UNIVERSITY OF GHANA
COLLEGE OF HUMANITIES

RESOURCE MANAGEMENT AND CLIMATE CHANGE ADAPTATION: IMPLICATIONS FOR FARMERS' LIVELIHOOD IN THE TRANSITION AGRO ECOLOGICAL ZONE OF GHANA

MABEL ENYONAM MENSAH

INSTITUTE OF STATISTICAL, SOCIAL AND ECONOMIC RESERACH

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BY

MABEL ENYONAM MENSAH
(10014725)

THIS THESIS IS SUBMITTED TO THE UNIVERSITY OF GHANA IN PARTIAL FULFILLMENT OF THE AWARD OF DEGREE OF DOCTOR OF PHILOSOPHY IN DEVELOPMENT STUDIES

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DECLARATION

I, MABEL ENYONAM MENSAH, author of this thesis titled "Resources Management and Climate Change Adaptation: Implication for Farmers' Livelihood in the Transition Agro Ecological Zone of Ghana", do hereby declare that the work presented in this thesis was done entirely by me at the Institute of Statistical, Social and Economic Research (ISSER), Universityof Ghana, Legon. All Literature cited in this thesis has been duly acknowledged. This study has never been presented either in whole or part for any degree in this University or elsewhere.

.... **Date: 19-12-2022**

(Mabel Enyonam Mensah)

PhD Candidate

This thesis has been submitted for examination with our approval as supervisors:

.... **Date: 19-12-2022**

(Dr Simon Bawakyillenuo)

Lead Supervisor

....

(Prof Akwasi Mensah-Bonsu) **Date: 19-12-2022**

CO - Supervisor

.... **Date: 19-12-2022**

(Prof Felix Ankomah Asante)

CO – Supervisor

DEDICATION

This work is dedicated to God Almighty without whom I would not have made it this far.
God my Provider!

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ABSTRACT

This study seeks to examine the imperatives of resource management in enhancing adaptation to climate change in Ghana. It explores the extent to which the effective use of resources impacts on climate change adaptation processes and how that in turn, influences the livelihoods of farmers in the Transition Agro Ecological Zone of Ghana. Adaptation to climate change needs planning and innovativeness. This study provides logical and empirical evidence that demonstrate that the effective use of resources positively influences climate change adaptation and invariably improves livelihoods. Primary and secondary data were used in this study. Primary data was collected from five farm communities purposely selected in the transition agro ecological zone of Ghana. Groups of farmers from three communities in Wenchi, and one community each from Techiman North and Nkoranza South districts were interacted with in a participatory focus group discussion. Data from the Ghana Living Standards Survey 7 (GLSS7) was the source of secondary data used for the study. The study assesses the importance of resources in building the adaptive capacity of farmers against the negative effects of climate change in the transition agro ecological zone of Ghana. Household adaptive capacity is estimated using Vincent (2007) framework, with variables from the GLSS7 data. Ordinary Least Square (OLS) and Simultaneous Quantile (SQ) regressions are used to estimate factors that influence the adaptive capacity of farmers. The effect of climate change adaptation on the livelihood of farmers is also estimated using the Simultaneous Quantile and Multinomial Logit regressions. Farmers' perception on climate change, the causes of climate change, and what can be done to reduce the negative effects of climate change were obtained from the primary data collected. Farmers' views on what resources and which stakeholders are important for capacity building and adaptation against the negative effects of climate change were also obtained from both primary and GLSS7 data. Results from the OLS and SQ regressions show that, locality, poverty status of the household, education level, size of landholding of household, ownership of bank account and possession of a mobile phone have a positive influence on household adaptive capacity. SQ results on the effects of climate change adaptation on the livelihood of farmers also show that household adaptive capacity, farm size, mixed cropping, farm diversification, livelihood diversification and ownership of farm land, all have a positive relationship with farmer's net income (a proxy for farmer's livelihood). Processing, however showed a negative relationship with farmer's net income. Findings from the primary data collated indicate the need for the provision of good roads for easy access to markets by farmers. Secondly, there is the need to revisit the use of standardisation and scaling for the sale of some farm produce like maize and groundnuts among others. The Study also recommends that basic amenities like water and toilets in their communities, access to credit and regular interactions with agricultural extension officers for training on new strategies to better adapt against the negative effects of climate change should be provided. Furthermore, empowering local authorities through legislation in fighting against the indiscriminate cutting down of trees and protection of water bodies is crucial.

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LIST OF ACRONYMS

AGRA	Alliance for a Green Revolution in Africa
DFID	Department for International Development
EPA	Environmental Protection Agency
FAO	Food and Agricultural Organization
GDP	Gross Domestic Product
GLSS	Ghana Living Standards Survey
HAC	Household Adaptive Capacity
HACI	Household Adaptive Capacity Index
IDS	Institute of Development Studies
IFAD	International Fund for Agriculture Development
IFPRI	International Food Policy Research Institute
IISD	International Institute for Sustainable Development
IPCC	Intergovernmental Panel on Climate Change
MESTI	Ministry of Environment, Science, Technology and Innovation
MoFA	Ministry of Food and Agriculture
MPES	Modern Productivity Enhancing Strategies
NGO	Non-Governmental Organization
OLS	Ordinary Least Squares
REDD	Reducing Emissions from Deforestations and Forest Degradation
SCP	Sustainable Consumption and Production
SDGs	Sustainable Development Goals
SL	Sustainable Livelihood
SLF	Sustainable Livelihood Framework
SSA	Sub Saharan Africa
UNEP	United Nations Environmental Programme
UNICEF	United Nations Children's Emergency Fund.
USDA	United States Agriculture Development

CHAPTER ONE

INTRODUCTION

1.1 Background

Climate change is affecting and will continue to impact on the global environment, especially, social, economic and ecosystem resources, in decades to come (Adami, Tubino, Ragazzi, Conto & Rada, 2020; Tahiru, Sackey, Owusu & Bawakyillenuo, 2019; Yaro & Hesselberg, 2016; USDA, 2016). Increasing population and the continual increase in demand for ecosystem services with regards to agriculture, mining, logging, and urbanization, would further increase the rate of degradation of the environment (Tahiru *et al*., 2019; Yaro & Hesselberg, 2016; FAO, 2010; FAO, 2008; IPCC, 2007). Climate change is real, global and inevitable, and the negative impacts on agricultural productivity in particular intense (AGRA, 2016; IPCC 2014; FAO, 2010). Agriculture is important in less developed countries, as a major contributor to Gross Domestic Product (GDP) and employment for a majority of rural poor (AGRA, 2016; AGRA, 2014; Tanko & Musstinat, 2014; FAO, 2010). Humans have had to adapt to their environments throughout history by developing practices, cultures, and livelihoods suitable for their various local conditions (AGRA, 2016; IPCC, 2014, 2007). Climate change, however, raises the possibility that existing societies will experience shifts, in temperature, storm frequency, flooding and other factors that previous experience has not prepared them for (Adami *et al*.,2020; IPCC, 2014). Societies would therefore have to learn to live with these changing environmental conditions, thus the need to build capacity and resilience to reduce vulnerability (Adami *et al*., 2020; Kurukulasuriya & Rosenthal, 2013). Reducing the effects of climate risks should not solely focus on tackling the genesis of the hazards, but also on strategies for capacity building to reduce vulnerabilities (Osman *et al*., 2017; Yaro *et al*., 2016). Risk reduction and capacity building remain a key challenge for both developing and developed countries due to the increasing exposure to climate change (Kurukulasuriya & Rosenthal, 2013). The impact of climate change is especially crucial for developing countries, unlike developed countries (Wahid *et al*., 2017; Preston, Yuen, & Westaway, 2011)) especially in Sub - Saharan region (Muchuru & Nhamo, 2019; IPCC, 2014), because, vulnerabilities stem from inadequate or lack of capacity to adapt due to poverty issues, inaccessible resources, over-reliance on natural resources for sustenance (Wahid *et al*., 2017; Nyamwanza & Kujuga, 2016; Ford *et al*., 2014), and developmental priorities (Adani *et al*., 2014).

A study conducted by Anamika, Suparana, Bhupen & Pernilleet (2013), in South Sikkim, India, an agrarian community, found that vulnerability to climate change was not due to the physical nor geographical factors alone but mostly on socio economic factors such as lack of livelihood opportunities, lack of healthcare, lack of access to education and limited available resources. These non-climatic factors made it difficult for farmers to overcome poverty and contributed to their weak resilience to overcoming the impact of climate change. The story may not be different from Ghana, which has about 70% of its rural population depending on agriculture and forest and has a high dependence on the climate for their livelihood (AGRA, 2016; EPA, 2017; AGRA, 2014; Mbow, Smith, Skole, Duguma, & Bustamante, 2014). Any variability in climatic conditions, therefore directly impacts on the livelihoods of farmers, who are mostly found in the rural parts of the country, where poverty levels are relatively high and therefore increases their vulnerabilities (EPA, 2017). Climate impacts increase pressure on rural dwellers. It endangers their operational systems (farm activities and general environment), as well as their well-being, rendering them even more vulnerable (Muchuru & Nhamo, 2019; Yiran & Stringer, 2017; EPA, 2017; Mbow *et al*., 2014; Adger *et al*., 2005). To reduce the vulnerabilities of rural farmers to the various effects of climate change, adaptation action at the local and regional levels is much needed (Muchuru & Nhamo, 2019; Yiran & Stringer, 2017;

Mbow *et al*., 2014; Adger *et al*., 2005). Awareness creation as well as planning for and implementation of adaptation measures form crucial parts of the climate change adaptation process (Muchuru & Nhamo, 2019; Mbow *et al*., 2014; Adger *et al.*, 2005).

The picture with regards to climate change adaptation in Sub Saharan Africa and for that matter Ghana remains diffuse and challenging due to power relations in the climate change adaptation discourse and conflicting views on the effects of climate change on agriculture (Muchuru & Nhamo, 2019; Sava et al., 2015; Annim-Kwapong & Frimpong, 2010). Some of the areas that need strengthening in the climate change adaptation discourse include; capacity building, awareness creation, climate information, well-resourced research and development systems, adequate climate change education into school curriculum, need for policy and budgetary allocation for climate change research and education and strengthening the relationships between scientific knowledge and traditional or indigenous knowledge (Yiran & Stringer, 2017; Sova *et al*., 2015; Biagini *et al*., 2014; Annim-Kwapong & Frimpong, 2010). All of these point to the availability, accessibility and effective deployment and use of resources.

Society has the ability to respond to the effects of climate change on their natural and self - made systems in a number of ways (USDA, 2016; IPCC, 2014; Morton, 2007). Generally, the strategic options for tackling impacts of climate change could be through mitigation, which addresses the root causes of climate change by eliminating completely where possible or reducing greenhouse gas emissions (USDA, 2016). Mitigation requires a change in lifestyle because it requires adjustments or changes in processes and behaviours that are leading to climate change such as any form of energy use or activity that increases the emission of greenhouse gases into the atmosphere (USDA, 2016; Gorddard *et al*., 2016; Wise *et al*., 2014). Adaptation is another means of addressing the negative impacts of climate change which is geared towards reducing the negative effects of present and future climate change, by putting in place measures that lower the risks posed by the consequences of climate change (Adami *et al*., 2020; Muchuru & Nhamo, 2019; Yiran & Stringer, 2017; USDA, 2016). Adaptation also takes advantage of the positive ways that climate change impacts on society (USDA, 2016). Thus, whilst mitigation concentrates on the causes and measures put in place to eliminate or reduce the determinants of the causes, adaptation measures focus more on what can be done to reduce the negative impacts (Adami *et al*., 2020; Muchuru & Nhamo, 2019; Yiran & Stringer, 2017; USDA, 2016, IPCC; 2014). There is the broad consensus internationally that even if the world makes a significant reduction in greenhouse gas emissions, the lag in the climate system means that the world would still be faced with decades of climate change due to greenhouse emissions already put into the atmosphere (USDA, 2016). Moreover, for developing countries that are seeking to industrialize and develop, issues of sustainability in development come to play. Sustainability entails ensuring a balance between economic growth, environmental care, and social welfare, that is, development in totality without leaving anyone behind (Muchuru & Nhamo, 2019; IFPRI, 2019; USDA, 2016; ADRA, 2016).

Agricultural development still remains a key driver to poverty reduction (welfare improvement) in most developing countries, and its importance in the climate change mitigation and adaptation discourse has been internationally recognized (IFAD, 2019; IFPRI, 2019; ADRA, 2016). For most developing countries, a majority of which are vulnerable to climate impacts, adaptation is generally prioritised over mitigation because failure to adapt would be a great threat to food security (IFAD, 2019; Muchuru & Nhamo, 2019; Yiran & Stringer, 2017). It is important to note, however, that there are synergies between adaptation and mitigation, especially in agriculture. A typical example being the use of climate-smart agriculture, a strategy whose objective is to increase productivity, whilst keeping sustainability in mind by enhancing climate adaptation and mitigation where possible (IFAD, 2019; Muchuru & Nhamo, 2019; FAO, 2013). Some soil and water management practices which have been noted for their mitigation potentials, are other examples of synergy between climate adaptation and mitigation (IFAD, 2019; Altieri & Koohafkhan, 2008).

In order to effectively manage resources in the face of climate change, there is the need to have a better understanding of what resources or systems are likely to be affected by the effects of climate change and how best capacity can be enhanced to deal with these changes (Biagini et al., 2014; Travis &Sumner, 2010; Morton, 2007; Lawler *et al*., 2010). Managing natural resources and ecosystems as well as being successful in climate change adaptation in the face of uncertain climate requires new approaches and certain resource management processes in order to improve rural livelihoods (Travis &Sumner, 2010; Morton, 2007; Lawler *et al*., 2010). Resource management is the efficient and effective development of an organization's resources when they are needed (Lawler *et al*., 2010; Klien, 1999; Remade, 1984). Such resources may include financial resources, human skills, and production resources (Lawler *et al*., 2010; Klien, 1999; Remade, 1984). Resource management entails sustainable socioeconomic development of human society through purposive and judicious utilization of natural resources and the maintenance of environmental quality. In terms of conservation, resource management is a set of practices pertaining to maintaining a balance in the natural environment (Lawler *et al*., 2010; Klien, 1999; Burton, 1996; Remade, 1984). Increasing human population, rapid industrialization, unplanned urbanization and steady technological growth amongst others, exert tremendous pressure on the utilisation of existing natural resources and thus requires effective management to check over exploitations and extinction of many of these non-renewable resources (AGRA, 2016; IPCC, 2014; Remade, 1984).

Possible socio-economic scenarios needed for climate change impact and adaptation analysis for different sectors was developed in 2006 by the United Nations Environmental Programme (UNEP, 2006). Land use, water use, food demand, agricultural policies and adaptive capacity were identified as important to explore in relation to agriculture (UNEP, 2006). UNICEF (2019), also in an evaluation and multiple solution series, identified knowledge, technology, innovativeness, infrastructure, institutions, and governance as dimensions to explore in assessing adaptive capacity. These identified dimension by both UNEPmand UNICEF are the underlying factors that build the adaptive capacity of economies, communities as well as households. These have been confirmed by studies and reports such as found in IFPRI (2019); World Bank (2018); USDA (2016); Nyamwanza and Kujuga (2016); Ford *et al*. (2014); Adani *et al*. (2014), amongst others. On this premise, this study, conceptualises resource management as the availability, accessibility and effective use of resources and categorised resources into; human resource, natural resource, capital resource and social resource.

1.2 Problem Statement

Although extreme poverty (people who live on $1.90 or less a day), has seen a decline globally (from 36% of the world's population in 1990 to about 10% of world's population in 2015), in Sub-Saharan Africa (SSA), the number of people living in extreme poverty is rather on the increase (World Bank, 2018; FAO/IFAD/WFD report, 2015). The number of people living in extreme poverty in SSA constitutes more than half the total number of extremely poor per the 2015 projection (World Bank, 2018). Whereas the East Asia, Pacific Region, Europe and Central Asia Region actually experienced a reduction in poverty levels, that of SSA increased, with 413 million people still leaving on less than $1.90 a day. Projections by the World Bank (2018) indicate that if this poverty trend continues, nine out of every ten people living in extreme poverty would be found in Sub Saharan Africa by 2030. In Ghana, majority of those who fall under the poverty line live in rural areas, and have agriculture as their mainstay (AGRA, 2016). These are mostly smallholder farmers who depend on rainfall for their activities (AGRA, 2016; Yaro, 2016). Although the overall poverty levels in Ghana has seen some improvements over the years, poverty in rural areas, urban slums and particularly the northern parts of the country seem to be persistent due to the impacts of climate change (William *et al*., 2018; Asante & Amuakwa-Mensah, 2015; MESTI, 2013). Unfortunately, it is these poor group that are most vulnerable to the negative impacts of climate change because of their reliance on the weather for their livelihood activities (De Souza *et al*., 2015). Data on the trend in the growth of Ghana's population from 1960 to 2021 shows an increase in growth in population across both rural and urban areas. The growth rate of the rural population although is at a decreasing rate, increased from 10,688,436 (56.82%) in 1999 to 12,681,435 (46.58%) in 2014 and currently stands at 13, 332,254(42.02%) in 2021 (FAO, 2015, World Bank, 2021). The negative impact of climate change and variability poses a challenge to the country's efforts at realising its vision of improving livelihoods (William *et al*., 2018; De Souza *et al*., 2015) if efforts are not hastened to build capacities of the rural populace.

The transition agro ecological zone of Ghana, originally a forested zone has gradually lost its cover into a wet savannah zone (Asante & Amuakwa-Mensah, 2015; Cudjoe, 2006) and has had its fair share of changes in vegetation due to climatic changes. These changes started manifesting as shifting agro ecological zones through West Africa since 1983 (Asante & Amuakwa-Mensah, 2015; Tarawali *et al*., 1999). These shifts and continual impact of climate change, which is said to be gradual and severe, has led to the loss of farmlands in low lying areas, destruction of food crops due to flooding or loss of crops due to drought (IPCC, 2014; AGRA, 2014; Codjoe & Owusu, 2011). The transition agro ecological zone in Ghana still exhibits a unique variation in climatic and vegetation conditions, which is attractive to a lot of farmers from other regions in Ghana especially those from northern part Ghana to farm (Cudjoe, 2006). Projections into 2020, 2050 and 2080 however, indicate a rate of desertification of 20,000 hectares per annum and a decrease in the suitability of cocoa production in current production areas, as well as low rice and tuber crop production, which will worsen the plight of the poor, particularly women and children (Asante & Amuakwa-Mensah, 2015). The transition agro ecological zone which is currently a haven for different categories of migrant farmers, some of whom transit down south after acquiring some wealth from their farming activities, is fast changing due to climate change impacts and human activities (Asante & Amuakwa-Mensah, 2015; Codjoe & Owusu, 2011). There is therefore a need for a strategy for recovery and sustenance.

The transition zone has two rainy regimes and has a variety of crop farmers, who farm crops like maize, yam, cassava, cowpea, groundnuts, vegetable and plantain (Addai & Owusu, 2014; Antwi Agyei *et al.*, 2014; Cudjoe, 2006). The transition zone which was popular for tobacco and yam production in the 1950s, still produces a large share of the country's yam, maize and cassava (Addai & Owusu, 2014; Antwi Agyei *et al.*, 2014; Nsiah & Sakyi Dawson, 2012; Cudjoe, 2006), and is basically one of the largest food baskets in Ghana. There is therefore the need to put in place strategies that can mitigate the rate of desertification as well as effectively deploy resources for capacity building for better adaptation against the negative impacts of climate change. Poverty and environmental degradation within rural localities could lead to migration to wetter regions and urban areas which could also pose problems like population densification, increasing number of people exposed to other effects from climate change like floods, diseases, heat waves primarily due to lack of adequate planning and infrastructure (MESTI, 2012). Vulnerability assessments indicate that such informal settlements are most likely to be negatively affected by climate change impacts like floods, droughts, and disease (cholera and Malaria) due to overpopulation (MESTI, 2012).

Although Ghana is less vulnerable to climate change compared to its neighbours in West Africa, climate change has negatively impacted on sectors such as agriculture, water, forests, fisheries, energy and health (De Souza *et al*., 2015). The Ghana National Climate Change Policy and National Climate Change Adaptation Strategy, put together in 2015 sought to help togther strategies against the impacts of climate change (De Souza *et al*., 2015), identified and outlined key priorities across the various affected sectors. Amongst the key areas of priority is agriculture because of its importance in poverty reduction and economic growth in the economy of Ghana. As identified in the UNEP (2006) study, wealth is one and the strongest explanatory variable that determines adaptive capacity, confirming the influence of poverty in building adaptive capacity. The wealthier one is, the more resources one has at their disposal to seek out and pay for adaptation options to reduce vulnerability against climate impacts. The UNEP (2006) study also identified scientific understanding of potential impacts (education, information), institutions (government and private sector), degree of flexibility of a society or household (how and where resources are managed), distribution of wealth (equity), access to information, technology, technological skills in building adaptive capacity for adaptation against the negative effects of climate change.

To successfully manage climate change, a better understanding will be needed on what combinations of resources to use and which resources should be prioritised (Pavlickova & Vyskupova, 2015). Active adaptive management based on potential future climate impacts scenarios will need to be a part of everyday operations (Lawler, 2009; Lawler *et al*., 2008).

Although many concepts and tools for addressing climate change have been proposed, there is little explicit recognition of climate change within the implementation level of agricultural policy (Morton *et al*., 2014). This is attributed to the weak collaboration between institutions. Morton *et al*. (2014) for examples cites the weak linkage between the agriculture and environment ministries in their study of some selected African countries. They noted that substantive agricultural issues feature in climate change discourses and thus the need to involve the agriculture ministry in putting together policies on climate change. To tackle the severe impacts of climate change calls for immediate action at multiple levels of all stakeholders (Morton *et al*., 2014). Climate adaptation needs planning and has to be strategic for effectiveness, because the process entails adjustments of natural and/or human systems as well as the exploitation of potential opportunities (Morton *et al*., 2014; IPCC, 2014; Travis & Sumner, 2010; Kohler *et al*., 2010; Gallopin, 2006; Nuoteva *et al*., 2010; Bates *et al*., 2008).

In most rural communities worldwide, agriculture plays a vital role in improving the well - being of the rural folks; it occupies 45% of the land and employs about 75% of the rural population (AGRA, 2016; Mutabazi *et al*., 2015; FAO, 2010). It is crucial, to enhance the adaptive capacity of the rural smallholders as they face some of the greatest vulnerabilities that may result from climate change. This is not only a matter of risk reduction but also building resilience to improve lives and livelihoods. With the extreme pressure on the existing natural resources, especially in the face of climate change, there is the need for innovativeness (Lawler *et al*., 2010) and transformation in the way resources are used, which will support a reduction of the negative effects of climate change as well as increase the productivity of the farmer.

A study by Williams *et al*. (2018), on the vulnerability of smallholder agricultural systems to climate change in Africa identified the need for effective decision making on allocation of scarce resources for building capacity to enhance the climate change adaptation process. The study also indicated the need to interrogate the trade-offs in resource management as well as put in place of a system that builds an understanding among stakeholders to guide possible pathways to reducing vulnerabilities. With the advent of climate change, the rate of degradation of natural resources is increasing and this has implications for soil productivity, household food security and the environment (Singh *et al*., 2016; IPCC, 2014; FAO, 2010), which could negatively affect the well-being of farmers. Increasing temperature, for example, has implications for water demand particularly for irrigation (Wang *et al*., 2014) and household consumption. Consumption of natural resources is steadily increasing with population growth and development. Overconsumption of natural resources threatens the fundamental economic, social and environmental systems, on which our development relies, thus affecting livelihoods in general and rural livelihoods and development in particular. Rural folks basically depend on the use of natural resources for their survival. With the growing evidence of climate change, it is required that relevant adaptation actions are put in place for survival (Simonet & Faton, 2015). Populations living in poverty are particularly vulnerable to the negative effects of climate change. Vulnerabilities to the effects of climate change in Ghana, for example, stems from an interplay between accessibility to and use of land and other resources, governance systems and policies (Padghem *et al*., 2015). "Supporting people experiencing poverty in their efforts to respond to climate change will be a defining climate challenge in the coming decades" (Logan *et al*., 2017 pg 1554). There would be the need for effective engagements, relevant knowledge production and information dissemination (Logan *et al*., 2017) to help decision makers in determining their priority areas for adaptation plans.

To be able to effectively put in place supporting structures, there would be the need to do a situational analysis of the local community; by finding out what resources there are, how easily accessible these resources are, who has access, how effectively the resources are being used, and to what extent the use of these resources is impacting on the livelihoods of the people. This study is grounded on the idea that in order to have favourable outcomes in planning adaptation strategies against the effects of climate change, it should be done within the framework of efficient resource management. This study, therefore, seeks to improve the understanding on the interrelationships between the effective and efficient use of resources in climate adaption and its effect on the livelihood of smallholder farmers in Ghana. From the foregoing, the research question this study seeks to address is: To what extent does resource management contribute to climate change adaptation and its implications on the livelihood of smallholder farmers in the transition agro ecological zone of Ghana?

1.3 Objectives of the Study

The main objective of the study is to examine the contribution of resource management to climate change adaptation and its implications on the livelihood of smallholder farmers in the transition agro ecological zone of Ghana.

The following specific objectives have been set to guide the study:

- To assess resources available to smallholder farmers for adapting to climate change in the transition agro ecological zone of Ghana.
- To examine the adaptive capacity of smallholder farmers for adapting to climate change.
- To examine the effect of climate change adaptation on the livelihood of smallholder farmers.

1.4 Relevance of the Study

As farming systems evolve, the problem of resource degradation sets in (Singh *et al*., 2016) and the effects of climate change exacerbates this problem, especially for smallholder farmers (Singh *et al*., 2016) making them more vulnerable. Examining the adaptive capacity of farmers in the transition agro ecological zone in Ghana would increase the understanding on what resources are necessary to build capacity and which resources enhance the adaptive capacity of farmers. This information would serve as a guide for policy makers and other stakeholders as they put together for implementation, relevant strategies for increasing agricultural productivity and improving the livelihoods of rural dwellers. Increasing agricultural productivity entails the intensive use of land as well as the effective and efficient use of other agricultural resources (Singh et al., 2016; AGRA, 2016). This study also improves the understanding on the inter linkages in the use of the resources that builds and enhances the adaptive capacity.

In the corporate world, in order to improve productivity and profit levels, management puts in place strategies for improving human resource through training, putting in place enhancing structures and even motivating staff to work harder. This study demonstrates how just as in the corporate world, having such enhancing structures as motorable roads, markets, easily accessible agricultural inputs and extension agents to train farmers in place, could be emulated by policymakers and other relevant stakeholders in advancing or advocating for efficiency and effectiveness in the use of resources for increased productivity to improve the well-being of farmers. The sustainable management of resources, a critical objective in the effort to reconcile socio-economic development and environmental preservation on a global scale, requires improved resource efficiencies and alternatives. This study therefore demonstrates how promoting the efficient and effective use of natural resources could improve rural livelihood and lead to sustained growth.

In order for the process of rural development, whose expected outcome is improved quality of life and economic well-being of people living in remote areas to be achieved, innovative strategies are required. This study demonstrates empirically how poverty weakens resilience due to lack of resources (low adaptive capacity) and places severe limits on the ability to adapt to environmental changes (UNICEF, 2019; Norris *et al*., 2015). This study further demonstrates that to reduce poverty, which is one of the Sustainable Development Goals (SDGs), the adaptive capacity of rural dwellers (smallholder farmers), needs to be enhanced to position them better to adapt against the negative effects of climate change.

Like the UNEP's Resource Efficiency programme, which seeks to promote efficiency and sustainable consumption and production (SCP) in both developed and developing countries as a strategy for building resilient households this study also demonstrates how the effective use of resources help build capacities against the negative effects of climate change.

This study also contributes to an improved understanding of the linkages between resource management and climate adaptation against the effects of climate change across the various categories of smallholder farmers in selected communities for future interventions and policy formulation towards improving livelihoods. There is not enough empirical evidence on how climate hazards impact on the livelihoods and resources of different well-being groups and how each group is responding to climate change. It is, however, important to know the differential climate impacts on different social groups to help future interventions.

This study also seeks to demonstrate how different farmer groups with different skill sets and resources adapt to the effects of climate change and how this influences their livelihoods. This could help government and other stakeholders in planning for interventions geared towards improving the lives of smallholder farmers. A comparison of livelihood indicators across some key variables from the study could also influence policy or serve as a guide to government and other stakeholders in drawing plans for interventions geared towards improving the adaptive capacity and welfare of smallholder farmers in the face of climate change. These would contribute towards achieving the objectives of the Sustainable Developments Goals 2 (Zero Hunger), 10 (Reduced Inequality) and 15 (Protection of Terrestrial Ecosystem).

1.5 Structure of the Thesis

The thesis is divided into eight chapters. The introductory chapter, presents a brief overview on climate change and adaptation and how it has affected humanity and the environment, the problem statement and objectives of the study. Chapter two contains an account of literature review, theoretical framework, and conceptualisation of the study. Chapter three presents the methodology of the study. Chapter four presents the background and socioeconomic characteristics of the study population, and in chapter five, resources of smallholder farmers for climate change adaptation is analysed and described. Chapter six presents findings on the estimation of the adaptive capacity of smallholder farmers in the transition agro ecological zone of Ghana and results from the ordinary least square and simultaneous quantile regressions on the factors that influence the adaptive capacity of farmers to climate change. The seventh chapter presents discussions on the effect of climate change adaptation on the livelihood of farmers, and the eighth chapter, which is the concluding chapter, presents the summary of the study, conclusion, and policy recommendation.

CHAPTER TWO

LITERATURE REVIEW AND CONCEPTUAL FRAMEWORK

2.1 Introduction

This chapter reviews various studies on climate change and variability and how different economies, communities and farm households have tackled the climate adaptation process to reduce their vulnerabilities against the negative impacts of climate change with regards to smallholder farming. The importance of resource availability, accessibility, and use; conceptualised as resource management, within the climate adaptation value chain is also reviewed. Literature on discourses on agroforestry, rural livelihoods, and poverty reduction strategies adopted by smallholder farmers to improve their livelihood and the environment is also reviewed. The chapter is divided into eight major sections: the introduction; climate change and agriculture; climate change adaptation, vulnerability, and capacity building; resource management in rural livelihoods; alternative livelihood strategies as climate adaptation strategies for smallholder farmers; the theoretical framework and conceptual framework of the study and conclusion.

2.2 Climate Change and Agriculture

2.2.1 Overview on Climate Change and Agriculture

Human activities such as the burning of fossil fuel, changes in land use and land cover have led to the increase in atmospheric concentration of greenhouse gases such as carbon dioxide, methane and nitrous oxide, leading to extreme weather events such as floods, drought, heat waves and storms ((IPCC, 2014; IPCC, 2007a). These disturbances are altering ecological systems around the globe (Olmstead, 2013; Lawler, 2009; Agrawal & Pernin, 2008) and pose stress to humanity and to rural livelihoods in particular (Arsano & Milman, 2013; Agrawal & Pernin, 2008). The impact of climate change is said to be gradual and severe and could lead to the loss of farmlands in low lying or coastal areas, destruction of food crops dues to flooding or loss of crops due to drought (IPCC, 2014; Mbow *et al.*, 2014; AGRA, 2014; Codjoe & Owusu, 2011). These changes pose a challenge to natural resources mangers and planners and calls for adaptation to reduce vulnerabilities. In the rural context, climate stresses are in two categories; that which reduces existing livelihood options and that which leads to the unpredictability in the flow of livelihood benefits (Agrawal & Pernin, 2008).

The world witnessed rapid changes in its ecosystems with the demand for ecosystem services significantly increasing between 1960 and 2005 due to the increase in the world's population, which had significant implications for food production (Altieri & Koohafkhan, 2008). As the world continues to experience a rather unstable state in climatic conditions, the vulnerability of agricultural farmers in general and smallholder farmers especially (AGRA, 2016; Morton *et al.*, 2014; Mbow *et al.*, 2014) is increased. Some notable negative effects of climate change include poor quality soils (AGRA, 2016), frequent drought, increased crop infestation by pests and diseases and changing vegetation types among others, all of which affects food production (Adger, 2006; Altieri & Koohafkhan, 2008; Ogunsola, Olugbire, Oyekale, & Aremu, 2015; Tarawali *et al.*, 1999). Conversion of forest and grassland into farmlands for example also influences the degree of climate variability (Mbow *et al.*, 2014; AGRA, 2016). These changes affect the livelihood of farmers and smallholder farmers in Sub Saharan Africa (SSA) particularly because they are said to be the most vulnerable (AGRA, 2016; Morton *et al.*, 2014). The demand for food globally is expected to increase by 60% as the world population hits 9.1 billion by 2050 (Alexandratos & Bruinsma, 2012). This has implications for world food supply and demand issues (AGRA, 2016). Agriculture plays an essential role in improving societal wellbeing; it occupies 40% of the land surface, consumes 70% of global water resource and is dependent on biodiversity at all levels (Altieri & Koohafkhan, 2008). Human activities such as urbanisation, deforestation due to logging, and agricultural activities such as shifting cultivation are said to have effects on the climate (FAO, 2008; IPCC, 2007). By 2025, it is estimated that about 480 million Africans are likely to experience water scarcity and water stress as well as a reduction in rain-fed agricultural yields in 2020 (FAO, 2008; IPCC, 2007).

