flooding
- Soil infertility
- Pest and diseases

26. Have the changes in the lagoon affected your livelihoods activities?

- Yes No Not sure

PART E

KEY ADAPTATION STRATEGIES AND ALTERNATIVE LIVELIHOODS SOURCES ADOPTED BY THE COMMUNITIES IN RESPONSE TO CLIMATE VARIABILITY TO REDUCE THEIR VULNERABILITIES AND BUILD THEIR RESILIENCE

27. Do you have access to early warning systems on climate change conditions?

- Yes No Not sure

28. If yes can you identify from the following the sources of information on early warning systems about climate change (*you may choose more than one option*)

- Community Radio
- family and friends
- Television
- religious groups
- Internet
- Social media (watsap, facebook, twitter)

29. What do you do to cope with the changing climatic conditions in order to protect your livestock/salt mining/crop produce? (*you may choose more than one option*)

- Change in planting times
- Digging of borehole/groundwater for livestock and irrigation
- Adopting improved crop varieties
- Fish farming
- Other (.....)

30. Has there been any alternative livelihood program(s) in this community to reduce dependency on the wetland resources?

- Yes
- No
- Not sure

31. What are the alternative livelihood strategies adopted? (*you may choose more than one option*)

- Mushroom Farming
- Trading
- Bee Keeping
- Vocational Skills acquisition
- Grass-cutter rearing

PART F:

KEY DETERMINANTS OF BUILDING ADAPTIVE CAPACITY AND RESILIENCE OF ECOSYSTEM SERVICES AND HUMAN LIVELIHOODS IN THE FACE OF CLIMATE VARIABILITY

32. Which of the following will make the supply of essential ecosystem services in the Songor wetland and your livelihoods sustainable? (*you may choose more than one option*)

- Afforestation
- Creating awareness of the value of the wetland
- Community participation in the wetland protection
- Diversifying to other sources of livelihood activities

33. Indicate how prepared you think this community is or not, in response to the perceived climatic variations

Statement	Yes =1	No= 2
1. Our community has plans in place to deal with climate- related events		
2. Our community is able to coordinate activities to respond quickly to the impacts of a natural event/hazard		
3. Our community has the infrastructure to curtail present and future impacts of climate change		
4. Our community is able to reorganize to respond to new situations		
5. Our community has institutions that support us when we need to reorganize to cope with new situations or problems		
6. Our community has the technological capacity to respond to climatic extreme events		
7. Our community members usually work well with each other during times of climate extreme events		
8. Our community is able to access outside support when needed		