ASSESSING CLIMATE CHANGE ADAPTATION STRATEGIES USED BY SMALLHOLDER LIVESTOCK FARMERS IN UPPER WEST REGION OF GHANA

BY

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THIS THESIS IS SUBMITTED TO THE UNIVERSITY OF GHANA, LEGON IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF MASTER OF PHILOSOPHY DEGREE IN AGRIBUSINESS

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DECLARATION

I, Shaibu Mohammed Tiyumtaba, the author of this thesis titled ***"ASSESSING CLIMATE CHANGE ADAPTATION STRATEGIES USED BY SMALLHOLDER LIVESTOCK FARMERS IN UPPER WEST REGION OF GHANA"***, do hereby declare that with the exception of my reference to people's work which have been duly acknowledged, the work contained in this thesis is the result of my research carried out under supervision in the Department of Agricultural Economics and Agribusiness, University of Ghana, Legon from August 2015 to June 2016. Attached in appendix 9 is the plagiarism result of this research. This work, either whole or in part has never been presented for another degree in this University or elsewhere.

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Shaibu Mohammed Tiyumtaba Date

(Student)

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

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Dr Edward Ebo Onumah	Prof Ramatu Mahama Al-Hassan
(Major Supervisor)	(Co-Supervisor)
Date:………………………………………	Date:………………………………

DEDICATION

I dedicate this work to my wife, Bashira, and my daughter, Manal Tipa-aya

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ABSTRACT

As a result of challenges of climate change, farmers over the years have adopted certain measures in order to adapt to their environment. The study assesses climate change adaptation strategies used by smallholder livestock farmers in the Upper West region of Ghana. This study measured the level of vulnerability and adoption of adaptation strategies and its determinants. The livelihood vulnerability index (LVI) and Tobit regression were used to measure the level of vulnerability and to determine the factors that influence the vulnerability of smallholder livestock farmers. Again, descriptive statistics (frequencies, percentages and charts) and power analysis were used to measure the level, intensity and effectiveness of adoption of adaptation strategies. The determinants of the adoption of adaptation strategies were obtained by employing the multinomial logit regression. Primary data was collected through the administration of questionnaire to 200 livestock farmers in Lawra and Nandom districts of Upper West region. This preceded a Focus Group Discussions in all study communities. The results indicated that, Nandom district (0.402), which was highly sensitive, were found to be more vulnerable to climatic stressors than Lawra district (0.374) when using the LVI and the LVI-IPCC approaches. Thus, of the seven major components that were considered in measuring the vulnerability status, Nandom district was found to be more vulnerable in five of them and Lawra district was more vulnerable in the other two. The results of the pooled sample further reveals that 1.5% and 26% of the farmers were found to be lowly and highly vulnerable respectively with 72.5% of the respondents being moderately vulnerable. The determinants of vulnerability were found to be gender of the farmer, age of the farmer, years of education, farming experience, pen ownership, FBO membership, access to credit, participation in Focus Group Discussions, number of extension contacts and noticed increased temperature. The levels of adoption of the adaptation strategies showed that 86 and 87% of the respondents adopted the indigenous and introduced feeding strategies with 51 and 92% of the respondents adopted the indigenous and introduced health strategies respectively. Also, 92 and 38% of the respondents were found to have adopted the indigenous and introduced breeding strategies, whiles 88 and 49% adopted the indigenous and introduced housing strategies. The determinants of the adaptation strategies as compared to the base category (non-adopters) were varied for each category. That is, farmers' age, access to veterinary services, noticed decrease rainfall and being an FBO member were found to influence the adoption level of the feed related strategies. Age of the farmer, farming experience, access to veterinary services and access to weather information influenced the adoption of the health related strategies. Furthermore, the adoption of the breed related strategies were influenced by age of the farmer, access to veterinary drugs, access to community livestock work, noticed decreased rainfall amount and noticed increased temperature. The house related strategies were influenced by gender, access to veterinary drugs, access to weather information and LVI. The study concludes that smallholder livestock farmers are vulnerable to climatic stressors and making efforts to adopting a number of strategies such as feed, health, housing and breed related strategies. It is therefore recommended that policies such as the recruitment of more AEAs and introduction of educational programmes to facilitate adult education, especially women farmers can help them to adopt robust and efficient strategies in order to reduce their vulnerability levels, thereby increasing productivity and livelihood of the farmers.

TABLE OF CONTENT

Contents **Page**

LIST OF TABLES

LIST OF FIGURES

LIST OF ACRONYMS

AEA-	Agricultural Extension Agent
AOGCMs-	Atmosphere Oceans Global Climate Models
ATPS-	African Technology Policy Studies Network
BRS-	Breed Related Strategies
CAHW-	Community Animal Health Worker
CCAFS-	Climate Change Agriculture and Food Security
CDF-	Cummulative Distributive Function
CLW-	Community Livestock Worker
CSIR-ARI-	Council for Scientific and Industrial Research – Animal Research Institute
CWs-	Community Workshops
DAs-	District Assemblies
EPA-	Environmental Protection Agency
FANRPAN-	Food Agriculture and Natural Resources Policy Analysis Network
FAO-	Food and Agricultural Organisation
FBO-	Farmer Based Organisations
FGD-	Focus Group Discussion
FRS-	Feed Related Strategies
GHG-	Green-House Gases
GMA-	Ghana Meteorological Agency
GSS-	Ghana Statistical Service
HeRS-	Health Related Strategies
HRS-	Housing Related Strategies
IESS-	Institute for Environment and Sanitation Studies
IIA-	Independence of Irrelevant Alternatives

ISDR-	International Strategy for Disaster Reduction
IPCC-	Intergovernmental Panel on Climate Change
LDV-	Limited Dependent Variable
LVF-	Livelihood Vulnerability Framework
LVI-	Livelihood Vulnerability Index
LS-	Livelihood Strategies
MP-	Member of Parliament
MESTI-	Ministry of Environment Science Technology and Innovation
MLGRD-	Ministry of Local Government and Rural Development
MNL-	Multinomial Logit
MNP-	Multinomial Probit
NAPA-	National Adaptation Programme of Action
NDCV-	Natural Disaster and Climate Variability
NGO-	Non-Governmental Organisation
NoA-	Non-Adopters
OLS-	Ordinary Least Squares
OSSR-	Optimal Sustainable Stocking Rate
PDF-	Probability Density Function
PRA-	Participatory Rural Appraisal
SPSS-	Statistical Package for Social Scientists
SSA-	Sub-Saharan Africa
UG-	University of Ghana
UNFCCC-	United Nations Framework Convention on Climate Change
VDS-	Veterinary Drugs Store

CHAPTER ONE

INTRODUCTION

1.1 Background

The benefits derived from livestock are societal, economic, and environmental (Ayantunde *et al.*, 2011; Herrero & Thornton, 2013). Rural pastoral poor farmers depends on livestock as their main source of livelihood (Adem *et al.*, 2015; Kosgey *et al.*, 2005; Kruska *et al*., 2003). Livestock products serve as sources of protein especially as demand for meat and milk are increasing as household income rises. Manure and traction are also benefits derived from owning livestock as it contributes to crop yield (Ayantunde *et al.*, 2011). In semi-arid areas, farmers are able to diversify their income by keeping livestock, indeed, keeping animals is an important coping strategy for the poor (LID, 1999).

Given the importance, agriculture is a major area that climate change has an impact on as a result of how sensitive the sector is (Kurukulasuriya & Mendelsohn, 2008). Climate change affects the livestock genotype-environment optimum (Rege *et al.*, 2011) and livestock farmers are vulnerable to the emerging climate change effects (Lyimo & Kangalawe, 2010). Other effects which are indirect include soil infertility, water scarcity, declining crop and livestock output and quality. This indirect effects may even be worse more than the direct effects (Nardone *et al*., 2010).

Reports show that due to multiple stresses and ineffective adaptation capacity, African continent is highly vulnerable to climate change (IPCC, 2007). Boko *et al.* (2007) report that agricultural growth in the greater part of the African sub-region is likely to be highly compromised by climate change. The impact of climate change on agricultural growth cannot therefore be overemphasized (IPCC, 2007). For example, the semi-arid areas of Tanzania, such as Shinyanga district are likely to be vulnerable to climate change in terms of its negative impacts on food production, and natural resources, and consequently people's livelihoods. The impact of climate change may mostly affect livelihood of poor communities because of low adaptive capacity and high dependence on rain-fed agricultural production.

The effects of climate change on livestock have been viewed differently by several authors. Some of these effects are reduced growth, low reproductive capacity, increased incidence of diseases and parasitic infestation and reduced meat and milk quantity and quality among others (Singh *et al.*, 2012). In times of heat stress cows show decreased feed consumption and activeness, increased respiratory rate and higher increase both peripheral blood flow and sweating; they also seek shade and wind. These characteristics have a detrimental effect on both production level and physiologic response of the cow (West, 2003). The effects lead to new diseases emerging through exposure of hosts to new and/or mixture of pathogens and vectors. Variations in temperature defines the level at which some insect vectors are infected with viruses like the blue tonge (ATPS, 2013).

Furthermore, climate change affects livestock by bringing about hazardous factors like droughts and floods which leads to disease epidemic, insect and pest infestation and animal stampede due to excessive heat (Middleton & Sternberg, 2013). The livelihoods of most people in the drier areas are based on livestock herding in the drier parts and rain-fed crop cultivation in the semi-arid regions. Other people also engage in wild harvesting from common resources, like the shea-fruits as it is in Northern part of Ghana. As a result of coping with the vagaries of the change in climate system for a long time, farmers have develop numerous strategies that enable them to manage risk and variability, however many dryland inhabitants remain vulnerable to natural perturbations, more especially those who experience highly variable climate patterns that characterize drylands (Middleton & Sternberg, 2013).

Also, livestock systems in African countries, like Ghana are constantly changing in response to drivers of climate change (Thornton *et al.*, 2009). Some of these drivers include rapid changes in smallholder production systems which requires significant changes in genotypes and their management; high rates of loss of diversity in livestock numbers, increased demand for quality foods; increased competition of market of produce in a globalizing economy; increased need for complex partnership arrangements in the ever-changing livestock commodity chain; and inadequate adaptive capacity to respond to the rapid changes (Rege *et al.*, 2011). The possible impacts of these drivers on livestock as well as the rural poor inhabitants who depend on them for their livelihood need to be considered.

Given the complex nature of livestock systems in African countries, an integration of policy, technological and institutional innovations is needed for improve nutritious feeding strategies, livestock breeding and genetics, improve health and other livestock management options (Thornton *et al.*, 2009). These innovations are some of the introduced adaptation strategies. Thus, livestock farmers have adopted a number of adaptation strategies in order to stabilize production. Notable among them are the provision of cold water and shed during periods of extreme warmth, provision of bedding and warmth during periods of extreme cold, hay preparation for dry season feeding among others (Singh *et al.,* 2012).

Also livestock, like humans are affected by some main diseases and parasites during certain periods of the year. Therefore, livestock farmers adapt during these periods by the use of plants and plant products in the treatment of livestock diseases. A study by Alawa *et al.* (2001) indicates that leaves, roots and barks of some tree species, extracts from some herbaceous plants and tubers are the most common sources of drugs. Other non-plant sources include local soap, kaolin, spent engine oil, wood ash and potassium. In many instances one source of drug, like the leaves of a certain plant can be used to treat many diseases. Sometimes, a combinations of more than one source is possible to be used to treat one or more than one diseases (Alawa *et al.*, 2001). For example, extracts or products from the mahogany tree (Khayasenegalensis A. Juss) are used to treat anthrax, diarrhoea, dysentery, footrot, helminth infections and ringworm (Alawa *et al.*, 2001).

Livestock production therefore needs to be considered as globally, the intended purpose is to overturn the deleterious effects of climate change (Herrero *et al.*, 2011). It is the reason why this current study seeks to assess climate change adaptation strategies used by smallholder livestock farmers in the Upper West region, Ghana.

1.2 Problem Statement

The quest to increase the number of livestock has always been the main goal of farmers. The increase in livestock numbers will mean that smallholder farmers can sell some of these livestock to be able to meet their livelihood needs. This therefore translates into poverty reduction.

Agricultural growth has great capabilities of reducing poverty across all countries (World Bank, 2008).

With an annual human growth rate of 2.5% (GSS, 2012), livestock and livestock products demand is increasing. The total production of meat in Ghana was 76,914 metric tonnes in 2003 and steadily rise to 127, 038 metric tonnes in 2012. With these quantities of domestic meat production, the total meat imports in 2003 and 2012 was 47, 823.5 and 122, 447 metric tonnes respectively. Thus, in 2003, 62% of the total meat demand could be produced domestically, whiles in 2012, domestic production stood at 51%. The demand gap was therefore filled through meat imports (MOFA, 2013). The inability of livestock producers to meet the total meat demand by consumers could be partly due to production challenges characterize by increasing treats of climate change.

In the arid and semi-arid areas of Northern Ghana, where annual rainfall has been decreasing, one way that farmers adapt to harmful impacts of climate change is by diversifying into livestock production. However, this sector is not also left out of the harmful impacts of climate change partly due to human activities. Human activities, in the twenty-first century, are therefore very likely to continue to change the atmosphere's composition. Globally, this will increase the average temperature and lead to rise in sea level (Barnett *et al.*, 2007). These changes are expected to reduce livestock numbers and cause a disproportionate effect on smallholder farmers and make them more vulnerable (Harvey *et al.*, 2014). The changing climate is aggravating current vulnerabilities of the poor people who depend on smallholding agricultural practices as a livelihood (Claessens *et al.*, 2012).

Livestock farmers are therefore vulnerable to climate change in that availability of biomass for livestock as feed will be limited by inconsistent increasing climate change impacts on water availability especially in the arid and semi-arid regions (Hegarty, 2012). Crop production and yield is directly proportional to the availability of feed for livestock. The biomass and crop residue is mostly used to feed livestock. In recent years, farmers are not able to feed their livestock all year round because of poor biomass and crop yield. Also, during prolong period of drought, density of grass and cover declined equally under both seasonal rotation and year-long systems of grazing (Mashiri *et al.*, 2008). FAO (2009) states that farmers are unable to effectively time their farming periods to coincide with the rains for maximum crop yield. Livestock productivity depends on the trend of availability of pasture. Following this, livestock owners are faced with severe shortage of feed and low livestock productivity in the late lean season which is usually from March to June. Declining trend in pasture productivity will seriously affect livestock productivity (Ayantunde *et al*., 2011). Seasonal rainfall therefore affects availability of feed, livestock production and ultimately the standards of living of people (Galvin *et al*., 2004).