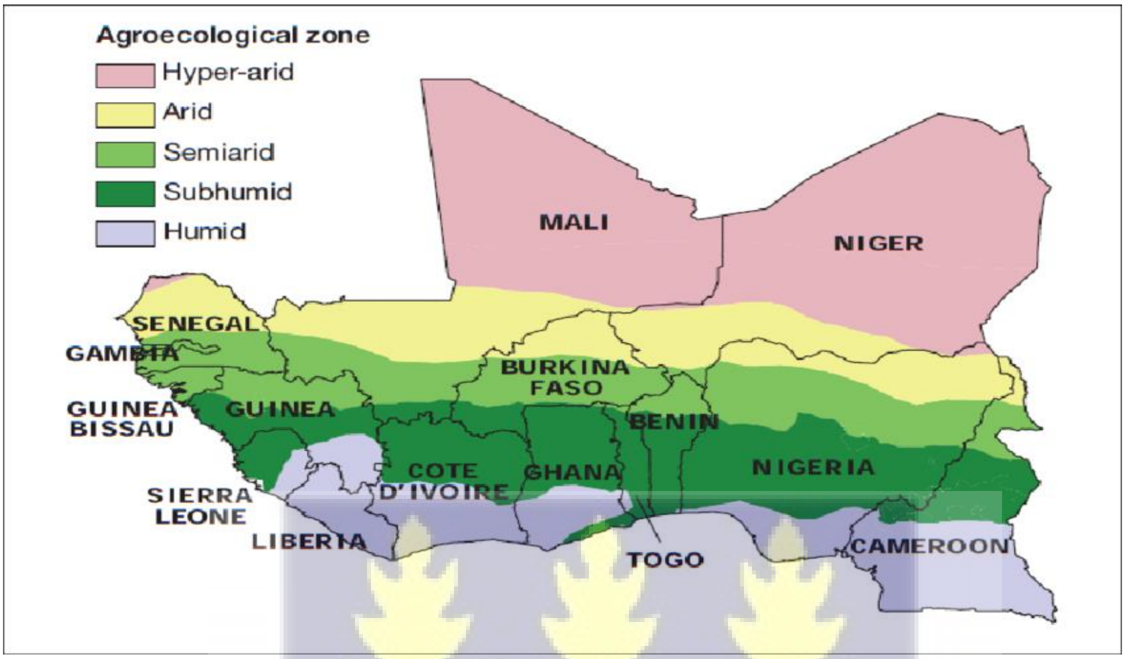
Smallholder farmers are the most badly affected by the variabilities and changes in climatic conditions which tend to affect their livelihoods drastically (Altieri & Koohafkhan, 2008). The effects of climate change manifests as low productivity of smallholder farmers, which renders them poor. Christiansen *et al*. (2011), however note that a 1% increase in agriculture per capita GDP could reduce the poverty gap by five times more than a 1% increase in per capita GDP in other sectors of a given economy, thus the need to build the capacity of farmers to better adapt against climate change impacts to increase productivity. Farmers in developing countries face a big challenge of unstable climatic conditions, because, they are mostly dependent on rain fed agriculture with about 80% of their farmers operating at the small-scale level (Yaro, 2013; Fosu-Mensah Vlek & MacCarthy, 2013; AGRA, 2016). The next sub-section describes how the negative impacts of climate change has led to a shift in agro ecological zones, and thus agricultural activities.

2.2.2 Shifting Agro Ecological Zones in West Africa

As far back as 1993, West Africa was described as experiencing a shift in ecological zones; parts of the Sahel region (Arid/Savannah) gradually changing into Sahara (Hyper arid/Sahara), termed desertification, parts of the Sudan region (Semiarid/Guinea savannah) also changing into Sahel termed sahelization of the savannah and parts of the Guinean region (Sub Humid/Semi deciduous rainforest) is also gradually changing into Savannah, also termed "savannnation" of the forest (Tarawali *et al*., 1999).

Figure 2.1 presents the agro ecological zones of West Africa, showing the Hyper-arid, Arid, Semiarid, Sub humid and Humid from the northern side to the south.

Figure 2. 1: Map of Agro-ecological zones of West Africa



Source: Bourn, 2013

Some authors also refer to these zones as Sahara, Sahel Sudan, Guinean and Guineo - Congonlian also from the driest region up north to the wettest region down south. Generally, the boundaries have shifted southwards with changes in climatic conditions and human induced activities. Tarawali *et al*. (1999), describe the West African ecological zone as Mid altitude, Humid, Semi humid and Semi-arid. The humid vegetation is mostly forest, the semi humid has some forest and savannah and the semi-arid, savannah and the arid and hyper arid extremely dry lands. The semi humid zone is subdivided into humid bimodal rainfall region, also referred to as the forest savannah zone or derived savannah zone and covers an area of 7 million hectares, with average rainfall between 1000 mm – 1500 mm and has two rainy seasons in a year; April to July and September to November (Tarawali *et al.*, 1999), similar to what is experienced in the Transition Agro Ecological Zone of Ghana, the study area for this study. The second region within the semi humid zone, is the drier monomodal rainfall area, located towards the northern side, also referred to as the Guinea savannah zone. It spreads over 8.5 million hectares with an average annual rainfall of 1200mm. It has a longer dry season and one rainfall season in a year, between May/June – September/October. Some manifestations of the shifts across the agro ecological zone in West Africa is what is being experienced in some farm communities in the Transition Agro Ecological Zone of Ghana as the non-suitability of some vegetation for cocoa production and the gradual change for some wet savannah vegetation to drier savannah vegetation. Knowledge about these changes and categories helps governments, development and relief agencies understand better the kind of vulnerabilities the various localities would be facing in the light of climate change and variability so they can come up with relevant, suitable and sustainable interventions for their survival.

2.2.3 Climate Change and Smallholder Farming in Ghana

Agricultural production in Africa is considered to be the most viable means in boosting economic development (FAO, 2010) but it is faced with a lot of challenges (Poulton, Dorward & Kydd, 2010) including the climate (AGRA, 2016; Niang *et al.*, 2014; Rurinda *et al*., 2014 FAO, 2010). Sub Saharan Africa (SSA) is ranked among the most vulnerable region to climate change due to its high dependence on rain-fed agriculture (Niang *et al.*, 2014) with majority of its farmers, smallholders (Batino & Wasara, 2011). Smallholder farmers like other farmers face all kinds of vulnerabilities including soil conditions, access to markets, declining natural resources, weak institutional support (Rurinda *et al*. 2014), but their case is particularly more severe per the size of their land and limited technological advancement (AGRA, 2016; Niang *et al*, 2014; Rurinda *et al*. 2014; FAO, 2010). These vulnerabilities are further worsened by climatic conditions (Altieri & Koohafkhan, 2008). Smallholder farmers per the size of their farmlands are unable to exploit economies of scale not only in production but also in marketing their products and storage (Rurinda *et al*., 2014). They use low technology, have low capitalization, faced with both climate and non-climate related issues like drought, floods, pests, and diseases, increasing population and decreasing landholdings (AGRA, 2016; Niang *et al.*, 2014; Rurinda *et al.*, 2014; FAO, 2010; Altieri & Koohafkhan, 2008). Development practitioners, however, see smallholder farmers as the driving force to economic growth and poverty reduction in Africa (AGRA, 2016; AGRA, 2014; Njang *et al.*, 2014; FAO, 2010; World Bank, 2008).

Smallholder farmers are categorised as producers whose farmland sizes are three hectares or below and practice what is termed "low resource agriculture" with a majority of them producing grains, almost all roots and tubers, plantain, and legumes (AGRA, 2014). Morton (2007) and AGRA (2016) report have categorised smallholder farmers as farmers whose farm size is below five hectares and are mostly found in developing countries, using family labour for their activities, with their main source of livelihood from the farming activities (Altieri & Koohafkhan, 2008; Morton, 2007). This renders them very vulnerable. Mutabazi *et al*. (2015), in their research in rural Tanzania on the determinants of poverty and vulnerability of smallholder farmers using descriptive statistics, a 3 stage least square econometric analysis and $1.25 as the poverty line, revealed that households leaving in agro-climatically less favourable areas were more income poor. Their findings also indicate that increasing farm sizes enhanced level of income of farmers, increasing it further also equally reduced future vulnerabilities. Farm experience was also found to reduce vulnerability. Their results indicate that large household sizes, as well as aging household heads, increased vulnerability of farmers to risks. Most smallholder farmers are dependent on the weather for their farming activities. The crop types cultivated by these farmers are usually staple, for household consumption and for sale (Tanko & Muhsinat, 2014). Mutabazi *et al.* (2015), note that farmers who perceive climate change to be human induced, tend to significantly reduce losses from climate impacts, thus increase their incomes. Farmers who perceive climate change probably adopt the necessary strategies to safeguard against the effects of the climate and subsequently enhance their productivity (Mutabazi *et al.,* 2015). Smallholder farmers are characterised by low productivity, high poverty levels, poor nutrition, lack of access to certain basic amenities like schools, health facilities, credit facilities and markets among others (Morton, 2007). There is the need to support local capacity building to enable farmers build the necessary capacity (World Bank, 2010) to reduce these vulnerabilities.

Reducing rural poverty in SSA forms part of the objectives of the Sustainable Development Goals (SDGs) (AGRA, 2016) and a holistic approach to farming in the face of the changing climate is critical. Agriculture in Africa has the potential to being highly productive in spite of the negative effect of the climate (AGRA, 2016; World Bank, 2010). This potential can only be tapped if smallholder farmers are well equipped to adapt and rapidly respond to the changing climate. Effective adaptation to reduce the negative effects of climate change would require some investments in integrated approaches such as the development and use of irrigation that improves the efficient use of water (Cassman, Grassini, & Van Wart, 2010), improving storage facilities and processing activities. "Making food systems more resilient in the face of increasing climatic variability" (AGRA, 2016) is key to reducing vulnerability and improving the livelihoods of smallholder farmers.

2.3 Climate Change Adaptation, Vulnerability and Capacity Building

In studying human-environmental interactions, it is important to understand vulnerability, adaptation and resilience issues (Adger, 2006). This understanding helps to appreciate better what smallholder farmers are faced with and how and who can move to help reduce their burden and improve their livelihoods. It is important that people perceive the risk due to climate and environmental issues they are faced with (Yaro, 2013; Fosu-Mensah *et al.*, 2013; Codjoe & Owusu, 2011). They must also perceive and accept that they are vulnerable, only then would they appreciate or feel the need for mechanisms to be put in place to mediate their vulnerabilities, through building adaptive capacity and resilience (Yaro, 2013). In the following sub-sections, the concepts of vulnerability, adaptation, adaptive capacity, resilience and factors that influences these concepts are discussed.

2.3.1 Vulnerability

Vulnerability has been defined in different contexts and means different things in engineering, psychology, anthropology, economics and in human-environment relations. Vulnerability is defined as a state of susceptibility to harm from the exposure to stress (in our case the climate and its changes and variability) and social change from the absence of the capacity to adapt (Adger, 2006). MacCarty *et al*. (2001), define vulnerability in terms of the degree to which a system is susceptible to climate change and the inability of the system to cope with the adverse effects of climate change, variability, and extremes. The system which is exposed to stress (the climate condition) in this case, is sensitive to the stress but does not have or has not built the necessary capacity to appropriately adapt to the stress. Turner et al. (2003), define vulnerability of a system as the degree to which the system is likely to experience harm due to the exposure to a stress, hazard or disturbance. The key components of vulnerability have been identified as the stress or disturbance that the system is exposed to, the sensitivity of the system to the stress or disturbance and the adaptive capacity and resilience of the system to cope (Adger, 2006; Nelson *et al.*, 2015). Social factors create and to a large extent contribute to vulnerabilities (Adger, 2006; Nelson *et al.*,2015). Vulnerability applies to issues of climate change, its impacts, and risks (Adger, 2006). Vulnerability cannot be isolated from the wider political economy of resource use and environmental change. Strategies for coping with climate challenges must include components (i.e., the stress or disturbance, the adaptive capacity and resilience of the system or person to cope) for reducing vulnerabilities.

2.3.2 Climate Change Adaptation

Climate change adaptation is defined by the United Nations Framework Convention on Climate Change (UNFCCC) as an adjustment in ecological, social and economic systems in response to observed or expected climatic stimuli and their effects or impacts. It refers to changes in processes, practices and structures to moderate potential damages or to benefit from associated opportunities (Biagini et al., 2014). The Intergovernmental Panel on Climate Change (2007), defines adaptation to climate change as the adjustment in natural or human systems in response to actual or expected climatic stimuli and their effects, which moderates harm or exploits beneficiary opportunities (Biagini et al., 2014). The United Nations Development Program UNDP (2005), has also defined climate change adaptation as "a process by which strategies to moderate, cope with and take advantage of the consequences of climatic events are enhanced, developed or implemented" (Biagini et al., 2014). These definitions draw attention to the different expectations from adaptation with regards to outcomes by different stakeholders.

According to Burton (2008), climate change adaptation is basically any activity, strategy, tool or approach used in reducing the negative effects of climate change on humanity, biodiversity and society at large and positioning humanity to new opportunities that may be present. Some other schools of thought view adaptation to climate change as an issue of risk management, which can be undertaken by individuals or the state, depending on the measure of risk (Patt &Schroter, 2007). In all of these, what is important is the reduction in vulnerability realised due to the adaptation action undertaken.

Adaptation could be anticipatory, that is putting measures in place before impacts or reactive; which happens after impact. Anticipatory adaptation is usually planned, whereas reactive adaptation is spontaneous or unplanned. (Burton, 2008; IPCC, 2007). Adaptation to climate change can involve both the building of adaptive capacity of individuals, groups or organisations to increase their ability to adapt to changes and the implementation of adaptation decisions, that is, transforming capacity into action (Adger et at., 2005). Adaptation is made up of actions throughout society by individuals, groups and governments. Adaptation can be motivated by many factors and this includes but not limited to the protection of economic wellbeing or the improvement of safety (Adger et al., 2005).

Burton (1996), classified climate adaptation options into structural, technical, institutional, and market base. Klien (1999), also outlines some climate adaptation options that farmers could use in reducing the negative impacts of climate change. This entails sharing or bearing the loss due to the negative impacts of climate change amongst farmers to lessen the burden, using strategies that would prevent/modify the negative effects to their advantage, change use of resource, change location, research, education and behavioral change. The way each of these strategies is effected can to a large extent be influenced by what resources are available, how efficiently they are being used and to what extent they are effectively used (Lawler *et al.*, 2010; Klien, 1999; Burton, 1996). Policy relevant frameworks used in examining climate change adaptation practices in the context of rural livelihoods and institutions needs to consider the following (Agrawal & Pernin, 2008):

i. What the likely increases in environmental risks are due to climate impacts.

ii. What the extent of reduction in livelihood opportunities are likely to be.

iii. What the stress on existing social institutions would be.

The risk climate change poses on rural livelihoods could be classified into four different types: across space, over time, across assets classes and households. Climate change adaptation strategies and coping mechanism in the context of rural livelihoods are equally categorised into four corresponding analytical types: mobility, storage, diversification and communal pooling. Access to markets is another potential adaptation strategy that encourages, specialisation, exchange and diversification (Agrawal & Pernin, 2008). Successful adaptation would therefore result in the reduction of spatial, temporal, asset-related and community level risk either directly or reducing risks by pooling uncorrelated risks associated with flows of livelihood benefits from different sources (Agrawal & Pernin, 2008). Mobility is a response to environmental risks that reduces the potential risk across space. Information on rainfall pattern enhances this adaptation strategy. Storage reduces risks over time, reduces waste as well. Diversification reduces risk across assets owned by households and communities. These adaptation strategies are further discussed in section 2.4 and 2.5 under livelihood strategies and alternative livelihoods as adaptation strategies.

2.3.3 Climate Change Adaptation and Adaptive Capacity

Climate change adaptation can be likened development agenda in the sense that, they are strategies employed to reduce vulnerability due to existing climate variability through socio economic development. These socio-economic agendas are geared towards building capacities and capabilities of individuals, households and communities. These built capacities are what is termed adaptive capacity. The adaptive capacity of a system, institution or person is therefore their ability to adjust to an exposure of danger, risk or damage and being able to take advantage of opportunities or respond to the consequences of a risk (IPCC, 2014). Keller & Adger (2000), also define adaptive capacity as the ability of a system to evolve in order to accommodate environmental hazards or policy change as well as expand the range of variability with which it can cope.

There are four dimensions to building adaptive capacity. These are: being able to live with change and uncertainties; being able to nurture diversity for resilience; the ability to learn by combining different kinds of knowledge and taking advantage of opportunities that can lead to socio-ecological sustainability (Mclead *et. al*., 2016). Low adaptive capacity usually manifests as low resilience and people with low adaptive capacity are usually unable to cope with restrictions nor compliance to resource use (Mclead *et.al*., 2016). Social capital, social networks, institutional arrangements, and governance are influencing factors for building adaptive capacity (Nelson *et al*., 2015; Mclead *et al.*, 2016; IPCC, 2014). Some schools of thought have measured economic development (GDP per Capita), in terms of adaptive capacity making developing countries seem more vulnerable to climate change (IPCC, 1996). That is the higher your GDP per Capita, the greater your adaptive capacity, given that it is the proper deployment and management of resources that builds adaptive capacity (Ogunsola *et al*., 2015; Mbow *et al*., 2014; UNEP, 2006; Remade, 1984).

Developing countries are characterized by low GDP per capita compared to developed countries and also lack the institutional capacity for adapting to environmental changes. This assertion could be true, in that, given resources and favourable circumstances, adaptation ultimately could reduce the impact of disturbances. Low GDP implies lower resources available to build the necessary capacity to reduce vulnerability (IPCC, 1996). Communities and countries could however have significant capacity to adapt to climate change and variability issues, using local knowledge and experience (Berkes & Jolly, 2001; Mortimore &

Adams, 2001). Using local knowledge and experience may not necessarily be dependent on state resources and in that sense, could be a way for communities and farmer families to build their own adaptive capacities or putting in place the necessary strategies to reduce their vulnerabilities (Yaro, 2013). The capacity to plan, learn and respond to climate stress have been identified as some key factors that enhance adaptive capacity (Mclead *et.al*., 2016). Other determining factors are the effectiveness and access to institutional support, local knowledge, practice and mechanisms of coping as well as the perception of climate change (Mclead *et.al*., 2016). Assessing the adaptive capacity of an ecosystem or human community ensures that the right intervention measures are implemented (Mclead *et.al*., 2016).

2.3.4 Resilience

Resilience is defined as the magnitude of disturbance that can be absorbed by a system before it radically changes to a different state and also as the ability to self-organise capacity for adapting to emerging circumstances (Folke, 2006; Carpenter *et. al*., 2001; Berkes *et. al*., 2001). Resilience is also used to describe a system's ability to bounce back to a reference state after a disturbance and the capacity of the system to maintain certain structures and functions even after the disturbances (Mclead *et. al*., 2016; Adger, 2006; Turner *et. al*., 2003). Resilience is evaluated in terms of the amount of change that a system can absorb or handle and still remain within a set of natural or desirable state (Turner *et. al*., 2003). Building capacity through improving skills, technology use and more sustainable use of resources, builds the resilience of farm households (Dalal-Clayton & Sadler, 2014). Resilient households mean there are adequate resources to fall back on in times of need or the ability to find other means of earning income when the weather fails and crop yield fails (Dalal-Clayton & Sadler, 2014). Developers of the Reducing Emissions from Deforestations and Forest Degradation (REDD) project, aimed at reducing carbon emissions from deforestation, for example, recognised the need to ensure that local communities had alternative sources of income before implementing the other aspects of their project by paying them for protecting forests (Dalal-Clayton & Sadler, 2014).

Vulnerability, resilience, and adaptation are all interrelated and most importantly, any intervention geared towards reducing vulnerability either through capacity building or resilience improves livelihoods and benefits all the society. Vulnerability and resilience according to Adger (2006), focus on socio-ecological systems, which in totality are the inter linkages between human action, social structures, management of natural resources and its implications to the environment. Building capacity and invariably resilience stems from how well available resources are accessible and utilised to improve the general welfare of the individual or community as a whole.

2.4 Resource Management in Rural Livelihoods

2.4.1 Livelihood Strategies

A livelihood is defined as the ability to combine capabilities, assets (material and social resources) and activities to achieve a set outcome (Scoones, 2009). A livelihood is said to be sustainable when it is able to cope with and recover from stress or shock, as well as maintain or enhance its capabilities and assets without undermining the natural environment (Scoones, 2009). Livelihood strategies are actions or measures put in place by humanity to reduce vulnerability, mostly adopted by farmers to manage the impact of climate on their activities and build their capacities towards improving their well - being (Morton, 2007). Diversification is a strategy aimed at reducing risks and increasing options in the face of a hazard or risk (Turner, 2003). Livelihood diversification are therefore strategies that help in spreading risk and reducing the vulnerability of farmers (Morton, 2007). These livelihood strategies for reducing climate risks should be used in an innovative way such that, each farming community could adapt to or mitigate against a disturbance using the resources that are available to them.

In the face of the rapid and uncertain changes in rainfall and temperature, farmers especially smallholder farmers due to their characteristics are faced with serious resource management issues. There is, therefore, the need to put in place measures for mitigation, building capacity and resilience by the use of alternative livelihood strategies to reduce climate risk. Changes in climate is known to reduce the carrying capacity of land and livestock production (World Bank, 2013) and hence the need for a plan. The African's livelihood and agricultural systems is largely dependent on rainfall, thus making the region vulnerable to climate change (FAO, 2010). As declared by the Heads of State and Leaders in Africa during the Malabo Declaration in 2014, there is the need for the transformation of the agricultural system in Africa for developmental purposes as well as to ensure a better life for the African people (AGRA, 2016). Transforming agriculture would require that the capacities of farmers are enhanced, especially the capacities of smallholder farmers since they form the majority of farmers in Africa and are the most vulnerable (AGRA, 2016). Livelihood strategies evolved to reduce vulnerability to climate shocks and to manage the impact of climate risks termed coping strategies (Morton, 2007). Strategies such as the use of bio-diversified crops, allocation of labour across seasons, diversification of economic activities, integrating livestock and crops, improving the storage of food and feed in the case of livestock rearing and late planting of legumes when cereals fail have been identified as alternatives for reducing vulnerabilities against climate change (Morton, 2007). The effectiveness of livelihood strategies may be observed with the end result of alleviation or reduction in the threat of environmental damage or in the changes of the well - being of farmers termed improved livelihood or a change in attitude or behaviour in processes (AGRA, 2016; Morton, 2007). It is important to note that successful intervention may require improving the skills, resources and technology use of farmers, since these are engines through which overall livelihood could be attained.

2.4.2 Provision of Alternative Livelihoods

The term alternative livelihoods became very commonly used in the 1980's when governments, donors and conservation and development agencies sought to discourage people from engaging in environmentally damaging activities but instead using more sustainable and environmentally friendly methods to reduce pressure on the environment which was being depleted very fast (Dalal-Clayton *et al.*, 2014). Alternative Livelihoods are interventions that seek to alleviate human threat to biodiversity through providing and encouraging the use of an alternative resource, an alternative occupation or an alternative method of lower impact of exploitation as found in use now as climate-smart agriculture (CSA), or sustainable intensification (SI) as alternative measures in improving productivity of farmers and invariably improving their livelihoods (AGRA, 2016). Alternative livelihood could therefore also be defined as an activity or a series of activities that promote both conservation and development without degrading the environment (Dalal-Clayton *et al.*, 2014). Another way may be having alternative sources of income in order to reduce pressure on the environment, that is alternative ways of making a living off-farm (Dalal-Clayton *et al.*, 2014). Livelihood focused interventions can be categorised into three broad but overlapping groups; alternative livelihood intervention, compensation, and "incentives" strategies (Dalal-Clayton *et al.*, 2014). The alternative livelihood intervention category is also further grouped into three categories. These are interventions to provide an alternate resource to the one being exploited, an intervention which provides an alternative occupation to reduce pressure on the environment and providing an alternative method for exploiting natural resource.

Provision of an Alternative Resource: The first category of provision of alternative livelihood intervention, entails the provision of an alternative resource to the one being exploited. For example, communities are encouraged to farm and eat cane rats instead of hunting for bush meat in West and Central African countries (Bennet *et. al*., 2007), as a means of conserving fauna as well as the environment since bush meat hunting in most cases ended in bushfires. In Guinea Bissau, an agroforestry strategy was employed to preserve the ecosystem and enhance food security. Farmers in this community were made to replace shifting cultivation with the planting of cashew orchards in response to perceived increasing climate instability (Temudo & Abrantes, 2014). The use of a cash crop, in this case, would increase income and the natural environment would also be improved.

Provision of an Alternative Occupation: The second intervention category is the provision of an alternative occupation so as to reduce the need to exploit natural resources for income. A good example is the promotion of butterfly farming as a substitute for expanding agricultural farmlands in Tanzania (Morgan-Brown *et al.,* 2010). Earnings from the butterfly farming served as an alternative income source to improve livelihoods. Farmers perceived a link between butterfly farming and conservation. The primary cause of pressure on natural resources stems from the fact that most rural folks usually smallholder farmers, are poor and lack alternatives (Brown, 2002; Roe *et al*., 2014). When the capacity of such farmers is built it invariably reduces the pressure they exert on their natural resources. LilieHolm & Weatherly (2010), give an example of wild coffee farmers who changed their marketing strategy from selling wild coffee seeds to processing the seeds before sale, thereby increasing their income. This strategy thus reduced their need to convert more forestland into farmland since their income levels had increased (LilieHolm & Weatherly, 2010). The ultimate way for conservation of the environment and improving livelihoods.

Provision of an Alternative Method: This category encourages the use of an alternative method for exploiting a natural resource that has a lower impact. Farmers in Mali and Burkina Faso, for example, have revived an old water harvesting system called Zai adopted (Altieri &

Koohafkhan, 2008). This method involves digging 20-30 cm deep pits in "rock - hard barren lands", into which otherwise water could not penetrate, to collect runoff and fill it with organic manure, which attracts termites into it. These termites dig channels that improve the soil structure and allows water to sip through. These termites in digesting the organic matter also make available nutrients to plants. Millet and sorghum are usually grown in Zai. Farmers use between 9000-18000 per acre and compost of between 5.6-11tonnes per hectare (Reij & Waters-Bayer, 2001). Farmers have used this method to reclaim hundreds of hectares of land in the Yatenga region of Burkina Faso (Altieri & Koohafkhan, 2008).

Basic assumptions underlie the use of alternative livelihood strategies; the introduction and use of alternative livelihoods should, in the long run, reduce the desire of smallholder farmers to exploit natural resources (Sieven *et al*, 2005). It is also assumed that farming communities are homogenous and have common characteristics (Wayne *et al*, 2013) and therefore the implementation of a strategy at the community level would reach other users of interest. Bene *et al.* (2009), however, caution that social and political structures could influence access to resources and opportunities at the community level. It is also important to note that the extent to which natural resources are exploited depends largely on the poverty levels of farm households (Kumpel *et al*, 2010). The poorer the household, the more dependent they would be on natural resource exploitation for survival (Kumpel *et al*, 2010). The third assumption is that interventions that are aimed at individuals, would automatically spread through the entire population and the desired impact of natural resource conservation is reached (Sieven *et al.*, 2005).

2.5 Alternative Livelihood Strategies as Climate Adaptation Strategies for Smallholder Farmers

Literature on agricultural development and sustainable livelihoods discuss how agricultural households adopt livelihood strategies as a response to climate and other stresses (Scoones, 1998; Boserup, 1965). Some of the strategies build capacity, some are coping strategies, while others help in mitigation against the climate, all geared towards improving the livelihood of farmers. Biodiversity management, integrated pest management, improved natural resource management, precision, and responsive farming are other examples of alternative livelihood strategies that build capacities. The essence is to create a portfolio of livelihoods with different risk attribution (Ellis, 2000; Mortimore & Adams, 2001) to reduce vulnerabilities. Its effectiveness may be observed in the end result of an alleviation or reduction in threat of environmental damage or in the changes in the wellbeing of farmers termed improved livelihood or a change in attitude or behaviour in our processes. It is important to note that successful intervention may require improving the skills, resources and technology use of farmers, since these are engines through which overall livelihood could be attained. The different alternative livelihood strategies that are available for use by farmers are discussed in the following sub-sections.

2.5.1 Livelihood Diversification

Farmers create what is termed "portfolios" that consist of a combination of farming and non-farming activities to reduce risk as well as improve their livelihoods (Kurukulasuriya & Roseenthal, 2013). It is an alternative livelihood strategy that entails the reassessment of crops, trees and livestock and varieties grown as well as diversification of income sources (Kurukulasuriya & Roseenthal, 2013). Some portfolio combination includes: complimenting crop production with livestock rearing, working on other people's farms in addition to their own farms, engaging in other income generating activities such as honey making, gari processing or soap making. Farmers could venture into off-farm activities like trading, cloth weaving, sewing and even processing (Altieri & Koohafkan, 2008). Cassava for example could be processed into gari, cassava dough and cassava chips which prevents post-harvest losses, increases shelve life and could earn the farmer higher income.

The promotion of butterfly farming as a substitute to expanding agricultural farmlands in Tanzania (Morgan-Brown *et al*., 2010), is an example of an alternative occupation to reduce the need to exploit natural resources for income. Here earnings from the butterfly farming served as an alternative income source to improve livelihoods. It is important to note that the extent to which natural resources are exploited depends largely on the poverty levels of farm households (Kumpel *et al*., 2010). The poorer the household, the more dependent they would be on natural resource exploitation for survival (Kumpel *et al*., 2010). The primary cause of pressure on natural resources stems from the fact that most rural folks usually smallholder farmers, are poor and lack alternatives. (Brown, 2002; Roe *et al*., 2014).

Whereas mixed farming entails farming crops and animals on the same piece of land to reduce vulnerability, mixed cropping or crop diversification, another livelihood strategy entails the growing of different crops on the same piece of land to reduce vulnerability to climate change or variability. This reduces weather related crop failure as well as the risk of disease. It helps to meet home consumption (Minot, 2013) and improve soil fertility in some cases (legumes). In Guinea Bissau an agroforestry strategy was employed to preserve the ecosystem and enhance food security. Farmers here replaced shifting cultivation with the planting of cashew orchards in response to the local social changes perceived increasing climate instability (Temudo & Abrantes, 2014). Here a cash crop is used, which would increase income in the long run and the natural environment has been improved. In another study conducted by Tanko & Muhsinat

(2014), in Abuja, Nigeria on the adaptation of arable crop farmers to climate change, some of the adaptation measures used by farmers were identified together with socio-economic factors affecting adaptation as well as a determination of the perception of farmers on climate change were examined. Results from the study show that 90% of farmers perceived long term changes in temperature and rainfall. The average farm size was 1.5 hectares, confirming that they are smallholder farmers and the most common adaptation strategy used by farmers was diversification of portfolio. The results also showed that number of years of education, age and extension significantly affect the uptake of adaptation measures as a strategy against the effects of climate change.

2.5.2 Employing Climate Smart Agriculture (CSA)

Climate Smart Agriculture entails the use of an alternative method of farming which reduces the impact of exploitation of a piece of land. This approach has three objectives; sustainably increasing agricultural productivity and incomes, adapting and building resilience to climate change and reducing or removing greenhouse emissions as much as possible (FAO, 2013). This approach enhances the resilience of farm systems to the effects of climate change. In a study conducted by Tarawali *et al.*,(1999), velvet beans; mucuna (*mucuna pruniens*) and stylo (*stylosanthes hamata and stylosanthes guianensis*) were used as an alternative land management strategy to improve soil fertility, increase crop yields, supress weeds on farmlands, as well as serve as feed for livestock, a good example of climate smart agriculture. The mucuna plant was first introduced in Benin and gradually adopted by Nigeria, Cameron, Cote d'Ivoire, and Mali. The Stylo plant was however introduced to all West African countries within the Sub Humid bimodal zone to serve as fodder for livestock but adoption was slow due to poor communication, lack of farmer motivation, land tenure issues and lack logistics for extension workers amongst others mention in the study. The stylo plant also improves soil fertility, crop yields, and serves as food for livestock. Use of these plants discourages the use of inorganic fertilizers, one of the objectives of climate smart agriculture.

In Ghana, farmers are known to have used diversified approach to resource management and cropping systems based on indigenous knowledge as measures for adapting to and coping with climate variability. Some of the approaches used entailed the use of local genotypes of food crops, such as drought tolerant or high yielding crops varieties (Ofori-Sarpong & Asante, 2004). Intercropping and agroforestry systems have also been used to meet the needs of subsistence farmers and conserve biodiversity as well (Ofori-Sarpong & Asante, 2004). In Nigeria, farmers and livestock keepers, exposed to the risk of climate change used strategies like changing to irrigation, shortening the growing season, using mulching to improve water retention in soils, planting different varieties of crops and cultivating different crops, all examples of climate smart methods of farming (Ishaya & Abayie, 2008). They identified some factors hindering adaptation strategies as a lack of current knowledge, lack of improved seeds, lack of access to irrigation and lack of information on the weather (Ishaya & Abayie, 2008).

2.5.3 Migration

This livelihood strategy involves the movement of farmers from one locality to another, where there is available and relatively more fertile farmland (Kurukulasuriya & Roseenthal, 2013). Changing environmental systems cause disruptions in ecosystems affecting opportunities to improve livelihoods (Adger & Adams, 2013), and this may lead to migration to relatedly more sustainable locations. In a study conducted in Semi-arid West Africa on the role of livestock mobility as a livelihood strategy for farmers in Mali and Niger, the mobility of livestock was portrayed as increasing the resilience of rural households. These farmers in Niger and Mali, use livestock as an alternative livelihood strategy and are using mobility as another strategy for survival. Mobility is said to be the most important adaptation strategy of pastoralists to variabilities of rainfall and drought (Morton, 2007). Laube, Schraven, & Awo (2012), in their study on "Smallholder adaptation to climate change: dynamics and limits in Northern Ghana" also identified migration as one of the major adaptation strategies of farmers in Northern Ghana. Although migration is seen as one of the most serious consequences of climate change, and has security and humanitarian implications, it can also be perceived as a positive response to climate change (Balwin & Gemenne, 2013).

Migration as an adaptation strategy is used to spread risks under difficult environmental conditions (Adger & Adams, 2013; Balwin & Gemenne, 2013), however, this may not always be the case as the ability to migrate is influenced by several factors (Adger & Adams, 2013; Balwin & Gemenne, 2013). The drivers of migration include economic, social, political and demographic factors and this affect decision making (Adger & Adams, 2013; Balwin & Gemenne, 2013; Geddes et al., 2012). Several research show that males for example are more likely to migrate than females and the youth are more likely to migrate than the elderly (Geddes et al., 2012). Migration as an adaptation strategy is also not so often a feasible option for the most vulnerable groups, leaving them trapped by climate variability. Issues of poverty, marginalisation, and inequality affect migration (Adger & Adams, 2013; Balwin & Gemenne, 2013). Although the economic benefits may be vast for those who are able to migrate, the social and psychological costs are often not well understood. Climate change induced migration bring to the fore, issues of sustainability of resource use and the fact that ecosystem resources change over time and space. It is therefore important to factor in these when migration is opted for as a strategy against the negative impacts of climate change (Adger & Adams, 2013).

2.5.4 Improving Post-Harvest Activities

Improving basic infrastructure such as access roads from farming communities, transport systems, markets, storage, and processing activities would enhance further the resilience of farmers and reduce their vulnerability to climate risk (Ogunsola *et al.*, 2015; Tanko & Muhsinat, 2014). Morton (2007), adds the improvement of storage as a strategic means of reducing vulnerability by reducing post-harvest losses. Codjoe & Owusu (2011), in a study conducted in three selected communities in the Afram plains in Ghana, an extreme drought prone area demonstrated how the occurrence of severe climate changes or variabilities could affect food production. They identified some cultural practices that hindered the building of resilience of local farmers and recommended the use of supplementary irrigation as a means of reducing the impact of climatic variability on crop production. The findings in the study indicate increasing farm-based storage facilities and improving transport systems as some key strategies against the impact of climate change and variability. Encouraging processing also termed value addition is also a way of increasing income since the processed item would sell higher than the raw produce, it also reduces losses during bumper harvest and serves as an alternative source of livelihood for the farmer as well (Rurinda *et al*., 2014). Access to markets could also enhance livelihoods (Rurinda *et al.*, 2014). Good markets imply good prices, access to markets implies good access roads, all of which lead to higher income and an overall improvement in wellbeing.

2.5.5 Improving Access to Information and Use of Indigenous Knowledge

Information is one key variable in climate action and farming narrative. Farmers would need information on the weather, how to maximize resource use in the face of climate variabilities as well as information on how to manage some of the impacts of climate change. In a study conducted in Ondo State, Nigeria (Ogunsola *et al.*, 2015), on understanding perception and adaptation to climate change among cocoa farmers, weather monitoring using both indigenous knowledge as well as from the media were mentioned as some of the strategies used by the cocoa farmers. The study also identified access to information and increasing farmers' awareness of climate change as important to improving the livelihoods of farmers. Fosu-Mensah, Vlek & MacCarthy (2013), in their study on perception and adaptation to climate change using the Sekyedumase district in Ghana as a case study, confirmed that perception of climate change influenced decision making in agriculture and identified changing planting time as one of the strategies used by farmers against the warmer climate being experienced. The study also identified access to extension as one of the determinants of adaptation to climate change. Codjoe & Owusu (2011), in a study conducted in three selected communities in the Afram plains in Ghana, an extreme drought prone area demonstrated how the occurrence of severe climate changes or variabilities could affect food production. For the effective introduction and implementation of adaptive measures to reduce adverse effects of the climate on food production, access to information on improved varieties, new technology, farm practices and the weather were among the key strategies recommended by the study.

2.5.6 Agroforestry as an Alternative Livelihood Strategy

Agroforestry is a land use system where trees, shrubs, and other plants are deliberately planted amongst agricultural crops to enhance both ecological and economic benefits (Mbow *et al.*, 2014). Agroforestry as a strategy helps to slow down rapid degradation and could help to reverse it. This strategy helps adapt to climate change and mitigation issues and is a relevant strategy for all ecological zones (Jamnadass, 2011; Blay *et al., 2007*; Leakey, 1996). Some of the benefits of agroforestry include improving the soil, water recycling and the tree canopy creates a micro-climate for crops and a more resilient ecosystem for better food production (Blay *et al., 2007*; Amanor, 1996). The agroforestry trees provide fuel, wood, timber, fruits and fodder for use by the farm households (Mbow *et al.*, 2014). Agroforestry moderates forest extremes and intra-annual climatic fluctuations. In effect, agroforestry as an alternative livelihood strategy does not only improve well-being but helps in adaptation and mitigation against climate change and variability as well as improves the environment (*ibid*). It serves as the solution to the seemingly difficult choice between reforestation and agricultural land use.

In a study conducted in the Fanteakwa district in the Eastern region of Ghana on the effect of the Taungya system of forest management on the livelihood of farmers, Mensah (2009), identified mode of land acquisition, education, receipt of incentives and percentage share of non-farm income as influencing factors of farmers' participation in the Taungya system of forest management, an agroforestry strategy employed by the Forestry Commission to grow degraded forests in the district. Indications from the study showed that this livelihood strategy improves the environment, increases food production as well as the well-being of participating farmers.

2.5.7 Employing Sustainable Intensification (SI)

This alternative livelihood strategy involves farmers increasing the productivity of the same piece of land by use of high yielding varieties, fertilizers and irrigation where necessary (Kurukulasuriya & Roseenthal, 2013). It requires the use of improved technology, irrigation systems, greenhouses as well as growing high yielding pest resistant varieties to increase output per hectare (Yaro, 2013). In a study conducted in the Northern part of Ghana, Yaro (2013), identified the use of adaptation strategies that fitted with the perceptions of the farmers on climate change and its impacts on on-farm operations and livelihoods in the region. The study also reflected non-climate factors that influenced their activities (Yaro (2013). Some of the strategies used by the farmers in adapting include, "strengthening the use of age-old multiple cropping practices" (Yaro (2013), using improved crop varieties (high yielding and hardy), use of mulch to improve soil fertility, for soil water retention as well as to control weeds. Farmers also adopting modern technologies of small-scale farming as a buffer against the scarcity of labour due to migration caused by climate issues.

In the Sahel region of Nigeria, communities were forced into adaptation strategies in response to a drought crisis that hit the region in the 1970s and 1980s. In their study, Mortimore & Adams (2001), demonstrate how the people in the farming communities in the Sudano-Sahelian of Nigeria adapted to drought. The farmers used different adaptive strategies in response to different crises or different environmental changes they encountered. Farmers, for example, reduced the number of labour allotted to farm activities with any reduction of rainfall. Biodiversity was also used in response to food crisis. The farmers sought indigenous knowledge and used high yielding crop varieties, for example, to increase yield as well as reduce crop losses due to pests and diseases. For land degradation crisis, use was made of what they termed "working the land harder"; that is, making use of strategies to reclaim the land and making it productive again. For stock crisis, animals were integrated and for coping with the changes and variabilities in weather conditions that hit them, livelihood diversification was used as a strategy. Manure from the animal farm was used for crop cultivation, farm animals were fed with crops or crop residues on the farm and profits from business or sale of animals was used to improve crop farm activities and other household activities.

Strategies used were basically geared towards increasing food production, income and other benefits from the same piece of land or less by effectively utilising inputs such as water, fertilizer, and pesticides whilst reducing the negative impacts on the environment (AGRA, 2016). Laube, Schraven, & Awo (2012), in their study on "Smallholder farmers' adaptation to climate change: dynamics and limits in Northern Ghana" suggested intensification using shallow groundwater irrigation by urban vegetable farmers. They recommended the adaptation of small-scale irrigation by farmers as a strategy to minimise the effects of climate change.

2.5.8 Remarks on Alternative Livelihood Strategies as Climate Adaptation Strategies

The effects of climate change vary from one ecological zone to the other. However, the alternative livelihood strategies identified have overlapping functions and are applicable across most of the ecological zones, except for migration which is more relevant in the arid zones. The agroforestry livelihood strategy, for example, is applicable in all the ecological zones for reducing carbon emissions, re-growing degraded lands, reducing runoffs and floods and can be used in reforestation programs. Employing climate-smart agriculture, agricultural intensification and livelihood diversification, use of indigenous knowledge, access to timely information is applicable to all the ecological zones to reduce the impact of climate variability for improved livelihoods.

Building the capacity and resilience of smallholder farmers to reduce their vulnerabilities and improve livelihoods would require some amount of investment in infrastructure, behavioural change, policy, and change in approaches to the use of natural resources. The relevance of Indigenous knowledge in agriculture and the creativity of smallholder farmers for survival over the years must also be tapped and harnessed. Strategies to improve food production, however, forms only one part of the solution. The capacity of the smallholder farmer needs to be built through extension services, availability and access to information on new varieties, technologies and back up of policies to protect farmers from land tenure issues. Markets and transportation systems are also crucial. Development practitioners see smallholder farmers as the driving force to economic growth and poverty reduction in Africa. There is therefore the need to put in place measures that enhance capacity for effective adaptation to the effects of climate change. Agricultural systems need a total transformation and institutional reforms which may require diversification, specialization as well as technical innovation to increase production, reduce vulnerabilities and also improve the environment.

2.6 Theoretical Framework of Study

This study is guided by some principles of Theories of Social Change. The process of adaptation to climate change could be likened to some processes in social change. The climate adaptation processes and the need for resource management to enhance these processes is explained by some theories of social change; Rodney (1973), emphasises that development of the human society, requires the improvement in skills, capacity of the individuals of that society, thus the need for creativity, which we now term innovativeness, greater freedom, responsibility, and self-discipline. Thus, humanity should be held accountable for the way they use resources. This study operationalises accountability as ensuring sustainability and material well-being, liken to improved livelihoods. Rodney, (1973), also touched on the essence of coming together to form groups for survival; which we term today as social cohesion (social capital) to gain access to certain facilities (Reed *et al*., 2013; Adger, 2003; Marshall, 2009).

In Morrison (2006), emphasis is made on the importance of culture and ideas in societal behaviour, which can be likened to indigenous knowledge today, in studying societal change. Indigenous knowledge is a key factor in adapting to climate change to reduce vulnerabilities (Tanko *et al*., 2014; Yaro, 2013; Kurukulasuriya *et al*., 2013; Reed *et al*., 2013; Laube &Awo, 2012). Societies go through many changes and have to make a lot of adjustments to survive against the negative impacts of climate change (Tanko *et al*., 2014; Yaro, 2013; Kurukulasuriya *et al*., 2013; Reed *et al*., 2013; Laube &Awo, 2012). Based on these theories a conceptual framework was put together to guide the discussions in this study.

Some aspects of Critical Social Theory were also used to practically explore and explain how smallholder farmers are adapting to climate change and where resource management fits in for improved livelihoods. Knowledge according to the critical theorist is continually progressive and never pure nor static or rigid (Baker *et al*., 2012; Vogel & Henstra, 2015) The aim of the Critical theorist is to go beneath the surface of social life to uncover the assumptions and masks that keeps humanity from understanding how the world for example works (Callaghan, 2016; Devetak, 2013). This can be achieved by use of reasoning, rationality and scientific method, and requires that is a researcher is self-reflective (Callaghan, 2016; Renault, 2015; Devetak, 2013). According to the Critical Theory, nature is not rigid to be technically controlled and the way to knowledge development is through a continuum process of critical thinking, reasoning and rationality with the goal of unearthing facts (Callaghan, 2016; Devetak, 2013). There is the need to compliment theoretical perceptions with practical efforts towards social transformation (Renault, 2015), which this study seeks to achieve. A distinction between theory and practice is critical and researchers should be able to align along these paths for problem solving (Renault, 2015; Callaghan, 2016; Devetak, 2013). It is impractical to attempt to attain technical control over practical societal realities (Frankfurt School; Renault, 2015; Callaghan, 2016; Devetak, 2013).

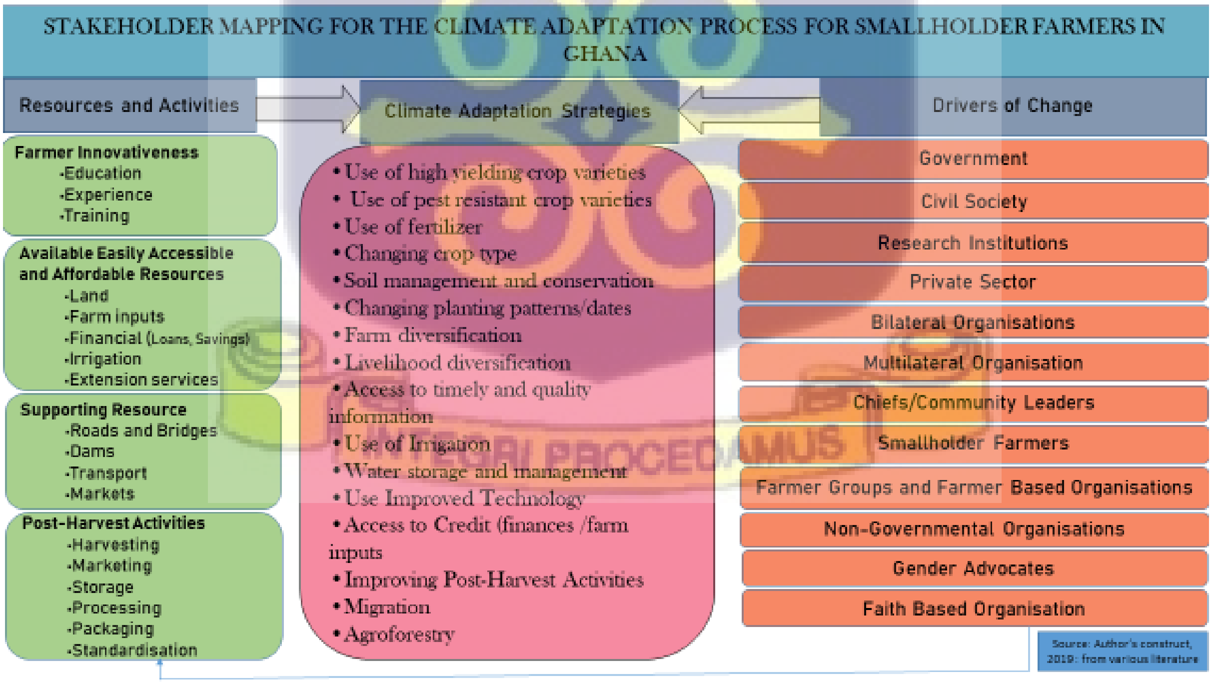
2.7 Conceptual Framework of the Study

In order to improve the well-being of smallholder farmers in the face of climate challenges, there is the need to reduce their vulnerabilities (IFPRI, 2019; AGRA, 2016; Yaro, 2013; Reed *et al*., 2013). This can be achieved by building the capacity and resilience of these vulnerable groups (smallholder farmers) through; improving basic infrastructure (Schools, Electricity, Access Roads, Health Facilities), making access to information on new technologies easy, improved seeds, fertilizers, markets, storage facilities and processing (Alternative Livelihood Strategies), improving policies on landholding, taxes, and subsidies and also taking into consideration beliefs, norms and culture of the people when formulating strategies (IFPRI, 2019; AGRA, 2016; Mcleod *et al*., 2016; Yaro, 2013; Reed *et al*., 2013; Fosu-Mensah, Vlek & MacCarthy, 2013; Codjoe & Owusu, 2011). What goes into enhancing the capacity of the smallholder farmer ranges from a combination of resources and climate adaptation strategies, as well as which stakeholders could expedite the various actions. The climate adaptation response is made up of a range of processes and thus needs planning (Preston *et al*., 2011).

The conceptual framework for the study is therefore formulated as shown in figure 2.2.

Figure 2.2 shows the interlinkages within the climate adaptation process.

Figure 2. 2 Conceptual Framework of the Study



Source: Author's Construct, 2019

Figure 2.2 shows the different resource categories, climate adaptation strategies, and some stakeholders that this study has teased out from various literature as necessary for capacity and resilience building for the successful adaptation against the negative impacts of climate change (IFPRI, 2019; World Bank, 2018; Mcleod *et al.*, 2016; AGRA, 2016; Nelson *et al.*, 2016; World Bank, 2010). Figure 2.2 showing the Stakeholder mapping, describes institutions and stakeholders at different levels, their functions and inter relationships, as well as the roles they play in enhancing resource management and the climate adaptation processes.

This serves as a guide in identifying, analyzing and mapping out at which level which stakeholder plays a particular role as well which stakeholders are relevant in building capacity and resilient in strategising against the negative impacts of climate change. The identified activities and institutions necessary to build the capacity of the smallholder farmer and farm communities are conceptualised in this study as the resources whose availability and access to the farmer and farm community would build or enhance their capacity to better adapt against the negative effects of climate change and variability. A list of available resources whose accessibility to the farmer, could improve their adaptive capacity is also outlined in Figure 2.2.

Resources influence the choice of climate adaptation strategy and this is illustrated by Antwi - Agyei *et al*. (2015), in their study conducted to assess how climate vulnerability is shaped by institutional and socio-economic processes. Some of their findings reveal that land tenure arrangements and infrastructural development influence the choice of climate adaptation strategy a farmer opts for. Land tenure issues for example limits adaptation options for migrant and female farmers. This study is of the view that one is vulnerable if they are susceptible to risks and yet lack the capacity (available and easily accessible resources) to adapt. An enhanced adaptive capacity and resilience, manifests as increased productivity, increased income, improved well-being, and improved environment. These are however interconnecting activities that happen concurrently to achieve the set of outcomes and have influencing effects as well. For instance, adopting alternative livelihoods, maybe influenced by some economic factors or financial considerations. The use of improved seeds and fertilizers, which is expected to increase crop yields, for example, would need resources like good markets, transport systems, storage and processing systems, that is, good functioning post-harvest activities to reduce any losses on the farm in order to improve farmer income.

Adaptation to climate change as has so far been discussed, is a continuous stream of activities, actions, decisions and attitudes that reflects existing processes and norms (Adger, 2005) and this stream of activities is equally motivated by the benefits from the actions taken or the cost of the inaction (Antwi – Agyei *et al*., 2015), as well as the improvement in safety or protection of the economic well-being of the people (Antwi – Agyei *et al*., 2015). Assessing adaptation cannot be done without evaluating what the adaptive capacity and resilience of farmer communities and the farmers themselves are. Adaptive capacity like resilience is multidimensional and is determined by a complex inter relationship of a number of different factors at different scales (Preston *et al*., 2011; Vincent, 2007; Adger *et al*., 2005).

Table 2.1 presents a comparison of factors that influence the climate change adaptation process to the characteristics of smallholder farming. From the Table 2.1, it can be seen that resources play a very crucial role in the climate adaptation process. The factors that influence climate adaptation outlined in the Table 2.1 are all resources. This is a clear indication of the important role resources play in the climate adaptation process to reduce vulnerability and improve livelihoods. These resources need to be managed effectively and efficiently to realise some satisfactory expected outcomes.

Table 2. 1: Factors That Influence Climate Change Adaptation Vs Characteristics of Smallholder Farming

Factors that Influence Climate Adaptation	Characteristics of Small Holding Farming that makes farmers vulnerable
Economic Processes (cost of inputs and services)	Low income
Equity (distribution and of economic well-being)	Lack access Usually, live below the poverty line
Institutional arrangement	Poor access
Infrastructural development	Poor infrastructure (especially for rural dwellers)
Development and diffusion of technology	Low /no education
Environmental processes	High dependence on natural resources (put a lot of pressure on the environment)
Prediction of risk and nature of actual risk	Poor access to information
Agronomic practices	Use of low technology/poor on-farm activities

Source: Authors Construct, 2019

There is evidence in the Ghana Living Standards Survey (GLSS) round 7 that indicates that most of the people who fall below the poverty line are rural dwellers, which is where we find most smallholder farmers. To reduce poverty (which is one of SDGs) in these areas would mean enhancing the capacity of these rural dwellers (mostly smallholder farmers), to better adapt to the effects of climate change, and what better way than to equip them to effectively and efficiently utilize the resources available to them in strategising to reduce their vulnerabilities against the negative effects of climate change.

For this study, resource management has been conceptualised as the accessibility, availability, suitability of resources, and in quantities and form that would be of relevance to the farmer communities and farmer households. The assumption by this study is that, the more resources are available and accessible to farmers, the more enhanced their adaptive capacity will be against the negative effects of climate change, and the higher the likelihood of improving their livelihood. As was demonstrated in Figure 2.1, the stakeholder map, there could be various climate adaptation choices available, but the farmer's choice of climate adaptation strategy would be dependent on their adaptive capacity, which would in turn be influenced by the farmer's inherent capabilities. These inter/intra activities and processes are also linked to the other stakeholders in the climate change adaptation process.

The aim of this study is to explore and practically demonstrate these interactions in the climate change adaptation process. Adaptive capacity, which is the ability to adjust or evolve to exposed stress or change is also linked to development (Adger *et al*., 2005). The key to empowering smallholder farmers to be self-sufficient and resilient in the face of any shock, is to build their adaptive capacity. To be able to better adapt to the impacts of climate change, it is important that the capacity of the smallholder farmer is enhanced. There is the need to ensure that these interlinkages are not taken for granted if we are to see any changes in the lives of smallholder farmers living in rural communities and who lack the needed resources to improve their livelihood.

2.8 Conclusion

This chapter presented the literature review, theoretical and conceptual frameworks, as well as the scope of the study. The literature review covered an overview of climate change and agriculture; climate change adaptation, vulnerability, adaptive capacity and resilience; resource management in rural livelihoods, and alternative livelihood strategies as means of reducing the negative effects of climate change on farmer livelihoods.

Various studies on climate change and variability and how different economies, communities and farm households have tackled the climate adaptation process to reduce their vulnerabilities against the negative impacts of climate change with regards to smallholder farming were reviewed. The importance of resource availability, accessibility, and use; conceptualized as resource management, within the climate adaptation value chain were also reviewed. Literature on discourses on agroforestry, rural livelihoods, and poverty reduction strategies adopted by smallholder farmers to improve their livelihood and the environment is also reviewed. Key findings include:

- Climate change, manifesting as rapid changes in ecosystems. The demand for ecosystem services increasing due to increasing world population and this has implications on world food supply and poverty reduction.
- The negative effects of climate change translating into low farmer productivity, increasing the vulnerability of farmers.
- Making food systems more resilient in the face of increasing climatic variability is key to reducing vulnerability and improving the livelihoods of smallholder farmers.
- Effective adaptation to reduce the negative effects of climate change would require some investments in some integrated approaches such as the development and use of irrigation that improves the efficient use of water, improving storage facilities, engaging in processing activities.
- Successful interventions may require improving the skills, resources and technology use of farmers, since these are engines through which overall livelihood could be attained. There is the need to support local capacity building to enable farmers build the necessary capacity to reduce these vulnerabilities.

The gap this study seeks to fill is bringing to the fore the importance of the effective use of resources in reducing vulnerabilities in the face of climate change. This study emphasises the importance of assessing the adaptive capacity of ecosystems or human community to ensure that the right intervention measures are implemented for proper deployment and management of resources that builds adaptive capacity. Effectiveness of livelihood strategies used may be observed with the end result of alleviation or reduction in the threat of environmental damage or in the changes of the well - being of farmers termed improved livelihood or a change in attitude or behaviour in processes

The Theoretical and Conceptual frameworks described in section 2.6 and 2.7 demonstrates further, using a stakeholder map, the climate change adaptation process, what resources and strategies are required and who the drivers of change are for effective resource management in the climate change adaptation to improve livelihoods.

CHAPTER THREE

METHODOLOGY

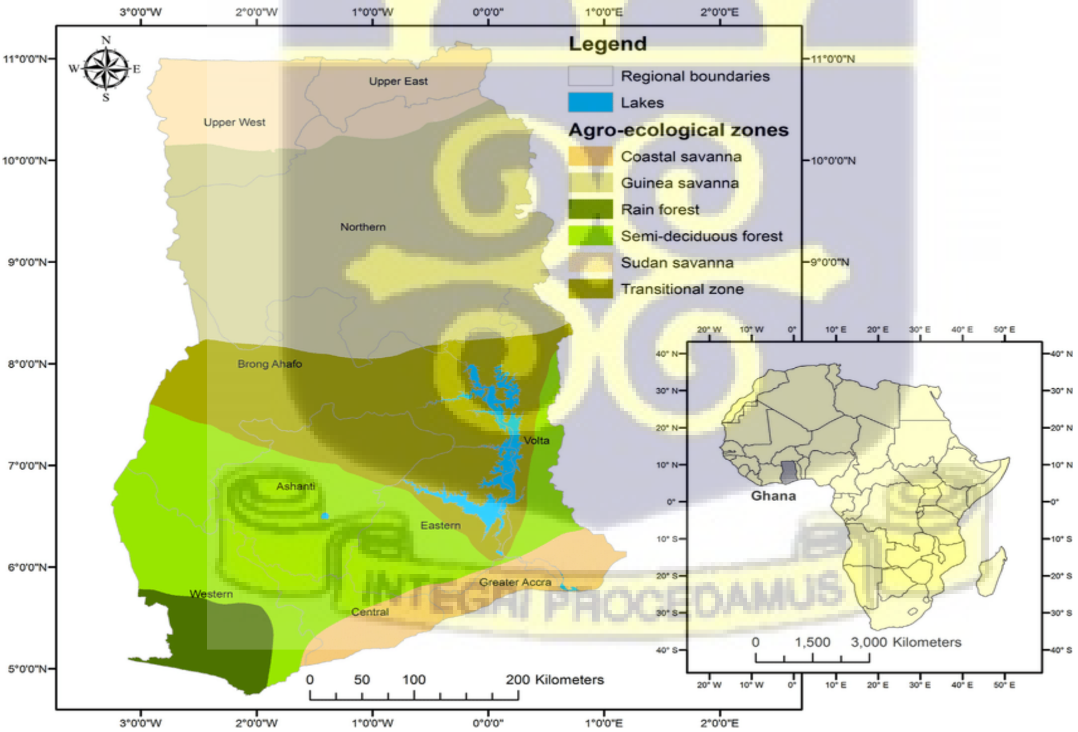
3.1 Introduction

This chapter presents the methodology of the study. Following the introduction, is the description of the study design and data gathering. The study area and study population are described in the third section. The Study sampling and data sampling are explained in the fourth section, followed by a description of the analytical framework of the study in the fifth section. The sixth section covers the analytical approaches used for each specific objective of the study and the seventh section limitations of study and the chapter conclusion forms the eighth section.

3.2 Study Area

The study area is the transition agro ecological zone of Ghana and presented in Figure 3.1

Figure 3. 1: Map of Ghana showing the Agro Ecological Zones



Source: Rhebergen et al., 2016

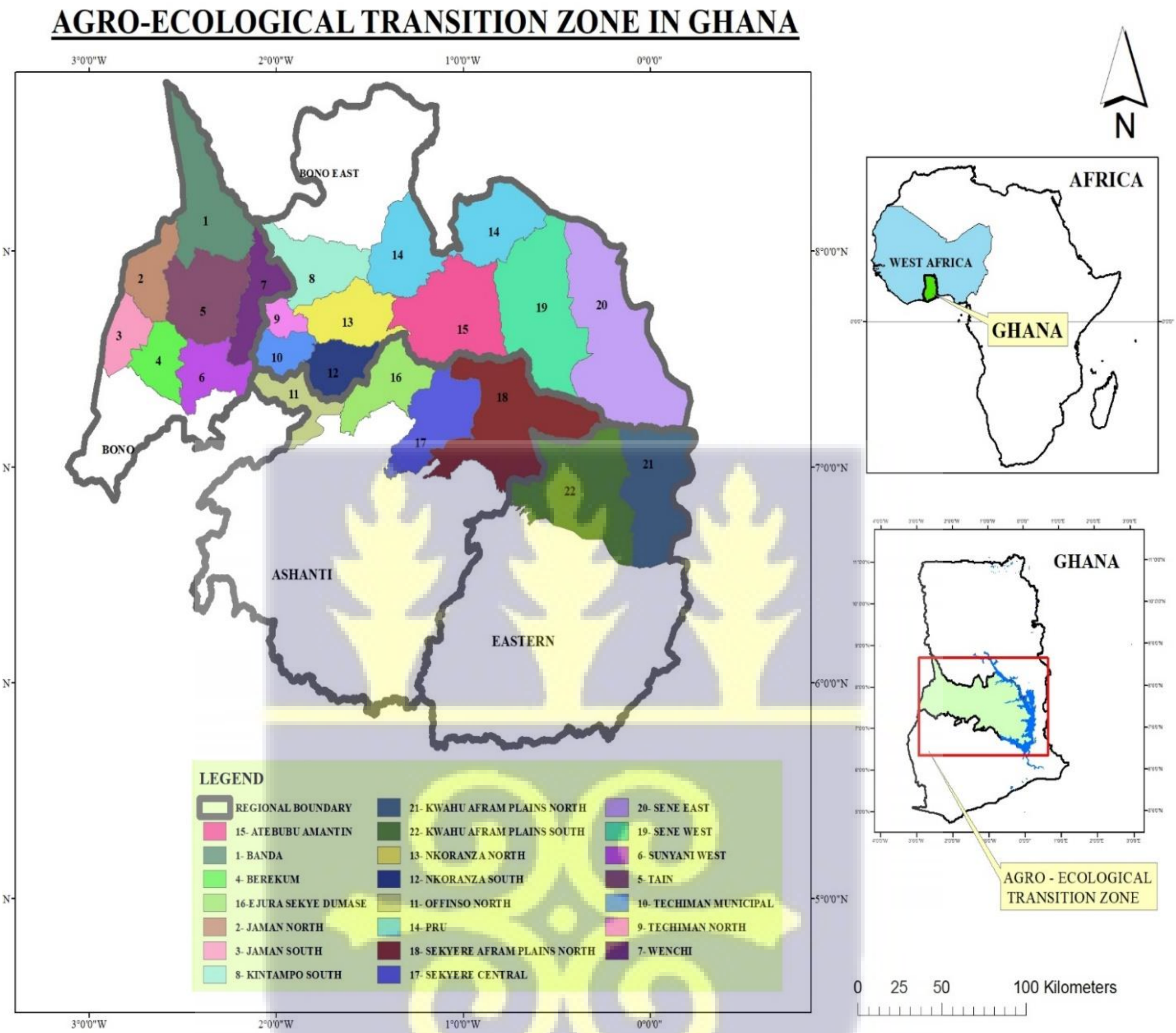
AS presented in Figure 3.1, the transition zone is located between the forest vegetation to the south and the savannah vegetation to the north of Ghana. And covers an area of 10,620km (Cudjoe, 2006). It has a unique climatic and vegetation conducive for farming a variety of crops. Thus, numerous farmers migrate to the zone to either do off season farming or actually settle in for farming. It has two rainy season regimes, with the major season commencing in April/May and ends in July/August. The minor rainy season is usually between September to October with an average annual rainfall of between 1150 mm to 1500mm and average temperature of 20 - 32 degrees Celsius (Antwi-Agyei *et al*., 2014; Cudjoe, 2006).