Also, livestock farmers are vulnerable to climate change as a result of the geographical location of the study region. Upper West region is located in a semi-arid environment, meaning that there is inadequate water available for livestock production. More importantly, previous researchers . Etwire *et al.*, (2013a); Ndamani & Watanabe, (2015) have identified it to be highly exposed, sensitive and have a low adaptation capacity to effect climate change. There is therefore the need to focus on livestock farmers. The effect of livestock farmers being vulnerable to climate change are that livestock population reduces due to decreased production. The increase in livestock production has been spatially uneven with livestock populations even decreasing or remaining stagnant in some locations (Lubungu *et al*., 2012).

To counter climate change effects, adaptation strategies are importantly needed and these must be developed within the context of a broad economic development policy (IPCC, 2007). Although there are several works on indigenous strategies farmers use to adapt to climate change, much of the research is focused on farmers as a whole, and data is mostly on the crop sector.

Interventions, especially the introduced strategies, are required to enhance the adaptive capacity and resilience of people to climate change in the long-term (ATPS, 2013), since Upper West region was found to be highly sensitive, a major component of vulnerability, to climatic stressors (Etwire *et al.*, 2013a).

From the foregoing, the level of vulnerability and adoption of adaptation strategies to climate change by livestock farmers are not known, and the fact that the determinants of vulnerability to climate change and adoption of adaptation strategies are unknown, this research therefore assesses the strategies used by smallholder livestock farmers in Upper West region of Ghana to adapt to climate change and aims to inform policy makers of the benefits of adopting specific strategies for enhanced livestock production. In achieving this, the following research questions would be addressed.

1. What is the level of vulnerability of smallholder livestock farmers to climate change
2. What factors influence the vulnerability level of smallholder livestock farmers to climate change
3. What is the level of adoption of adaptation strategies used by smallholder livestock farmers to climate change

4. What factors influence the adoption of adaptation strategies used by smallholder livestock farmers

1.3 Research Objectives

The main objective of the research is to assess strategies used by smallholder livestock farmers in the Upper West region of Ghana to adapt to climate change. The specific objectives are to:

1. Measure the level of vulnerability of smallholder livestock farmers to climate change

2. Determine the factors influencing the vulnerability level of smallholder livestock farmers to climate change

3. Measure the level of adoption of adaptation strategies used by smallholder livestock farmers to adapt to climate change
4. Determine the factors influencing the adoption of adaptation strategies used by smallholder livestock farmers

1.4 Justification of the Thesis

The findings of this research will address the needs of stakeholders such as researchers, development change agents like NGOs, policy makers and donors through the following ways: Firstly, this study measures the level of vulnerability of smallholder livestock farmers of each of the two districts (Lawra and Nandom) in the Upper West region of Ghana to the vagaries of climate change. This will guide decision-making on international aid and investment. Thus, policy makers will be informed on which district is more vulnerable so that priority can be given to the more vulnerable district given a limited resource.

Also, certain household, institutional and environmental factors are responsible for the vulnerability level of every society. Some of these factors are considered in chapter three. At this level, those factors that contribute significantly to the level of vulnerability of smallholder livestock farmers will be identified. The lack of or inadequacy and presence of a particular factor in a certain location contributes to measure the vulnerability level. Therefore, knowing these factors will again help policy-makers and donors to identify and use the right measures for adaptation to climate change at local, national and international level for climate change adaptation.

Furthermore, this study determines the level of adoption of both indigenous and introduced strategies. Knowing the strategies that are most important to livestock farmers will guide development change agents in promoting the use of the strategies to other livestock farmers both within and outside these districts.

Finally, the findings will identify the socio-economic, institutional and environmental factors that influence the level of adoption of these climate change adaptation strategies and will therefore aid policy makers to make inform decisions on which factors to improve for improve adoption of the strategies.

1.5 Organization of the Thesis

The thesis is organized into five main chapters. Chapter one is composed of the study background, the problem statement for which the research seeks to investigate, research questions and objectives as well as justification of the study. Chapter two consists of a review of literature relevant to this research; whiles chapter three entails the methodology (the study area, sampling techniques used and methods of data analysis to achieve the relevant objectives).

Finally, chapter four presents the empirical results of the survey conducted and chapter five is made up of summary of the findings, conclusion and suggested policy recommendations and future research areas.

CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

This chapter presents the relevant literature related to this study. It presents some terminologies and concepts, state of climate change in West Africa and narrowing down to Ghana level, impacts of climate change on livestock, types of climate change adaptation strategies and constraints to adoption of adaptation strategies, technology adoption theories, review of methods of analysis for measuring vulnerability to climate change and determining factors influencing vulnerability of farmers to climate change and adoption of adaptation strategies.

2.1 Important Terminologies and Concepts

This section defines and gives further explanations to terminologies that relates to this study. These terminologies include; adaptation and adaptation strategies, indigenous and scientific knowledge, vulnerability and its components to climate change as well as adoption.

2.1.1 Adaptation and Adaptation Strategies

Adaptation is the process of adjusting to real climate and its effects. Whiles adaptation seeks to control or avoid injury/trauma in human systems, human intervention may influence adjustment to expected climate change and its effects in natural systems (Field *et al.*, 2014). In other words, adaptation is defined as the adjustments in social or economic systems made to reduce the vulnerability of society by responding to actual or expected climate effects (Smit & Pilifosova, 2001; Smith *et al*., 1996). Farmers, particularly smallholder farmers depend on these adaptation strategies to adapt to the effects that characterize climate change. In general, vulnerable individuals have various options, obtain through indigenous and scientific knowledge, to enhance their adaptive capacity and decrease their risk associated with shocks and stress (Kasperson & Kasperson, 2001).

2.1.1.1 Indigenous Knowledge

Indigenous or traditional knowledge is based on the traditional practices in local societies. Indigenous knowledge is defined as that aspect of a cumulative generational knowledge obtained through peoples' cultural practices, beliefs and norms and their relationship with the environment (Berkes, 1999).

According to (FAO, 2009) indigenous knowledge also known as wisdom knowledge is one which is gained over a period of time and orally transmitted from generation to generation.

Indigenous knowledge system is build-on on narratives. These narratives can in turn provide intergenerational ideas of different kinds of environmental resource phenomena (Alexander *et al.*, 2011).

Indigenous knowledge often enhances further knowledge about the meaning of climate change to livelihoods, beliefs and ways of life beyond the meaning presented by statistically significant changes (Alexander *et al.*, 2011). For example, in the past, we could predict when the seasons would begin. The rainfall could be predicted to the day using signs like bird calls. The birds are still there, but now they don't make the sounds (Shaffer, 2014).

Over decades, indigenous knowledge has played an important role in solving problems, especially those related to climate change (FAO, 2009). The rural poor whose main occupation is farming in Ghana has established various means of adjusting to changes in the climate system, by depending on indigenous traditional information and beliefs (FAO, 2009). Indigenous traditional beliefs could give understanding for the evolution of robust and useful strategies (FAO, 2009).

Feed Related Strategies (FRS) is considered the first most important indigenous adaptation strategy. With the challenge of climate change, it is important to consider other alternatives to be able to meet the increasing demand for meat, milk and eggs by developing countries (Hegarty, 2012). Productivity of pasture depends on climate change while livestock productivity depends on availability of pasture, livestock mobility and livelihood diversification options (Ayantunde *et al.*, 2011).

With increasing human population, crop fields are been lost to grazing areas, forcing pastoralists to travel long distances in search of feed and water for their livestock (Bassett & Turner 2007). Crop residue becomes the main source of feed ingredients to West African Farmers (Ayantunde *et al.*, 2011). Other farmers utilise leguminous crop residue such as cowpea and groundnut haulms and cereal straws like millet, maize, rice and sorghum for dry season feeding (FAO, 2014). In addition, cereal grains are produced and offered as feed to poultry. Other types of poultry feed include fresh grasses and cotton seed cake (Amadou *et al.*, 2012).

The second most important indigenous strategy is Health Related Strategies (HeRS). Climate change affects the health of farm animals by posing heat-related diseases and stress. Khan *et al.* (2013) note that the latex, shoots and leaves derived from calotopis procera plant can be used to reduce pain and treat wounds in farm animals. Also, the grasshopper of the plant can also be used to enhance the sexual behavior in farm animals. The authors further indicate that raw fruits obtain from caparis deciduas is used to treat anthelmintic ailments and to increase appetite for grazing among livestock.

Another indigenous strategy is the House Related Strategies (HRS). Planting fodder trees around livestock sheds and pens to reduce effects of cold or heat waves is an important adaptation strategy used by some farmers (Singh *et al.*, 2012). Other housing related strategies include; keeping animals outside the house at night during summer, freeing animals during adverse climatic conditions to search for feed and safe place as well as constructing platforms/perches inside houses (Meena *et al.*, 2008) reports that, provision of fire in livestock sheds and pens during extreme cold is another adaptation strategies adopted by farmers. Also, the housing condition of farm birds is usually in small cages and that creates room for the spread of diseases such as gastro-intestinal parasites (Nghonyuji *et al.*, 2014).

The fourth indigenous adaptation strategy considered in this study is the Breed Related Strategies (BRS). Most farmers destock their large animals and keep small animals during adverse climatic conditions. Small animals are said to survive better in those conditions as they require less water and feed. Whiles some farmers obtain exotic breeds, others are of the view that, local breeds do not require plenty water and are able to resist to a good number of diseases and well survive in adverse climatic condition (Singh *et al.*, 2012).

2.1.1.2 Scientific Knowledge

On the other hand, scientific knowledge through which introduced strategies are build, is defined as a set of statistically analyzed records which depends on exact or specific meaning of exogenous and endogenous factors which can be measured empirically and that show acceptable levels of reliability and validity (Alexander *et al.*, 2011).

Several technologies and practices are available for smallholder farmers in Northern Ghana to enable them better adapt to the effects of climate change (Etwire et al., 2013b). Some farmers are able to adjust and adapt better than others depending on farm management practices, land management practices, farm characteristics, livelihood strategies and farmer socio-demographic characteristics (Mabe *et al.*, 2014). Some farmers are however not able to fully take advantage of the technical and economic opportunities around the strategies since adoption only takes place after awareness (Etwire *et al*., 2013b).

The Feed Related Strategies (FRS) is considered to be the most important introduced adaptation strategy. Adaptation to climate change through nutritional improvement will also be achieved by breeding of new pasture varieties that are adapted to anticipated climatic conditions (Hegarty, 2012). Pastoral strategies for maintaining production include moving livestock according to vegetation needs and water availability, keeping species-specific herds to take advantage of the heterogeneous nature of the environment, and diversifying economic strategies to include agriculture and wage labor, among others (Galvin *et al*., 2004). Moore and Ghahramani (2014) classified adaptation options into two (2); feed-base and genetic adaptation options. The genetic adaptation option can be related to that of specie or breed related strategies considered in this work, and as discussed below.

The feed-base adaptations, on the other hand, are useful to the extent that they allow the Optimal Sustainable Stocking Rate (OSSR) to increase (Moore & Ghahramani 2014). The greater impact of climate change on OSSR and hence profitability in drier environments means that much larger proportional improvements are needed from adaptation strategies (Moore & Ghahramani 2014). Among the livestock enterprises considered in their analysis, the main advantage of the feed-base adaptations (especially higher soil fertility) over the genetic adaptations was that they can be employed effectively across all the livestock enterprises (Moore & Ghahramani 2014). A study by Amadou *et al.* (2012) indicate that self-compounded feed among poultry farmers in three West African cities of kano (Nigeria), Bobo Dioulasso (Burkina Faso) and Sikasso (Mali) were very common, with some farmers using the commercial feed and home-made feed mash depending on the location.

Another introduced strategy is the Health Related Strategies (HeRS). Heat stress among livestock is one common source of health concerns since it causes mortality and morbidity. Adaptation option suggested has been the provision of shade (proven to be highly economical) or the use of active cooling mechanisms such as sprinklers, increasing air velocity and provision of cool drinking water. Other health strategies include regular cleaning of the animal house, disinfection as measures to prevent occurrence of diseases, changes in stocking density and nutritional measures (Skuce *et al.*, 2013). Also, strategic alterations to the timing of the application of anthelmintic treatment may be able to nullify the effects of the lengthening transmission season (Morgan and Wall, 2009).

Direct access to water such as rivers and pools is effective in cooling animals in a grazing situation, as animals will stand in the water and splash it over themselves. Health related strategies also include management change that seeks to decrease opportunities for parasite transmission, such as alternating grazing of lambs on a particular pasture (Skuce *et al.*, 2013).

In terms of the housing strategies, modern livestock housing requires that, production of livestock by confinement requires heating, ventilation and cooling for the animal buildings. Some houses may be mechanically (artificially) or naturally ventilated (Skuce *et al*., 2013). The use of natural ventilation, a common management practice by poor farmers, in animal buildings should be maximized through the use of open-sided sheds (Skuce *et al*., 2013). The ultimate purpose of ventilation is to supply fresh air to, and meet the heating/cooling requirements of animals. It fulfills this purpose by bringing fresh air into the building airspace to replace and dilute the heat, moisture, toxic gases, and contaminants that eventually build up indoors (Zhang and Funk, 2000). Other housing strategies include the supply of water and bedding/litter (Skuce *et al*., 2013) cleaning and disinfection.

The fourth introduced strategy is the Breed Related Strategies. Breeds of livestock reared in West Africa are the local, exotic or an improved breed of both the local and the extotic types. In most cases, the exotic types are bred through artificial insemination or natural service methods (Boettcher and Perera, 2009). A wide range of genetic improvements – those that improve the efficiency with which livestock convert forage to animal product – are also potentially viable adaptations to the reductions in forage supply that can be expected under future climates (Moore & Ghahramani 2014). Conventional breeding methods rely on physical characteristics or phenotypes to calculate the breeding values (BV) of animals. Breeding strategies are geared towards improving on meat yield and quality traits like carcass weight, marbling, intramuscular fat, eye muscle area (Lee *et al*., 2014).

Hoffmann (2013) classified breeding strategies into two main groups namely: classification based on general adaptation and that of fodder and feeding adaptation strategies. Classification based on general adaptation include; locally adapted, poorly adapted, drought resistant, drought susceptible, hardy, heat sensitive, rough weather and rustic breeds of livestock. Rustic refers to breeds that are adaptable to a wider range of environments. On the other hand, classification based on fodder and feeding adaptation strategies include; coarse vegetation, good feed conversion, good foragers, good walkers, long walking and feeding intervals, night grazers, poor fodder quality users, among others. Skuce *et al.*, (2013) also considers more heat-tolerant lines/strains, in other words genetic selection among livestock as a breed related strategy.