The transition agro ecological zone is characterised by the wet savannah vegetation and has trees up to about 15mm high often scattered, with soil type mainly Laxisols (Antwi Agyei *et al*., 2014; Addai & Owusu, 2014; Nsiah & Sakyi Dawson, 2012; Cudjoe, 2006). Laxisols are fragile soils with shallow top soil underlain with compact concrete and impermeable iron pans. Farmers in this vegetation zone are known for their use of cassava to regenerate the soil and for soil fertility management (Antwi Agyei *et al*., 2014; Addai & Owusu, 2014; Nsiah & Sakyi Dawson, 2012).

The transition agro ecological zone, is one of the biggest food baskets in Ghana producing staple crops such as maize, yam, rice, groundnuts, cowpea, plantain, sorghum cassava, some vegetables like pepper and tomatoes and cash crop cocoa, and recently cashew (Antwi Agyei *et al*., 2014; Addai & Owusu, 2014; Nsiah & Sakyi Dawson, 2012; Cudjoe, 2006). The transition agro ecological zone of Ghana, consists mainly of the Bono East and Bono regions, part of Ashanti and Eastern Regions. This is made up of the forest and savannah transition vegetation.

Figure 3.2 presents the map of the study area showing the various districts within the regions in the transition agro ecological zone.

Figure 3. 2: Map of the Regions with the Districts Within the Transition Agro Ecological Zone



Source: GIS Laboratory University of Ghana, Legon, 2020

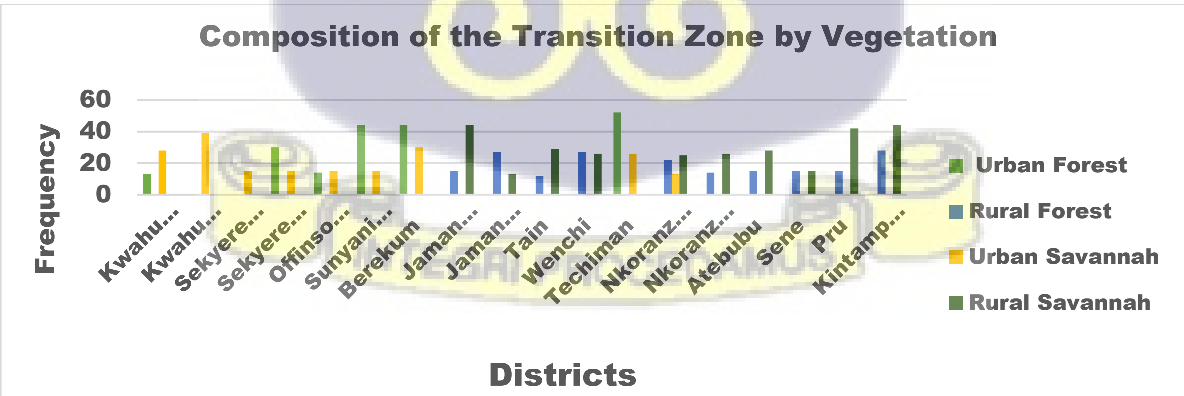
Figure 3.2 shows that, the Offinso North, Ejura Sekyere Dumase, Sekyere Afraim Plains North and Sekyere Central districts are the four (4) districts in the Ashanti region that fall within the transition agro ecological zone. The Eastern Region has 2 districts: Kwahu Afraim Plains North and South districts, while Bono Region has 7 districts: Wenchi, Banda, Tain, Sunyani West, Berekum, Jaman North and South districts within the transition agro ecological zone. The Rest

(9), fall within the Bono Region; Techiman main, Techiman North, Nkoranza North and South, Kintampo South, Pru, Atebubu and Sene East and West districts.

Jaman North, Wenchi, Kintampo South, Techiman Main, Techiman North, Nkoranza North and South and Tain districts fully fall within the transition zone, whilst Banda, Sene East and West have about three thirds of the land towards the southern side, within the transition zone. Ejura Sekyere Dumase, Jaman South, Offinso, Sekyere Afram Plains North and Sekyere Central Kwahu Afram Plains North and South all have about two thirds of the total land towards the Northern side, falling within the transition zone. Pru district is mainly Savannah but has about one third of its land southwards within the transition agro ecological zone. Sunyani West and Berekum mainly a forest vegetation zone, has about one third of its land falling within the transition agro ecological zone, northward, sharing borders with Tain and Wenchi respectively (Abbam *et al*., 2018).

Figure 3.3 presents the composition of the transition agro ecological zone by vegetation and locality across the districts within the zone.

Figure 3. 3: Composition of Transition Agro Ecological Zone by Vegetation and Locality Across the Districts



Source: Computed from GLSS7 data

As depicted in Figure 3.3, all the districts within the transition zone have some savannah and some forest vegetation cover, with the proportion of savannah to forest, varying across the different districts. The Nkoranza South district however, uniquely has rural forest and savannah, but also some urban savannah vegetation zones.

3.3 Philosophical Underpinnings of the Study

This study is guided by the Pragmatic Interpretive Framework, which focuses on the use of the most suitable methods, techniques, and procedures of research that best achieves set objectives and also not limited by any fixed Philosophical ideas nor realities (Creswell, 2013; Goldkuln, 2012). It thus makes room for flexibility in the methods used in this research, to explore the suitable solutions for the problems identified by this study.

The Ontological belief under Pragmatism is that; Reality is what is useful, practical and what works (Creswell, 2013). The Epistemological belief under pragmatism, that is the way knowledge is constructed is by the use of many tools of research which reflects both deductive (objective) evidence and inducive (subjective) evidence (Creswell, 2013; Goldkuln, 2012). The Axiological belief assumed by the pragmatic interpretive framework is that knowledge produced reflects both the researcher's and respondent's views, thus values are discussed (Creswell, 2013; Goldkuln, 2012). The approach to inquiry (methodological beliefs) used by pragmatism entails the use of both qualitative and quantitative approaches to data collection (Creswell, 2013; Goldkuln, 2012). which aligns with the approach used by this study.

3.4 Study Design and Data Gathering

The study was conducted using mixed methods research design. Mixed method is used in this study in the interest of exploiting the strengths of both qualitative and quantitative approaches, as well as offsetting their weakness (Starr, 2014; Denzin & Lincoln, 2012). Whereas the estimation of precise quantities of variables and relation equations were obtained using quantitative methods, other nuances were explored from the qualitative approach employed to harness respondents' own views on their own situation, which adds depth, deeper understanding and extra richness to that which this study seeks to interrogate (Starr, 2014). This also served as a way of triangulating findings from both approaches for relevance and completeness of information (Starr, 2014; Denzin & Lincoln, 2012). Both qualitative and quantitative analysis were employed for the study objectives one and three and quantitative analysis was solely used for objective two, using the GLSS7 data set. Findings from objective two were however used in the quantitative analysis of objective three, which were triangulated with findings from the qualitative analysis.

Primary Data: Open ended interview guides are used for the participatory focus group discussions conducted in five selected communities for this study. Farmers in each community visited were divided into sub groups of a minimum of six participants and each sub group was tasked with brainstorming sessions on their perceptions on what climate change is, what in their view are the causes of climate change and what effects it has on their activities, using the study's interview guide to guide proceedings. Farmer's perception on what climate change adaptation strategies they use and what their challenges were also interrogated. Farmers were also asked about their views on what resources they deemed necessary for the climate adaptation process and who in their view should be the drivers of change in their communities. Data on what resources are available and easily accessible by each community was also collected for comparison. After each brainstorming session, each sub group's leader shared with the whole group what the outcomes of their discussions were.

Secondary Data: Ghana Living Standards Survey (GLSS) round 7 was used as the secondary data source for this study. The Ghana Living Standards Survey (GLSS) is a national survey that provides information on the standard of living of the people of Ghana (GLSS6 & GLSS7 Report). Data from the survey conducted provides information on the demographic characteristics, employment, agriculture, education and skills of members of households. It also provides information on household income, consumption and expenditure patterns (GLSS6 & GLSS7). The GLSS has been conducted since 1987, an initiative of World Bank and Ghana Statistical Service (GSS), to provide a comprehensive and current information of the living conditions of the people to aid in policy formulation and implementation (GLSS6 & GLSS7). The GLSS7 is the 7th round of such a survey and was conducted in 2016/2017 (GLSS7 Report).

Relevant academic papers, articles, journals and publications, were downloaded for reviewing in this study from JSTOR, Science Direct and Science Daily websites using Google Scholar. Key words like climate change adaptation, adaptive capacity, poverty, resource management, rural livelihoods and livelihood diversification were used to guide the search for relevant articles.

3.5 Study Sample and Data Sampling

The study used both primary and secondary data sources for analysis. The subject of this study are farmers in the transition agro ecological zone. From a sample population of 14,009 in the GLSS7 data, selecting farmers in the transition agro ecological zone for data analysis reduced the sample size to 860 farmer household. The transition agro ecological zone of Ghana is made up of 22 districts in all, 4 from the Ashanti region, 2 from Eastern Region, and 7 and 9 from Bono and Bono East Regions respectively.

Table 3.1 presents the regions, districts and number of households that were captured in the transition agro ecological zone in the GLSS7 data.

Table 3. 1: Distribution of Sampled Households from the GLSS7 Data by Regions and Districts

DISTRICTS	Eastern Region	Ashanti Region	Bono Region	Bono East Region	District Totals
Kwahu Afram Plains North	41	0	0	0	41 (4.77%)
Kwahu Afram Plains South	39	0	0	0	39 (4.53%)
Sekyere Afram Plains	0	15	0	0	15 (1.74%)
Sekyere Central	0	45	0	0	45 (5.23%)
Offinso North	0	29	0	0	29 (3.37%)
Sunyani West	0	0	59	0	59 (6.86%)
Berekum	0	0	74	0	74 (8.60%)
Jaman South	0	0	59	0	59 (6.86%)
Jaman North	0	0	40	0	40 (4.65%)
Tain	0	0	41	0	41 (4.77%)
Wenchi	0	0	53	0	53 (6.16%)
Techiman	0	0	0	78	78 (9.07%)
Nkoranza South	0	0	0	60	60 (6.98%)
Nkoranza North	0	0	0	40	40 (4.65%)
Atebubu	0	0	0	43	43 (5.00%)
Sene	0	0	0	30	30 (3.49%)
Pru	0	0	0	70	70 (8.14%)
Kintampo South	0	0	0	44	44 (5.12%)
Regional Totals	80 (9.30%)	89 (10.35%)	326 (37.91%)	365 (42.44%)	860 (100%)

Source: Computed from GLSS7 data

Techiman district as captured in the data has 78 respondents, representing 9.07 percent of total respondents, followed by Berekum and Pru districts with 74 (8.60%) and 70 (8.14%) respondents respectively. Sekyere Afram Plains had 15 respondents captured, representing 1.74% of total number of respondents. From Table 3.1 it can be seen that, only 18 out of the 22 districts (ref Figure 3.2), within the transition zone are captured in the GLSS7 data. Sene East and Sene West districts are captured as Sene district, Techiman Municipal and Techiman North district captured are also captured as Techiman district. Banda and Ejura Sekye Dumase districts were not captured at all (ref Figure 3.2). The 18 districts are made up of communities from urban and rural forest and savanna vegetation (Figure 3.3). This gives the study a very good basis of comparison on climate impacts and adaptation strategies as well as resource, availability, access and use.

Primary data collection focused only on five farm communities from three districts within the transition zone; (Buosu, Subinso No.2 and Braman (Wenchi district), Offuman (Techiman North district) and Dotabaa (Nkoranza South district). These were purposively selected for participatory focus group discussions. Buoso in the Wenchi district is an indigenous community, noted for cocoa production, but now growing cashew as a result of the fast changing vegetation zone and climate change. Subinso No2 and Braman are located at the norther border of Wenchi district, closer to the dry savannah agro ecological zone. Dotobaa and Offuman are both mountainous farm communities. Offuman is however more of a forest vegetation, but gradually losing its forest due to human activities. Dotabaa on the other hand has a wet savannah type of vegetation.

The essence is to unearth the varying challenges that farmers with different socioeconomic characteristics and vegetation types have had to contend with due to the negative effects of climate change and what adaptation strategies they have adopted so far. Participatory focus group discussions were held with both migrant and indigene farmers to explore the varying experiences with regards to resource management in adapting against the negative impacts of climate change. Agricultural extension agents in charge of all the farm communities visited, were part of the discussions and deliberations to also seek their views and confirmation on some of the issues that were discussed.

Populations with lower capacity are unable to properly respond to climate change due to economic poverty and marginalization and will disproportionately experience the challenges posed by climate change (Hallegate *et al*., 2016; IPCC, 2014). De Souza *et.al*. (2015), in their study on intersections between ecological and socio economic systems, used "Hotspots Approach for their Regional Climate Change Adaption Research" and they defined hotspots as "regions where strong climatic signals combine with a large concentration of vulnerable, poor or marginalized people" (De Souza *et al*., 2015). The Climate Adaptation Research in Africa and Asian (CARIAA), therefore prioritized; Glacier-fed river basins, Low lying delta and Semi-arid in Africa and Asia as those particularly vulnerable to the impacts of climate change (De Souza *et al*., 2015; Ford *et al*., 2015). These areas are inhabited by large number of vulnerable people (Kilory, 2015; IPCC, 2007). It is invariably indicative that they used ecological zones, poverty lines and the rate of development to guide their choice of research area. This study used a similar approach in purposively selecting the five farm communities, using location, nature of vegetation and migrant-indigene status as an indication for vulnerability, to guide proceedings, with guidance from the agricultural agents in the districts.

3.6 Analytical Framework

Based on the theoretical framework of this study, presented in chapter two, that knowledge is not static (critical social theory), and the fact that climate change adaptation and resource management could be explained using the theories of social change, the integrated livelihood analytical framework by Reed *et al*. (2013), is adopted by this study. This framework underpins the importance of resource management in the climate adaptation process to reduce the vulnerability of smallholder farmers to the negative effects of climate change. This analytical framework is selected because it depicts the realities of rural smallholder farmers who are faced with diversified approaches to reducing their vulnerabilities with regards to climate change. The conceptual framework of this study is also constructed to demonstrate the interlinkages between resources, climate adaptation strategies and various stakeholders in the climate change adaptation process to reduce vulnerabilities and improve the livelihoods of farmers.

Several frameworks relate vulnerabilities due to climate change to livelihoods, but in explaining the variability of farmers' vulnerability, adaptive capacity and adaptation, this study aligns with Chambers (1989), who built his theory of vulnerability and adaptation on case studies of poor smallholder farmers. Chambers (1989) stipulates that poor people seek to reduce their vulnerability by developing strategies and diversifying their portfolios of capital assets in order to achieve their desired livelihood outcome. These activities are, however, influenced by the capabilities of the people as well as their tangible assets (resources and stores) and intangible assets (claims and access) (Chambers & Conway, 1992). The Sustainable Livelihood Framework (SLF), also brings to bare how sustainable livelihood outcomes are achieved from the access to some livelihood resources and the influence of other factors (Scoones, 1998). The SLF outlines how trends, context, and conditions (political and economic environment, social setting, climate trends, policies) shape how livelihood resources are combined to achieve outcomes. Although the SLF framework (Scoones, 2009; Scoones, 1998; Chambers, 1989) illustrates how various livelihood strategies (diversification, agricultural intensification, agroforestry) are adopted to improve livelihoods (improved well-being, enhanced adaptive capacity, improved environment) with the influence of formal and informal institutions and organisations, it lacks the holistic approach of unearthing the determining factors influencing the choice of livelihood combinations smallholder farmers make or would make in reducing their vulnerabilities (Reed *et al.*, 2013).

The Integrated Livelihood Framework analysis by Reed *et al*. (2013), however, helps to diagnose vulnerability to climate change in-depth by incorporating other analytical frameworks such as the ecosystem services framework, the influence of social learning, diffusion of innovation as well as transition and adaptive management to the SLF. Innovation, for example, may be important in developing strategies that enhance resilience, that is coming up with new ways of doing things, combining existing resources or use of untapped resources in achieving some livelihood outcomes (Reed *et al.*, 2013). The essence is to be able to account for factors that are likely to constrain or enhance how adaptation would occur in a given rural setting. The Integrated Livelihood Framework also helps to identify and compare options that reduce vulnerabilities and involves four broad steps:

- Determining the likely level of exposure to climate change, and how climate change might interact with existing stresses and other future drivers of change.
- Determining the sensitivity of stocks of capital assets and flows of ecosystem services to climate change.
- Identifying adaptation options and factors influencing decisions to develop and/or adopt different adaptation strategies, based on innovation or the use/substitution of existing assets.
- Identifying and evaluating potential trade-offs between adaptation.

Based on the ideals from these livelihood frameworks by Chamber (1989); Scoones (1998); & Reed *et al*. (2013), the analytical approaches for this study were carefully formulated to reflect their emphases.

For objective one of this study, resources available to farmers are assessed from both primary data collected and the GLSS7 data. From the participatory focus group discussions, farmers' perceptions of climate change, the effects of climate change on their activities and what resources and stakeholders in their view would enhance their adaptation against the negative effects of climate change to improve their livelihood are evaluated. A livelihood is the means by which people combine resources and a set of activities and interactions to make a living (Scoones, 2009). Different people use various complex strategies to either transform, improve, diversify, cope or adapt to achieve some livelihood outcomes. The interaction of environmental and social forces is usually interdependent and influences to a large extent the livelihood choices people make (Reed *et al*., 2013; Scoones, 2009; Yohe & Tol, 2002).

This study presumes that resource availability and access have implications on the planning and activities in the climate adaptation process. It is these resources that are combined for use to build the needed capacity for the adaptation to the negative effects of climate change. Unearthing these with regards to different farmer households and farm communities would go a long way to enhance the activities of policymakers and other stakeholders in their interventions towards reducing vulnerabilities against the effects of climate change. The capacity of a household to cope with climate risks depends to a large extent on the enabling environment of the community, whilst the adaptive capacity of the community is reflective of the resources and processes in the region (Smit & Pilifosora, 2003; Yohe & Tol, 2002). Thus, it is imperative to have a certain minimal level of adaptive capacity to be able to properly strategise to reduce ones' vulnerability against climate change. Following Jamshidi *et al*. (2020); Egyir *et al*. (2015); & Asante *et al*. (2012), this study sought to examine what the adaptive capacity of the farmers in the study area is, using the framework from Vincent (2007) to estimate the threshold adaptive capacity for the household. Factors that influence the adaptive capacity of farmers are also examined using regression analysis.

Adaptability to climate change through changes in processes, practices, and structures is important for reducing impacts and a practical response to climate impact is to improve adaptation strategies (IPCC,2001; Burton, 1996). It is equally important to understand the complex relationship between climate change and other existing and future stresses in order to be able to formulate effective strategies to reduce vulnerabilities (Reed et al., 2013). Climate change cannot be totally avoided and it is unpredictable, worsening the plight of smallholder farmers who are already vulnerable, due to their characteristics. These farmers like all others have no alternative than to continually strategise to reduce their vulnerabilities against the negative climate impacts. Following Adami (2020); Wahid *et al*. (2017); Abid *et al*. (2015); & Bawakyillenuo *et al*. (2014), this study interrogates the influence of climate change adaptation on the livelihood of farmers.

The expectation of this study is that, a farmer who adapts better to the negative impacts of climate change would better enhance their livelihood. The objective of climate adaptation is to reduce the sensitivity of a system to climate impacts, increase the resilience to cope with the changes occurring due to climate change and variability, as well as alter the exposure of the system to climate hazards with an outcome of improved livelihoods (Adami, 2020; Wahid *et al*., 2017; Abid *et al*., 2015; Bawakyillenuo et al., 2014).

3.7 Analytical Approaches

In this section, the different analytical tools employed in addressing each objective of this study are discussed. Resource management by the respondents and the framework used in the estimation of the adaptive capacity of respondents are described. A detailed account of the regressions used in this study is also given.

3.7.1 Assessing the Resources of Smallholder Famers in the Transition Agro Ecological Zone of Ghana

In order to assess the resources available to farmers in the transition agro ecological zone, resources in the zone are teased out from the GLSS7 data and described, using frequencies and percentages. Using primary data, a thematic analysis is also used to describe farmers' perception of climate change; causes and adaptation strategies, as well as resources needed for the adaptation process.

Description of Resources of Farmers

Using the conceptual framework as a guide, farmers' activities, resources and actors (institutions and stakeholders) are teased out from both the GLSS7 and primary data and described. Resources owned by farmers, community resources available to farmers as well as services rendered by agricultural extension agents to farmers were described using frequency and percentage estimations from the GLSS7 data. Adaptation to climate change requires participation of multiple actors from such sectors as research, policy, agricultural extension, local community, private welfare organisation and farmers (Bryan *et al.*, 2013). This study explores if such is the situation in the study area.

Thematic Analysis of Farmers' Perception on Climate Change and Resources Needed

Each group leader's notes from the group's discussions on farmer's perception on climate change, causes of climate change, the effects of climate change on their communities and what resources and which actors they deemed necessary for a successful climate action were collated for each community after the brainstorming sessions. This was done for all the five communities selected for this study for the thematic analysis, using the conceptual framework for this study as the coding frame (main thematic structure) for the analysis. The open-ended questionnaires for the primary data collection were therefore formulated using the coding frame as a guide. The patterns that ran through the responses from each of the groups' submissions were first teased out (data condensation) for each community into categories (1st cycle coding). These 1st order codes were subsequently re grouped under more concise categories (2nd order coding) and tabulated by communities. Some "Voices" from the main group discussions were also captured and presented in boxes for discussion.

A study conducted by Wahid *et al*. (2017), on understanding climate change vulnerability, adaptation and risks perceptions at the household level confirms the need for government assistance in the provision of basic resources such as good quality agricultural inputs, information, extension services and modern technologies amongst others. The importance of collaboration with other stakeholders in building the capacity of local communities to reduce their vulnerabilities was also emphasised. The thematic analysis in this section of the study on farmers' perceptions on climate change and resources used by farmers to reduce the negative impacts is used to confirm whether the assertion by Wahid at al. (2017), is also the case in the study area.

3.7.2 Examining the Adaptive Capacity of Smallholder Farmers

A three stage approach is used. The adaptive capacity of farmers is first estimated from the GLSS7 data using key socioeconomic variables selected from Vincent (2007) framework. This is followed by an examination of the relationship between the estimated adaptive capacity with some key variables known to influence adaptive capacity. Ordinary Least Square and Simultaneous Quadrant regressions are run to further interrogate the influence of some selected key socio economic variables on the estimated household adaptive capacity.

Estimation and Comparison of the Adaptive Capacity of Smallholder Farmers

Using the framework from Vincent, (2007) the threshold household adaptive capacity index (HACI) for each farmer household is first estimated, using variables from the GLSS7 data. These estimates are then cross tabulated with some key socio economic variables like gender, age, education, poverty status, size of farm land and urban/rural agro ecological locality and described.

Studies by Egyir *et al*. (2015) and Asante *et al*. (2012) also estimated a certain threshold adaptive capacity of farmer households. Both studies by Egyir et al. (2015) and Asante et al. (2012) confirm the need to estimate a certain threshold adaptive capacity, which this study also seeks to do using the household adaptive capacity estimation framework by Vincent (2007). Although the studies by Egyir et al. (2015) and Asante et al. (2012) estimate a certain threshold adaptive capacity in their studies, these were done for specific purposes, that is; threshold adaptive capacities needed for the adoption of modern productivity enhancing strategies (MPES) and the adoption of a new technology respectively.

The Vincent (2007) framework however, demonstrates the need for households to possess a certain basic adaptive capacity in order to be able to adapt against the negative impacts of climate change and variability with ease. Various studies have demonstrated that the climate change adaptation process entails a complexity of activities, which includes the adoption of new technologies and modern productivity enhancing strategies; institutional set ups, policies and societal norms and rules (Tahiru *et al*. 2019; Siders, 2018; Osman *et al*., 2017; Yaro *et al*., 2016; Egyir *et al*., 2015; Yaro *et al*., 2014; Bawakyillenuo *et al*., 2014 Asante *et al*., 2012). Thus, to build and enhance the adaptive capacity of farmers needed to facilitate the climate change adaptation process, factors to consider should include human attributes that influences the adoption of a new strategy – technology (Asante et al., 2012), the makeup of the household, social, financial, natural and physical resources (Tahiru *et al*., ,2019; Masud *et al*., 2017; Yaro *et al*., 2016; Yaro *et al*., 2014; Bawakyillenuo *et al*., 2014; Vincent, 2007). Vulnerability to the negative impacts of climate change stems from the inadequacy or lack of capacity to adaptive due to poverty issues or over reliance on natural resources (World Bank, 2019; Nyamwaza & Kujuza, 2016; Ford *et al*., 2014; Adami *et al*., 2014; Anamula *et al*., 2013).

The Vincent (2007) model, uses the weighted average of five basic household resources that are considered to build capacity for the estimation of household adaptive capacity. Vincent (2007) identified five variables; economic wellbeing, demographic structure, dependence on a natural resource, interconnectivity and housing quality from theory and expert judgement. The weights assigned to each of the five composite sub-indices was done according to their varying relative contribution towards building household adaptive capacity (Vincent, 2007). The assumption here is that, the contributions of these variables is what builds up that basic adaptive capacity needed by a household for survival against any climate risks.

The Household Adaptive Capacity (HAC) is estimated using the relation equation:

HAC = (20% Economic wellbeing) + (20% Demographic Structure) + (20% Dependence on Natural Resource) + (20% Housing quality) + (20% Interconnectivity) ……………………………………………. (i)

Economic wellbeing: An estimate of the market value of total assets of each farmer household in the transition agro ecological zone, calculated from the GLSS7 data, variable named ***Assetval_index*** and used as a proxy for economic wellbeing.

Demographic Structure: This variable is made up of Dependency Ratio (50%) and whether or not any member of the Household has a long term illness (50%) [HIV, Diabetes, A severe disability]. The Dependency ratio of each farmer household is estimated by finding the ratio of the Non-working population (NWP) (age <18 and age>65) to that of the working population in the household (age between 18 and 65). For the variable on disability or long term illness, a variable on the "disability of any member of the household" was identified in the GLSS7 data, with the value zero (0) assigned to a household with no member with disability and one (1) to household that has member with disability. Thus, demographic structure is estimated using the equation:

Dep_Disable = (0.5*dependency ratio) + (0.5*member disability) ……………...(ii)

Dependence on Natural Resource: constitutes the contribution of a natural resource to household wellbeing. Access to potable drinking water is used as a proxy for this variable in this study. All human populations have a physiological need for water for productive livelihood (Dolsak & Prakash, 2018; Masud *et al.*, 2017; Vincent, 2007). A measure of the variable "source of water" was identified from the GLSS7 data (***nat_res_dep***), and recoded based on ease of access, that is, proximity to household; how clean the source of water is; and how much it costs a household to have access to the water.

In the GLSS7 data, drinking water for the house is categorised into:

- Pipe-borne inside dwelling
- Pipe-borne outside dwelling but on compound
- Pipe-borne outside dwelling but from nearby standpipe
- Public tap/Standpipe
- Bore-hole/Pump/Tube well
- Protected well
- Rain water
- Protected spring

- Bottled water
- Sachet water
- Tanker supply/Vendor provided
- Unprotected well
- Unprotected spring
- River/Stream
- Dugout/Pond/Lake/Dam/Canal

Thus, for this study, these were re-grouped into:

a. "easy access to portable drinking water" =1

- Pipe-borne inside dwelling
- Pipe-borne outside dwelling but on compound
- Pipe-borne outside dwelling but from nearby standpipe
- Public tap/Standpipe
- Bore-hole/Pump/Tube well
- Protected well
- Protected spring

b. "difficulty in getting access to portable drinking water" = 0

- Bottled water - high cost
- Sachet water - high cost
- Tanker supply/Vendor provided - high cost
- Unprotected well - unclean
- Unprotected spring - unclean
- Rain water - seasonality
- River/Stream - unclean
- Dugout/Pond/Lake/Dam/Canal - unclean

Inter connectivity in higher level processes: A Proxy of membership in any social group was used here. The variable "membership of any social group was identified in the GLSS7 data and 0 assigned to household with no member in any social group and 1 for the household that has a member in any social group (***social_cap)***. This study assumes that membership in a social group serves to connect people to have access to information, idea sharing and financial assistance which is the essence of interconnectivity.

Housing Quality: Quality of wall of housing and roofing material used for housing were used to recode household housing into two categories (high quality housing and low quality housing). These variables were identified from the GLSS7 data as (***house_qual)***.

The main construction material used for the outer wall of housing is categorised in the GLSS7 data as:

- Mud/Mud bricks/Earth
- Wood
- Metal sheet/slate/asbestos
- Stone
- Burnt bricks
- Cement blocks/concrete
- Landcrete
- Bamboo
- Palm leaves/Thatch (grass/Raffia)

The main construction material used for the roof of a house is also categorised in the GLSS7 data as:

- Mud/Mud bricks/Earth
- Wood
- Metal sheet
- Slate/Asbestos
- Cement/Concrete
- Bamboo
- Thatch/Palm leaf or Raffia
- Roofing tile

Housing quality was therefore categorised in this study as "high quality" or "low quality" depending on what combination of wall and roof material type was used in putting up a house. A household with housing made of mud walls and thatch roof was categorised as being of "low quality" and one made of brick wall with aluminum sheets was categorised as "high quality". This study assumes that a house made from mud and thatch could easily be destroyed by heavy rains and floods which increases the vulnerability of that household in terms of the additional cost that would be incurred to rebuild the destroyed structure, reducing further the adaptive capacity of that household (Vincent, 2007).

Access to clean portable water, provision of shelter, quality healthcare, food security, and access to other resources are sustainable development interventions that promote equity and improves the welfare of vulnerable groups in society, thereby enhancing their adaptive capacity as well (World Bank, 2019; Dolsak & Prakash, 2018; Masud *et al*., 2017; Vincent, 2007). For any system to meaningfully adapt to the impacts of climate change, it needs to attained a certain threshold of adaptive capacity (Asante *et al*., 2012). Thus, the need for farm household to build and attain a basic adaptive capacity to be able to adapt against climate impacts. Issahaku (2019), also estimated adaptive capacity and used that as an indicator of wellbeing to assess the food security and nutritional status of farmer households in a rural community. Studies by UNICEF (2019); World Bank (2018); Williams *et al*. (2018); Mcleod *et al*. (2016); Nelson *et al*. (2015), confirm the need for and the essence of aggregating these selected variables for the estimation of household adaptive capacity as proposed in the Vincent (2007) framework.

Comparison of Estimated Adaptive Capacity across Some Selected Socioeconomic Variables

The estimated adaptive capacity is a continuous variable, ranging from 0 to 1. There is no rule for classifying adaptive capacity levels (Jamshidi *et al*., 2020). Vincent (2007), in her study ranked the households according to the value of estimated adaptive capacity. Households with estimated adaptive capacity values closer to 1 were deemed to have higher adaptive capacity than those whose values were closer to zero. This method is plausible for a small sample size (less than 100), but for a larger sample size and for the purpose of further interrogation and analysis on the influence of other factors on household adaptive capacity, categorising it into different levels may probably be more laudable to enable for interventions and policy making (Asante *et al*., 2012).

Both Eygir *et al*. (2015); & Asante *et al*. (2012), categorised estimated adaptive capacity into 3, as follows:

0.00/0.33 = as low adaptive capacity

0.34/0.66 = as moderate adaptive capacity

0.67/1.00 = as high adaptive capacity

Jamshidi et al. (2020) categorised estimated household adaptive capacity into 4 as follows:

< 0.25 = 1, indicating Very low adaptive capacity

0.25/0.50 = 2, indicating Low adaptive capacity

0.50/0.75 = 3, indicating Moderate adaptive capacity

> 0.75 = 4, indicating High adaptive capacity

This study categorises the estimated household adaptive capacity into five categories, as follows:

0.00/0.20 = 1, indicating Very low adaptive capacity

0.21/0.40 = 2, indicating Low adaptive capacity

0.41/0.60 = 3, indicating Moderate adaptive capacity

0.61/0.80 = 4, indicating High adaptive capacity

0.81/1.00 = 5, indicating Very high adaptive capacity

This study presumes that this level of categorisation would enable the capturing of more information on any underlying relationship between household adaptive capacity and the explanatory variables for policy making and target interventions.

Using the categories, estimated household adaptive capacity was compared across some selected variables empirically found to influence adaptive capacity, to examine the significance and strength of the relationship:

(i) compare estimated HAC by Gender of household head: (Male/female)

(ii) compare estimated HAC by Poverty status of household: (Very poor, Poor and Non poor)

(iii) compare estimated HAC by Rural and Urban location

(iv) compare estimated HAC by Ecological zone: (Urban Forest, Urban Savannah, Rural Forest and Rural Savannah)

(v) compare estimated HAC by Farm size: (Small, Medium and Large)

(vi) compare estimated HAC by Size of Land holding by household: (Small, Medium and Large)

(vii) compare estimated HAC by Education level: (No Education, Basic Education, Secondary Education and Tertiary Education)

(viii) compare estimated HAC by Age categories: (less than 18, 18-24, 25-34, 35-44, 45-54, 54-65, above 65)

Pearson's chi square and Cramer's V were used to test the statistical significance of the relationship and the strength of the relationship between household adaptive capacity and the selected variables respectively.

Examining the Factors that Influence the Adaptive Capacity of Smallholder Farmers

Factors that influence household adaptive capacity are examined using both the Ordinary Least Square (OLS) and Simultaneous Quantile (SQ) regressions. Both regressions were run to examine the factors that enhance or otherwise the adaptive capacity of farmers. Whilst the OLS is limited to explaining the mean of the dependent variable, the SQ regression goes beyond that to explaining the influence of the covariates on the dependent variable at any point of distribution, that is across different quantiles of estimated adaptive capacity (Arshad *et al.*, 2018; Koenker & Hallock, 2001). Aheto (2020) notes that distributions may not vary only by their means as found in linear regression models. SQ regression gives a more holistic explanation on how different covariates influence the dependent variable (Arshad *et al.*, 2018), that is, it brings out critical aspects of the relationship that exists between the dependent variable and the explanatory variables (Aheto, 2020). This could serve as pointers to policy makers and other stakeholders regarding who are the vulnerable and what interventions to employ to improve their adaptive capacity. Some explanatory variables that were insignificant in the OLS regression could show different significance in the SQ regression. This study therefore employed both regressions for comparison as well as bring out these nuances. Quantile regressions employ the linear programming technique and uses the 50th percentile as benchmark, below and above which the influence is worse or better respectively (Koenker & Hallock, 2001). This choice of regression enables this study to examine if there are any significant difference or otherwise in how these factors influence the different levels of household adaptive capacity.

Factors that have been empirically found to influence household adaptive capacity were teased out from literature and used as variables in the regressions, using data obtained from GLSS 7. This study notes that, the variables used as sub-indices in the estimation of the threshold household adaptive capacity, could not be included as influencing factors for the regressions. Key socio economic variables such as household size, age, square of age and dependency ratio were taken out to eliminate multi collinearity and confounding variable issues. Pairwise correlation was also conducted on the selected variables to test the correlation between variables in the regression equation using Stata Statistics/ Data analysis Software. Based on the outcome of the pairwise correlation, the regression equation is specified as:

$$HAC = \beta_0 + \beta_1 Edlevel + \beta_2 Marital + \beta_3 Gender + \beta_4 QtyLand + \beta_5 Loanapplied + \beta_6 Pstatus + \beta_7 OwnBankacc + \beta_8 TotalValueRemit + \beta_9 TotalvalueFarmEquip + \beta_{10} Locality + \beta_{11} AmP \; \beta_{12} \, ICTSkills + \varepsilon \ldots\ldots (iii)$$

where:

- HAC is Household adaptive capacity the (dependent variable)
- Edlevel is the indication of level of education of head of household (No education = 0, Basic = 1, Secondary = 2, Tertiary = 3)
- Marital indicates Marital status (Married = 1 and 0 otherwise)
- Gender is Gender of Household Head (Male=1, Female =0)
- Qtyland is size of household landholding (Ha) (Small = 1, Medium = 2, Large = 3)
- Pstatus is poverty status (very poor = 1 poor = 2 non-poor = 3)
- Ownership of bank account used as a proxy for access to credit (Yes =1, No = 0)
- LoanApplied indicates whether a farmer has applied for a loan or not (Yes =1, No = 0)
- Locality is the location of household (Urban = 1 Rural = 0)
- AmP is access to mobile phone (Yes = 1, No = 0)
- ICTSkills is whether a crop farmer has ICT skills or not (Yes = 1, No = 0)
- TotalValueFarmEquip is the total value of farm equipment owned by farmer
- TotalValueRemit is the total value of remittances received by a farm household.

Having a phone enhances information flow, which is a critical intangible resource that enhances the adaptive capacity of the farmer. Information could be gotten either through phone conversations, messages or from the internet. A farmer who has some ICT skills further enhance their capacity by browsing the internet for relevant information. Owning a bank account is crucial for accessing a bank loan. It is in fact the first step to acquiring a bank loan. Thus, discourses on the importance the granting banks loans to farmers without first ensuring that they have bank accounts, could be limiting, as having a bank account, is the first step in acquiring a bank loan. This enhances the financial capacity of the farmer for climate change adaptation.

Having other forms of jobs aside farming is a known climate change adaptation strategy that buffers farmers against weather failure. These are resources are intangible resources that enhance the adaptive capacities of farmers.

Apriori Expectations

The Apriori Expectations of the study are, that Being Non poor, Education, Locality, Ownership of bank account, Loan applied, Total value of farm equipment, Size of landholding, Ownership of mobile phone, ICT skills, Total value of remittances received would all have a positive effect on the Household adaptive capacity of farmers

The direction of effects for gender and marital status are not known.

Statistical Tests and Goodness of Fit

A conventional t-test is used to test the null hypothesis that the nth explanatory variable of the regression has no influence on household adaptive capacity of the farmer. The t-value is an indication of the significance of the coefficient of the explanatory variable (Acock, 2012; Pindyck & Rubinfeld, 1998). For statistical significance, P - values of 10%, 5% and 1% significant levels are used. Bootstrapping is employed in estimating the standard errors of the coefficients in the simultaneous quantile regression estimates, as a means of reducing heteroscedasticity (Aheto, 2020; Zietz *et al*., 2017; Ortas & Alvarez, 2015).

R^2 and F statistics are used to test the Goodness of Fit of the regression models (Acock, 2012; Pindyck and Rubinfeld, 1998). R^2 is a measure of how well the regression model fits data, that is, the proportion of variation in the household capacity (dependent variable) explained by the explanatory variables included in the multiple regression equation (Acock, 2012; Pindyck and Rubinfeld, 1998). A weak or strong value of R^2 varies by the concept being explained (Acock, 2012). For fairly exploratory areas, R^2 near 0.3 is considered as reasonably good, R^2 less than 0.1 weak, R^2 between 0.1 and 0.2 moderate and R^2 greater than 0.3 strong (Acock, 2012). It should be however noted that this may not be applicable in highly sensitive research areas (clinical research). For regressions with many predictors, the researcher could report both the adjusted R^2 and R^2 (Acock, 2012).

The F statistic is an indication of the significance of the relationship between the dependent variable and the predictors. That is, a measure of the overall significance of the effect of explanatory variables on the dependent variable. Usually, a low value of F is associated with a weak (linear) relationship between the dependent variable and the variables included as predictors and a high value is associated with a strong (linear) relationship between them (Acock, 2012; Pindyck and Rubinfeld, 1998).

3.7.3 Examining the effect of climate adaptation on the livelihood of smallholder farmers.

A two stage approach is used here. The climate change adaptation strategies used by farmers and the resources they require for the adaptation process is first described. This is followed by an examination of the effect of climate change adaptation on the livelihood of farmers using Simultaneous Quantile regression.

Farmers' climate change adaptation strategies are obtained the primary data collected and described using percentage estimations. The resource needs of farmers for a successful climate change adaptation process were described using percentage estimations.

Theoretically driven indicators of the factors that influence climate change adaptation were identified from previous studies and used as predictors of a farmer's income level (proxy for livelihood) in a regression to examine the effect of climate change adaptation on the livelihood of farmers. A household's capacity to adapt happens within an institutional context, which can either facilitate or constrain the process the process of adapting to the effects of climate change. Poverty has also been identified as a major determinant of adaptive capacity and thus, influences the climate change adaptation process as well. Farmer income is operationalised here as an indication of a certain level of livelihood. Total assets of a farmer's household are estimated from the GLSS7 data and used as indicator of farmers' net income. Different items owned by each farm household is listed and values assigned to each item as provided by the GLSS7 data. The different values are then summed up to give the total value of assets for each farm household. Farmers' total assets was estimated and used as indication of farmers' net income. These were divided in to quintiles and used as a proxy for farmer's livelihood levels. These were run against some selected socioeconomic variables empirically proven to influence climate change adaptation as well as some climate change adaptation strategies, used as dummies in the regression equation. The Simultaneous Quantile regression, uses the 50th percentiles as the benchmark, below and above which, livelihood levels are worse or better respectively. The Simultaneous Quantile regression results thus explains the combined effects of the socioeconomic variables and climate adaptation strategies on the livelihood of the farmer.

This study assumes that a farm household that effectively uses resources, has a more enhanced adaptive capacity for coping with negative climate impacts and thus have greater wealth, represented by the total value of assets. Also, climate change and variability affect farmers living in the same community equally, thus the differences that may be observed in climate change adaptation processes could be attributed to the differences in poverty levels or livelihoods which is a reflection of total assets.

Several studies indicate that one's ability to successfully adapt against the negative impacts of climate changes is dependent on one's adaptive capacity (high adaptive capacity implies low vulnerabilities against climate impacts) and one's experience as a farmer, captured as number of years in farming. The assumption here is that a more experienced farmer would better adapt against climate impact. Age of farmer, education level of farmer, household size, gender of farmer, distance from farm to motorable road, access to extension service, access to loans, diversification of farm activities, processing, land ownership, migrant, access to information (use access to mobile phone and ICT are used as proxies for this), and access to and use of improved varieties all influence adaptation against the negative effects of climate change (Mcleod *et al*., 2016; EPA, 2017; AGRA; 2016; Abid *at al*., 2015; Mbow *et al*., 2014).

Vulnerability to the negative impacts of climate change stems from inadequate or lack of capacity to adapt due to poverty (IFPRI, 2019; World Bank, 2018; Logan *et al*., 2017; Mcleod *et al*., 2016; EPA, 2017; AGRA; 2016; Abid *et al*., 2015; Mbow *et al*., 2014; IPCC, 2014), over reliance on natural resources for sustenance (Nyamwaza & Kujuza, 2016; Ford et al., 2014) as well as developmental priorities (Adami *et al*., 2020). Following these previous studies, this study chose those variables that could be found in the GLSS7 data to run a Simultaneous Quantile and Multinomial Logit regressions to examine the effect of climate change adaptation on the livelihood of farmers. The net income of farmers was first estimated from the GLSS7 data and then categorized into 5 levels (Quintiles) using Stata. A pairwise correlation was then ran using Stata software to eliminate variables that did not fit into the regression equation.

The expectation of this study is that, adapting well against negative climate impacts reduces risks and minimises losses, which would translate into increased income from farm activities. Increased income /reduced losses imply improved livelihoods. It is however noted here that, since the GLSS data was not originally collected for a climate change adaptation study, some of the variables used in the estimations in previous studies may all not be included in the estimation in this study. Quite a reasonable number of variables were found though.

The Regression equations used are specified as:

$$Mlogit(TotalAssets) = \beta_0 + \beta_1 HAC2 + \beta_2 Mixmono + \beta_3 Farmsize + \beta_4 FarmDiverse + \beta_5 LiviDiverse + \beta_6 \text{Processing} + \beta_7 Tenancy + \varepsilon \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (iv)$$

$$SQ(TotalAssets) = \beta_0 + \beta_1 HAC2 + \beta_2 MixMono + \beta_3 Farmsize + \beta_4 FarmDiverse + \beta_5 LivDiverse + \beta_6 \text{Processing} + \beta_7 Tenancy + \varepsilon \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (v)$$

Description of variables in the specified regression model

Total Assets is the estimated value of the total assets owned by a farm household, used as a proxy for total income of the farmer and denotes the likelihood that a farmer would fall within a certain category of income bracket, depending on whether he/she is successful in adapting to the negative impacts of climate change. Success here is operationalized as adequately overcoming the factors that limits/constraints a farmer from adapting to climate change to reduce their vulnerability.

- HAC2 is the predicted value of household adaptive capacity from the regression on factors that influence the adaptive capacity of farmer. Thus, variables such as education level, gender, poverty status, ownership of bank account (a proxy for access to credit) and owning a phone (a proxy for access to information), that were used as explanatory variables in the first regression (ref: equation iii) were all dropped from this equation.
- Mix/Mono farming indicates whether a farmer has different crops on their farm (Mix farming = 1, Mono farming = 0)
- FarmDiverse is Farm diversification, indication whether a farmer rears livestock/fish in addition to his crops) (Yes = 1, No = 0)
- LivDiverse indicates whether farmer engages in any form of livelihood diversification (Yes = 1, No = 0)
- Processing indicates whether farmer processes any farm produce? (Yes = 1, No = 0)
- Tenancy is the indication of land ownership (Own farmland = 1, rented = 0)
- Farmsize is the size of farmland in hectares

Apriori Expectations

The Apriori Expectations of this study are, that Household adaptive capacity, Size of farmland, Tenancy, Farm diversification and Livelihood diversification would all have a positive effect on the livelihood of farmers.

Statistical Tests and Goodness of Fit

A conventional t-test is used to test the null hypothesis that the nth explanatory variable of the regression has no influence on household adaptive capacity of the farmer.

Similarly, as was done in the previous regressions, for statistical significance, P - values of 10%, 5% and 1% significant levels are used. Bootstrapping is employed in estimating the standard errors of the coefficients in the simultaneous quantile regression estimates, as a means of reducing heteroscedasticity (Aheto, 2020; Zietz *et al.*, 2017; Ortas & Alvarez, 2015). R^2 and F statistic are used to test the Goodness of Fit of the regression model (Acock, 2012; Pindyck and Rubinfeld, 1998).

3.8 Limitation of Study

Although the GLSS was not originally formulated to collect data for climate change and adaptation research, the key relevant variables needed to demonstrate how resources are used to build household adaptive capacity and their importance in climate change adaptation activities by households were obtained from the GLSS7 data. Nonetheless, very useful information was obtained from the GLSS7 data for the analysis of this study with plausible policy changing outcomes. The participatory focus group discussions held during the primary data collection also provides supportive information on the perception of farmers on climate change and the climate change adaptation process.

3.9 Conclusion

This chapter presented a description of the study area; the study design and data gathering; the study sample and data sampling; as well as the analytical framework and the various analytical approaches employed to achieve each objective of the study. The use of thematic analysis used to describe farmers' perception on climate change, climate change and what resources are needed for a successful climate change adaptation process was explained. The framework of Vincent (2007), for estimating household adaptive capacity was described. The OLS and Simultaneous quantile regressions employed to examine the factors that influence house adaptive capacity the regressions used in examining the effect of climate change adaptation on the livelihood of farmers were also described.

CHAPTER FOUR

SOCIO – ECONOMIC CHARACTERISTICS OF FARMERS

4.1 Introduction

This chapter presents the socio economic characteristics of farmers in the transition agro ecological zone. A description of the ethnic composition within the transition agro ecological zone and other characteristics such as age, gender, size of household and level of education of farmers are discussed in section 4.2 Section 4.3 presents a discussion on location and poverty status of farmer households. Landholdings, farm sizes, crops cultivated and the different types of farm equipment owned by farmers are presented in section 4.4.

4.2 Composition of Ethic groups, Age, Level of Education, Gender and Size of Household of Farmers

Table 4.1 presents the composition of ethnic groups in the transition agro ecological zone. The most occurring ethnic group is the Boron/Banda group 44.02% (372), mostly settlers from the Northern part of Ghana. Also found in the transition zone are the Dargartis (Dagaba, Wala and Lobi) constituting 8.40% (71), Asantes 8.17% (69), Kokombas 5.68% (48) and Ewes 4.14% (35). Yeji, Nchumuru and Krachi together constitute 3.92% (33) of the sample population and the Kwawus, constituting 3.43% (29). Other ethnic groups like the Kusasi, Dagomba, Mosi, Kotokoli, Avatime, Logba and Fantes are also found in the transition zone. It has been empirically demonstrated that the transition agro ecological zone has many migrants especially from the northern part of Ghana for farming purposes (Owusu *et al*., 2018; Antwi-Agyei *et al*., 2014; Cudjoe, 2006).

Table 4. 1: Composition of Ethnic Groups

Ethnic Group	Frequency	Percent
Agona	1	0.12
Akyem	3	0.36
Aowin	1	0.12
Asante	69	8.17
Boron (Brong) (including Banda)	372	44.02
Chokosi (Anufor)	4	0.47
Denkyira / Twifo	1	0.12
Fante	6	0.71
Kwahu	29	3.43
Wasa	1	0.12
Bawle	1	0.12
Dangme (Ada, Shai, Krobo, Osudoku,Ningo	9	1.07
Ewe	35	4.14
Avatime, Nyongbo, Tafi, Logba	4	0.47
Gonja	12	1.42
Nkonya	1	0.12
Yeji, Nchumuru, Krachi, Nawuri, Bassa A	33	3.91
Nkomi, Wiase, Dwan	5	0.59
Bimoba	5	0.59
Kokomba	48	5.68
Basare(Kyamba)	16	1.89
Kotokoli	3	0.36
Wali (Wala)	6	0.71
Dagarte (Dagaba), Lobi , Wali (Wala)	71	8.40
Dagomba	11	1.30
Kusasi	12	1.42
Mamprusi	5	0.59
Nankansi, Talensi & Gurense (Frafra)	19	2.25
Nanumba	1	0.12
Mosi	9	1.07
Kasena (Paga)	3	0.36
Mo	10	1.18
Sisala	14	1.66
Other Grusi (e.g. Lela, Templensi, Biri	1	0.12
Busanga	4	0.47
Wangara (Bambara, Madingo & Dyula)	4	0.47
Other Tribes From Ghana	10	1.18
Other Tribes From Outside Ghana	3	0.36
Fulani	1	0.12
Zabrama	2	0.24
Total	845	100

Source: Computed from GLSS7 data

Table 4.2 presents the gender, age and highest education level attained by farmers. The sample is made up of 64.49 percent males and 35.51 percent females. The mean age of the respondents is 45.7 years with a standard deviation of 15.95. 14.19% of the farmers are 65 years and above.

Table 4. 2: Gender, Age and Level of Education of Respondents

	Category	Percent
Gender	Male	64.49
	Female	35.51
Age of respondents in years	Less than 18	0.12
	18-24	6.05
	25-34	21.86
	35-44	25.12
	45-54	18.14
	55-64	14.19
	65 and above	14.53
Minimum age in years	17	
Maximum age in years	97	
Mean age in years	45.67	
Standard dev of age in years	15.95	
Highest Education Attained	None	0.99
	Basic	71.22
	Secondary	16.61
	Tertiary	11.18

Source: Computed from GLSS7 data

A majority of the respondents have basic education (71.22%), with only 0.99 percent having had no education at all. From. Abid *et al*. (2015), in their study on the determinants on farmer's choice of climate change adaptation strategy, identified age, gender and level of education among others as the determinants. Wahid *et al*. (2017), in their study on understanding climate change vulnerability, adaptation and risks perception at household level, also identified age, gender and education of farmer as demographic characteristics of the farmer that influences the adaptive capacity against the negative impacts of climate change.

The expectation of this study is the higher the level of education of the farmer, the greater the adaptive capacity, "ceteris *paribus*" and the better their adaptation against the negative effects of climate change as has been demonstrated by previous studies on the influence of education in building adaptive capacity against the negative effects of climate change.

Table 4.3 presents a cross tabulation of gender between the age and level of education of farmers. From Table 4.3 it can be seen that more females (34.75%) are 55years and above compared to males (25.27%). Age and gender have been empirically depicted by various studies (Jamshidi *et al*. (2020); Wahid *et al*. (2017); Yaro *et al*. (2016); Egyir *et al*. (2015); Abid *et al*. (2015) as having influence in building household adaptive capacity against the negative impacts of climate change.

Table 4. 3: **Cross Tabulation of Age and Education by Gender**

	Gender (Frequency)		
Age Category (Age in Years)	**Female**	**Male**	**Total**
less than 18	1	0	1
18 - 24	22	30	52
25-34	59	129	188
35-44	63	153	216
45-54	54	102	156
55-64	49	72	121
Above 64	57	68	125
Total	305	554	859
Education level	**Female**	**Male**	**Total**
None	1	5	6
Basic	161	272	433
Secondary	24	77	101
Tertiary	10	58	68
Total	196	412	608

Source: Computed from GLSS7 data

With regards to education, out of the 433 (71.22%) farmers who have basic education, 161 (37.18%) of them are females and they constitute 82.14 percent of the female sample, while 272 (62.82%) of them are males, constituting 66.02 percent of the male sample. About 85.29 percent of farmers who have tertiary education are males with only 14.71 percent are females.

Table 4.4 presents the household size of farmers. Majority (76.60%) of farmer households are small, and have household sizes of between one to five members. Only 2.00 percent of farm households have large household size of between 11 and above. The mean household size is 3.84, with a standard deviation of 2.57.

Table 4. 4: Size of Household of Respondents

	Category	**Percent**
Household Size	Small (1-5)	76.60
	Medium (6-10)	21.40
	Large (11 and above)	2.00
Minimum Household Size	1.00	
Maximum Household size	16.00	
Mean Household size	3.84	
Standard Deviation	2.57	

Source: Computed from GLSS7 data

Household size depending on the composition of working and non-working members, which influences the dependency ratio, can be of disadvantage to the household in terms of building adaptive capacity against the negative effects of climate change. The higher the household size with more dependents, the lower the adaptive capacity of that household (Jamshidi *et al*., 2020; Yaro *et al*., 2016; Asante *et al*., 2012; Vincent, 2007).

Table 4.5 presents household size by gender of household head.

Table 4. 5: Size of Household by Gender

	Gender		
Size of Household	**Female**	**Male**	**Total**
Small	265	393	658
Medium	35	149	184
Large	5	12	17
Total	305	554	859

Source: Computed from GLSS7 data

About 86.88 percent of the total sample of female headed households, have small household size constituting 40.27% of total households with small household size. Whilst 70.94 percent of the total sample of male headed households have small household size also constituting 59.73% of total households with small household size. Of the 17 (19.79%) households that have large household size, 12(70.59%) of them, constituting 2.17% of the total male sample, are male headed households, with 5 (29.41%), constituting only 1.64 percent of the female sample, being female headed households.

Table 4.6 presents the primary occupation and marital status of farmers. About 65 percent of the respondents are self-employed, out of which 71.91 percent are into agriculture (ie. 46.74 percent of the total sample).

Table 4. 6: **Primary Occupation and Marital Status of Respondents**

Categories	
Employment status	**Percent**
Public Employee	7.21
Private Employee	10.93
Self-employed (non-agricultural)	18.26
Self-employed (agricultural)	46.74
Unemployed	5.12
Retired	0.35
Other Inactive	11.40
Marital Status	**Percent**
Married	49.77
Consensual Union	11.05
Separated	3.60
Divorced	7.56
Widowed	12.56
Never Married	15.47
Total	100

Source: Computed from GLSS7 data

Majority of the respondents are married (49.8%) with 3.60 percent of them separated and 15.47 percent of them never married.

Table 4.7 presents various farm equipment owned and used by farmers for their farm activities. Some of the equipment include plough, axe, cutlasses, hoes, harvesters, tractors, and spraying machines which are assets to farmers, which are necessary resources that a farmer would need or acquire as part of capacity building to better adapt against the negative effects of climate change.

Table 4. 7: **Farm Equipment Own by Farmers**

Equipment Name	**Frequency**	**Percent**
Axe	1	0.21
Canoe	32	6.79
Cutlass/Machete	25	5.31
Fishing net	28	5.94
Harvester	33	7.01
Hoes	35	7.43
Other animal drawn equipment	35	7.43
Other tractor drawn equipment	46	9.77
Outboard motor	40	8.49
Plough	32	6.79
Protective clothing/safety equipment	25	5.31
Spraying machine	46	9.77
Tractor	38	8.07
Trailer/cart	34	7.22
Water Pumping Machine	21	4.46
Total	471	100

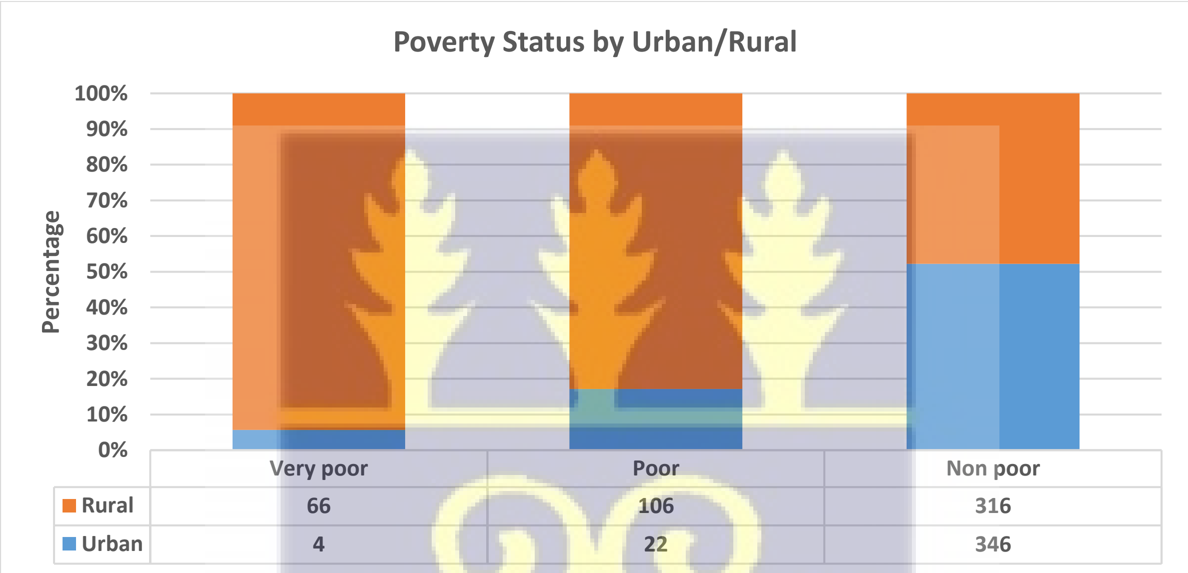
Source: Computed from GLSS7 data

The expectation of this study was to see higher frequencies for equipment such as cutlasses and hoes, which are the most common farm equipment for smallholder farmers. Some of the constraints that have been reported by farmers to adapting against the negative effects of climate change include, lack of assets (Masud *et al*., 2017; Abid *et al*., 2016) capital resource constraints (Osmam *et al*., 2017; Wahid *et al*., 2017; Abid *et al*., 2015).

4.3 Poverty Status of Farmers

Figure 4.1 presents poverty status by urban and rural localities. Urban localities have fewer households that fall under the very poor 5.71 percent and poor 17.19 percent poverty status compared to households in rural localities. Both rural and urban localities however have considerable proportions of non-poor households, although that of urban is greater. The ratio of poor to non-poor generally widens as one moves from urban to rural localities as shown in Figure 4.1.

Figure 4. 1: **Poverty by Urban and Rural Households**

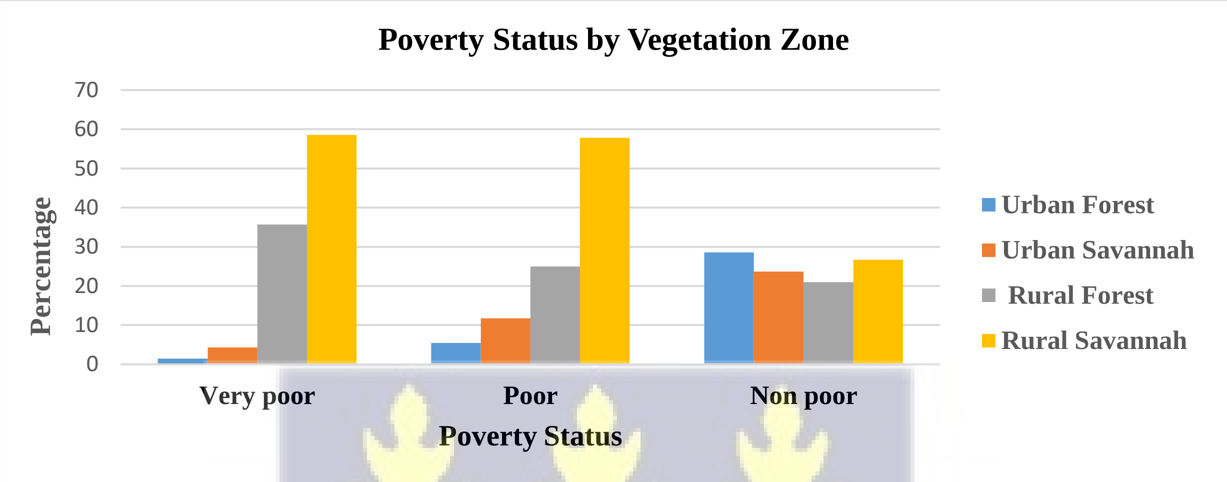


Source: Computed from GLSS7 data

Rural communities face challenges from social and economic factors which intensifies with additional stress from the negative impacts of climate change (Wahid *et al*., 2017; Mbow *et al*., 2014). Climate change invokes a vicious cycle of poverty trap on poor households, as they have insufficient resources to fall back on when disaster strikes according to Wahid *et al*., 2017; Nyamwamza & Kujuza, 2016 and Sen, 1980. It has been noted that poverty is both a condition and a determinant of vulnerability (Tanner and Mitchel, 2008).

Figure 4.2 presents the poverty status of farmers by the vegetation type and locality within the transition zone. Rural forest and rural savannah have higher incidence of poverty, with rural savannah, showing the highest incidence (58.57%) of very poor households, followed by rural forest (35.71%).

Figure 4. 2: Poverty Status by Vegetation and Locality



Source: Computed from GLSS7 data

Urban savannah however, has only 4.29 percent of households who are very poor, with urban forest showing the least incidence of poverty (1.43%). There is empirical evidence that the incidence of poverty worsens with locality (De Souza *et al*., 2015; Ford *et al*., 2015; Kilory, 2015) and this is further worsened by whether a household is in the savannah zone or forest zone as can be seen from Figure 4.2. The incidence of poverty increases vulnerabilities to the negative effects of climate change as has been empirically reported in previous studies (Hallegate *et al*., 2016; Kilory, 2015; IPCC, 2014).

Table 4.8 presents a cross tabulation of poverty status by gender of household head. As can be seen from Table 4.8, out of the 70 households that are very poor, about 78.57 percent of them are male headed households and 21.43 percent are female headed households. Majority (82%) of the female headed households are non-poor. This constitutes 37.82 percent of the total number of households that are non-poor.

Table 4. 8: Poverty Status by Gender of Head of Household

	Gender		
Poverty status	**Female**	**Male**	**Total**
Very poor	15 (21.43%)	55 (78.57%)	70 (100%)
Poor	40 (31.25%)	88 (68.75%)	128 (100%)
Non poor	250 (37.82%)	411 (62.18%)	661 (100%)
Total	305 (33.51%)	554 (64.49%)	859 (100%)

Source: Computed from GLSS7 data

Male headed households on the other hand have 74.18 percent of the total male headed households being non-poor, which also constitute 62.18 percent of the total number of households that are noon poor. This is an indication that female headed households in the transition agro ecological zone are generally doing better with regards to poverty reduction and are more likely to have higher adaptive capacity to better adopt adaptation strategies against the negative impacts of climate change. Vulnerability to the negative impacts of climate change stems from inadequate or the lack of adaptive capacity to adapt due to poverty (Abid *et al*., 2015; Ford *et al*., 2014).

Table 4.9 presents a cross tabulation of poverty status by level of education and age of head of the household. Generally, household heads with higher level of education (Tertiary) are non-poor (97%), 66 households. All the 30 households that are very poor (100%) and 89.29 percent of household heads who are poor have basic education. The only respondent who is less than 18 years old is non poor.