2.1.2 Vulnerability to Climate Change

Vulnerability is an elusive concept because its meaning and understanding is different in many disciplines of studies such as economics, engineering, psychology (Aspires, 2014). It can be define as the likelihood to which a system or subsystem will experience deleterious effect due to its state of exposure to a hazard (Turner *et al.*, 2003). In other words, vulnerability is the susceptibility of a given population, system, or place to harm from exposure to the hazard and directly affects the ability to prepare for, respond to, and recover from hazards and disasters (Cutter *et al*, 2009). Vulnerability refers to the potential for loss (Barnett *et al*., 2007). The IPCC has defined vulnerability as the degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability as define is the potential for loss of property or life from environmental hazards (Cutter *et al.*, 2000). It can also be defined as the propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope and adapt (Field, 2014).

Research indicates that vulnerability is measured not by exposure to natural hazards such as perturbations and stresses alone but also resides in the sensitivity and resilience of the system experiencing such hazard (Turner *et al*., 2003).

At any point in time, people are likely to be vulnerable due climatic situations that engulf the strategies they have in place (Galvin *et al.*, 2004). Vulnerability occurs due to socioeconomic factors (economic, social and political constraints) and biophysical factors which cause a change in the environment (Galvin *et al.*, 2004). This study therefore defines vulnerability as the extent to which a systems' affinity to perturbations of climate extremes is most likely to occur.

2.1.2.1 Elements of Vulnerability

Vulnerability is of two types- physical and social vulnerability. Social vulnerability is the extent to which a system or sub-system is likely to be susceptible to the effects of climate change due to interrelationship of social, economic and demographic factors (Dumenu & Obeng, 2015). The elements of vulnerability include adaptive capacity, sensitivity and exposure. Exposure refers to the availability of people, species or ecosystems, livelihoods, services, resources, infrastructure, environmental functions, economic, social, or cultural assets in locations and settings that could be adversely affected (Field *et al.*, 2014). Sensitivity on the other hand refers to the degree at which a system is instantly affected by a perturbation (Fussel, 2007). Sociopolitical and ecological situations both shape sensitivity and it involves continuous adjustments and responses made in anticipation of disturbances (Kasperson & Kasperson, 2001). Adaptive capacity is the ability of a system to cope or respond successfully to the impacts of climate change with impacts of climate change (IPCC, 2007; Smit & Pilifosova, 2001)**.**

In this study, adaptive capacity is defined as the ability of smallholder livestock farmers to use local (within their environment) and scientific materials (which can easily be access) to be able to withstand the effects of climate change.

2.1.3 Adoption of Adaptation Strategies

Namara *et al.* (2007) define adoption as an act of accepting a technology with approval. Adoption refers to a situation when an individual or an organization make decision to receive or reject a given new technology (Rogers, 1995). Feder *et al.* (1985) distinguish between farm level and aggregate adoption of a technology according to its coverage. The authors defined farm level adoption as the degree to which a new improved technology is incorporated into the production process in long-run equilibrium when the producer has complete knowledge concerning the new innovation and its prospects, and applies it on his farm.

2.2 State of Climate Change in Ghana

Ghana depends mainly on rainfed agriculture and is extremely vulnerable to climate variability and change (FAO, 2009). In Ghana, recorded temperatures rose about 1ºC over the last 40 years of the twentieth century, while rainfall and runoff decreased by approximately 20 and 30 percent, respectively (EPA-Ghana, 2000). In Ghana, climate change and climate variability have brought several exposure-sensitivities on different people and at different times. Due to the multiplicity of climate change and climate variability effects, adaptation strategies invariably could be influenced by several factors (Bawakyillenuo *et al*., 2014).

The climate of the Northern Savannah zone is relatively dry. It is therefore not surprising that many of the farmers reported noticing decline in rainfall amount. Also, most farmers have noticed that, the average temperature in their localities has increased whiles rainfall amount has decreased in the past 30 years, and that perceptions of temperature changes slightly across study localities (Teye *et al.,* 2015).

Determination of climate change among some farmers in Ghana is a problem. For instance, a number of farmers were not certain about what climate change actually means, although they maintained that the rainfall pattern had changed (Teye *et al.*, 2015). Recent studies show that mean annual temperature in Ghana has increased by 1.08^0C since 1960, an average of 0.218^0C per decade (McSweeney *et al.*, 2008). Ghana has experienced about a 18^oC rise in temperatures over the past three decades, with rainfall decreasing by 20% and run off by 30% (McSweeney *et al.*, 2008). In other studies, temperatures are expected to change by 0.68^0C, 2.08^0C and 3.98^0C in 2020, 2050 and 2080 respectively (EPA, 2011). Also, based on future scenarios total annual rainfall is expected to decrease by 9–27% by the year 2100, with the range representing spatial variations (EPA-Ghana, 2000). Furthermore, estimates by MESTI (2013) show an increase of temperatures from 1.7°C to 2.04°C by 2030 in the northern savanna regions, with average temperatures rising as high as 41°C. The climate of the Lawra district is the tropical continental type. The period between February and April is the hottest, whiles the period between April and October is the only wet season. Climate change has led to the change in weather pattern (GSS, 2014a).

2.2.1 Historical Impacts of Climate Change on Livestock

There is no enough literature on the impact of climate change on livestock rearing even with several studies that climate change exacerbate on agriculture, especially crop production (Seo & Mendelsohn, 2006). Nonetheless, the following impacts have been noticed by other researchers.

Livestock are affected by climate change immediately and accidentally. The immediate effects, as a result of wind speed, temperature and humidity, influence growth, products obtain from livestock (milk, meat and wool production) and reproductive system. The accidental effects lead to a reduction in the quantity and quality of pasture and forage availability, and increase incidence of parasitic diseases that affect livestock (Houghton *et al.*, 2001; Seo & Mendelsohn, 2006).

The impact of climate change on animal production has been categorized by (Rotter and vande Geijn, 1999) as; availability of feed grain, pasture and forage crop production and quality, health, growth and reproduction and disease and their spread. Animal health may be affected by climate change in four ways: heat-related diseases and stress, extreme weather events, adaptation of animal production systems to new environments, and emergence or re-emergence of infectious diseases, especially vector borne diseases which are critically dependent on environmental and climatic conditions. Upadhyay *et al.* (2016) state that thermal stress on Indian livestock particularly cattle and buffaloes have been reported to decrease oestrus expression and conception rate. In Ghana, frequently observed climate change impacts in the four ecological zones were erratic rainfall, reduction in crop yield, prolonged drought and shift in cropping season (Dumenu & Obeng, 2015).

2.2.2 Projected Impacts of Climate Change on Livestock

Projections of future climate change are generally made with the use of coupled atmosphere–ocean global climate models (AOGCMs), which provide a comprehensive, but still uncertain, representation of the climate system (Barnett *et al.*, 2007). Global mean surface temperature is projected to increase by between 1.48C and 5.88C and global mean sea level to rise by between 9 and 88 cm by 2100. These ranges are subject to both scientific uncertainties and to the range of future greenhouse gas emission scenarios (Barnett *et al.*, 2007). Agriculture is experiencing a lot of changes, with major changes anticipated in livestock systems globally (Herrero & Thornton, 2013). The demand for livestock products is projected to grow substantially in the coming decades (Herrero & Thornton, 2013). There is significant uncertainty about both how livestock systems might evolve to meet the increased the demand for livestock products and what the social and environmental consequences of these changes will be (Herrero & Thornton, 2013).

Climate change has a heavy impact on resources that are highly sensitive, especially water resources, soils and coastal zones (Barnett *et al.*, 2007). Climate model projections suggest an increase in global average surface temperature of between 1.8 and 4.0 8C to 2100, the range depending largely on the scale of fossil-fuel burning between now and then and on the different models used (IPCC, 2007).

Climate change impacts will also shift growing zones, and influence the presence of weeds, diseases and pests. Increased temperature and rainfall will likely alter forage composition, create favorable conditions for livestock diseases and pests, and lead to more animal deaths from heat exhaustion (NAPA, 2007).

2.2.3 Impacts of Climate Change on Livestock and Livestock Producers

As atmospheric greenhouse gas concentrations continue to rise and record temperatures are being recorded globally it is clear that greenhouse warming is a real threat to animal agriculture (Collier & Zimbelman, 2007). Climate change in particular global warming is likely to affect the health of farm animals, both directly and indirectly. Direct effects include temperature-related illness and death, and the morbidity of animals during extreme weather events. Indirect impacts follow more intricate pathways and include those deriving from the attempt of animals to adapt to thermal environment or from the influence of climate on microbial populations, distribution of vector-borne diseases, host resistance to infectious agents, feed and water shortages, or food-borne diseases (Nardone, *et al.*, 2010). Hot environment impairs production (growth, meat and milk yield and quality, egg yield, weight, and quality) and reproductive performance, metabolic and health status, and immune response. The process of desertification will reduce the carrying capacity of rangelands and the buffering ability of agro-pastoral and pastoral systems (Nardone *et al.*, 2010).

Acclimation to high environmental temperatures involves responses that lead to reduced heat load. The immediate responses are the reduction of feed intake, increase in respiration rate and water intake and changes in hormonal signals that affect target tissue responsiveness to environmental stimuli (Collier & Zimbelman, 2007). Mitigation strategies against heat stress can be achieved through various means. Existing heat abatement technologies such as improved shade, ventilation and spray cooling will remain cornerstones of any piggery (Cottrell *et al.*, 2015).

2.3 Agricultural Technology Adoption Theories

Many theories have been outlined to provide meaning *to* technology acceptance (Röcker, 2010). These theories are user acceptance, decision making, personality, organizational structure and diffusion theories (Hilmer, 2009).

All these theories predict prerequisites for the adoption of innovation (Rissanen, 2014). A number of sub-theories make-up these theories. For instance, the user acceptance theory includes sub-theories such as reasoned action, planned behavior, technology acceptance and motivational theories. The decision making theories include rational choice/game theory, decision making under uncertainty, risk management, change management and media richness theories. The personality theories include technology life cycle theory and non-technology related approaches (social cognitive theories). The disruptive technology and creative destruction theories comprise the organizational structure theory. Finally the diffusion theory comprise the innovation diffusion and technology life cycle theories (Hilmer, 2009).

For the purpose of this study, the diffusion theory is discussed into detail since it focuses on the environment. Diffusion is the process of communicating an innovation through certain process over a period of time among individuals in a society (Rogers, 1995). The author further states that the four main elements of diffusion of innovations include communication channels, time and social system.

The diffusion process includes five stages. These are the awareness, interest, evaluation, trial and adoption stages (Beal and Bohlen, 1957). At the awareness stage, a farmer becomes aware of a new idea such as the drought resistant livestock breed. Thus, the farmer has knowledge that an idea does exist, but do not enough details about it. The farmer may know only the name of the product and may not know what the idea or product is, what it will do, or how it will work.
The interest stage is the second stage during the diffusion process. At this stage, a farmer wants more knowledge about the idea or product. He wants to know what it is, how it works, and what its potentialities are. He may say to himself that this might help him increase his income, or help him control diseases occurrence among his livestock.

The diffusion process continues to the third stage, the evaluation stage. During this stage, the farmer makes a mental trial of the idea. He puts the information into use obtained in the previous stages to his own situation. He asks himself, "Can I do it; and if I do it, will it be better than what I am doing now - will it increase my income, or will it help maximize any other values which I deemed important?"

At the fourth stage, if the farmer decides that the idea has possibilities for him, he will try it. The trial stage is characterized by small-scale, experimental use, and by the need for specific information which deals with: "How do I do it; how much do I use; when do I do it; how can I make it work best for me?"

Finally, the adoption stage is characterized by large-scale continuous use of the idea, and most of all, by satisfaction with the idea. This does not mean that a farmer who accepts an idea must use it constantly, but rather he accepts the idea as good and intends to use it in his on-going farm activities (Beal and Bohlen, 1957).

2.4 Review of Empirical Research

In carrying out this study, the achievement of the objectives resulted in the use of a metric, Livelihood Vulnerability Index, to estimate vulnerability and two statistical tools, Tobit and multinomial logit models to estimate the relationship among variables. The livelihood vulnerability index was used to measure the vulnerability status of each livestock farmer. The Tobit model was employed to determine the determinants of vulnerability, and finally the multinomial logit model was used to determine the factors influencing the adoption of adaptation strategies.

2.4.1 Measuring Vulnerability of Smallholder Livestock Farmers

Vulnerability is complex and often not driven by a single factor (FAO, 2013). There are a number of proposed methods to measure a group's vulnerability (Galvin *et al.*, 2004). According to (FAO, 2013), the measurements of vulnerability have been categorized into three main methodologies namely; indicator based, models and GIS-based and stakeholder based methodologies. The indicator based methodologies have four sub-indexes namely; socio-economic, physical process, coastal and livelihood vulnerability indexes. Opiyo *et al*. (2014) also identifies these measurements of vulnerability to include; socio-economic, biophysical and an integrated approach. The integrated approach unites both the socio economic and biophysical factors. The socio-economic vulnerability assessment approach focuses on the socio-economic and political status of individuals or groups. Thus it focuses on identifying the adaptive capacity of individuals or communities based on their internal characteristics. The limitation of the socio-economic approach is that it focuses only on variations within society, it does not account for the natural resource bases of society. They further state that the biophysical attempts to assess the level of damage that a given environmental stress causes on both social and biological systems. The limitation of this approach is that, it neglects both the structural factors and human agency in producing vulnerability and in coping or adapting to it. The third approach is the integrated vulnerability analysis, which combines both the socio-economic and biophysical factors. This approach includes all the internal state of vulnerability and the external situation (Opiyo *et al.*, 2014).

The integrated approach extends to developing the Livelihood Vulnerability Index (LVI). In this regard, two approaches are presented: the first expresses the LVI as a composite index comprised of seven major components while the second aggregates the seven into IPCC's three contributing factors to vulnerability— exposure, sensitivity, and adaptive capacity (Hahn *et al*., 2009; Etwire *et al.*, 2013; Panthi *et al.*, 2015). This study has adopted the latter method to measure the LVI's of smallholder livestock farmers to climate change.

Hahn *et al*., (2009) report that Mabote district (0.005) was more vulnerable than Moma district (-0.074). Whiles Mabote district was more exposed to climatic perturbations, the adaptive capacity of Moma district was higher than Mabote district, but Moma district was more sensitive than Mabote district. Etwire *et al.*, (2013) in a study of regional assessment of vulnerability studies in Ghana, the findings reveal that Northern region (0.004) was the most vulnerable region followed by Upper East (-0.007) and then Upper West region (-0.015). The reasons are that Northern Region was the most exposed followed by Upper East and then Upper West. Upper East was however more adaptive and therefore show more resilience than the Upper West with Northern showing the least adaptive capacity. In terms of sensitivity, Upper West was more sensitive than Northern. The least sensitive region was Upper East region.