Table 4. 9: **Poverty Status by Level of Education and Age of Head of Households**

	Poverty Status			
Education Level	**Very Poor**	**Poor**	**Non poor**	**Total**
None	0	1	5	6
Basic	30	50	353	433
Secondary	0	3	98	101
Tertiary	0	2	66	68
Total	30	56	522	608
Age in years	**Very poor**	**Poor**	**Non poor**	**Total**
less than 18	0	0	1	1
18 - 24	1	1	50	52
25-34	10	23	155	188
35-44	20	34	162	216
45-54	18	25	113	156
55-64	11	22	89	122
Above 64	10	23	92	125
Total	70	128	662	860

Source: Computed from GLSS7 data

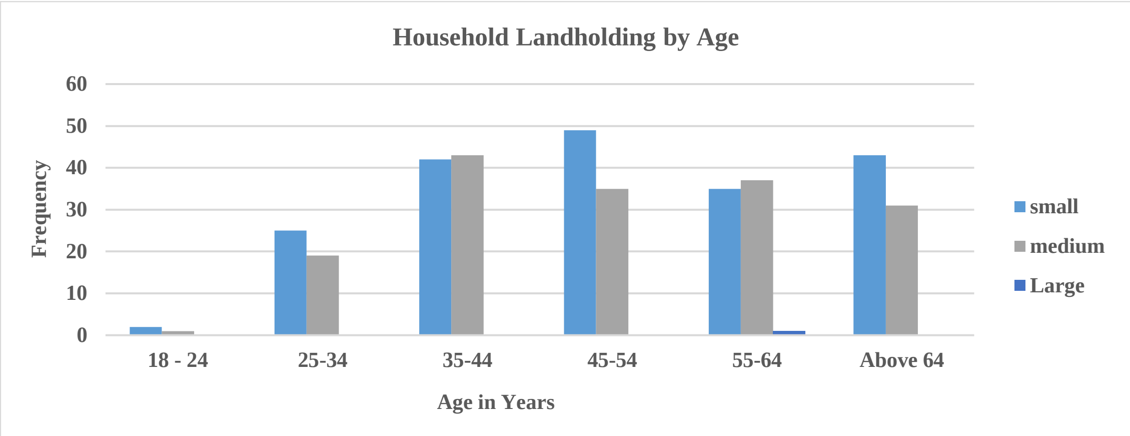
The most occurring age group under very poor and poor poverty status are those who fall between 35-44 years (28.57%) and (26.56%) respectively. This constitutes 9.26 percent and 15.74 percent respectively of the total number of respondents that fall under the age between 35-44 years. About 73.60 percent of the above 64 years' group are non-poor, whilst 96.15 percent of the age group between 18 – 24 are non-poor.

Education and age of farmer has been reported in previous studies as influencing household adaptive capacity and subsequently adaptation against the negative effectives of climate change (Jamshidi *et al*.,2020; Wahid *et al*., 2017; Yaro *et al*., 2016; Abid *et al*.,2015; Vincent, 2007). The constitution of the age groups in a household influence to a large extent the dependency ratio of the house, and this could affect the adaptive capacity of the household (Jamshidi *et al*., 2020; Yaro *et al*., 2016; Asante *et al*., 2012; Vincent, 2007).

4.4 Farmer Household Land Holding, Farm size and Crops Cultivated

Figure 4.3 presents the of size of landholdings by age of head of farm household.

Figure 4. 3: Size of Household Landholding by Age

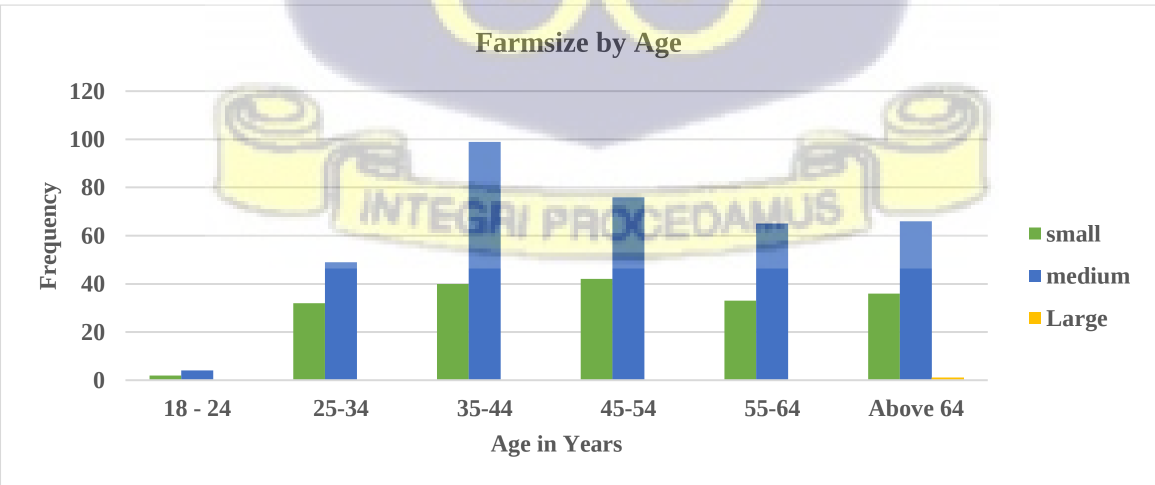


Source: Computed from GLSS7 data

All the age groups have small land holdings. Age group 45-54 has the highest number of respondents having small landholdings, followed by those above 65 years. The only one with large size landholding falls within the age bracket 55-64.

Figure 4.4 presents the size of cultivated farm land by age of household head. All the age groups have more farmers with medium farm size. The only person with large farm size, a female (ref to Table 4.10) falls under the above 64 age category.

Figure 4. 4: Cultivated Farm Size by Age



Source: Computed from GLSS7 data

Table 4.10 presents the size of household landholding and farm size by gender. Generally, males have bigger landholdings and farm sizes than females. About 84.94 percent males have medium size landholdings. The only large size farm land is owned by a male. Majority of females have small size landholdings (78.07%) and cultivated farm lands (58.38%). Males on the other hand have majority (56.63%) of them owning medium size landholdings and cultivated farm lands (77.42%).

Table 4. 10: Size of Household Landholding and Farm Size by Gender

	Gender		
Size of Land Holding (Hectares)	**Female**	**Male**	**Total**
Small	89	107	196
Medium	25	141	166
Large	0	1	1
Total	114	249	363
Size of Farmland (Hectares)	**Female**	**Male**	**Total**
Small	101	84	185
Medium	71	288	359
Large	1	0	1
Total	173	372	545

Source: Computed from GLSS7 data

Table 4.11 presents the number of farmers who cultivated their farmlands in the past 12 months (the year of reference, is the year before the GLSS7 data was collected - 2016).

Table 4. 11: Land Ownership by Cultivation of Farmland in the Past 12 Months

Cultivated farmland in the past 12 months	**Land Ownership Status**		
	Tenant Farmer	Owner of Farmland	Total
Yes	215	316	531
No	6	8	14
Total	221	324	545

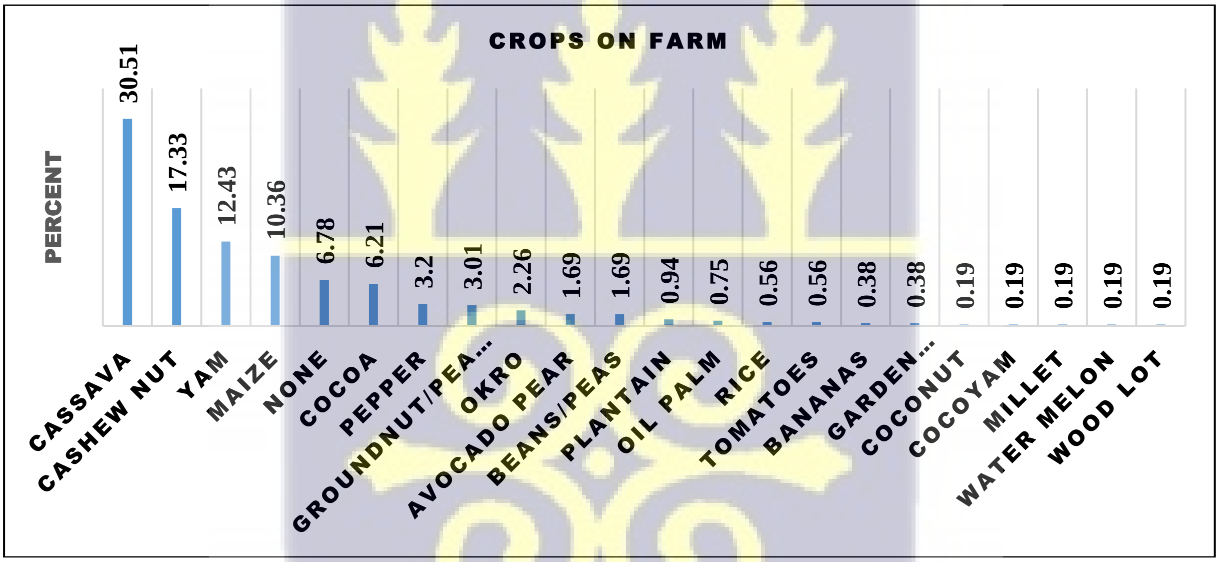
Source: Computed from GLSS7 data

Out of the total of 531 farmers who indicated that they had cultivated crops in the reference year, 215 (40.49%) of them are tenant farmers and 316 (59.51%) own their farmlands.

Figures 4.5 and 4.6 present the different crops growing and harvested on farms.

As can be seen from Figure 4.5, cassava is the most occurring crop (30.51%) growing on farmlands, followed by cashew (17.33%), yam (12.43%), maize (10.36%) and cocoa (6.21%). Cashew is a non-traditional tropical tree crop gaining importance in recent times globally and the the government of Ghana has an agenda of developing its cultivation to diversify their export base (Dubbert, 2019; Peprah *et al*., 2017; Wongnaa, 2013).

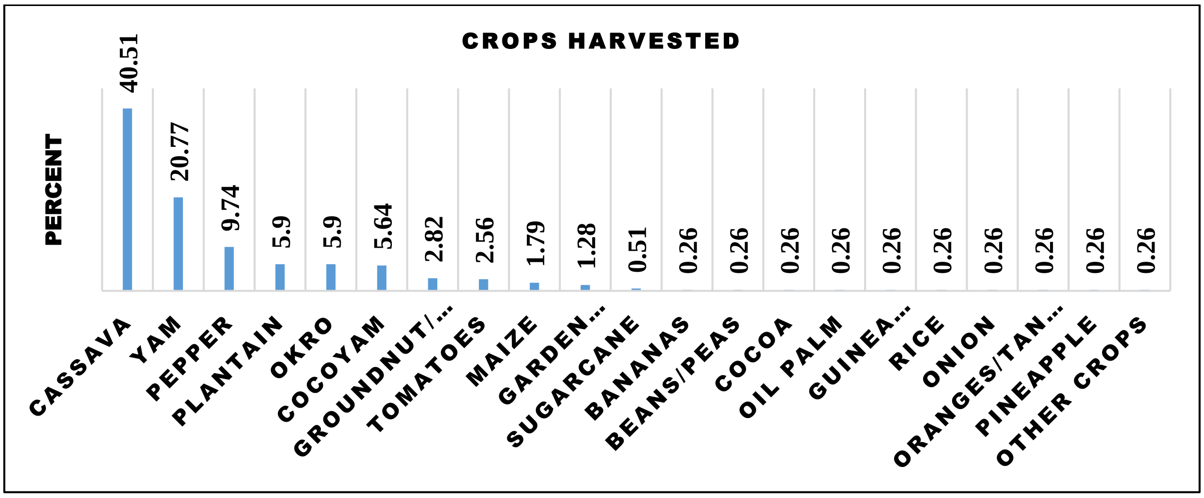
Figure 4. 5: **Crops Growing on Farm in the Past 12 Months**



Source: Computed from GLSS7 data

Cashew is currently the second most important non-traditional export crop in Ghana. Some farmers are fast replacing their cocoa farms with cashew tree crop in the transition zone due to socioeconomic reasons such as high cost of pesticides and insecticides and fertilizers use associated with cocoa production (Peprah *et al*., 2017). The fast deterioration the vegetation due to climatic conditions is also a contribution factor to the switch from cocoa production to cashew (Peprah *et al*., 2017).

Figure 4. 6: Crops Harvested in the Past 12 Months



Source: Computed from GLSS7 data

About 40.51 percent of farmers harvested cassava, 20.77 percent of farmers harvested yam, followed by pepper (9.74%) and plantain (5.9%). Only 1.79 percent of farmers harvested maize and 0.26 percent of them cocoa, as shown in Figure 4.6.

4.5 Conclusion

This chapter presented the socio-economic characteristics of the farmers. The ethnic composition showed the Boron/Banda ethnic group as the most occurring (44.02%) in the transition agro ecological zone. Majority of the farmers (71.22%) have basic education with a mean household size of 3.84 and mean age of 45.67. Majority of the very poor and poor farmer households were found in the rural locality. The only one with large size landholding falls within the age bracket 55-64, with largest farm size owned by a female who is above 64 years of age. The most occurring crops found growing on farmlands include cassava, cashew, yam and maize and the most occurring crops harvested are cassava, yam, pepper and plantain.

CHAPTER FIVE

ASSESSING RESOURCES AVAILABLE TO FARMERS AND FARMERS' PERCEPTIONS ON CLIMATE CHANGE IN THE TRANSITION AGRO ECOLOGICAL ZONE

5.1 Introduction

This chapter presents a description of the resources available to farmers and the perception of farmers on climate change in the transition agro ecological zone. In Section 5.2, various resources available to farmers for adapting to the effects of climate change are obtained from the GLSS7 data and described. Section 5.3 covers a thematic analysis on farmers' perception on climate change, the causes of climate change, what resources are needed for adapting against the negative impacts of climate change and which stakeholders are needed for a successful climate change adaptation process.

5.2 Resources of Smallholder Farmers

In this section, resources available to farmers in the transition agro ecological zone are teased out from the GLSS7 data and described. This study notes that there are basic resources that farmers need to own or acquire for their farming activities (ref Table 4.7), which contribute to building their adaptive capacity. There are however resources that have been empirically identified as enhancing the adaptive capacity of farmers (Jamshidi *et al*., 2020; Tahiru *et al*., 2019; Wahid *et al*., 2017; Yaro *et al*., 2016; Egyir *et al*., 2015; Bawakyillenuo *et al*., 2014; Bryan *et al*., 2013; Asante *et al*., 2012) and these are presented in Table 5.1.

Table 5.1 presents resources owned by farmers in the transition agro ecological zone. Seventy-eight percent of farmers have mobile phones, which is an important resource for access to information through communication, a vital component for strategizing against the impact climate change. Only 12 percent of respondents however have ICT skills.

Table 5. 1: Resources Owned by Respondents

	Response in Percentages	
Resources	**Yes (Percent)**	**No (Percent)**
Mobile phone	78.00	22.00
ICT skills	12.00	88.00
Bank account	52.00	48.00
Has applied for a loan	5.50	94.50
Farm equipment	16.00	84.00
Does some form of processing	23.00	77.00
Engages in other jobs aside farming	33.00	67.00
Land Ownership (Owns land = yes)	59.40	40.60
Owns Livestock/Fishing	23.30	76.70

Sources: GLSS7 Data

Having a phone enhances information flow, either through phone conversations, messages or from the internet. A farmer who has some ICT skills would further enhance their capacity, since they would be able to browse the internet for relevant information.

Twenty-three percent of farmers do some form of processing of their farm produce, whilst 33 percent of them engage in other jobs aside farming (alternative livelihood), which are good climate adaptation strategies. Engaging in other jobs aside farming buffers farmers against weather failure, ensuring that, there would be something to sustain the household when farming fails due to weather failure (Yaro *et al*., 2016; Bawakyillenuo *et al*., 2014; Asante *et al*., 2012). Processing farm produce, another climate adaptation strategy reduces spoilage as well as adds value to the farm produce processed, giving the farmer a relatively higher price for the processed produce (Tahiru *et al*., 2019; Yaro *et al*., 2016; Egyir *et al*., 2015).

This study notes that the enabling skills acquired by the farmer and innovations exhibited to perform these functions is what is conceptualized as a resource. These are intangible resources, and innovations, that is, peculiar characteristics of the individual that shapes their capacities to adopt specific strategies (Yaro et al., 2016; Asante et al., 2012).

Whereas 52 percent of farmers say they have bank accounts, only 5.50 percent of them have ever applied for loans. Loans or access to credit has been identified as one of the resources that help farmers in adapting against the impacts of climate change (Tahiru *et al*., 2019; Siders, 2018; Osman *et al*., 2017; Yaro *et al*., 2016; Egyir *et al*., 2015; Bawakyillenuo *et al*., 2014; Asante *et al*., 2012). It is a requirement by banks or any well-established financial institution to own a bank account as the first step to accessing loans. Owning a bank account is an asset or an intangible resource to the farmer. that can open other avenues. Owning a bank account is crucial for accessing a bank loan. It is infact the first step to acquiring a bank loan. Acquiring a loan, enhances the financial capacity of the farmer for climate change adaptation.

16 percent of farmers have their own farm equipment. This study argues that owning or acquiring one's own basic farm tools makes a farmer more efficient, all things being equal and adds to building their adaptive capacity.

Tables 5.2 presents resources available to farm communities in the transition agro ecological zone. As can be seen from Table 5.2, majority (79.4%) of farm communities have no agricultural extension agents stationed in the communities, 23.9% has access to extension agent. About 53.3 percent of farmers indicated that no extension agents visit their farm communities and 79.3 percent of them have no farmer associations nor farmer cooperatives (87.8%). These institutions are however important resources that enhance the climate adaptation process (Tahiru et al., 2019; Wahid *et al*., 2017; Osman et al., 2017; Yaro *et al*., 2016; Bryan *et al*., 2013), by giving direction, purpose and creating an enabling environment (Asante et al., 2012). Majority of farmers (90%) indicated extension agents from MoFA as those who visit their farms. Other farmers (61.5%) indicated agents from COCOBOD, with local NGOs and Agricultural cooperatives representing 1.5% and 0.9% respectively.

Table 5. 2: Community Resources and Perceptions

Resources/ Perceptions	Response (Percent)	
	Yes	No
Does Community have Extension Agent	23.90	76.10
Is Extension Agent Stationed in Community	20.60	79.40
Does Extension Agent visit your community	46.70	53.30
Does Community have farmer Associations?	20.70	79.30
Does Community have Farmer Cooperatives?	12.20	87.80
Does Community have Mutual Aid	55.38	44.62
Irrigated Fields in Community	8.04	91.96
Which institutions do they come from?	**Percent (multiple resources)**	
MoFA	90.00	
Local NGO	1.50	
Agricultural Cooperatives	0.90	
Other	7.60	
COCOBOD	61.50	
Other Cocoa Service Institutions	38.50	

Source: GLSS7 data

This study notes that community resources cannot be linked to any one individual farmer only. The emphasis here on agricultural extension agents for example is to increase their visibility in communities through more engagements with farmers. The ideal would be one extension agent per farm community, but agents stationed at district officers could take advantage of fm stations in communities for information dissemination and education. Quarterly or half yearly meetings could also be held with farmers for brainstorming and training. These are further discussed in the sub section on Farmers' Perception on Actors and Roles (Page 111).

The adverse effects of climate change especially on agricultural production requires the collaborative efforts of governmental and non-governmental organisations, other private sector institutions and farmer based associations to assist farmers reduce their vulnerabilities (Dolsak & Praskash, 2018; Kaivato, 2018; Masud *et al.*, 2017). These organisations assist farmers by way of research, training farmers on new techniques and technologies, provision of improved farm inputs and financial assistance. The presence of such institutions and the services they provide are intangible resources whose availability and accessibility benefits all community members.

Table 5.3 presents services rendered by agricultural extension agents in communities.

Table 5. 3: Services Rendered by Extension Agents in Communities

Services	Percent
Use of Seeds	36.00
Planting	35.00
Use of Chemical	10.00
Use of Fertilizer	11.00
Mechanisation	4.30
Irrigation	0.35
Animal Husbandry	2.04
Credit	0.35
Crop disease control	-
Line and pegging services	-
Measuring of Cocoa farm	-
New methods of farming	-
Post-harvest (Marketing, Storage)	11.11
Nothing	43.06

Source: GLSS7 data

Some of the services rendered by agricultural extension agents to farmers include teaching farmers use of seeds (36%), planting (35%), use of chemicals (10%) and the proper use of fertilizers (11%), in terms of timely applications and what quantities to apply. Although pruning, use of lines and pegging on farms and crop disease control was mentioned as services rendered by extension agents, there were no percentages assigned. The efficient and effective use of resources is key in strategising against the impacts of climate change. The use of improved seeds and the how planting is done is especially crucial if farmers are expected to have high crop yield in the face of climate change. (AGRA, 2016; FAO, 2013; Ofori & Asante, 2004) The question remains therefore that, how can farmers living in remote communities, lacking some of these critical resources be able to reduce their vulnerabilities against the negative impacts of climate change.

Findings from the GLSS7 data also shows that, for farmers who have access to agricultural extension agents, when asked if they complied with all they are taught, 66.3 percent of them respond in the affirmative, while 32.5 percent of them said sometimes. For their perception on whether they have noticed any changes in rainfall patterns from the GLSS7 data, 56.27 percent of farmers indicated that they have. The expectation of this study is that farmers who perceive changes in the weather pattern, would be more proactive in finding solutions to the negative impacts of these changes they have observed and will would be more willing to adapt to these negatives changes than farmers who have not seen any changes.

5.3 Thematic Analysis of Farmers' Perceptions on Climate Change and Resource Needs

Results from the analysis of the responses from participatory Focused Group Discussions (FGD) held with farmers on their views on climate change, climate adaptation strategies and what resources are needed to reduce the negative impacts of climate change are presented in this section. It is important that farmers' views on what they perceive as climate change is sought to guide any intervention project geared towards improving their activities. Perceiving climate change is the first step in the process of adapting to climate change in agriculture (Abid *et al.*, 2015). This study is of the view that farmers' understanding on what is happening around them, in terms of the negative impacts of climate change on their farm activities would help them design appropriate strategies or seek for appropriate assistance to reduce their vulnerabilities against these negative effects.

5.3.1 Perceptions of Farmers on Climate Change

Table 5.4 presents farmers' perceptions on climate change from the participatory FGD held with the 5 farm communities. Farmers from all 5 communities indicated that they perceive a change in rainfall pattern. The farmers said they either experienced too heavy or just too little rainfall, and were no longer able to predict when the rains would come or stop.

Table 5. 4: **Perceptions of Farmers on Climate Change**

Farmers Perception on Climate Change	
Community	**Responses**
Buosu	Change in rainfall pattern
	Change in vegetation
	Change in temperature
	Hammattan in August
	Change in intensity/ duration of rainfall
Offuman	Change in rainfall pattern
	Change in vegetation
	Insufficient rainfall
Subinsu no2 and Branam	Change in rainfall pattern
	Change in vegetation
	Change in temperature– global warming
	Change in crop calendar
	Change in intensity of rainfall
Dotobaa	Change in rainfall pattern
	Change in vegetation
	Change in intensity of rainfall
	Change in planting season

Source: Fieldwork, 2020

Farmers from all five communities also perceived a change a vegetation. Farmers in Offuman indicated that they have lost most of their forest due to chainsaw operations and believe this is contributing to the change in temperature and the intensity of rainfall they are experiencing. These farmers are of the view that climate change is real, and this is what they is affecting their the cropping calendar. These findings are consistence with previous related studies (Adami *et al.*, 2020; AGRA, 2016; IPCC, 2014). The farmers also mentioned that they experience unusually intense sun shine and strong storms, which they also attribute to the indiscriminate felling of tress.

Some voices of farmers on the perception of climate change are as captured in Box 5.1.

Box 5. 1 "Voices" of farmers on their perception of climate change

"due to the felling of trees, there are no wind breaks, so the storms just come through the village and destroy our property and farms, it brings a lot of dust during the dry season too." (Participant A, participatory group discussion – Dotobaa, 2020)

"we no longer have hail storms like we use to during our childhood, and our rivers are also running dry. Something has changed." (Participant A, participatory group discussion – Subinsu No.2, 2020)

"we cannot even use the previous year's rainfall pattern to predict the current year's rainfall. We keep losing money due to rainfall failure." (Participant A, Participatory group discussion – Buosu, 2020)

Source: Fieldwork, 2020

5.3.2 Perceptions of Farmers on the Causes of Climate Change

Table 5.5 presents the perception of farmers on the causes of climate change.

Table 5. 5: Perceptions of Farmers on the Causes of Climate Change

Farmers Perception on the Causes of Climate Change	
Community	**Responses**
Buosu	Indiscriminate cutting down of trees (Chain saw operators and individuals)
	Bush fire
Offuman	Cutting down of trees
	Bush fires
	Continuous use of chemicals
Subinsu no2 and Branam	Cutting down of trees
	Bush fire/Charcoal burning
	Use of chemicals
Dotobaa	Cutting down of trees
	Bush fires

Source: Fieldwork, 2020

On their perceptions on what the causes of climate change are, farmers from all five communities attributed climate change to the indiscriminate cutting down of trees by both individuals and chain saw operators. Farmers also attributed bush fires as also contributing to climate change. Charcoal burning and the continuous use of chemicals were also mentioned as possible causes of climate change. During the discussion sessions with farmers, some of them were of the view that climate change was a natural phenomenon, while others mentioned that it was due to the indiscriminate manner in which natural resources are managed. These farmers may be right, considering the way human activities such as mining, chain saw operations and some large scale farming activities have led to the destruction of river bodies and reduced our forest lands to almost nothing (Tahiru *et al*., 2019; Yaro & Hesselberg, 2016; FAO, 2010; FAO, 2008; IPCC, 2007).

Some voices of farmers on the causes of climate change are presented in Box 5.2.

Box 5.2 Some "Voices" of Farmers on the Causes of Climate Change

"I believe climate change is natural. It is nature's way of telling us that we are not taking good care of what we have. We have to do something" (Participant A, participatory group discussion - Offuman, 2020)

"Climate change is due to God. I believe He is the controller of everything" (Participant B, participatory group discussion - Offuman, 2020)

Source: Fieldwork, 2020

5.3.3 Farmers' Perceptions on the Effects of Climate Change in their Communities

Table 5.6 presents the perception of farmers on the effects of the negative impact of climate change in their communities. Some of the negative effects of climate change that cut across all the farm communities include low crop yields, change in vegetation, decrease in soil fertility and increase in animal disease and crop pest outbreaks.

Table 5. 6: **Farmers Perceptions on the Effects of Climate Change in their Communities**

Farmers Perception on the Effects of Climate Change	
Community	**Responses**
Buosu	Change in vegetation
	Changing soil types (low fertility)
	Loss of crops due to less or too much rains than expected
	Low crop yields
	Increasing worm infestation
Offuman	Change in vegetation
	Low crop yields
	Increase in crop diseases and animal diseases
	Worm infestation (fall worms)
	Lack of water
Subinsu no2 and Branam	Change in vegetation
	Low yields
	Low income for farmers
	Drying up of rivers/ Water scarcity
	Rainstorms destroys farms/homes
	Increase in disease outbreak
	Air pollution – dry winds
Dotobaa	Change in vegetation (high wind speed – no more tree cover to break winds)
	Loss of soil / low soil fertility
	Crop failure/low yields
	Extreme temperature regimes (very cold/ very hot)
	Irrigation - extra cost
	Changing planting time affects availability of farm products

Source: Fieldwork, 2020

Farmers indicated that the change in vegetation has affected the types of crops they grow. Buoso community for example, used to be one of the highest cocoa producing farm communities in the Wenchi district, but most of the cocoa farms have now been changed into cashew farms due to the change in vegetation, which is no longer suitable for growing cocoa. Offuman, a mountainous forest community indicated increase in worm infestation. Dotabaa, indicated high cost of irrigation due to unreliable rainfall pattern and also mentioned that they experience extreme temperature regimes (unusually cold weather conditions), which is causing all kinds of health problems. Farmers in the Dotobaa community also mentioned that the change in vegetation was so drastic that, the neighboring farm community, who are in a low-lying area harvest their yams more than a month earlier than they do now. But in the past, they all harvested yam around the same time. Dotobaa is a mountainous farm community. Vegetable farmers in Dotabaa mentioned that they had no choice but to use irrigation for their activities, least they lose their crops, and this is "extra cost" to them.

5.3.4 Farmers' Perception on Who the Actors in the Climate Action Discourse should be and the Roles they should Play

Table 5.7 presents the responses of farmers on actors and the roles they play in the climate change adaptation process from the participatory group discussions held.

Table 5. 7: Farmers' Perception on Actors and Roles they should Play

	Actors and Roles they Play
Community	**Responses**
Buosu	**Government:** • task force to prevent tree cutting and bush burning • enact laws for punishing culprits of bush burning and chainsaw operators
	Agricultural extension officers: • training of farmers
	Farmers/ Farmers associations: • to bargain for better prices • negotiate for access to credit/loans and reduction in prices of farm inputs
	Fire Volunteers: • Formation of self-help farmer groups to fight bush fires
Offuman	**Government:** • policies on prices • enactment of laws on cutting of trees/ bush burning/hunting • empowering community heads and assembly representatives • policies in place for easy access to loans for farmers • ensure the provision of basic amenities such as toilets, access to water, roads
	Agricultural extension officers: • training and provision of guidance to farmer
	Farmers: • to organise ourselves into associations to better bargain on prices and solve problems on scaling

	• access loans • fight against bush fire • fight for developmental issues (markets, roads, transport)
Subinsu no2 and Branam	**Government:** • to supply tree seedlings for reforestation • to give subsidies on farm inputs (agro chemicals, fertilizer, improved seeds) • to build warehouses and markets • pricing of farm produce, roads, irrigation systems • banks to give credit to farmers
	NGOs and individuals (large scale farmers): • to help with training of farmers
	Agricultural extension agents: • to train farmers
	Assembly men and Community heads: to serve as laison between farmers and government through MCE • to stop chain saw operators • prevent felling of trees/ bush burning • institute community laws to deal with perpetuators of bush burning and indiscriminate tree cutting
Dotobaa	**Government**: • Policies for banks to give loans to farmers • irrigation
	Extension agents: • to train farmers on best practices
	Farmer groups: • to access loans • negotiate on prices (farm inputs and produce)
	MP/ Assembly representative/Opinion leaders: • to spearhead developmental issues such as the provision of good roads and basic amenities to farm communities

Source: Fieldwork, 2020

Findings from the FGD points to government as the main actor of change in the climate change adaptation process. Government plays both a facilitating and an implementation role either directly or through local government. These roles include policy formulation on land acquisition and tree felling, pricing of farm inputs, and farm produce, decisions on provision of certain basic amenities such as water, schools, health facilities, for communities amongst others.

Farmers also mentioned Agricultural extension agents as one of the actors. These agricultural extension officers train and educate farmers on best farm practices and introduce them to new techniques and farm inputs. The role they play is crucial in the climate change adaptation process.

Farmers pointed to themselves as actors as well and indicated that forming themselves into farmer groups and cooperatives could give them a stronger voice to resolve some of the challenges they face due to the negative effects of climate change. NGO's and Large-scale farmers were also mentioned as actors in the climate change adaptation process.

To achieve any improvements in the livelihood of farmers and the environment as well as improve food security and poverty issues, there is the need for a collaborative effort by all stakeholders in the agricultural and environmental value chain. Farmers mentioned that though they sometimes organise themselves into groups to create awareness on bush burning or tree planting, they do not get the needed support from government nor the representatives of government within their communities. The farmers therefore call on government to empower assembly men for the implementation of and adherence to policies on governance issues with regards to bush burning and tree felling especially. Collaborative effort is key for success.

5.4 Conclusion

This chapter presented a description of resources available to farmers in the transition agro ecological zone of Ghana, obtained from the GLSS7 data. Farmers' perception of climate change, its causes, how it has affected their activities, resources needed and who in their view the drivers of change in the climate action discourse should be were described using frequency and percentage tables and thematic analysis. Availability of resources like agricultural extension agents, water, good roads, transport, storage, access to credit and improved seeds were mentioned as important in adapting to the negative impacts of climate change. Farmers also mentioned the importance of policies on land acquisition, bush burning and tree felling and the empowering of local assembly members to help farmers in their efforts to fight against tree felling and the destruction of their river bodies by such illegal activities. Farmers identified government as the main actor in the climate change adaptation process for the provision of good roads, water, markets and price setting of farm inputs and produce. They also identified that the collaborative efforts of farmer groups and other stakeholders in the agricultural value chain is key to success.