In a district study of an assessment of impacts of climate change on crop-livestock farmers in Nepal, Panthi *et al.* (2015) observe that Dhading district (0.2889) was more vulnerable to climate change and variability than Kapilvastu district (0.28863). Syangja district (0.2592) was the least vulnerable to climate change impacts. Dhading district was more expose, Syangja was more adaptive and Kapilvastu district was more sensitive.

Luers *et al.* (2003) in assessing the vulnerability of wheat yields to climate variability and change, proposed a new method to quantifying vulnerability that integrates four essential concepts namely, the state of system relative to a threshold of damage, sensitivity, exposure and adaptive capacity.

While there is no consensus on the best approach to vulnerability assessment, in general they entail considering one or more of: exposure to climate risks, susceptibility to damage, and capacity to recover. It is difficult to determine the superiority of any given approach to vulnerability. Regardless of the definitions used and the approach taken, for the sake of clarity, comparability, and theoretical and methodological development, each vulnerability study should make clear the definitions it uses and the method of assessment it deploys (Barnett *et al.*, 2007). Vulnerability can be measured by combining poverty indicators with a measurement of the diversity of resources (Adger *et al.,* 2001). Measuring vulnerability is a complex endeavor that requires the ability to analyze the relationships between diverse indicators. A powerful tool for this type of analysis is integrated modeling (Galvin *et al.*, 2004).

The indicator approach computes indices based on selected indicators. Most often, indicators are made up of one or several proxy indicators or variables (Dumenu & Obeng, 2015). A vulnerability assessment, by contrast, considers the climate event in the context of other stresses and perturbations that together produce impacts from compound events. Vulnerability depends upon the assets (labour, human capital, productive assets) that a household has, the entitlements to food that it possesses, and the extent to which people, given the assets at their disposal, can adapt (Kasperson & Kasperson, 2001). Again, Kasperson & Kasperson (2001) observed that history matters greatly and snapshots are inadequate for understanding vulnerability, not all the poor are vulnerable, the processes involved are complex and dynamic, vulnerability typically involves multiple stresses; differential vulnerability is the norm; vulnerability to what must be answered and vulnerability is not a residual concept in global environmental change; it is an integral part of such change.

In another studies, to assess gender-based based vulnerability to climate change, vulnerability analysis was employed by using household adaptive capacity approach. This approach determines the potential impact and adaptive capacity, and vulnerability is determine by the difference between the potential impact and adaptive capacity (Amusa *et al.*, 2015).

2.4.2 Factors Influencing Vulnerability to Climate Change

The vulnerability of people and their environment to climate change is a function of socio-economic and biophysical factors (FFC & FANRPAN, 2013). In identifying the determinants of household vulnerability to climate change, Mutsvangwa-Sammie *et al*. (2013) state that male farmers, farming experience, member of a social group, annual household income are associated with higher crop production. The authors however found that education of the farmer, age of the household head, extension contacts and access to weather information has no effect on crop production.

In their study of vulnerability determinants to poverty among female headship, Muleta & Deressa, (2014) found out that an illiterate and an increase in the age of a female headship is associated with increased vulnerability to poverty. Households that has access to extension service are associated with increased vulnerability but those who has access to credit scheme are associated with decrease vulnerability (FFC & FANRPAN, 2013).

2.4.3 Factors Influencing the Adoption of Adaptation Strategies

Several household, institutional and environmental factors influence the decision to adopt an innovation (Bawakyillenuo *et al.*, 2014). Using a logistic regression, Ngombe *et al.* (2014) in their study of factors influencing conservation farming practice in Zambia noted that household size, age of household head, marital status, adult labour availability, farm income and livestock holding were the household factors that influence adoption. The climatic factors were agro ecological region I and II whiles the institutional factors were distance to vehicular road and access to loans. Hassan & Nhemachena (2008) in determining farmers‟ strategies for adapting to climate change reveals that for farmer's age, older farmers are more experience and expect older farmers to adapt to climate change better than farmers whose age are lesser. However, they also assumed younger farmers to have a longer planning horizon and to take up long term measures that will influence their decision to increase production levels. Deressa *et al.* (2010) report that age has a positive influence on the choice of livestock sale as an adaptation strategy by farmers during extreme climatic events.

Farmers' income has a positive relationship with adoption and is significant at 1 percent significant level. The implication is that, for every unit of increase in the farmers' income, there would be a 0.24 increase in adaptation to strategies. It has been noted that, lack of fund constraints the adoption and risk bearing abilities of farmers (Iheke and Oliver-Abali, 2011).

In the study of socioeconomic factors influencing adoption of cocoa technologies in Ghana, using a Tobit model, farming experience, farmer training, age of household head, gender, household size, age of the farm and social capital were identified to influence the adoption of cocoa technologies Baffoe-Asare *et al.,* (2013). Farmers' farming experience was positively related to the adoption of climate change mitigation strategies. This implies that the probability of adoption would increase with increase in farming experience. Highly experience farmers are likely to have more information and knowledge on changes of climatic conditions and crop and livestock management practices (Iheke and Oliver-Abali, 2011).

A study in Kenya by Ahmed *et al.* (2013) identified education of the household head, experience in water storage, farm size, awareness of farmers of techniques in water harvesting, farming as a main source of income and age as factors influencing the adoption of rainwater harvesting techniques, using a logistic regression. Farm size is negatively related to adoption index and was significant at 5 percent. This implies that as the size of the area to be cultivated is increased, there would be decrease in the level of adaptation to strategies due to cost implications. That is because the farmers incur greater cost in the adoption of strategies when he has very large hectarage of land (Iheke and Oliver-Abali, 2011).

Also, Fadare *et al.* (2013) noted that in their study of the factors influencing the adoption of improved maize varieties opine that educational status of the farmer, farm size, use of fertilizer, access to extension visits and geographical location of the farmer influenced their decision to adopt a particular maize variety. They assumed that a higher education level and more farming experience will improve awareness of potential benefits and willingness to participate in local natural management activities to take advantage to increase production levels. Therefore, they expected that improved knowledge and farming experience will positively influence farmers' decision concerning production levels. With farm size, a farmer with large farm size would easily make a choice that increases production levels while farmers with small farms are expected to diversify their options (Hassan and Nhemachena, 2008).

In another studies of the adoption intensity of smallholder maize farmers, the probit model results reveal that age, education, farm size, livestock asset, participation in social groups, extension services, seed access, yield potential and location of the farmer affected the adoption decisions (Ghimire *et al.*, 2015). Age of the farmer was significant at one percent and negatively related to the adoption of climate change mitigating strategies. This implies that the older the farmer becomes, the lower the probability of adopting farm management and crop diversification strategies. As farmers level of education increases, there would be an increased awareness of available adaptation strategies to climate change (Iheke and Oliver-Abali, 2011).

2.4.4 Measuring the Adoption Level of Climate Change Adaptation Strategies

Evidence of adoption in some other studies has been demonstrated using qualitative methodology. Such studies have stated the importance of the adopter perception in accepting an innovation. Nti *et al.* (2002) employed participatory rural appraisal tools in their study on adoption of improved fish smoking technology.

Bonabana-Wabbi (2002) asserts that The measurement of adoption is estimated by intensity and rate of utilization of the introduced technology and this further depends on the nature of the data, that is whether it quantitative or qualitative or a mixture of both. Alene *et al.* (2000), in their study of the determinants of adoption and intensity of the use of improved varieties of maize in Ethiopia employed a quantitative method, Tobit model and a qualitative method.

Kante *et al.* (2008) use ethnographic case study in three villages in Mali (West Africa) to ascertain shea butter producers' perceptions toward technologies that improve the efficiency of shea butter production. However, the result from case studies may differ from place to place resulting from cultural variation across space. Evidence of technology adoption from different places may therefore be different from that of northern Ghana when the method of analysis is rooted from a case study.

CHAPTER THREE

METHODOLOGY

3.1 Introduction

The conceptual framework of this study establishes the relationship of how climate change imparts on smallholder livestock farmers, thus making them vulnerable to climatic stressors, adaptation measures they adopt in order to adapt and the levels of adoption of the adaptation strategies. The methods of addressing each objective are also outlined, including the description of the study area, sources and methods of data collection and software used to analyse the results.

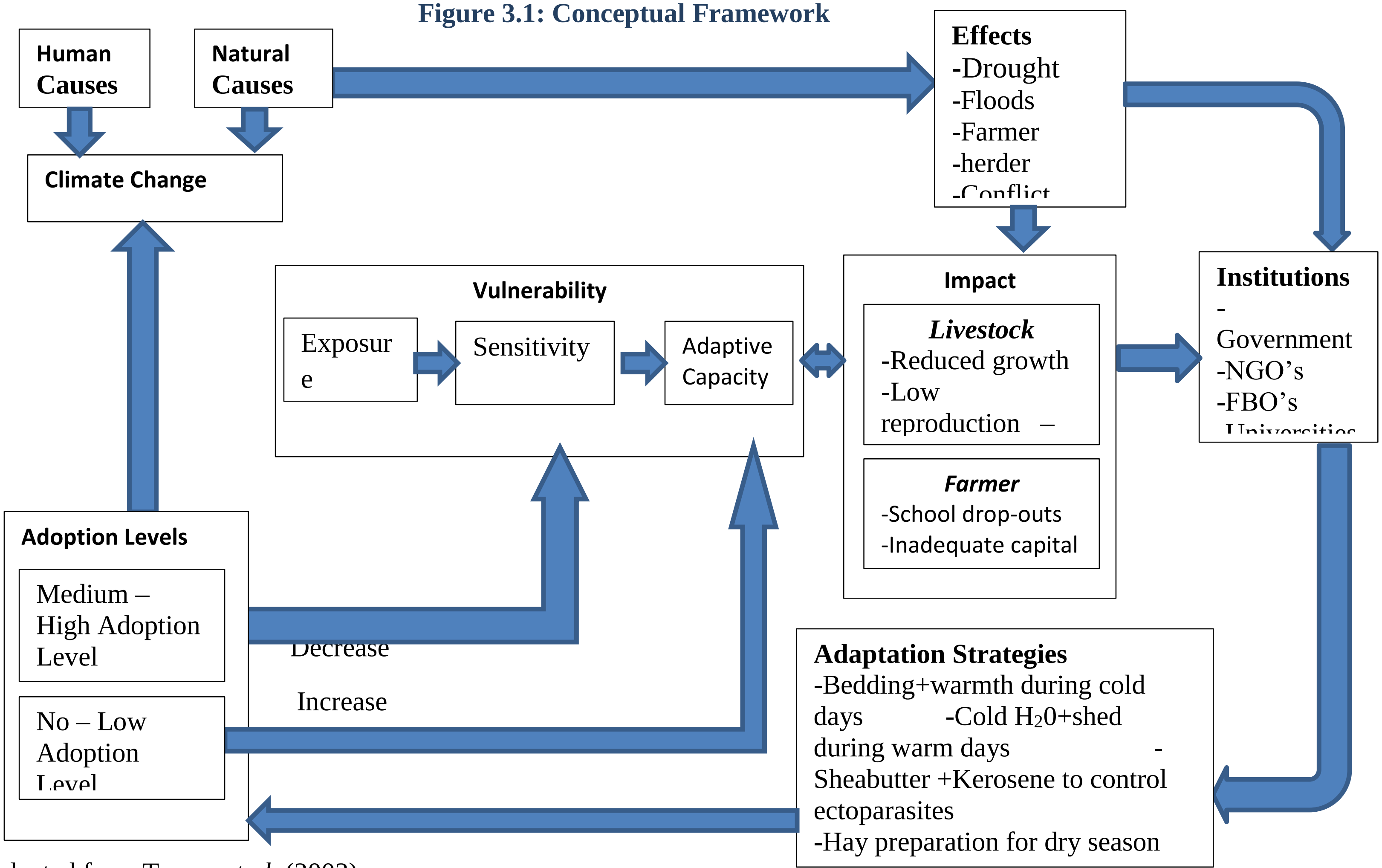
3.2 Conceptual Framework

The conceptual framework of this study (Figure 3.1) emanates from the general view that climate change is the result of human activities such as all activities that releases carbon-dioxide (CO_2) into the atmosphere and natural events such as changes in volcanic activity, solar output, the earth's orbit around the sun and variations in ocean currents or atmospheric circulation. This brings about climate change effects such as droughts, floods, farmer-herder conflict which affects the reproductive and productive capacity of livestock and the livestock farmer respectively.

The impact of climate change on livestock could be one or more of the following; reduced growth, low reproductive capacity, increased incidence of diseases and parasitic infestation, reduced milk and meat yield and quality, etc. For the impact on the farmer, the income from the sale of livestock is sometimes used by farmers to cater for other household needs including the payment of school fees and many other economic, social, cultural and religious activities.

Livestock is also considered as a source of income which can be sold and reinvested in farming activities particularly in the food crop sector.

Figure 3.1: Conceptual Framework



Source: Adapted from Turner *et al*. (2003)

Whiles the aforementioned effects have an impact on livestock and livestock farmers; it is also a worry to researchers in research-based institutions, universities, NGOs, FBOs, etc. On this score, researchers help farmers by introducing new climate change adaptation strategies such as provision of bedding and warmth during cold days, provision of cold water shed during warm days, hay and silage production, formulation of feed for livestock feeding, a mixture of sheabutter and kerosene to control ectoparasites and among others, for the adoption by farmers. These introduced or research-based strategies are to find solutions to the negative effects of climate change.

When the adaptation strategies are identified, it is disseminated to farmers to apply. For the purpose of this study, the adoption by farmers has been grouped into two (2) folds; No-Low adoption and medium-High adoption. When farmers do not or adopt slowly, it results in increased vulnerability. Thus, the sum of exposure and sensitivity will be higher than their adaptive capacity. On the other hand, medium-high adoption results in reduced vulnerability, hence the sum of exposure and sensitivity will be less than their adaptive capacity, thereby posing reduce or low impacts of climate change and the cycle continues. No-Low adoption levels lead to negative effects of climate change. The reverse (medium-high adoption level) is true for positive effects.

Vulnerability is therefore a function of three (3) factors; these include exposure, sensitivity and adaptive capacity of livestock farmers. These three factors have been explained in chapter two of this study. Livestock farmers who are exposed to drought, floods, etc are more sensitive. Their ability to adapt therefore measures their level of vulnerability.

3.3 Methods of Data Analysis

This section presents the various methods of achieving the specific objectives of the study.

3.3.1 Measuring the Vulnerability Level of Smallholder Livestock Farmers

There has been a paradigm shift of measuring vulnerability using qualitative methods which are centered on conceptual models and frameworks to more quantitative or empirical methods due to developments in vulnerability science. The quantitative methods also provides evidence-based and empirically derived information which support the adaptation decision making process for climate change policies (Cutter *et al.,* 2009). The study therefore adopts a quantitative method of measuring vulnerability as explained below.

3.3.1.1 Measuring Vulnerability of Smallholder Livestock Farmers-LVI Approach

Vulnerability is measured by the Livelihood Vulnerability Index (LVI) using Microsoft Excel software. The procedure of estimating the LVI can be described as a framework. The Livelihood Vulnerability Framework (LVF) is commonly used in measuring vulnerability to climate change. The framework makes it possible to analyze each of the major components that constitute livelihood.

The LVI is estimated for each of the two (2) districts under study, having in mind the vulnerability definition used by Intergovernmental Panel on Climate Change (IPCC) (Hahn *et al.*, 2009). The authors considered seven major components which include socio-demographic profile, livelihood strategies, social networks, health, and access to food, access to water, and natural disasters and climate variability. Each component is made up of a number of other sub-components known as indicators. Each of these indicators is measured on a different scale. It is therefore important to normalize each as an index using equation (1).

$$index_{sd} = \frac{S_d - S_{\min}}{S_{\max} - S_{\min}} \tag{1}$$

Where S_d is the observed sub-component indicator for district, d and S_{min} and S_{max} are the minimum and maximum observed values respectively.

The sub-component indicators are then averaged using equation (2) to obtain the index of each major component:

$$M_d = \frac{\sum_{i=1}^{n} index_{sdi}}{n} \tag{2}$$

Where M_d is one of the seven major components [Socio-Demographic Profile (SDP), Livelihood Strategies (LS), Social Network (SN), Health (H), Food (F), Water (W), or Natural Disaster and Climate Variability (NDCV)] for district d; $index_{s_{di}}$ represents the sub-components, indexed by i , that make up each major component, and n is the number of sub-components in each major component. Once the values for each of the seven major components for each of the districts are calculated, they are also averaged using Equation (3) to obtain the district-level LVI:

$$LVI_d = \frac{\sum_{i=1}^{7} W_{Mi} M_{di}}{\sum_{i=1}^{7} W_{Mi}} \tag{3}$$

Alternatively, LVI_d can be rewritten as:

$$LVI_d = \frac{W_{SDP}SDP_d + W_{LS}LS_d + W_H H_d + W_{SN}SN_d + W_F F_d + W_W W_d + W_{NDCV}NDCV_d}{W_{SDP} + W_{LS} + W_H + W_{SN} + W_F + W_W + W_{NDCV}} \tag{4}$$

Where w_{Mi}, the weights of each major component, is a function of the number of sub-components that make up each major component and are included to ensure that all sub-components contribute equally to the overall LVI.

Following Hahn *et al.* (2009) and Panthi *et al.* (2015), the vulnerability spider diagram was then used to illustrate the vulnerability index of each major component.

3.3.1.1 Measuring Vulnerability of Smallholder Livestock Farmers, IPCC-LVI Approach

Following from the LVI approach to vulnerability measurement, Hahn *et al*. (2009) then calculated a new variable and named it LVI-IPCC, using equations (1)-(3). The authors considered the IPCC definition of vulnerability and re-grouped the seven major components into three contributing factors. That is, the LVI-IPCC diverges from the LVI when the major components are combined. These combinations are exposure, adaptation capacity and sensitivity using the following equation:

$$\mathrm{CF_d} = \frac{\sum_{i=1}^{n} W_{Mi} M_{di}}{\sum_{i=1}^{n} W_{Mi}} \tag{5}$$

Where CF_d, is an IPCC-defined contributing factor (exposure, sensitivity, or adaptation capacity) for district d, M_{di} are the major components for district indexed by i, w_{Mi} is the weight of each major component, and n is the number of major components in each contributing factor. Once the exposure, adaptation capacity and sensitivity are estimated, the three contributing factors are then combined using the following equation;

$$LVI - IPCC_d = (e_d - a_d) * S_d \tag{6}$$

Where $LVI - IPCC_d$ is the LVI for district d, expressed using the IPCC vulnerability framework. The calculated exposure score for district d (equivalent to the natural disaster and climate variability major components) is denoted as e_d, a_d is the calculated adaptation capacity score for district d (weighted mean of socio-demographic, livelihood strategies, and social networks major components), and S_d is the calculated sensitivity score for district d (weighted mean of the health, food, and water major components). The $LVI - IPCC$ is scaled from -1(least vulnerable) to 1 (most vulnerable). Microsoft Office excel was employed in estimating the livelihood vulnerability index as described by (Hahn *et al.*, 2009). Tables 3.1 and 3.2 presents the contributory factors, major and sub-components of the livelihood vulnerability index.

Table 3.1: Contributing Factors to LVI Per IPCC Approach

Contributing Factors	Major Components
Exposure	Natural disasters and climate variability
Adaptive capacity	Socio-demographic profile
	Livelihood strategies
	Social Network
Sensitivity	Health
	Food
	Water

Source: Hahn *et al.* (2009)

Following Hahn *et al*. (2009) and Panthi *et al*. (2015), the vulnerability triangle diagram was then used to illustrate the vulnerability index of each contributing factor.

Table 3.2: Major and Sub-Components Comprising the Livelihood Vulnerability Index

Major Components	Sub-components	Measurement
Water	Household reporting water conflict	Percent
	Household that utilize a natural water source	Percent
	Average time to water source	Minutes
	Household that do not have a consistent water supply	Percent
Socio-demographic Profile	Dependency ratio	Ratio
	Female- headed of household	Percent
	Household where head of household has not attended school	Percent
	Households with orphans	Percent
	Household with rooms made of mud	Percent
	Household with earth floor	Percent
	Household with grass/thatch roof	Percent
	Average number of persons per room	Number
Livelihood Strategies	Households with family member working in a different community	Percent
	Households dependent solely on agriculture as a source of income	Percent
	Average agricultural livelihood diversification index (range: 0.20-1)	1/# livelihood
Social Network	Average receive : give ratio	Ratio
	Average borrow : lend money ratio	Ratio
	Households that have not gone to their local government for assistance in the past 12 months	Percent
Health	Average time to health facility	Minutes
	Households with family member with chronic illness	Percent
	Households where a family member had to miss work or school in the past 6 months due to illness	Percent
	Average malaria exposure*prevention index (0-12)	Month*Bednet indicators
Food	Households dependent solely on the family livestock farm for food (as source of protein)	Percent
	Average number of months household struggle to find an animal (food) for household consumption (range:0-12)	Number
	Average livestock diversity index (>0-1)	1/# livestock
	Household that do not reserve young livestock species for breeding purposes	Percent
Natural Disaster and Climate variability	Average number of flood and drought events since 2004	Count
	Households that did not receive a warning about the pending natural disaster	Percent
	Households with an injury or death as a result of flood or drought since 2004	Percent
	Mean standard deviation of monthly average of average maximum daily temperature since 1985	Celsius
	Mean standard deviation of monthly average of average minimum daily temperature since 1985	Celsius
	Mean standard deviation of monthly average precipitation since 1985	Millimeter

Source: Adapted from Hahn *et al*. (2009)

3.3.1.2 Testing for the Difference between Two LVI's

The two-sample student t-test (2-tailed) is employed to test difference between LVIs computed for Lawra and Nandom districts.

Statement of Hypothesis

Null hypothesis (H_0): There is no significant difference between the mean LVIs of farmers in Lawra (μ_1) and Nandom (μ_2), thus H_0: $\mu_1 = \mu_2$

Alternate hypothesis (H_1): There is significant difference between the LVIs of farmers in Lawra (μ_1) and Nandom (μ_2), thus H_1: $\mu_1 \neq \mu_2$

When the t-test is obtain, the decision rule is such that: if the $t_{cal} > t_{cri}$, the null hypothesis is rejected, otherwise do not reject the null hypothesis

3.3.2 Factors Influencing the Level of Vulnerability

Many a time, some dependent variables have limited ranges, usually either discontinuous or range bounded. Such variables are called Limited Dependent Variables (LDV). One of such variables is in the case of objective 2. That is, not all smallholder livestock farmers may be vulnerable, hence the introduction of censored observations or measurements. To guide extension agents, researchers and policy-makers to make policy decisions on vulnerability, it is important to determine the factors that influence the vulnerability level of smallholder livestock farmers to climate change in the Upper West region of Ghana. Following Dhungana *et al.* (2004); Musemwa *et al*. (2013), this study employs the Tobit model to explain the vulnerability level of smallholder livestock farmers to climate change.

A Tobit model is a statistical model proposed by Tobin (1958) to describe the relationship between a non-negative dependent variable *yi* and an independent variable (or vector) *xi*

(Musemwa *et al*., 2013). The term is called Tobit because it consists of two terms, the first part shows the Probability Density Function (PDF) of the non-censored observations (linear part) whiles the second part is the Cumulative Distribution Function (CDF) of the censored observations (probit part) and is clearly indicated in the likelihood function below.

$$LogL = \sum_{Y_i > 0} -\frac{1}{2}\left[\log(2\pi) + \log\sigma^2 + \frac{(Y_i - \beta X_i)^2}{\sigma^2}\right] + \sum_{Y_i = 0} \log\left[1 - F\left(\frac{\beta X_i}{\sigma}\right)\right] \qquad (7)$$

The measurements or observations that would be generated thereof is more likely to be censored to the right (from above) or to the left (from below). On this basis, it is also called a censored regression model. Censored regression models are applicable when the variable to be explained is partly continuous but has positive probability mass at one or more points. Censored regression models are designed to estimate linear relationships between variables when there is either left or right-censoring in the dependent variable. Censoring from above arises when cases with a value at or above some threshold, all take on the value of that threshold, so that the true value might be equal to the threshold, but it might also be higher (Bruin, 2006). In the case of censoring from below, values that fall at or below some threshold are censored. Greene (2002) argues that it is more suitable to have data censored at 0 than at 1, because, when the dependent variable (vulnerability level) is censored at 0, the conventional regression methods fail to account for the qualitative difference between the limit (0) observations and non-limit (continuous) observations. A Tobit model censored at zero (0) will therefore be selected to determine the factors that influence the vulnerability level of smallholder livestock farmers.

Tobit models ensure that there is no information loss of the dependent variable, as in the case of probit models. We can therefore state that Tobit model is an extension of the Probit model. Also, vulnerability values are a range of values from 0 to 1. The dependent variable (vulnerability level) in the regression equation cannot have a normal distribution, but rather a censored distribution since its values lies from 0 to 1 (Dhungana *et al.*, 2004). When data is censored, the distribution that applies to the sample data is a mixture of discrete and continuous distributions (Greene, 2002). Vulnerability values are therefore partly continuous and partly discrete, thus the main reason why Ordinary Least Squares (OLS) cannot be used to model such data. OLS estimation using a censored sample, results in inconsistent estimates (Dhungana *et al.*, 2004). Again, the vulnerability values are not dichotomous data, such that they can either be 0 and 1. This also disqualifies the use of logit or profit models, since the dependent variable is partly continuous and partly discrete. Therefore, the Tobit model was found to be the most appropriate model to use.

The Tobit model for determining the vulnerability level of a farmer to climate change is specified as follows:

$$Y_i^* = \beta_0 + X_i \beta_i + \varepsilon_i, \qquad \text{i= 1,2, ……., n. But } 0 \leq Y_i = V_{CV} \leq 1 \tag{8}$$

$$Y_i = \begin{cases} Y_i^*, & Y_i^* > 0 \\ 0 & Y_i^* \leq 0 \end{cases} \tag{9}$$

Where: Y_i is the actual observable vulnerability dependent variable which can be explained as; Y_i=1, if farmers are highly vulnerable to climate change and variability; Y_i=0, if farmers are not vulnerable to climate change and variability; Y_i^* is a latent response variable, which is desired (potential) vulnerability; ß is a vector of unknown parameters to be estimated; X_i is an observed

1 × k vector of explanatory variables; ε_i is an error term, independent of the X_i and Zero (0) is the minimum vulnerability or the vulnerability threshold.

The parameters are estimated using the maximum likelihood method. It is generally the most efficient estimation procedure in the class of estimators that uses information on the distribution of the endogenous variables given the exogenous variables (Karki and Bauer, 2004). By running a regression of the independent variables X's on the dependent variable Y, yielded the following empirical Tobit model:

$$Y_i = \beta_0 + \beta_1 GEN + \beta_2 AGE + \beta_3 EDU + \beta_4 FEXP + \beta_5 INC + \beta_6 FBO + \beta_7 EXT + \beta_8 ACCTVS + \beta_9 ACCTWI + \beta_{10} SZFLK + \beta_{11} FGDsWKS + \beta_{12} POWSHP + \beta_{13} IncrsdTm + \beta_{14} DecrsdRfall + \beta_{15} CRD + \mu_i \quad (10)$$

Hypothesis Testing

In testing for the significance of each of the independent variables, the z-statistics was employed. Decision rule: if Zcal>Zcri, the null hypothesis is rejected, otherwise, do not reject the null hypothesis.

Table 3.3 presents the independent variables, the measurements and expected signs considered in the Tobit model.

3.3.2.1 Variable Description

Gender: Gender refers to the biological identity of the farmer. It is a dummy variable which has the value of one if the farmer is a male and zero if otherwise. Male farmers have more access to resources than female farmers, and hence are able to adopt strategies that make them less vulnerable (Nabikolo *et al.*, 2012; Obayelu *et al*., 2014). The authors further put it that, female headship reduced the likelihood of adaptation to climate change. Majority of highly vulnerable households were headed by females (Opiyo et al., 2014).

Table 3.3: Description of Variables for the Tobit Regression

Variable	Description	Measurement	Sign
Y_i	Vulnerability index	0 < LVI≤ 1	
GEN	Gender of farmer	Dummy: 1=Male, 0=Female	-
AGE	Age of farmer	Years	+/-
EDU	Years of education	Years	-
$FEXP$	Farming experience	Years	-
INC	Annual income	Ghana Cedis	-
FBO	Member of a Farmer Based Oganisation	Dummy: 1=Yes, 0= No	-
EXT	Number of Extension contacts	Number	-
$ACCTVS$	Access to Veterinary Service	Dummy: 1=Yes, 0= No	-
$ACCTWI$	Access to weather information	Dummy: 1=Yes, 0= No	
$SZFLK$	Size of Flock	Number	-
FGDsWKS	Participation in Focus Group Discussions & Community Workshops	Dummy: 1=Yes, 0= No	- _
$POWSHP$	Pen Ownership	Dummy: 1=Yes, 0= No	-
$IncrsdTm$	Increased Intensity of temperature	Dummy: 1=Yes, 0= No	+
$DecrsdRfall$	Decreased Amount of rainfall	Dummy: 1=Yes, 0= No	+
$CRDT$	Household access to formal credit	Dummy: 1=Yes, 0= No	-

Age of the farmer: It is a description of how old or young a farmer is. Age is measured in years. This may have an effect on vulnerability because younger farmers may be able to adopt some measures to avert climate change than aged the farmers.