CHAPTER SIX

ADAPTIVE CAPACITY OF SMALLHOLDER FARMERS IN THE TRANSITION AGRO ECOLOGICAL ZONE

6.1 Introduction

This chapter presents a discussion on the results of the estimated household adaptive capacity and the relationship between the estimated household adaptive capacity and some key socio-economic variables. The Ordinary Least Square and Simultaneous Quantile Regression results on the factors that influence household adaptive capacity of farmers in the transition agro ecological zone of Ghana are presented and discussed in this chapter.

6.2 Results on Estimates of Adaptive Capacity of Smallholder Farmers

Table 6.1 presents the summary statistics on estimated household adaptive capacity.

Table 6. 1: **Summary Statistics on Estimated Household Adaptive Capacity**

	Estimated Household Adaptive Capacity	**Categories of Household Adaptive Capacity**
Number of Observations	856	856
Mean	0.62	3.54
Standard Deviation	0.18	0.96
Minimum	0.04	1
Maximum	0.96	5

Source: Computed from GLSS7 data

The mean adaptive capacity from Table 6.1 is 0.62, equivalent to 3.54 for the categorised household adaptive capacity and it is between moderate and high adaptive capacity, with a standard deviation of 0.18 and 0.96 for the categories. This means that majority of farmers in the transition agro ecological zone have moderate to high adaptive capacity. The maximum estimated household adaptive capacity is 0.96 (category 5) and the minimum is 0.04 (category 1). A farmer with a higher adaptive capacity is expected to have a greater capacity to adapt to the negative impacts of climate change (Jamshidi *et al*., 2020; Issahaku, 2019; Yiran & Stringer, 2017; Yaro *et al*., 2016; Egyir *et al*., 2015; Bawakyillenuo *et al.*, 2014; Asante *et al*., 2012).

The expectation of this study therefore is more than 50% of the farmers in the transition agro ecological zone should be able to fairly adapt to the negative impacts of climate change, all other factors held constant.

Table 6.2 presents the results of the estimates of household adaptive capacity of farmers and the rankings. About 55.72 percent of the farmers have very high to high adaptive capacity with about 13.31 percent of them having very low to low adaptive capacity.

Table 6. 2: **Household Adaptive Capacity - HAC**

Household Adaptive Capacity (HAC) Level	Frequency	Percent
Very high adaptive capacity	125	14.60
High adaptive capacity	352	41.12
Moderate adaptive capacity	265	30.96
Low adaptive capacity	90	10.51
Very low adaptive capacity	24	2.80
Total	856	100

Source: Computed from GLSS7 data

Table 6.3 presents a cross tabulation of household adaptive capacity by gender. Overall, the adaptive capacities of 305 female headed households were compared to 551 male headed households.

Table 6. 3: Comparing Household Adaptive Capacity by Gender

	Ranking of Household Adaptive Capacity					
GENDER	**Very high**	**High**	**Moderate**	**Low**	**Very Low**	**Total**
Female						
Frequency	37	147	101	20	0	305
Percent	12.13	48.20	33.11	6.56	0	100
Male						
Frequency	88	205	164	70	24	551
Percent	15.97	37.21	29.76	12.70	4.36	100
Total						
Frequency	125	352	265	90	24	856
Percent	14.60	41.12	30.96	10.51	2.80	100
Pearson chi2(4)	**28.80**	**Pr = 0.00**				
Cramér's V	**0.18**					

Source: Computed from GLSS7 data

From Table 6.3, 60.33 percent of the female headed households have high to very high adaptive capacity, whereas 53.18 percent of the male headed households have high adaptive capacity to very high adaptive. About 6.56% of the female headed households fall under the very low to low adaptive capacity level, whilst 17.06% of the male headed households have very low to low adaptive capacity. This could probably mean that male headed households may be more vulnerable to the negative impacts of climate change than female headed households.

Although the chi-squared statistic is significant at $p < 0.00$, Cramer's V of 0.18 however indicates a weak strength in the relation between gender of the household head and household adaptive capacity. This could mean that, although there is an association between gender and household adaptive capacity, the influence of gender on household adaptive capacity may not be strong. The regression in the subsequent section on what factors influence household adaptive capacity would further interrogate this.

Table 6.4 presents a cross tabulation of household adaptive capacity by locality. From Table 6.4, whereas the urban locality has 76.22 percent of households with high to very high adaptive capacity, only 40.13 percent of households in the rural locality have high to very high adaptive capacity.

Table 6. 4: Adaptive Capacity by Urban and Rural Location

Locality	**Ranking of Household Adaptive Capacity**					
Urban /Rural	**Very High**	**High**	**Moderate**	**Low**	**Very low**	**Total**
Urban						
Frequency	77	205	75	12	1	370
Percent	20.81	55.41	20.27	3.24	0.27	100
Rural						
Frequency	48	147	190	78	23	486
Percent	9.88	30.25	39.09	16.05	4.73	100
Total						
Frequency	125	352	265	90	24	856
Percent	14.60	41.12	30.96	10.51	2.80	100
Pearson chi2(4) =	**121.26**	**Pr = 0.00**				
Cramér's V =	**0.38**					

Source: Computed from GLSS7 data

Only 3.51 percent of households in the urban locality have very low to low adaptive capacity, compared to 20.78 percent of households in the rural locality. Social differentiation and inequalities manifest as differences in adaptive capacity (De Souza *et al*., 2015; Ford *et al*., 2015; Kilory, 2015). That is, the adaptive capacity of a household could be influenced to a large extent by whether they live in a rural or an urban locality. Households in rural localities would therefore mostly manifest lower adaptive capacity (Yaro *et al*., 2016; Bawakyillenuo *et al.*, 2014; Asante *et al*., 2012).

Results from the cross tabulation indicates that the strength of the relationship (Cramer's V = 0.38) between household adaptive capacity and the locality of the household is moderate, confirming empirical evidence on the influence of locality on adaptive capacity, with a chi – squared of 121.26, also significant at p< 0.00.

Household adaptive capacity is again cross tabulated by ecological zones as defined in the GLSS7 data (rural and urban forest and rural and urban savannah). The results are as presented in Table 6.5.

Table 6. 5: Household Adaptive Capacity by Ecological Zone

	Ranking of Household Adaptive Capacity (HAC)					
Ecological Zone (EZ)	**Very high**	**High**	**Moderate**	**Low**	**Very low**	**Total (EZ)**
Urban Forest						
Frequency	37	111	40	8	1	197
Percent	18.78	56.35	20.3	4.06	0.51	100
Urban Savannah						
Frequency	40	94	35	4	0	173
Percent	23.12	54.34	20.23	2.31	0	100
Rural Forest						
Frequency	17	70	61	35	12	195
Percent	8.72	35.9	31.28	17.95	6.15	100
Rural Savannah						
Frequency	31	77	129	43	11	291
Percent	10.65	26.46	44.33	14.78	3.78	100
Total (HAC)						
Frequency	125	352	265	90	24	856
Percent	14.6	41.12	30.96	10.51	2.8	100
Pearson chi2(12) =	**135.61**	**Pr = 0.00**				
Cramér's V =	**0.23**					

Source: Computed from GLSS7 data

Generally, households in the urban zones have higher adaptive capacity than those in the rural zone. Out of the 197 households in the urban forest zone, 75.03% of them have high to very high adaptive capacity, whereas within the rural forest zone, out of a total of 195 households, only 43.62% fall within the high to very high adaptive capacity level. Households within the rural forest ecological zone generally exhibit higher adaptive capacity (44.62%) than those in the rural savannah ecological zone (37.11%). The trend is however different within the urban forest/savannah zones. Households in the urban forest ecological zone have 4.57% of households with very low to low adaptive capacity, whilst those in the rural forest zone have 24.10% of households with very low to low adaptive capacity.

Statistical tests conducted shows a significant relationship between household adaptive capacity and ecological zone, at a significant level of $p< 0.00$, with a moderate strength of relation of a Cramer's V of 0.23. An association of moderate strength between household adaptive capacity and ecological zone further confirms the influence of locality on household adaptive capacity.

Table 6.6 presents a cross tabulation of household adaptive capacity by poverty status. From Table 6.6, it can be seen that out of the 125 households who fall under very high adaptive capacity, 94.40 percent of them are non-poor and only 0.80 percent of them are very poor. Whereas, out of the 24 households that fall under the very low adaptive capacity level, 62.50% of them are very poor and 29.17% of them are non-poor. On the other hand, out of the 70 households that fall under very poor poverty status, only 1 household (1.43%) has very high adaptive capacity, with 21.43% and 40% of them having very low and moderate adaptive capacity levels respectively. Table 6.6 shows a significant relation between the poverty status of a household and the household adaptive capacity with a $p < 0.00$ value and a Cramer's V value of 0.32 showing a moderate strength in relationship between poverty status and household adaptive capacity. This is indicative that poverty status of the household significantly influences the adaptive capacity of the household and vice versa.

Table 6. 6: Household Adaptive Capacity by Poverty Status

	Poverty Status			
Ranking of Household Adaptive Capacity (HAC)	**Very Poor**	**Poor**	**Non poor**	**Total (HAC)**
Very high adaptive capacity				
Observation	1	6	118	125
Percent Very high HAC	0.80	4.80	94.40	100
Percent Poverty Status	1.43	4.69	17.93	14.6
High adaptive capacity				
Observation	12	39	301	352
Percent High HAC	3.41	11.08	85.51	100
Percent Poverty Status	17.14	30.47	45.74	41.12
Moderate adaptive capacity				
Observation	28	52	185	265
Percent Moderate HAC	10.57	19.62	69.81	100
Percent Poverty Status	40.00	40.63	28.12	30.96
Low adaptive capacity				
Observation	14	29	47	90
Percent Low HAC	15.56	32.22	52.22	100
Percent Poverty Status	20.00	22.66	7.14	10.51
Very low adaptive capacity				
Observation	15	2	7	24
Percent Very low HAC	62.5	8.33	29.17	100
Percent Poverty Status	21.43	1.56	1.06	2.80
Total Observation	70	128	658	856
Percent	8.18	14.95	76.87	100
Total Percent Poverty Status	100	100	100	100
Pearson chi2(8)	**171.57**	**Pr = 0.00**		
Cramér's V	**0.32**			
gamma	**-0.56**	**ASE = 0.04**		
Kendall's tau-b	**-0.31**	**ASE = 0.03**		

Source: Computed from GLSS7 data

Poverty is an important determinant of adaptive capacity, that is, it would be difficult for a poor farmer to invest in farm inputs (high yielding varieties, fertilizers, insecticides), some form of technology (irrigation), or even purchase certain kinds of farm equipment, which are resources that build/enhance adaptive capacity against the negative effects of climate change. this confirms the ascertain that, high levels of poverty results in low investments (Tahiru *et al*., 2019; Osman *et al*., 2017; Yaro *et al*., 2016), especially for farmers.

The challenge to responding to climate change is building the adaptive capacity of the vulnerable in society to enable them reduce the effects of the negative impacts on them (Osman *et al*., 2017; Yaro *et al*., 2016). Poverty reduction and for that matter the advancement of economic growth can largely be achieved if conscious efforts are made to build the capacity of the very poor (Osman *et al*., 2017) to set them apart to better adapt against the negative impacts of climate change.

The cross tabulations of household adaptive capacity by age, education, land holding, and farm size were all found to be insignificant. These are presented as appendices. Regression analysis is used to further investigate any relations between household adaptive capacity and these cross tabulated variables in the next section.

6.3 Regression Results of the Factors that Influence the Adaptive Capacity of Smallholder Farmers

Table 6.7 presents results of the factors that influence the adaptive capacity of a farmer. The OLS results show F (16, 345) = 13.24, p< 001 implying a highly significant relationship between household adaptive capacity and the set of explanatory variables in the regression model. The R- squared and Adjusted R – squared for the OLS regression are 0.380 and 0.352 respectively, an indication that 38.00% or 35.20% (for the Adjusted R-squared, having eliminated all bias) of the variance in household adaptive capacity can be explained by the regression model. This indicates a strong relationship between the predictors and household adaptive capacity using either the R-squared or Adjusted R- squared as a measure. For the SQ regression, the Pseudo R-squared values for the 20th, 40th, 60th and 80th quantiles are 0.2404, 0.2292, 0.2324 and 0.2110 respectively, indicating that 24.04%, 22.92%, 23.24%, and 21.10% of the variance in household adaptive capacity is explained by the predictors of the regression model at the 20th, 40th, 60th and 80th levels respectively.

Table 6. 7: OLS and SQ Results on Factors that Affect the Adaptive Capacity of a Farmer

	Ordinary Least Square	Simultaneous Quantile Regression			
Explanatory Variables	**HAC**	**20th Quantile**	**40th Quantile**	**60th Quantile**	**80th Quantile**
Basic Education	0.056***	0.013	0.035	0.060**	0.074***
Secondary Education	0.064*	0.037	0.113*	0.080***	0.054
Tertiary Education	0.023	0.029	-0.029	0.020	-0.008
Married	-0.008	-0.039	0.007	0.020	0.020
Male	-0.043*	-0.041	-0.057	-0.060**	-0.040
Household landholding (Ha) - Medium size	0.042**	0.092***	0.068***	0.040*	0.033
Household landholding (Ha) – Large size	0.106	0.288***	0.155***	0.038	-0.029
Poverty status: Poor	0.097***	0.151***	0.118***	0.060	0.073
Poverty status: Non poor	0.150***	0.180***	0.178***	0.100**	0.133**
Owns bank account	0.038**	-0.020	0.013	0.060**	0.046*
Has applied for a Loan	-0.03	-0.077*	-0.055	-0.040	-0.044
Location: Urban	0.097***	0.114***	0.122***	0.120***	0.079***
Mobile phone	0.070***	0.125***	0.054	0.060**	0.054*
Ict skills	0.046	0.018	0.055	0.000	0.073
Total value of remittances	0.000	0.000	0.000	0.000	0.000
Total value of farm equipment owned	0.000	0.000	0.000	0.000	0.000
Constant	0.409***	0.342***	0.412***	0.500***	0.569***
Observations	362	362	362	362	362
R-squared	0.380				
Adjusted R-squared	0.352				
F (16, 345) = 13.24	Prob > F = 0.000				
0.20 Pseudo R2	0.2404				
0.40 Pseudo R2	0.2292				
0.60 Pseudo R2	0.2324				
0.80 Pseudo R2	0.2110				
Level of Significance	*** p<0.01, ** p<0.05, * p<0.1				

Source: Computed from GLSS7 data

This indicates a moderate-to-strong relationship between household adaptive capacity and the explanatory variables. The regression results show a positive significant relationship of six of the explanatory variables with household adaptive capacity for both the OLS and Simultaneous Quantile (SQ) regressions. These are education, size of landholding, poverty status, ownership of a bank account, locality and owning a phone. Male however showed a negative relationship with household adaptive capacity for both regressions, with loanapplied, showing a negative relationship with household adaptive capacity in the SQ regression, although it did not show any significance in the OLS regression. Marital status, ICT skills, Total value of remittances received and Total value of farm equipment did not show any significant relationship with household adaptive capacity in both the OLS and SQ regressions.

Results from the OLS regression in Table 6.7 show that household adaptive capacity increases as education level increases from no education to basic education and this is significant at 1%, that for the SQ shows a significant result at the 5% significant level at the 60th quantile and 1% at the 80th quantile, which indicates that, the increase in household adaptive capacity due to an increase in education from no education to basic education is only significant at a higher quantile of adaptive capacity (60th and 80th quantiles). The plausible explanation for this is that, for a farmer to experience any significant change in adaptive capacity due to a change in education level from no education to basic education, that farmer's adaptive capacity must have already been little above moderate adaptive capacity. Results from the SQ regression also show an increase in adaptive capacity with a change in education from no education to secondary education for both the OLS (10% significant level) and SQ (10% significant level at the 40th quantile and 1% significant level at the 60th quantile) regressions. Education is a key socio-economic factor that has been empirically shown to influence adaptive capacity and climate change adaptation choices and decisions (Yaro *et al.*, 2016; Abid *et al.*, 2015; Asante *et al.*, 2012). Farmers acquire knowledge through education (Yiran & Stringer, 2017).

Results from the OLS regression in Table 6.7 also shows that as poverty status improves from very poor to non-poor, the adaptive capacity of the farmer also increases and this is significant at 1% for both the OLS and SQ regressions. In the SQ regression however as a farmers' poverty status changes from very poor to poor, the changes seen in household adaptive is only experienced at the lower quantiles (20^{th} and 40^{th} quantiles) at the 1% significance level. This implies that only those with very low to low adaptive capacity will actually see a change with a change in poverty status from very poor to poor. As a farmer moves from very poor to non-poor poverty status however, there is a significant change in the adaptive capacity of the farmer at the 20^{th}, 40^{th} 60^{th} and 80^{th} quantiles, significant at the 1% significance level for the 20^{th} and 40^{th} quantiles and 5% significance level for the 60^{th} and 80^{th} quantiles. The OLS regression results also showed significance at the 1% significance level. A confirmation of the assertion that, vulnerability to the negative impacts of climate change stems from the inadequate or lack of capacity to adapt due to poverty as indicated by studies such as IFPRI (2019); World Bank (2018); Logan *et al*. (2017); EPA (2017); AGRA (2016); Mcleod *et al*. (2016); Abid *et al*. (2016); Qaisrani (2015); IPCC (2014); Anamlau *et al*. (2013); ODI (2013); Sen (1980). Therefore, interventions targeted at improving poverty status could invariably enhance household adaptive capacity as well, which could also lead to a reduction in vulnerabilities against the negative impacts of climate change. Being poor in itself is a risk and extreme weather conditions are known to adversely affect the poor (Qaisrani et al., 2018; Sen, 1980).

As the size of landholding of the farm household increases from small size to medium size household adaptive capacity also increases and this is significant at 5% significance level for the OLS regression results and the 1% significance level for the SQ regression results at the 20^{th} and 40^{th} quantiles and 10% significance level at the 60^{th} quantile. Although household adaptive capacity does not show any significant change with an increase in household landholding from small size to large size in the OLS regression, the SQ regression results however show an enhanced adaptive capacity at the 20th and 40th quantiles at the 1% significance level, with the magnitude of increase decreasing from the 20th to the 40th quantile. This could mean that increasing landholding could increase the adaptive capacity at the lower quantiles of adaptive capacity (very low to low adaptive capacities) but this increases at a decreasing rate as one moves from the 20th quantile to the 40th quantile of adaptive capacity level.

Location of the household is also shown to positively influence household adaptive capacity. As the location of the household changes from rural to urban, household adaptive capacity is also enhanced, and this is significant at the 1% level for the OLS regression results, as well as for the SQ regression results at the 20th, 40th, 60th and 80th quantiles. These results confirm the positive influence of locality on adaptive capacity from other studies (Yaro *et al.*, 2016; De souza *et al.*, 2015; Ford *et al.*, 2015; Kilory, 2015; Bawakyillenuo *et al.*, 2014; Mbow *et al.*, 2014; Asante *et al.*, 2012).

Results from both the OLS and SQ regressions in Table 6.7 also show that household adaptive capacity is positively enhanced by owing a mobile phone, which are significant at the 1% level for the OLS regression and the 1% level of significance at the 20th quantile, 5% level of significance at the 60th quantile and 10% level of significance at the 80th quantile of the SQ regression. The plausible reason for this is that, a farmer with a phone is more likely to have information on weather, prices, new technology and would be able to have easy access to extension agents via telephone and this is likely to enhance their adaptive capacity. Mobile phones serve as the medium for information dissemination either through messages, phone call conversation or internet search and these findings support findings from previous empirical studies by Mcleod *et al*., 2016 and Abid *et al*., 2015, that mobile phone services enhance the adaptive capacity of households. Access to information is a key variable in the climate change adaptation discourse, since timely information on weather, prices, and access to farm inputs is crucial for productivity, especially in the face of climate change as shown by studies by (Wahid *et al*., 2017; Abid *et al*., 2015). Information dissemination could be by phone conservations, through messages via phones as well as via internet search, which can be done on phones.

Ownership of a bank account also shows a positive association with household adaptive capacity, significant at the 5% level for the OLS regression and 5% and 10% significant levels at the 60th and 80th quantiles respectively for the SQ regression. This indicates that a farmer who owns a bank account is more likely to enhance their adaptive capacity than one who doesn't. Although the OLS results show significance, the results from the SQ regression shows that this is significant at the higher quantiles of adaptive capacity. Loan applied however showed a negative relationship with household adaptive capacity at the 20th quantile, with a significance of 10%. This study notes that household adaptive capacity, is built from the management and combination many resources, which includes owning a bank account. This study argues that, although ownership of a bank account is not a direct resource it is a step in the direction of acquiring financial assistance from a bank or other financial institution and is therefore an asset to the farmer that could enhance their adaptive capacity. Farmers like any other individual in the country who is eighteen years old and above can walk to any bank and ask to open an account for savings purposes and this could lead to subsequent loan acquisition after a few months. All that is needed, is to meet the minimum requirements for account opening and this is subject to each bank.

Farmers during the focus group discussion mentioned financial assistance as a resource that could help them in their climate change adaptation efforts and this has also been empirically proven by previous studies (Masud *et a*l., 2017; Wahid *et al.*, 2017; Yaro et al., 2016; Egyir et al., 2015; Abid, *et al.*, 2015; Mbow *et al*., 2014). Ownership of bank account and whether a farmer applied for a loan or not, are indicators used to assess access to some form of financial assistance, a key factor in the climate action discourse (Yiran & Stringer, 2017*;* Wahid *et al.*, 2017; Abid, *et al.*, 2015).

Male farmers show a negative association with adaptive capacity the 10% significant level in the OLS regression and 5% significance level at the 6oth quantile in the SQ regression. This indicates that as gender changes from male to female household adaptive capacity decreases. This assertion came up during the participatory focus group discussions. Most females complained about the numerous house chores they have to do before going to the farm, and having to go long distances to fetch water both for domestic use and use at the farm. This study believes that some of these factors among others could be the reasons why such a trend is being observed. The challenge to responding to the negative effects of climate change is building the capacity of the vulnerable and disadvantage groups in society through social equity and access to resources (Osman *et al.*, 2017; Yaro *et al.*, 2016; De Souza *et al.*, 2014). This study suggests that farmer households should be educated more on gender and equity issues to help empower domesticated women adapt better to the negative effects of climate change.

6.4 Conclusion

This chapter presented results on the estimates of household adaptive capacity, and the relationship between the estimated household adaptive capacity with gender, locality, poverty status, education and some other key socio economic variables to examine if there were any significant associations. OLS and SQ regressions were then ran to examine what factors influence household adaptive capacity. Locality, poverty status, owning a mobile phone, size of landholding, owing a bank account and education were all found to positively influence household adaptive capacity. Several studies have demonstrated that, one's ability to successfully adapt against the negative impacts of climate change is dependent on one's adaptive capacity. A high adaptive capacity indicates low vulnerabilities against negative climate impacts. The age of the farmer, education, poverty status of farmer, household size, gender of farmer, distance from farm to motorable road, access to extension service, access to loans, diversification of farm activities, processing farm produce (IFPRI, 2019; World Bank, 2018; EPA, 2017; AGRA, 2016; Abid *et al*., 2015), land ownership, migrant, information (access to and use of mobile phone and ICT) (IFPRI, 2019; World Bank, 2018; Logan *et al*., 2017) and access to improved varieties (Mcleod *et al*., 2016; Mbow *et al*., 2014; Anamlau *et al*., 2013), are all factors that have been shown empirically to having influence on the adaptive capacity of the farmer.

CHAPTER SEVEN

THE EFFECT OF CLIMATE CHANGE ADAPTATION ON THE LIVELIHOODS OF FARMERS

7.1 Introduction

This chapter presents a discussion on the climate change adaptation strategies used by the study subjects, farmers and the resources they require for the adaptation process. This is followed by analysis of results from the Simultaneous Quantile regression on the effect of climate change adaptation on the livelihood of farmers.

7.2 Description of Climate Change Adaptation Strategies Adopted by Farmers

Table 7.1 presents farmers' responses on what climate change adaptation strategies they adopt to reduce the negative effects of climate change on their activities. Farmers also proposed the provision of supporting infrastructure to enhance their adaptation efforts. From Table 7.1, tree planting was mentioned as one of the climate change adaptation strategies used by farmers from four farm communities (Buosu, Subinso No2 & Branam, and Dotobaa). Farmers should be encouraged to leave some tress on their farms to serve as wind breaks and also help to improve the environment. Farmers from the Offuman community mentioned prevention of bush fires as an adaptation strategy. They also mentioned changing of planting time as a strategy to avoid army worm infestation. Some farmers in Dotobaa indicated that land acquisition was a challenge to farmers and proposed an improved legislation by government for easy land acquisition especially by tenant farmers. Farmers of Dotobaa also mentioned the use of improved seeds as an adaptation strategy. Fertilizer use and irrigation were also mentioned as strategie used by farmers of Subinso No2 & Branam and Dotobaa respectively to reduce the negative impacts of climate change on their farming activities.

Table 7. 1: Climate Change Adaptation Strategies Adopted by Farmers

Climate Change Adaptation Strategies Adopted by Farmers	
Community	**Responses**
Buosu	Re afforestation
	Protect river bodies (Prevent cutting of trees around rivers)
	Prevent bush fires/hunting
	Prevent the cutting down of trees (chainsaw operators)
	Information on Weather
	Shifting cultivation
	Use of previous years' experience to forecast rains or calculate current years' rainfall pattern
	Dams and irrigation systems
	Reduce post-harvest losses - Improve road and transport system, provide ware houses for storage, improve marketing value chain, build factories for processing.
Offuman	Access to farm inputs (quality/ improved seeds, fertilizers, equipment)
	Proper land management /Training (Agricultural extension officers)
	Changing planting time to avoid army worms
	Planning of planting and fertilizer application
	Tractor services
	Improved marketing of farm produce (scaling and pricing)
	Information on rainfall
	Farm land acquisition
	Water for irrigation/ spraying chemicals
Subinsu no2 and Branam	Planting of trees
	Prevent bush burning
	Prevent indiscriminate cutting of trees
	Prevent charcoal burning
	Use of fertilizer
	Reduce use of chemicals
	Credit farming
	Training programmes to improve skills of farmers (good land management practices)
Dotobaa	Tree planting
	Prevent bush fires
	Use improved seeds – fast growing and high yielding
	Use of irrigation
	Land acquisition issues limits what strategies to use. – Migrant farmer
	Extension agents to help with training

Source: Fieldwork, 2020

These strategies, both proposed and adopted would enable farmers to maximize the use of their farmlands, in terms of harvest per hectare of land. Farmers from Buosu proposed the provision of warehouses in farming communities and the establishment of processing units for perishable crops as strategies that could reduce post-harvest losses to invariably reduce the negative impacts of climate change on farmers, since these provisions could cushion them against post-harvest losses. When post-harvest losses are reduced, farmers could maximise the returns on their farm activities. Farmers from Buosu and Subinso No2 & Branam indicated that there was the need to fight against the indiscriminate cutting down of tress to protect the environment. Farmers of Offuman community proposed that weather information and improving marketing with regards to scaling and pricing of farm produce are key climate adaptation strategies that are crucial for reducing vulnerabilities against the negative effects of climate change.

Some voices on the climate adaptation strategies used by farmers are presented in Box 7.1.

Box 7.1 Some "Voices" of farmers on climate change adaptation strategies

"Government should empower assemblymen to enforce certain laws at the community level, that is one way of ensuring that task force formed to fight against bush burning and tree felling at the community level can work. As it is, we have no power" (Participant B, participatory group discussion - Buoso, 2020).

"Our lands have become so bare, we need to grow more tress" (Farmer B, - Dotobaa, 2020)**.**

"If the roads were good and I can easily get transport, I would send most of the produce to the market myself, so I make more money from my harvest" (Participant C, participatory group discussion - Offuman, 2020).

. "Middlemen take too much and pay little when they come to purchase our farm produce" (Participant D, participatory group discussion - Offuman, 2020).

"It is not their fault, the roads are too bad, so when they come all the way to buy, we have no choice but

Source: Fieldwork, 2020

The farmers suggested that government should find a way to standardize the scaling and pricing of farm produce especially for maize, rice and groundnuts farmers. They complained that middlemen determine the prices and quantities for their produce. The farmers attributed this to the bad nature of the roads leading to the farms, thus, they have no choice than to sell to these traders when they come all the way. Although the farmers believe that getting higher prices for their farm produce could help in reducing the negative impacts of climate change, they also believe that middlemen are not solely to be blamed for the shortcomings. Governments and other stakeholders are therefore encouraged to put necessary measures in place to ease the burden of farmers. Access to some form of credit was also mentioned as a way of strategizing against the negative impacts of climate change.

Farmers recounted that, they needed funds to buy improved seeds and even fertilizers. Some farm practices that can help farmers reduce the negative impacts of climate change like spraying against pests and diseases, use of irrigation, changing crop varieties where necessary all require finances. The farmer should therefore be empowered to have easy access to these facilities to enable them strategise against the negative impacts of climate change.

7.3 Resources Needed by Farmers for Effective Climate Change Adaptation

Farmers from the five farm communities after thorough discussions and deliberations identified some resources as necessary for the easy adaptation against the negative effects of climate adaptation. These resource needs by farmers for climate change adaptation is as presented in Table 7.2. Access to credit in the form of farm inputs or finances was mentioned by farmers from all fives communities as one of the crucial resources needed for effective climate change adaptation. Availability of farm inputs such as improved seeds and fertilizer were also mentioned as resources that aid the climate change adaptation process.

Table 7. 2: Resource Needs for Climate Change Adaptation

Resource Needs for Effective Climate Change Adaptation	
Community	**Responses**
Buosu	Financial assistance (Access to loans)
	Knowledge (education and training)
	Farm inputs – improved seeds, fertilizers
	Good roads (fix roads leading to farm communities)
	Irrigation
	Markets/storage (to reduce post-harvest losses)
	Warehouses in our locality to store farm produce.
	Good prices for farm produce
Offuman	Tractor services
	Motor king carry water and farm produce
	Farm inputs (seeds, fertilizer, cutlasses, spraying machines, weedicides/ insecticides)
	Roads linking farms communities to main road
	Adequate funds
	Farmland acquisition
	Agricultural office in community (Extension officer)
	Education and training
	Markets
Subinsu no2 and Branam	Education/training of farmers on the need to plant trees
	Credit farming
	Irrigation
	Availability of farm inputs
	Bad roads
	Markets
	Warehouses for storing farm produce to for better pricing
	Extension offices for education
	Tractor services
Dotobaa	Farm inputs (fertilizer)
	Financial support (access to loans)
	Irrigation
	Access to extension agent

Source: Fieldwork, 2020

Good roads, Markets, Warehouses for storage of agricultural produce and agricultural extension services were also mention by farmers as resources that aid the climate change adaptation process. These resources enhance adaptive capacities for better adaptation against negative climate impacts (Abid et al., 2016; Osmam *et al*., 2017; Yaro *et al*., 2016).

Farmers also mentioned need for more knowledge acquisition to improve their skills, through education or training on the implications of climate change on their activities and the best practices to reduce its negative impacts. Farmers mentioned that agricultural extension agents as well as NGOs could be the actors here (ref Table 5.7 pg 111-112). Studies by Tahiru *et al*. (2019); Yaro et al. (2016), confirms the role of NGO's in building the capacity of farmers.

Some voices of farmers captured on the resources needed to enhance climate change adaptation are highlighted in box 7.2.

Box 7.2: Some "Voices" on Resources Needed to Enhance the Climate Change Adaptation Process

"We get nothing from our farm activities when our rents are high and we are not allowed to plant certain crops" (Migrant farmer A- Dotobaa, 2020).

"when they set fire on their farms and it destroys our farms, we have no say, but when we make any mistake, they make us pay. The law should treat us all equally when we burn the farms" (Migrant farmer B - Dotobaa, 2020).

"The men leave the water fetching to us women, but it is a difficult task. We have to see to the children at home too, and also fetch water for spraying chemicals on farm, this is too much if we are able to buy the motor king, it can solve that problem for us." (Women's group - Offuman, 2020)

Source: Fieldwork, 2020

Government policies and community laws on land acquisition and bush fires were also mentioned as key resources for the climate adaptation process by farmers. Migrant farmers who participated in the focus group discussions reiterated that land and tenancy issues were critical to their survival and success, and this is confirmed by the regression results in section 7.4 of this chapter. This confirms the vital role of societal rules and policies in enhancing the capacities of farm households for climate change adaptation (Yaro *et al*., 2016).