Years of Education

Education (EDU) is measured as years of formal education. More education favours adaptation due to faster knowledge acquisition (Nabikolo *et al*., 2012). Obayelu *et al*. (2014) posited that increasing farmers' years of education would increase their likelihood of adopting some particular strategies, which reduces vulnerability. Also Farmers are highly vulnerable if they have no basic/primary education (Opiyo *et al.*, 2014).

Years of Farming Experience

Farming experience (FExp) denotes the number of years the farmer has been involved in livestock production.

Flock/Herd Size

Flock size (SZFLK) represents the number of livestock own by the farmer. Flock size made the highest contribution to gross returns (Rangnekar, 2006), implying that, an increase in the gross return of smallholder livestock farmers can help the farmer to acquire some measures in order to reduce vulnerability. Opiyo et al., (2014) note from their study that the highly vulnerable farmers had no milking herd and own less than two livestock species.

Annual Income of farmer

Annual income of farmer (INC) refers to the total amount obtained from all livelihood diversification activities such as sale of crops, livestock and engagement in off-farm income generating activities for a twelve month period. According to Yaro, (2013) farmers who have their sources of income diversified are able to reduce their vulnerability to climate change effects.

Pen Ownership: It describe whether the livestock farmer have a pen for housing the animals or not. Some farmers do not usually have structures to keep the animals especially at night, but rather, they are left to sleep in the open which may post health problems.

Member of a Farmer Based Organization (FBO): As farmers belong to an FBO, the assumption is that they are able to access better information concerning climate change issues, and are at an advantageous position to reduce vulnerability to climate change. FBO membership (FBO) is a binary variable which is given a value of one if the farmer belongs to a famer based organization and zero if otherwise.

Access to Credit: farmers who access credit can buy quality feed for his livestock given that the natural pasture has been burnt. Access to credit (CRDT) is also a binary variable which has the value of one if the farmer had access to credit and zero if otherwise. Access to credit facilitates adoption of technologies (Nabikolo *et al*., 2012), thereby reduces vulnerability of smallholder livestock farmers in the Upper West region to climate change. Farmers who had access to credit facilities are reported to be less vulnerable to climate extremes (Opiyo *et al*., 2014).

Participation in Focus Group Discussion (FGD) and Community Workshops (CWs): It tells whether the farmer do participate in Focus group discussions or not. Participation in such group may influence farmer's understanding about vulnerability.

Number of Extension Contacts

Extension visit (EXT) refers to the number of meetings the farmer had with extension agents for the past twelve months, with the 12^{TH} month observed during the time of the data collection. A farmer is considered to be likely less vulnerable if he gets access to extension services (Opiyo *et al*., 2014).

Access to Veterinary Service: It is a variable with the aim of knowing whether or not the farmer has access to veterinary services or not. It is denoted by ACCVS.

Access to Weather Information: The study is of the view that access to weather information can influence vulnerability to climate change. Opiyo *et al.* (2014) noted that farming households who have access to early warning information, through weather forecast, is considered to be likely less vulnerable.

Noticed Decreased Rainfall Amounts: Decrease rainfall can result in inadequate pasture and water available to livestock. If this happens, farmers would have to provide some supplementary feed to the animals, which may come with cost.

Noticed Increased Temperature: Increased temperature leads to increased evaporation rate, and there will be less water available to growing crops in the field, which eventually produces biomass and crop residue for livestock feeding.

Expected Values for the Tobit Model

According to Sigelman & Zeng (1999) there are three expected values of the Tobit model.

Expected value of the latent variable y^*

$$E(y^*) = x_i\beta \tag{11}$$

Expected value of $y / y > 0$

$$E(y / y > 0) = X_i\beta + \sigma\lambda(\alpha) \tag{12}$$

Where $\lambda(\alpha) = \frac{\phi(\frac{x_i\beta}{\sigma})}{\Phi(\frac{x_i\beta}{\sigma})}$, is the inverse Mills ratio.

Expected value of y

$$E(y) = \Phi\left(\frac{x_i\beta}{\sigma}\right)\left[x_i\beta + \sigma\lambda\left(\alpha\right)\right] \tag{13}$$

Where $\lambda(\alpha) = \frac{\phi(\frac{x_i\beta}{\sigma})}{\Phi(\frac{x_i\beta}{\sigma})}$, is again the inverse Mills ratio. This is the probability of being uncensored multiply by the expected value of y given y is uncensored

Interpretation and Marginal Effects of the Tobit Model

Tobit regression coefficients are interpreted in similar manner like Ordinary Least Squares (OLS) regression coefficients; however, the linear effect is on the uncensored latent variable, not the observed outcome. Thus the estimated Tobit coefficients are the marginal effects of a one-unit change in *xj* on y*, thus, the unobservable latent variable can be interpreted in the same way as in a linear regression model. But such an interpretation may not be useful since we are interested in the effect of *X* on the observable *y* (or change in the censored outcome). It can be shown that change in *y* is found by multiplying the coefficient with *Pr(a<y*<b)*, that is, the probability of being uncensored. Since this probability is a fraction, the marginal effect is actually attenuated. This means that, the result would be interpreted using the coefficients. In the above, *a* and*b* denote lower and upper censoring points. For example, in left censoring, the limits will be: *a* =0, *b*=+∞.

There are three marginal effects in the Tobit model which corresponds to the three expected values.

Marginal effect on the latent dependent variable, y^*

$$\frac{\partial E(y^*)}{\partial x_k} = \beta_k \tag{14}$$

The coefficient indicates how a one-unit change in an explanatory variable x_k changes the latent dependent variable y^*

Marginal effect on the expected value for y uncensored observations

$$\frac{\partial E\left[y/y>0\right]}{\partial x_k}=\beta_k\left\{1-\lambda(\alpha)\left[\frac{x_i\beta}{\sigma}+\lambda(\alpha)\right]\right\} \tag{15}$$

Where $\lambda(\alpha)=\frac{\phi(\frac{x_i\beta}{\sigma})}{\Phi(\frac{x_i\beta}{\sigma})}$. This indicates how one-unit change in an explanatory variable x_k affect uncensored observations.

Marginal effect on the expected value for y (censored and uncensored)

$$\frac{\partial E(y)}{\partial x_k}=\Phi(\frac{x_i\beta}{\sigma})\beta_k \tag{16}$$

$$E(y)=\Phi(\frac{\mu}{\sigma})\left[\mu+\sigma\lambda\right] \text{ Where } \lambda=\frac{\phi(\frac{\mu}{\sigma})}{\Phi(\frac{\mu}{\sigma})} \text{ and } \mu=X_i\beta \tag{17}$$

Substituting equations 16 and 17, into the marginal effect equation it turns to be,

$$\frac{\partial E\left[y\right]}{\partial x_k}=p(y>0)\frac{\partial E\left[y/y>0\right]}{\partial x_k}+(E\left[y/y>0\right]))\frac{\partial p(y>0)}{\partial x_k} \tag{18}$$

Equation (18) is called the McDonald and Moffitt's decomposition. It allows us to recognize how a change in x_k affects the conditional mean of y^* in the positive part of the distribution as well as the probability that the observation will fall in that part of the distribution.

The estimated probability of observing an uncensored observation at the values of X in given in equation 19.

$$\Phi\left(\frac{X_i\beta}{\sigma}\right) \tag{19}$$

As this scale factor, ϕ, moves closer to the fewer censored observations, then the adjustment factor, σ becomes irrelevant and the coefficient β_k gives us the marginal effect at these particular values of X .

Fitness of the Model

The likelihood ratio chi – square compared with the p-value is used to describe the significant fitness of the model. We are able to tell if the respective coefficients are statistically significant or not by observing the individual p-values.

Assumptions underlying the Tobit model

There are two basic assumptions underlying the Tobit model. If the error term ε_i is either heteroscedastic or non-normal, then the maximum likelihood estimates are inconsistent (Karki and Bauer, 2004). Notwithstanding, it is possible to get consistent estimates with heteroscedastic errors if the heteroscedasticity is modeled right.

3.3.3 Measuring Levels of Adaptation Strategies to Climate Change

Three key areas were considered in measuring the levels of adaptation strategies. These include measuring levels of adoption, intensity and effectiveness of the adaptation strategies. For this section, qualitative methods, especially Participatory Rural Appraisal (PRA) tools were employed. PRA tools are usually inexpensive materials or objects, and in the domain of farmers' environment, are used to describe the nature of a situation.

3.3.3.1 Measuring Adoption Levels of Adaptation Strategies

This study defines adoption of adaptation strategies as the use of at least one strategy. Level of adoption is then measured as the percentage of smallholder livestock farmers who adopt at least one strategy. Descriptive statistics (frequency, percentages and bar chart) was used to achieve this objective.

3.3.3.2 Measuring Intensity of Adoption of Adaptation Strategies

The study employs a qualitative but subjective method to measure the intensity of adoption. This method is adopted from Babatunde *et al*. (2008) who also used the subjective approach of measuring vulnerability to food insecurity based on respondent's frequency of and severity of using coping strategies. In this study, intensity of adoption, expressed as a percentage of farmers who adopt a particular strategy, refers to the degree at which a particular adaptation strategy is being used. The methods of power analysis, which can also be described as some form of ranking, were specifically employed. The power analysis has to do with assigning material such as pebbles/stones, sticks, etc to the farmer, so that the farmer places a number of pebbles he/she thinks best describe the extent to which the strategy is been adopted. The number of pebbles given to a strategy by the farmer was expressed as a percentage and the results would be presented using bar-chart.

3.3.3.3 Measuring Effectiveness of Adaptation Strategies

Effectiveness of the strategies refers to how useful the strategies are to the farmer. This can be measured if the farmer observes an improvement in his/her livestock. The method of power analysis were again employed, but were categorized into a four point likert scale (Adams & Ohene-Yankyera, 2015) as follows, depending upon the number of pebbles picked by the farmer.

Table 3.4: Categorization of Effectiveness of Adaptation Strategies

Category of Effectiveness	Number of Pebbles pick by farmer
Not effective	0-1
Somewhat effective	2-4
Moderately effective	5-7
Very effective	8-10

Each category will then be expressed as a percentage of total number of adopters and presented in tabular a form.

3.3.4 Factors Influencing the Adoption of Introduced Adaptation Strategies

Probit and logit models are the most commonly used models used by researchers (Hausman & Wise, 1978;, Wu and Babcock, 1998) to identify and quantify the effects of factors that influence the adoption of agricultural technologies; this is due to the nature of the dependent variable. The dependent variable can take on two or more variables. If it takes two variables, then binary logit or probit model is appropriate to use. The multinomial logit (MNL) or multinomial probit (MNP) is the preferred model to use over the binary logit or probit models if the dependent variable takes on more than two variables.

We considered the multinomial logit because there is high probability of farmers adopting more than two strategies in the study area. The multinomial logit model is chosen for this study over MNP because it is widely used in studies involving multiple choices; it is also easier to compute (Hassan and Nhemachena, 2008; Karki and Bauer, 2004).

The multivariate analysis involved the use of the multinomial logit model to analyse the predictors of climate change perceptions (Teye *et al.*, 2015). The multinomial logit model was used to determine the factors that influenced the adoption of climate related technologies introduced by research (Etwire *et al.*, 2013a). Deressa *et al*. (2010) adopted the MNL model to analyze the factors affecting the choice of coping strategies in response to climate extreme events in the Nile basin of Ethiopia. According to them, the advantage of MNL is that it permits the analysis of decisions across more than two categories, allowing the determination of choice probabilities for different categories.

Kurukulasuriya and Mendelsohn (2006) employed the multinomial logit model to see if crop choice by farmers is climate sensitive. Similarly Seo & Mendelsohn (2006) used the multinomial logit model to analyze how livestock species choice is climate sensitive.

In this study therefore, the dependent variable are the adaptation strategies identified, which are unordered to justified the use of ordered logit and probit, and so, the use of the multinomial logit is justified. The strategies adopted by smallholder livestock farmers in adapting to climate change and variability are broadly categorized into five (5) main groups namely, Feed Related Strategies (FRS), Health Related Strategies (HRS), Housing Related Strategies (HRS) and Breed Related Strategies (BRS). The fifth category, worth considering is the category of livestock farmers who were not adopting any adaptation strategy usually referred to as Non-adopters (NoA). Each of these strategies was identified by reviewing literature, conducting focus group discussion and key informant interview at the community level. Each farmer was then asked to list the adaptation strategies they use in their farming activities to ensure effective livestock improvement in the face of climate change. A farmer may be using more than one strategy at a time. Descriptive statistics represented in the form of bar charts was used to show the percentage of farmers using each strategy.

The theoretical framework behind the multinomial logit model is the utility theory. This is important because, it gives an accurate understanding of the probabilities. It also motivates and makes distinctions among the alternative model specifications. Finally, it provides the theoretical basis for calculation of changes in consumer surplus from changes in the attributes of the alternatives. This theoretical framework which is based on the random utility model as specified by Greene (2003) is specified as follows:

$$U = X\beta + \varepsilon \tag{20}$$

Where U denotes a farmer's decision to adopt an adaptive strategy.

X=Explanatoryvariable

β = Parameter to be estimated

ε = the error term

Assuming Y_a and Y_b are a smallholder livestock farmers' utility of two choices, which can be represented as U^a and U^b. For example, U^a could be the utility derived from Feed Related Strategies whiles U^b could represent the utility derived from Health Related Strategies. The choice by the farmer between the two strategies indicates which one provides a higher utility; the farmer's utility is however latent. Hence the observed indicator is equal to one (1) if $U^a > U^b$ and zero (0) if $U^a \leq U^b$.

A common formulation is the linear random utility model, specified as:

$$U^a = X'\beta_a + \ell_a \tag{21}$$

$$U^b = X'\beta_b + \ell_b \tag{22}$$

Following from (Greene, 2002), a smallholder livestock farmer choosing the feed related strategy is modeled to be a function of three main characteristics: socioeconomic, institutional and environmental characteristics as shown in equation (23).

That is, the probability that an i^{th} smallholder livestock farmer chooses a j^{th} climate change adaptation strategy is given as:

$$\Pr ob(Y_i = 1) = \frac{e^{\beta_j X_i}}{\sum_{k=1}^{3} e^{\beta_k X_i}}, \qquad j=0,1,\ldots\ldots\ldots 3 \tag{23}$$

Where β_j is a vector of coefficients; $X_{i's}$ are the exogenous variables,

Assuming $\beta_0 = 0$, equation (23) will be normalized to remove indeterminacy and the probability estimated as follows:

$$\Pr ob(Y_i = 1 | X_1) = \frac{e^{\beta_j X_i}}{1 + \sum_{k=0}^{3} e^{\beta_k X_i}} \qquad \text{j= 0,2,……J, } \beta_0 = 0. \tag{24}$$

Estimating Equation (24) using maximum likelihood method yields the log-odds ratio presented in Equation (25):

$$In\left(\frac{P_{ij}}{P_{ik}}\right) = X_i(\beta_j - \beta_k) = X_i \beta_j , \qquad \text{if k = 0.} \tag{25}$$

Where: $P_{ij} =$ Maximum utility that the *i*th smallholder livestock farmer gains in choosing the *j*th adaptation strategy over the *k*th adaptation strategy;

The choice of any adaptation strategy to climate change is therefore the log-odds in relation to the base alternative, non-adopters. According to Greene (2003), the coefficients of the Multinomial Logit are difficult to interpret and associating β_j with the jth outcome is tempting and misleading. Instead, the marginal effects are usually derived to explain the effects of the exogenous variables on the endogenous variable in terms of probabilities as presented in Equation (26).

$$\frac{\partial P_j}{\partial X_i} = P_j\left[\beta_j - \sum_{K=0}^{J} P_k \beta_j\right] = P_j\left(\beta_j - \overline{\beta}\right) \tag{26}$$

The marginal effects measure the expected change in the likelihood of choice of a particular climate related strategy with respect to a unit change in an exogenous variable (Greene, 2002).

The empirical model specification is therefore specified as:

$$\begin{aligned} Y_{ij} &= \beta_0 + \beta_1 Gen + \beta_2 Age + \beta_3 FExp + \beta_4 AWI + \beta_5 AVS + \beta_6 AVDs \\ &+ \beta_7 ACLW + \beta_8 FBOMem + \beta_9 NDRain + \beta_{10} NITemp + \mu_i \end{aligned} \tag{27}$$

Where *i* = smallholder livestock farmer and *j* = adaptation strategies

Hypothesis Testing

In testing for the significance of each of the independent variables, the z-statistics was again employed. Table 3.5 describes how the independent variables are measured and their expected signs.

3.3.4.1 Variable Description

The description of the explanatory variables in the multinomial regression model are explained the same way as it is explained in the Tobit regression model in objective two, except for access to veterinary drugs and community livestock worker, which are descriped below.

Access to Veterinary drugs and Community Livestock officer: the main interest is to find out if the farmer can access veterinary drugs or community livestock officer or not. These are important variables that may influence adoption of health related strategies.

Table 3.5: Description of Exogenous Variables for the Multinomial Logit Model

FACTOR	EXOGENOUS VARIABLES	MEASUREMENTS	EXPECTED SIGN
	Gender	Dummy: 1=Male, 0=Female	+
	Age of farmer (AGE)	Years	+/-
Household	Farming Experience (FExp)	Years	+
	Access to Weather Information	Dummy:1= Yes, 0=Otherwise	
	Access to Formal Veterinary Service (AccFVS)	Dummy:1=Yes, 0=Otherwise	+
	Livelihood Vulnerability Index (LVI)	Dummy: 1=Vulnerable, 0=Otherwise	+
Institutional	Access to Veterinary Drugs (AccVD)	Dummy:1=Yes, 0=Otherwise	+
	Access to Community Livestock Worker (AccCLW)	Dummy:1=Yes, 0=Otherwise	+
	FBO Membership	Dummy:1=Yes, 0=Otherwise	+
	Noticed Decreased Rainfall (NDR)	Dummy:1=Yes, 0=Otherwise	+
Environmenta	Noticed Increased in Temperature	Dummy:1=Yes, 0=Otherwise	+

Testing for Multicollinearity

Multicollinearity is an econometric problem which when serious, can lead to biased estimates. It is difficult to completely do without collinearity of the independent variables; in view of this, Allison, (1999) states that, the estimates of a regression model can be considered for interpretation when the tolerance in not less than 0.4 and the Variance Inflation Factor (VIF) is not more than 2.5.

For a regression model, $Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + ... + \beta_K X_K + \varepsilon$, (28)

K different VIFs can be calculated for each $X_{i.}$ This can be done in three steps.

First, randomly pick one of the independent variables as a dependent variable, and regress it on the rest of the independent variables. For example, following from equation 30, the equation would be $X_i = \alpha_0 + \alpha_2 X_2 + \alpha_3 K_3 + \alpha_k X_k + \ell$ (29)

Where α_0 is a constant and ℓ is the error term.

Then the VIF for $\beta_i s$ can be calculated using the following formula

$$VIF = \frac{1}{1 - R_i^2} \quad (30)$$

Where R_i^2 is the coefficient of determination of the regression equation in equation 31, with X_i on the left hand side (dependent variable), and all other predictor variables (the rest of the Xs) on the right hand side.

Finally, analyse the magnitude of multicollinearity by considering how large the VIFs for each of the $\beta_i s$ are. A variable with VIF more than 2.5 would need to be drop from the model, given that, all observations of that variable are correct.

3.3.5 Data and Data Sources

Data used in this study was collected through primary and secondary sources. Primary data was collected from focus group discussions (FGDs) and individual farmer interviews. Prior to this, a reconnaissance survey was conducted in some selected communities. This provided a platform where farmers were engaged to collect information about their farm activities prior to the interviews. The visited communities, Metor, Naburnye, Orbilli, Kasalgre in the Lawra district and Zedung, Wallanteng, Zimoupare and Segru in the Nandom district, were among the selected communities in which Climate Change, Agriculture and Food Security (CCAFS) projects are undertaken.

Questionnaire were designed to cover areas such as socio-demographic characteristics of the farmer, income sources, availability and access to services, livestock composition and housing information, climate change among others. Focus group discussion guide was developed and discussions were held in each community. Based on the responses from the FGD and pre-tested questionnaire, further improvements were made on the questionnaire. The survey covered a period of six (6) weeks. See appendix 9a and 9b for details. Rainfall and temperature data of thirty years (1984-2014) period for both Lawra and Nandom districts were collected from the Ghana Meteorological Agency. Finally, reference materials used in this study were obtained from working and discussions papers, journal articles, project reports and text books.

3.3.6 Study Area

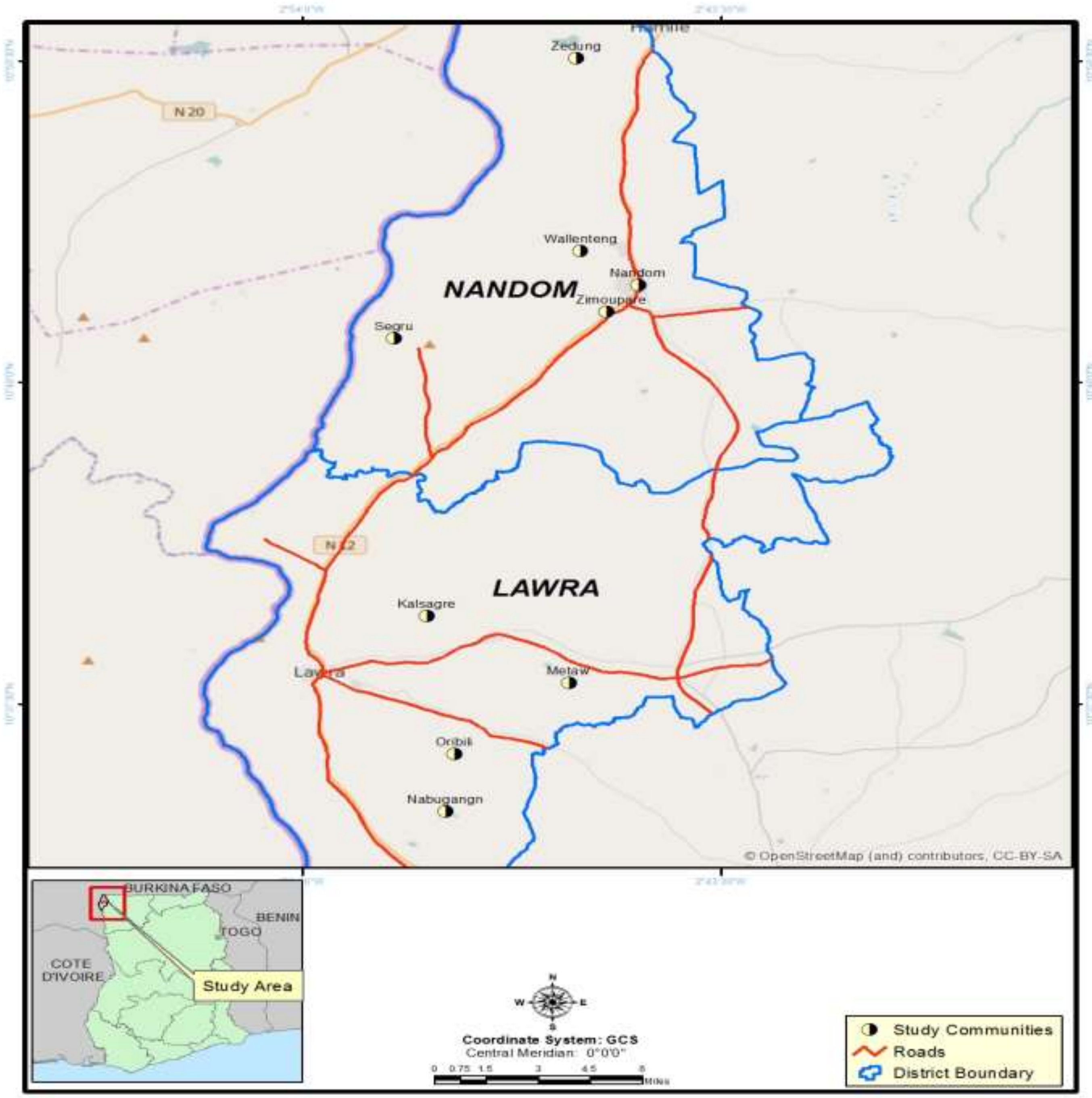
This study was undertaken in two districts in the Upper West region of Ghana, specifically Lawra and Nandom districts. The Lawra District is one of the eleven districts constituting the Upper West Region. It lies in the north-western part of the Upper West Region of Ghana. It is bounded to the north by Nandom District, to the east by Lambussie-Karni District to the south-west and west by the Republic of Burkina Faso. It lies between Latitude 10^{o} 35^{o}- 10^{o} 40 North and $2^{o}50$-$2^{o}50$-$2^{o}53$ West. The total land mass of the district is 527.37 square kilometres. This represents about 2.8 percent of the Region’s total land mass, estimated as 18,476 square kilometres. The Lawra District has over 80.0 percent of the people living in the deprived areas. The population of the district is 54, 887, representing 7.8 percent of the regional population. The population density of the district is 104.1 per square kilometer. The district’s relief and drainage is gently rolling with a few hills ranging between 180 and 300 metres above sea level. It is drained by the Black Volta River, to the west and that separates the district from Burkina Faso (GSS, 2014a).

The district is located within the Guinea Savannah Zone characterized by short grasses and few woody plants. The commonest tree species, mostly drought and fire resistant include Baobab, Dawadawa, Shea trees and Acacia. The climate of the area is the tropical continental type with average annual temperature ranging between 27°C and 36°C. There is a potential to access ground water all year round for dry season farming due to fractured pattern in the rocks (GSS, 2014a). The soils, developed from the Birimian and granite rocks, in the district consist mostly of laterite type. The environment has undergone considerable degradation largely attributed to human activities. Agriculture, which employs about 78 percent of the economically active people, is the main important economic activity in the district. About 80 percent of the farmers are into subsistence agriculture, producing mainly maize, millet, groundnuts, soya bean and cowpea. Animal production is a major agricultural activity undertaken by the people to supplement incomes from crop farming (GSS, 2014a).

On the other hand, the Nandom district is located in the north – western part of the region. It is specifically between Longitude 2°25 W and 2°45W and Latitude 10°20 N and 11°00 S. It is separated by Lawra district to the South, Lambussie-Karni district to the East and Burkina Faso to the North and West. The total land mass of the District is estimated at 404.6 square kilometres, representing about 3.1% of the Region's total land mass. The district is located within the Guinea Savannah vegetation is characterized by short grasses with scattered fire resistant trees such as the Shea trees, acacia and Baobab trees. The vegetation of the area is good for livestock rearing (GSS, 2014b).

The district climate is also tropical continental with minimum and maximum temperatures falling within 23^0C at night and a maximum of 42^0C during the day. The average monthly temperature varies between 21^0C and 32^0C. The highest monthly maximum temperature, which mostly occurs in May could rise as high as 40^0C before the onset of rains and lowest minimum temperature decreasing to about 12^0C in December when the Harmattan winds from the Sahara dry up the vegetation. The relief and drainage of the area could be described as gently undulating with few separated hills which is about 180 meters above sea level. The common types of soil in the District are sandstone, gravel, mudstone, alluviam, granite and shale (GSS, 2014b). The map of the study area is shown below.

Figure 3.2: Map of the Study Area



Source: GIS Laboratory, University of Ghana

3.3.7 Sampling Procedure

A multi-stage sampling technique was applied in sampling respondents for this study. Upper West region was purposively selected and again, two (2) districts, Lawra and Nandom, were purposively selected based on the fact that, the project dubbed "Adaptation at Scale in Semi-Arid Regions, ASSAR" is currently bieng implemented in these two districts. The chosen districts are part of the Wa portion of the Wa-Bobo-Sikasso transect, a name given to a portion of Ghana-Burkina Faso-Mali of which the ASSAR project targets. Both Lawra and Nandom districts share borders with the neighboring Burkina Faso, a more semi-arid country.

Each district was then stratified into four strata. The basis of using stratified sampling was to group the CCAFS communities, from which the sample communities will be chosen, so that one community will be randomly selected from each group. Simple random sampling technique was used to select one community from each stratum making a total of eight (8) communities. For each stratum, all the communities involve were written separately on a small piece of paper and wrapped. It was then mixed-up such that no one could identify which paper has a particular community. The lottery method was then used to randomly select one community from each stratum. Then again, simple random sampling technique was used to select 25 smallholder livestock farmers from each community, making a total of two hundred (200) livestock farmers. Structured questionnaires were administered to each of these 200 smallholder livestock farmers.