Farmers also mentioned that, the lack of basic amenities like toilet facilities and water affects their activities. Some women also mentioned that due to the lack of water, they had to travel long distances just to fetch water, both for domestic use and for mixing chemicals for spraying on farms, adding an additional burden to them. They suggested that the availability of motor king tricycles could help ease their burden. The motor king, tricycle is a hardy locomotive, that can go almost everywhere and was mentioned as a resource that could be useful to farmers for their activities as a way of strategising against the negative impacts of climate change. Farmers could fetch water with it as well as use it to convey their farm produce from the farms to their homes, markets or roadside for sale. Several studies have emphasized the need for the provision of basic amenities as a way of capacity building against the negative effects of climate change (Williams *et al*., 2018; Wahid *et al*., 2017; Abid *et al*., 2016).

The pursuit of reducing the negative impacts of climate change and equity goals all lead to the improvement of livelihoods of vulnerable groups in society (Dolsak & Prakash, 2018; Masud *et al*., 2017). Making these basic resources available to farmers enables them adapt better against the negative effects of climate change. Activities that enhance the adaptive capacity of the most vulnerable socioeconomic groups essentially promotes sustainable development, and thus improves the general wellbeing of the people (Dolsak & Prakash, 2018; Williams *et al*., 2018; Masud *et al*., 2017; Wahid *et al*., 2017; Abid *et al*., 2016).

7.4 Effect of Climate Adaptation on the Livelihoods of Farmers

Both Multinomial Logit and Simultaneous Quantile regressions were used in estimating the effect of climate change adaptation on the livelihood of farmers. Results of the Multinomial regression showed a Pseudo R-squared value of 0.163 and had five significant variables. The Simultaneous Quantile regression however had 7 significant explanatory variables with Pseudo

R-squared values of 0.1902, 0.2288, 0.2606, and 0.1326 for the 20th, 40th, 60th, and 80th quantiles respectively. Results of the Simultaneous Quantile regression was therefore chosen over the Multinomial logit regression for the analysis and is presented in Table 7.3. The Multinomial regression result is presented in the appendix II.

Table 7.3 presents results from the Simultaneous Quantile regression on the effects of climate change adaptation on the livelihood of farmers.

Table 7. 3: Simultaneous Quantile Regression - Climate Change Adaptation on Farmers' Livelihood

	Quintiles of Net Income			
Explanatory Variables	**20th Quantile**	**40th Quantile**	**60th Quantile**	**80th Quantile**
Predicted Household adaptive capacity	1.982*	3.472***	3.858***	4.271***
Mixed farming	0.002	0.090	0.238*	0.279
Farm diversification	0.354	0.586	0.444	0.507**
Livelihood diversification	1.258***	1.247***	0.944***	0.595***
Processing	-0.212	-0.155	-0.295	-0.466**
Medium farm size (Ha)	0.288	0.278	0.227	0.094
Large farm size (Ha)	3.260***	1.977***	0.785**	-0.273
Owner farmland	0.287	0.638***	1.159***	1.215***
Constant	0.039	-0.179	0.069	0.734
Observations	354	354	354	354
Pseudo R2 – 20th quantile	0.1902			
Pseudo R2 – 40th quantile	0.2288			
Pseudo R2 – 60th quantile	0.2606			
Pseudo R2 – 80th quantile	0.1326			
Level of Significance	*** p<0.01, ** p<0.05, * p<0.1			

Computed from GLSS7 data

The Pseudo R-squared values of the SQ regression are 0.1902, 0.2288, 0.2606, and 0.1326 for the 20th, 40th, 60th, and 80th quantiles respectively, indicating that 19.02%, 22.88%, 26.06%, and 13.26% of the variance in value of total assets of farmers, which is an indication farmers' total income and livelihood, is explained by the independent variables of the regression model at the 20th, 40th, 60th and 80th quantiles respectively. This indicates a good-to-moderate association between climate change adaptation and the livelihood of farmers per the regression model specified. The maximum estimated value of farmers' total assets was found to be 374,175.00ghs and the minimum of 0.00ghs, with a mean of 11,200.66ghs and standard deviation of 28,869.56ghs.

From Table 7.3, seven of the explanatory variables, show a significant relationship with estimated net income. Five out of the seven explanatory variables show a positive and significant relationship with farmers estimated net income. These are household adaptive capacity, mixed farming, farm diversification, livelihood diversification, size of farmland, and Ownership of farm land. Processing however shows a negative relationship with farmer's income.

Results from Table 7.3 show a positive association between the predicted house adaptive capacity and farmers' net income at the moderate to very high adaptive capacity levels and at different quantiles. This is an indication that the net income of a farmer is likely to increase with an increase in adaptive capacity of the farmer from very low to moderate adaptive capacity, but the increase in net income would only be realized by those in the 80th quantile (highest income levels). This is significant at the 5% level. A farmer's net income is also likely to increase, when the household adaptive capacity increases from very low to high adaptive capacity, and this is significant at all the 4 quantiles of income level at the 10%, and 5% levels for the 20th and 40th quantiles respectively and the 1% level for the 60th and 60th quantiles. When a farmer's adaptive capacity improves from very low to very high adaptive capacity, the increase in farmer's net income is also experienced by all the 4 quantiles, and this is significant at the 1% significance level for all the 20th, 40th, 60th and 80th quantiles. Farmers with higher adaptive capacity are likely to adaptive better to the negative effects of climate change (World Bank, 2019; Osmam *et al.*, 2017; Wahid *et al.*, 2017) which could translate into improved livelihoods due to improved income, all other factors held constant.

From Table 7.3, Farm diversification, another climate change adaptation strategy which finds the farm keeping farm animals in addition to their crops also shows a positive relationship with 10% significance level at the 20th quantile. Farmers sell these animals for extra income in times of need. This serves as a good back up in the face of climate change.

Livelihood diversification shows a positive relationship with farmer's net income at the 20th, 40th and 60th quantile at the1% significance level, at the 20th and 40th quantiles and the 5% level for the 60th quantile. Livelihood diversification is another climate change adaptation strategy used by farmers to reduce their vulnerabilities against the negative impacts of climate change (Egyir *et al.*, 2015; Loison, 2015; Bawakyillenuo *et al.*, 2014; Antwi-Agyei *et al., 2014;* Kurrukulasuriya & Roseenthal, 2013). Apart from the fact that livelihood diversification implies that the farmer would have other sources of income that would increase household income, it also reduces over reliance of farmers on natural resources as well as rain fed activities, thus reducing their vulnerabilities against the negative effects of climate change (Egyir *et al.*, 2015). A farmer who engages in other livelihood activities aside farming is likely to have other income from that activity, which enhances their adaptive capacity. These findings confirm the assertion that livelihood diversification, a known climate change adaptation strategy, enhances the capacity of farmers and thereby reduces their vulnerabilities against the negative impacts of climate change as empirically proven by studies by Muchuru & Nhamo (2019); Egyir *et al*. (2015); Loison (2015); Bawakyillenuo *et al*. (2014); Antwi-Agyei *et al*. (2014); Kurrukulasuriya & Roseenthal (2013).

From Table 7.3, as the size of farm land increases from small to medium and large size, farmer's net income also increases. The increase in net income is experienced by all farmers within the different quantiles categories of net income, for increase in farm size from small to large at 1% significance level. With the change in farm size from small to medium, the change in net income is experienced at the 40th, 60th and 80th quantiles at 5% and 1% significance level respectively. A farmer who owns a bigger farm is more likely to harvest more crops than one with a smaller farm and should therefore earn more from their harvest, all things being equal. Increasing farm sizes therefore enhances farmers' income as has been empirically shown by previous studies (Masud et al., 2017; Mutabazi *et al*., 2015; and Abid *et al*., 2015). This study notes that farmers who fall within the 20th quantile of net income, did not experience an increase net income with an increase in in farm size from small to medium. Thus, although increasing farm size as a climate adaptation strategy could lead to increase in net income, such interventions should carefully assess farmers' farmland resources before using this as a strategy.

Table 7.4 presents the size of household land holdings and size of farmland cultivated.
As can be seen from Table 7.4, 33.94% of farm households have small farm sizes of between 0.50-5.00 hectares. This means that for these 33.94% percent of households to experience any significant increase in income, they have to increase their farm sizes to large farm size (>100hectares), which would be a great impossibility for these farmers.

Table 7. 4: Size of Landholding and Farm Size of Respondents

	Category	Percentage
Size of Land Owned by Households (Hectares)	Small (0.00 -5.50)	57.41
	Medium (6-10)	42.09
	Large (>100)	0.50
Minimum Land Owned	0.10	
Maximum Land Owned	50000	
Mean	38.16	
Standard Deviation	836.40	
Size of Farmland (Hectares)	Small (0-5.5)	33.94
	Medium (6-100)	65.87
	Large (>100)	0.18
Minimum Farm size	0.25	
Maximum Farm size	112.50	
Mean	13.91	
Standard Deviation	15.50	

Source: Computed from GLSS7 data

Note that there is only one person with large farm size in the study area (ref Table 4.10 pg 93).

From Table 7.4, majority of farm households (57.41%) have small landholdings, that is between 0.50 to 5.50 hectares, with the minimum landholding of 0.10 hectare and maximum landholding of 50,000 hectares. The mean landholding is 38.16 hectares. Meanwhile, the minimum and maximum farm sizes are 0.25 hectares and 112.50 hectares, with a mean farm size of 13.91 hectares. Size of landholding showed a positive association with household adaptive capacity in the regression on factors that influence household adaptive capacity (ref Table 6.7, pg 118). And the predicted household adaptive capacity equally shows a positive relationship with farmer's net income. this means that these 57.41% of households with small landholdings are only likely to see an increase in their farm income if they are able to increase their landholdings from small to medium or large holdings, all things being equal.

Findings from some studies suggest that size of farmland and landholding of household influence household adaptive capacity against the negative impacts of climate change (Jamshidi, 2020; Osmam *et al*., 2017; Yaro *et al*., 2016; Abid *et al*., 2015). Farmers with larger farm sizes are likely to earn more from their farm activities, all things being equal. It could also be easier for farmers to use part of their farm land for trials of newly introduced adaptation strategies as well as rent out some of their farm lands to other farmers for extra income. These are likely to enhance their higher adaptive capacity.

From Table 7.3, mixed cropping shows a positive relationship with farmer's net income at the 60th quantile with a significance level of 10%, indicating that the benefits of engaging in mixed cropping as a climate change adaptation strategy manifests as increased net income only for those farmers in the upper income quantiles. Mix cropping is a well-known climate adaptation strategy that have been empirically proven to cushion farmers against the negative impacts of climate change (Egyir *et al.*, 2015; Yaro *et al.*, 2014; Minot, 2013). When one crop fails, the farmer can fall on the other crops for consumption and sales. When prices of farm produce are not stable, a farmer who has variety is able to fall on the produce that has higher price in a particular season. On the other hand, when pest and diseases strike a farm, a farmer who has variety of crops on their farm may not lose everything, compared with the farmer who does mono cropping.

From Table 7.3, ownership of farm land also shows a positive relationship with farmer's net income. At the 1% significant level at the 40th, 60th and 80th quantiles. This study believes that being the owner of your farm enables you to easily take decision on what climate change adaptation strategies to use compared to a tenant farmer.

Table 7.5 presents the cropping types and land ownership status of farmers.

Table 7. 5: Cropping type and Land Ownership of Farmers

	Category	Percentage
Cropping Type	Single/Mono cropping	29.57
	Multiple Cropping	70.43
Land Ownership	Owner with Deeds	13.90
	Owner without Deeds	45.50
	Tenant Farmer	40.60

Source: Computed from GLSS7 data

From Table 7.5, majority (70.43 percent) of farmers do multiple cropping with 29.57 percent engaging in mono cropping. Based on the regression results, it means it is likely that the 29.57% of farmers doing mono cropping are probably not experiencing any increase in net income, given that, farmers doing mixed cropping are only likely to experience a change in net income at the higher (60th) quantiles of net income, from the regression results. Multiple cropping is a known climate change adaptation strategy, that reduces farmers' risk against pest and diseases as well as failure of rainfall (Yaro (2013; Minot, 2013).

From Table 7.5, majority of farmers (59.40 %) farm on their own lands, with 40.60 percent being tenant farmers. Of the 59.40 percent of farmers who own their own farmlands, 76.60 percent of them have no land title deeds to the farmlands they own. The regression results in Table 7.3 indicates that farmers who own their own farm lands are likely to experience a change in net income at the 40th, 60th, and 80th quantiles, all things held constant. This means that the 40.60% tenant farmers may probable not experience any change in net income all things being equal.

Table 7.6 presents a cross tabulation of cultivated farm sizes and land ownership status of farmers. About 53.51 percent of the 185 farmers who cultivate small farm lands are tenant farmers, with 46.49 percent of them owing their own farmlands.

Table 7. 6: Land Ownership by Cultivated Farm Size

Size of Cultivated Farmland in Hectares	Land Ownership Status		
	Tenant Farmer	Owner of Farmland	Total
Small	99	86	185
Medium	122	237	359
Large	0	1	1
Total	221	324	545

Source: Computed from GLSS7 data

With farmers who cultivate medium size farmlands, 66.02 percent of the 357 farmers own their farmlands, with 33.98 percent of them being tenant farmers. Discussions from the focus group discussions held during the filed visit, had migrant farmers complaining of being unable to undertake some strategies like growing tree crops because land owners disallow these. This gives landowners an advantage over tenant farmers which could translate into increased farmer income as seen in the regression results in Table 7.3.

7.5 Conclusion

This chapter presented results from the Simultaneous Quantile regression on the effects of climate change adaptation on the livelihood of farmers. Household adaptive capacity, size of farmland, mixed cropping, farm diversification, livelihood diversification and ownership of farmland all had a positive relationship at different quantiles of farmer's net income. Processing showed a negative relationship with farmer's net income at the 80^{th} quantile. The climate change adaptation strategies adopted by farmers as well as resources needed to aid the climate change adaptation process were also described. Farmers used strategies like use of improved seeds, fertilizer, changing planting time, weather information, irrigation, prevention of bush fires and the indiscriminate cutting of trees. Resources like access to some form of credit, markets and policy on pricing of farm inputs and produce, access to good roads, and basic amenities like water and toilets were mentioned by farmers as important for a successful climate change adaptation process.

The most vulnerable to the negative effects of climate change are those living in poverty and those dependent on rain fed activities like agriculture for their livelihood (World Bank, 2019; IFPRI, 2019). Successful climate adaptation requires resource management processes in order to improve rural livelihood (Anamika *et al.,* 2013). Climate adaptation is especially relevant to developing countries, which are struggling to address the challenges of climate variability due to their relatively lower adaptive capacity (Ford *et al.,* 2014*;* Krysanova *et al.,* 2010). Highly developed countries have also had significant deficiencies when it comes to preparedness for climate impacts, but they equally have a higher capacity to deal with it (Preston, 2011). A farmer with a higher adaptive capacity is more likely to better adapt against the negative impacts of climate change.

CHAPTER EIGHT

SUMMARY, CONCLUSION AND RECOMMENDATIONS

8.1 Introduction

This chapter presents the summary, conclusion and recommendations of the study. The first section, summaries the aim of the study, data types, methods used and findings of the study. Conclusions drawn from the study, based on the findings of the study are discussed in section 8.3, and the last section of this chapter presents the recommendations of the study, based on the findings of the study.

8.2 Summary of Study

This study sought to assess the importance of resources in building the adaptive capacity of farmers against the negative effects of climate change in the transition agro ecological zone of Ghana. It also sought to assess what factors influence the adaptive capacity of farmers and the effect of climate change adaptation on the livelihood of farmers. Using a mixed methodological approach, primary data was collated from five farm communities purposely selected in the transition agro ecological zone of Ghana. Groups of farmers from three communities in Wenchi and one each from Techiman North and Nkoranza South districts were interacted with in a participatory focus group discussion. The GLSS7 data set was the main secondary data source used to help address the objectives of the study.

Farmers perceptions on what climate change is, the causes of climate change, and what can be done to reduce the negative impacts of climate change were obtained from the primary data. Farmers' views on what resources and which stakeholders are important for capacity building and adaptation against the negative effects of climate change were also obtained from both primary and GLSS7 data. Household adaptive capacity was estimated using Vincent, (2007) framework, with variables from the GLSS7 data. The estimated household adaptive capacity was cross tabulated by some key socio economic variables, with the significant results, based on the chi squared test performed presented and discussed. Ordinary Least Square (OLS) and Simultaneous Quantile (SQ) regressions were used to estimate what factors influence the adaptive capacity of farmers. The effect of climate change adaptation on the livelihood of farmers was also estimated using the Simultaneous Quantile and Multinomial Logit regressions. Farmers perceptions on what climate change is, what causes climate change, and what can be done to reduce the negative effects of climate change were obtained from the primary data collected. Farmers' views on what resources and which stakeholders are important for capacity building and adaptation against the negative effects of climate change were also obtained from both primary and GLSS7 data. Key findings from the study indicates that:

Effective Use of Resources Enhance Household Adaptive Capacity and Climate Change Adaptation

Results from the thematic analysis points to the fact that farmers perceive that climate change is real and are of the view that human activities such as the indiscriminate felling of trees and destruction of river bodies, can be attributed to its occurrence. Farmers mentioned the need for good roads for easy access to markets. Standardisation and scaling for the sale of farm produce like maize and groundnuts was identified as a constraint that could negatively affect farmers' income. Provision of basic amenities like water and toilets in farm communities was mentioned by farmers as means of enhancing their adaptive capacity to the against the negative effects of climate change. Easy access to credit and agricultural extension officers (regular interactions for training on new strategies) were also mentioned by farmers as resources that build their capacity to better adapt against the negative effects of climate change.

Findings from both the OLS and SQ regressions also show a positive association between locality, poverty status of the household, education level, size of landholding of household, ownership of bank account, possession of a mobile phone and household adaptive capacity. Further confirming that the effective use of resources builds the adaptive capacity of farmer households against the negative impacts of climate change.

Engaging in Climate Change Adaptation Improves the Livelihood of Farmers

The SQ regression results on the effects of climate change adaptation on the livelihood of farmers show that the predicted household adaptive capacity, farm size, mixed cropping, ownership of farm land, farm diversification and livelihood diversification all have a positive relationship with farmer's net income, used as a proxy to indicate farmer's livelihood. This indicates that farmers who use climate change adaptation strategies are more likely to see improvements in their livelihood.

Policy Reforms and Empowerment of Local Authorities are Important Elements in the Climate Action Discourse

These are key institutions that could positively influence the climate change adaptation process. Governments through local authorities could ensure that these institutions are working effectively and efficiently. The implementation of existing policies as well as formulating new ones to suit pending challenges are key for success. Farmers during the participatory focus group discussions for example suggested that government should empower local authorities (assembly representatives and community heads) through legislation in fighting against the indiscriminate cutting down of trees and protection of water bodies.

8.3 Conclusion and Implications of Findings for Resource Management and Capacity Building for Adaptation to Climate Change

Results from the study established the importance of resources in building the adaptive capacity against the negative impacts of climate change. It also established that household adaptive capacity is by itself an important factor in the climate change adaptation process. Locality and poverty status were also found to influence the adaptive capacity of farm households as well as the livelihood of farmers. There is therefore the need to improve rural infrastructure and put in place measures that would build farmer household capacities to help them adapt better against the negative effects of climate change.

Poorer households have lower adaptive capacity and thus are more vulnerable to negative climate change impacts. There is the need to mainstream climate change adaptation into the development agenda, that is, ensuring that developmental activities address issues that are critical for building adaptive capacity and climate change adaptation against the negative effects of climate change (Ayers & Dogman, 2010).

These findings are consistent with the conceptual framework of the study which stipulated that a combination resources and activities, influenced by the various actors of change would lead to a certain outcome of improved livelihoods with climate change adaptation strategies. This is also consistent with Rodney (1973) assertion in Theories of Social Change on the need to improve the skills and capacity to develop the human society. Rodney (1973), also emphasised the need for creativity, social cohesion and sustainability. Development is a form of adaptation which leads to increased adaptive capacity and adaptation to potential climate stresses should also be seen as a form of development that increases resilience and leads to progress in economic and social indications (Milmam &Arsano, 2013).

It has been projected that future climate change will undoubtedly result in even more dramatic shifts in the states of many ecosystems (IFPRI, 2019, World Bank, 2018; ADRA, 2016; IPCC 2014), and these shifts would have implications on agricultural production, food security and for that matter poverty issues (IFPRI, 2019, World Bank, 2018; ADRA, 2016). Natural resource managers and conservation planners therefore have a huge challenge and task to deal with (Mnenwa & Maliti, 2010), in a sense that river bodies, forests and lands would have to be better protected from indiscriminate mining activities, tree felling and pollution. This would help preserve as well as improve our environment to solve the pressing food security and poverty reduction needs for the present generation and the future.

Sensitization on the need to adopt new and appropriate technologies in the face of climate change is important because climate change is real and the earlier humanity begins appreciating the fact and aligning appropriately, the better (IFPRI, 2019, World Bank, 2018; ADRA, 2016). There would be the need to build technical and financial capacities and alternative livelihood mechanisms as well as strengthen the relationship between scientific knowledge and traditional or indigenous knowledge (IFPRI, 2019, World Bank, 2018; ADRA, 2016) to build the necessary adaptive capacities for successful adaptation against the negative effects of climate change.

8.4 Recommendations

Based on the findings of the study the following recommendations are made:

- Resource management that leads to the building of household adaptive capacity should form a key part of the development agenda for rural development. Just as the poverty status of households are monitored and evaluated periodically using the Ghana Living Standards Survey, the adaptive capacity of farmer households could equally be periodically monitored and evaluated to ensure that rural households are well set and equipped to better adapt against the negative effects of climate change. As a national strategy, just as a poverty line has been established to monitor those who fall below or are likely to fall below the line for government interventions, a threshold could also be established as an achievable target for adaptive capacity, below which a household or community could be marked for suitable interventions that could push them up to the threshold adaptive capacity or beyond. Findings from this study suggests that such a measure is imperative as some of the factors that influence adaptive capacity could only enhance it at a certain quantile mostly above the 50th percentile of estimated adaptive capacity (moderate adaptive capacity).

- Poverty alleviation activities should be on the agenda of the government, development partners and other NGO's. As poverty status was found to influence both adaptive capacity and the climate change adaptation process, solving poverty issues would therefore be geared towards reducing vulnerabilities against the impacts of climate change. This study suggests that government through the ongoing LEAP programme for poverty reduction, could support poor farmers with income generating activities that would give them a more sustained income, instead of being fed with pocket money.
- The rate of development of basic infrastructure (access to water, roads, transport marketing and other agricultural post-harvest activities) for farm communities should be increased to help build up the needed adaptive capacities of farmer households in farming communities for better adaptation against the negative effects of climate change.
- Farmers should be encouraged to open bank accounts, so they can easily assess financial assistance in the form of loans from financial institutions.

- Livelihood diversification should be encouraged as a lifestyle to reduce dependence on climate related activities for improve livelihoods. Where necessary, farmers should be assisted to acquire irrigation systems for off season farming as well as cushioning themselves in case the weather fails.
- Local assembly representatives should be empowered through legislation so together with community heads and farmers would to be able to discipline the perpetrators of indiscriminate tree felling and destruction of river bodies as suggested by farmers from the participatory focus group discussions held.
- The number of extension agents per district should be increased. Extension agents could be trained to use local fm stations for education and information dissemination.
- This study also recommends the strengthening of existing farmer groups and farmer cooperatives as well encouraging farmers who have not already formed such groups to do so or join existing ones close to their communities. These groups increasing the bargaining power of farmers and gives them a stronger voice than their individual efforts would.
- This study also recommends that, a collaborative effort by all stakeholders (government, development partners, NGO's, chiefs, community heads, farmers) in the climate action discourse is crucial for survival against the negative effects of climate change. Agricultural extension agents for example could organise quarterly stakeholder meetings with farmers and other stakeholders in the agricultural value chain for brainstorming sessions on how to improve their activities to better adapt against the negative effects of climate change. There is the need for proactiveness by all stakeholders for improved livelihoods.

This study notes that these recommendations are subject to the assumption that farmer households have at least a certain minimum threshold adaptive capacity (moderate), since some farmers may not be able to benefit from some of these interventions if they fail to attain the threshold adaptive capacity, as seen from the results from this study.

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APPENDICES

APPENDIX I
Questionnaire for Primary Data Collection

INSTITUTE OF STATISTICS SOCIAL AND ECONOMIC RESEARCH
UNIVERSITY OF GHANA
PHD RESEARCH

The purpose of this questionnaire is to obtain data for a PhD research titled: "Imperatives of Resource Management in Climate Adaptation: Implications for Smallholder Farmer Livelihood in the Transition Agro Ecological Zone of Ghana". This research is being undertaken at the **Institute of Statistical Social and Economic Research (ISSER), University of Ghana, Legon** and it is entirely an academic process as part of the doctoral programme in Development Studies. All information gathered would therefore be confidentially treated. All respondents are entreated to be candid with their responses to the questions. Please select option (s) that best capture or reflect your response. Where options are not provided, you may state your response in the spaces presented. You are allowed to withdraw from this research at any point you feel uncomfortable or desire to discontinue participating.
Thank you.

Date:
Time:
Interviewer:

INTERVIEW GUIDE FOR FOCUS GROUP DISCUSSION IN SELECTED FARMER COMMUNITY

Name of community …………………………………… District……………………..

Attendance: Males………………..
Females………………

Discussions in small groups, then each group's leader will share with the main group what the group discussed and agreed on

- What is Climate Change
- Is it happening in your community?
- How do you know?
- What in your view are the causes of Climate Change?
- How is it affecting:
    - Your community
    - Your farm activities

- Do you think something can be done about the effects? [Adaptation? / Mitigation?]

  Yes [ ] No [ ]

- If Yes, what do you do currently and what do you think needs to be done? [Strategies]

  1.
  2.
  3.
  4.
  5.

- What resources do you think would be needed to do so, and why?

- Write the 10 most important resources that you think would be necessary for this process.

- What role in your view can the community play in reducing the impact?

- What role do you think individual farmers or farmer households can also play to reduce the impacts?

- What Role do you think Government should play?

- Are there any other Institutions that you know off that can also play a role?

- What in your opinion are the constraints in adapting to the impacts of climate change and variability in this community or district?

- Can you suggest some strategies that could be employed to enhance the system to benefit individual, the community, and sustenance of the environment?
  New institutions
  Existing institution
  Others

- Who should the drivers of change be?
  1.
  2.
  3.
  4.
  5.

Explain answer
……………………………………………………………………………………………………
……………………………………………………………………………………………………
……………………………………………………

- What constraints do you perceive would be a hindrance to achieving these?

16) Opportunity Analysis

What are the Opportunities for upgrading in the face of climate Change?	Who would these opportunities benefit?	Who are the drivers of change?	Why has it not happened\ happening at as low pace?	What would it take for it to happen?
Access and use of resources (farmland, water, labour,)				
Farm Activities				
Information and extension services				
Improving Post-Harvest Activities				
Improving the environment				
Improving Basic Infrastructure				
Farmer Income	Farmers			

APPENDIX II

Multinomial Logit Regression Results on the Influence of Climate Change Adaption on the Livelihood of Farmers

	Quintiles of Net Income				
Explanatory Variables	**1st Quintile**	**2nd Quintile**	**3rd Quintile**	**4th Quintile**	**5th Quintile – set as the Base**
Predicted household adaptive capacity	-8.543***	-5.631***	-0.549	0.697	
Mixed farming	0.016	-0.311	-0.359	0.594	
Farm diversification	-1.386***	-0.677*	-0.906**	0.089	
Livelihood diversification	-3.792***	-1.312***	-0.362	-0.172	
Processing	0.559	0.685*	0.832**	0.696*	
Medium farm size (Ha)	-0.715*	-0.471	-0.035	-0.612	
Large farm size (Ha)	-13.190	-13.512	-14.306	-14.963	
Owner farmland	-1.743***	-1.560***	-0.972**	-0.223	
Constant	6.376***	4.755***	0.923	-0.913	
Observations	354	354	354	354	
Pseudo R2	0.163				
Level of Significance	*** p<0.01,	** p<0.05,	* p<0.1		

Source: Computed from GLSS7 data

Summary of Total Asset of Farmers

	Percentiles	Smallest		
1%	0	0		
5%	20	0		
10%	72.5	0	Obs	860
25%	302.5	0	Sum of Wgt.	860
50%	1280		Mean	11200.66
		Largest	Std. Dev.	28869.56
75%	5185	168095		
90%	35125	186300	Variance	8.33e+08
95%	67703	253780	Skewness	5.180244
99%	138005	374175	Kurtosis	43.94201

Variable	Obs	Mean	Std. Dev.	Min	Max
totassetval	860	11200.66	28869.56	0	374175

Source: Computed from GLSS7 data

5 quantiles of totassetval

	Percentiles	Smallest		
1%	1	1		
5%	1	1		
10%	1	1	Obs	860
25%	2	1	Sum of Wgt.	860
50%	3		Mean	2.94186
		Largest	Std. Dev.	1.456027
75%	4	5		
90%	5	5	Variance	2.120015
95%	5	5	Skewness	.0829434
99%	5	5	Kurtosis	1.628049

Source: Computed from GLSS7 data

APPENDIX III

Cross tabulation of Household Adaptive Capacity by Some Key Socioeconomic Variables

Cross tabulation of Household Adaptive Capacity by Size of Land Holding

		Household Adaptive Capacity				
Qty of Land HH	Very high	High	Moderate	Low	Very low	Total
Small	27	65	70	24	9	195
	13.85	33.33	35.9	12.31	4.62	100
Medium	26	61	59	17	3	166
	15.66	36.75	35.54	10.24	1.81	100
Large	1	0	0	0	0	1
	100	0	0	0	0	100
Total	54	126	129	41	12	362
	14.92	34.81	35.64	11.33	3.31	100
Pearson chi2(8) = 8.6925 Pr = 0.369						
Cramér's V = 0.1096						

Source: Computed from GLSS7 data

Cross tabulation of Household Adaptive Capacity by Education

attained)	very high	high adap	moderate	low adapt	very low	Total
None	17 6.61	78 30.35	100 38.91	46 17.90	16 6.23	257 100.00
Basic	74 17.17	186 43.16	128 29.70	36 8.35	7 1.62	431 100.00
Secondary	19 18.81	51 50.50	23 22.77	7 6.93	1 0.99	101 100.00
Tertiary	15 22.39	37 55.22	14 20.90	1 1.49	0 0.00	67 100.00
Total	125 14.60	352 41.12	265 30.96	90 10.51	24 2.80	856 100.00

Pearson chi2(12) = 77.7129 Pr = 0.000
Cramér's V = 0.1740

Source: Computed from GLSS7 data

Cross tabulation of Household Adaptive Capacity by Size Farmland

Capacity)	small	medium	Large	Total
very low adaptive ca	2 8.70	21 91.30	0 0.00	23 100.00
low adaptive capacity	23 30.67	52 69.33	0 0.00	75 100.00
moderate adaptive cap	66 34.20	126 65.28	1 0.52	193 100.00
high adaptive capacit	70 38.25	113 61.75	0 0.00	183 100.00
very high adaptive ca	23 32.86	47 67.14	0 0.00	70 100.00
Total	184 33.82	359 65.99	1 0.18	544 100.00

Pearson chi2(8) = 10.3092 Pr = 0.244
Cramér's V = 0.0973

Source: Computed from GLSS7 data

Cross tabulation of Household Adaptive Capacity by Age

years)	very high	high adap	moderate	low adapt	very low	Total
less than 18	0 0.00	0 0.00	1 100.00	0 0.00	0 0.00	1 100.00
18 - 24	3 5.77	29 55.77	15 28.85	4 7.69	1 1.92	52 100.00
25-34	33 17.65	76 40.64	49 26.20	26 13.90	3 1.60	187 100.00
35-44	18 8.37	106 49.30	66 30.70	19 8.84	6 2.79	215 100.00
45-54	33 21.29	44 28.39	55 35.48	16 10.32	7 4.52	155 100.00
55-64	29 23.97	47 38.84	30 24.79	10 8.26	5 4.13	121 100.00
Above 64	9 7.20	50 40.00	49 39.20	15 12.00	2 1.60	125 100.00
Total	125 14.60	352 41.12	265 30.96	90 10.51	24 2.80	856 100.00

Pearson chi2(24) = 55.8356 Pr = 0.000
Cramér's V = 0.1277

Source: Computed from GLSS7 data

Summary of Categorised Household Adaptive Capacity

RECODE of HAC (Household Adaptive Capacity)

	Percentiles	Smallest		
1%	1	1		
5%	2	1		
10%	2	1	Obs	856
25%	3	1	Sum of Wgt.	856
50%	4		Mean	3.542056
		Largest	Std. Dev.	.9590968
75%	4	5		
90%	5	5	Variance	.9198666
95%	5	5	Skewness	-.4580242
99%	5	5	Kurtosis	2.925806

Source: Computed from GLSS7 data