3.3.8 Software used and Presentation of Results

The statistical tool employed during the result analysis is version 13 of STATA. The data was then presented in the form of frequencies, percentages, tables and figures.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Introduction

The empirical results of the study are presented in this chapter. It gives detail discussions of the socioeconomic characteristics of the respondents, level of vulnerability of smallholder livestock farmers, factors that influence farmers' vulnerability and followed by estimates and discussions of the level of adoption of adaptation strategies. Finally, it presents a discussion of the factors that influence the adoption of adaptation strategies by smallholder livestock farmers to climate change.

4.2 Socio-Economic Characteristics of the Respondents

The socio-economic characteristics of the respondents discussed in this section include gender, age distribution, years of farming experience, educational level and marital status of the respondents. Others include material make-up of respondents' houses, household size, main occupation, engagement in off-farm activities, extension contacts, farmer based organisation membership and farm size of the respondents.

4.2.1 Gender of the Respondents

The gender composition of the respondents indicates that there were 74% and 26% of the respondents been men and women respectively in the Lawra district. Also in the Nandom district, men and women respondents were 60 and 40% respectively. Furthermore, the pooled sample of men and women respondents indicates 67 and 33% respectively. Since household heads were interview, the findings is consistent with GSS (2010) as it states that male and female-headed households were 77.4 and 22.6% respectively. Table 4.1 gives further details of gender participants.

4.2.2 Age Distribution of Respondent

The minimum and maximum ages of the respondents interviewed were 22 and 90 years, with the mean age of a farmer been 48.34. This study categorized ages of respondents into five groups. Because of the wide range of definitions of who is an adult, this study further classified the adult group into three. Those within the ages of 20 – 34 are named youth, young – adults are those within ages 34 – 44 years, whiles mid-adults are those who fall within the ages of 45 – 54. The fully/matured adults are those with ages 55 – 64 years category, and the aged, per this work, are those with sixty-five (65) and above. About 82% of the farmers were economically active, age 15-64 whiles 18% were economically inactive (GSS, 2012).Table 4.1 and 4.2 gives further statistics of the age groupings.

4.2.3 Farming Experience/Years of Experience in Livestock Production

Farming experience of a farmer is measured by how long he/she has been rearing livestock. The farming experience of respondents ranged from 1 – 70 years. In Lawra and Nandom district, a farmer has an average of 18 and 20 years of farming experience respectively, whiles the average for the pooled sample is 19 years. This is because, most (64%) of the farmers who participated in the survey were household heads, clustered around the adult age range of 34-64 years.

The farming experience was further categorized into five (5). Majority of the respondents both in Lawra (46%) and Nandom (52%) districts have experience between 1 – 15 years of farming experience. Also, 35% of the total respondents have farming experience ranging from 16 – 30 years, whiles only 1.5% of the total respondents have 61 – 75 years of farming experience as shown in Table 4.1 and 4.2.

Table 4.1: Socioeconomic Characteristics of Smallholder Livestock Farmers

Characteristics of farmer	Lawra		Nandom		Pooled	
	Frequency	**%**	**Frequency**	**%**	**Frequency**	**%**
Gender						
Men	74	74	60	60	134	67
Women	26	26	40	40	66	33
Age Groups						
20 – 34	16	16	20	20	36	18
34 – 44	19	19	32	32	51	25.5
45 – 54	28	28	19	19	47	23.5
55 – 64	19	19	11	11	30	15
65+	18	18	18	18	36	18
Farming Experience						
1 – 15	46	46	52	52	98	49
16 – 30	39	39	31	31	70	35
31 – 45	10	10	14	14	24	12
46 – 60	3	3	2	1	5	2.5
61 – 75	2	2	1	1	3	1.5
Educational Status						
None	87	87	58	58	145	72.5
Basic	12	12	35	35	47	23.5
Secondary	1	1	6	6	7	3.5
Post-Sec	0	0	0	1	1	0.5
Tertiary	0	0	0	0	0	0
Marital Status						
Single	3	3	5	5	8	4
Married	81	81	86	86	167	83.5
Divorced	1	1	1	1	2	1
Widowed	15	15	8	8	23	11.5
Main Occupation						
More crops-Less Livestock	87	87	96	96	183	91.5
Less crops-More Livestock	11	11	0	0	11	5.5
Petty trading	1	1	3	3	4	2
Others	1	1	1	1	2	1
Off-farm activities						
Yes	26	26	20	20	46	23
No	74	74	80	80	154	77
Extension Contacts						
Yes	13	13	25	25	38	19
No	87	87	75	75	162	81
FBO Membership						
Yes	36	36	28	28	64	32
No	64	64	72	72	136	68

Source: Field Survey, 2016

Table 4.2: Descriptive Statistics of Continuous Variables

Socioeconomic Characteristics	Minimum	Mean	Maximum	Standard Deviation
Age	22	48.34	90	14.40
Farming experience	1	18.91	70	13.97
Household Size	1	8.08	21	3.60
Flock Size (dominant specie)	0	8.12	49	8.62
Years of Education	0	2.24	15	4.10
Persons/Room	1	2.13	6	0.97

Source: Field Survey, 2016

4.2.4 Educational Level of Respondents

The mean years of education was found to be 2.24, with minimum and maximum years attended by a respondent been zero (0) and fifteen (15) years respectively. The number of respondents without at least, basic education are higher (87%) in Lawra district than at Nandom district (58%). This means that only 13% and nearly half (42%) of the respondents had at least basic education in Lawra and Nandom districts respectively. Of the total respondents, only 0.5% had post-secondary education, with no recorded case of a farmer having tertiary education. This is consistent with (GSS, 2012). Table 4.1 and 4.2 illustrates the education levels and statistics of the respondents.

4.2.5 Marital Status of Respondent

Since most of the respondents were household heads with age range from 22-90, it was common to find most (83.5%) of them married. The GSS (2014a, 2014b) results shows that about 50.1 and 48.3% of the population age 12 years and above are married in Lawra and Nandom districts respectively. The widowed were 11.5% of the total respondents. It also shows that, there were more widows (15%) at Lawra district than at Nandom district (8%), with equal distribution (1%) of divorced category in both districts. See table 4.1 for details.

4.2.6 Household Size

The mean household size in the pooled sample was found to be approximately eight (8) people as shown in table 4.2. This is above the 6 people per household in both districts as indicated by (GSS, 2014a). The maximum number of people in a household was however more in Lawra than in Nandom district. It was also possible to find only person making a household in Nandom district.

4.2.7 Main Occupation of Respondent

All the farmers interviewed are practicing crop-livestock systems. However, the study further classified the main occupation as shown in table 4.1. There is no farmer who solely cultivates crops or livestock only. The usual and common practice of agricultural system in the study area is a mixture of two. It was on this basis that this study sought to find out the skewness of the respondents to the main occupation they practice. The pooled result and which agrees with GSS, (2012) shows that 91.5% of the respondents are growing crops more than they rear livestock, 5.5% of the respondents' rear livestock more than they cultivate crops, 2% of the respondents are into petty trading and 1% is into other businesses. In Nandom district specifically, no respondents rear more livestock more than they cultivate crops. Details are shown in Table 4.1

4.2.8 Engagement in Off-farm Activities

Engagement in off-farm activities serves as a supplementary source of income to the respondents since most of the income they generate comes from and crop and livestock activities. For this reason, the combined data shows that, only 23% of the respondents are engaged in off-farm activities, such as pito brewing which are mostly done by women. Men on the contrarily are engaged in livestock trading where they cross the Black Volta River to neighbouring Burkina Faso to buy livestock to sell in major markets in Lawra and Nandom districts. Others were engaged in dry season gardening near the Black Volta River. More (26%) respondents were engaged in off-farm activities in Lawra district than they were engaged in Nandom district (20%). Table 4.1 gives further details.

4.2.9 Extension Contacts

In line with Baffoe-Asare *et al.,* (2013) receiving extension visits helps build the capacity of the farmer, as he/she will get to know new practices for enhanced livestock production. The combined results show that, only 19% of the respondents received extension service, with respondents in Nandom district higher (25%) than in Nandom district (13%).

4.2.10 Membership to a Farmer Based Organisation

Majority (68%) of the respondents do not belong to any organisation. Thus 32% of the respondents belong to Farmer Based Organisations in the districts. There were more (36%) respondents belonging to a farmer based organisations in the Lawra district than at Nandom district.

4.2.11 Farm Size

For this study, farm/flock size refers to the number of stock holding per farmer. Apart from poultry, also known as monogastrics, which belong to non-ruminating animal type, the mean farm size of the dominant specie (goats) of ruminating animals is about 8, as shown in table 4.2.

The findings is different from the findings of Ngombe *et al.,* (2014) who found the average farm size to be about 3.5 animals per farmer.

4.3 Level of Vulnerability of Smallholder Livestock Farmers

In all, thirty-two (32) sub-components (indices) of vulnerability were considered among seven (7) major components. Appendix 1 presents the results of the major and sub-component results of the LVI. In the Lawra district, Naburnye community, with an LVI value of 0.388, is most vulnerable among the four communities. Likewise, in Nandom district, Segru community, which has an LVI value of 0.421, is most vulnerable to climate change. Nandom district is more vulnerable to climate change.

Following Luers *et al*. (2003), vulnerability assessments should shift away from attempting to quantify the vulnerability of a place or community; instead, the emphasis should be on the vulnerability of the selected variables of concern and to specific sets of stressors. On this basis, two streams of vulnerability of smallholder livestock farmers in the two districts are discussed here, firstly, the vulnerability indices of the major components and secondly the vulnerability indices of socially differentiated groups.

For the major components, first of all, the Socio-Demographic Profile major component was made up of eight (8) sub-components, as indicated in Appendix 1 and 2. Dependency ratio is number of economically inactive persons to the number of economically active persons. Economically inactive persons are sum of all persons below the age of fifteen (15) years and those of sixty-five (65) and above (GSS, 2012). The dependency ratios of Nandom district (0.94) is higher than that of Lawra district (0.84). On the average, each economically active person in Ghana has one additional inactive person to support (GSS, 2012). For instance, the Nandom ratio of 0.94 shows that for every 100 economically active persons, there are 94 additional economically inactive persons to support.

Female-headed households were also considered as a sub-index under this major component. A female headed household in this study refers to those household heads who are either widowed and/or whose husbands have migrated for the past six months. There are however, 21 and 10% of female headed households in Lawra and Nandom districts respectively. The findings in Nandom district is almost in line with that of Hossain and Huda, (1995) who reported that, as many as 9% of rural households are managed or headed by women in rural Bangladesh.

Formal education of household head was also considered as a sub-component in this study. About 73% of the respondents, mostly of household heads are uneducated. Formal education tends to improve the ability of smallholder farmers to better comprehend issues affecting them and therefore look for possible solutions at the appropriate places (Etwire *et al.*, 2013a). The percentage of female-headed households in Lawra was 21% and 10% in Nandom district. Also, the percentage of orphans, also a sub-component were higher in Nandom (31%) and 20% in Lawra district. Higher percentage of female-headed households and orphans are indicators of higher vulnerability.

The living standard of a farmers' household can be reflected base on the materials used to build the house. In this study, farmers' household is considered vulnerable if the house is made of

mud, earth floored and roof with either thatch or mud. The reason is that, mud houses can easily be affected by weather perturbations than houses build with concrete wall. The results show that, 99 and 93% of the farmers' household is built with mud in Lawra and Nandom districts respectively. Most houses are roofed with iron sheets (zinc) as it show in the results that 16 and 4% of farmers' household are roof with thatch and mud respectively. In both districts, 14% of the respondents had their rooms' earth floored. Also, for each district, the average numbers of persons sleeping/passing the night in a room are two. In terms of socio-demographic profile, Lawra district (0.385) was found to be the most vulnerable district than Nadom district (0.344).
The second major component considered in this study is the livelihood strategies. Three sub-components were used to measure this major component as shown in appendix 1 and 2. Most of the family members have migrated to the cities to work. Migration is therefore a form of an adaptation strategy, but the limits of this research work did not extend to this discipline.

The results indicate that, 42 and 65% of the respondents in Lawra and Nandom districts have at least one family member working outside the community respectively. Households with higher number of members working outside the community are likely to be more vulnerable. The reason is that those working outside the community are mostly the economically active force, who would leave their wives, children and possibly the aged back at home (Lawra or Nandom), to fend for themselves. They (migrants) argue with the view of working to feed their family back at home, but usually their (migrants) support is low, making the other family members more vulnerable. Hahn *et al.* (2009)also found that Mabote district were more (0.625) vulnerable than Moma district (0.215).

Also, the percentage of households who had their income solely from Agriculture in Nandom and Lawra districts were 80 and 74% respectively. However, both district had the same average livelihood diversification index of 0.32. Respondents derived their household income from crops, livestock and other off-farm activities. The average number of livelihoods a farmer lived on in both districts are two, mostly crops and livestock production, which is in line with the findings that Mabote and Moma districts were reported on the average employing 2.4 and 1.9 livelihoods strategies (Hahn *et al.,* 2009). Also, unlike socio-demographic profile, the livelihood strategies of Nandom district (0.581) were found to be more vulnerable than that of Lawra district (0.474). A study of vulnerability index in two districts in Mozambique shows that Mabote also showed greater vulnerability on the Livelihood Strategies component (0.297) than Moma (0.246) (Hahn *et al.*, 2009).

Social Network is the third major component and consists of three sub-components. Farmers in Lawra and Nandom districts are reported to be giving help to others slightly more than they receive. Help packages are usually in the form of assisting each other in the farm, purchase of school uniform, books and pens, school bags and sometimes physical money. Again, in both districts, respondents are reported to be borrowing more than they lend. Some of the farmers are into FBOs through which they monthly due to the group, qualifying them to borrow when they are in need. Monies borrowed are usually use to buy fertilizer to fertilize the deteriorating land, plough back into business, especially the women who are involve in pito brewing and other petty trading, paying of children’s school fees and buying of food to complete the season whenever, they run out of food. Details are found in appendix 1.

The percentage of households that reported not going to their local government, including chiefs, assembly member and Member of Parliament (MP) for assistance in the past twelve months is high as 98% both districts. This finding is similar to that of Hahn *et al.* (2009) who found that the social network sub-components for Mabote and Moma districts in Mozambique were similar since over 95 and 92% said they had not approached their local government for assistance in the past month. In terms of social network, nearly the two districts have the same scale of vulnerability except that Nandom (0.239) appears to be more vulnerable than Lawra (0.236). The findings in Mozambique further reveals that in terms of social network, Mabote district were more vulnerable (0.480) than Moma district (0.457) (Hahn *et al*., 2009).

The fourth major component is food, which consists of four sub-components as indicated in appendix 1. As much as 79% of the respondents depend on the family farm (crop and livestock) for their food and protein needs. Due to seasonal variations in (decreasing) rainfall amounts, farms are performing poorly, enabling farmers to buy food to complete the season before they harvest at the end of the cropping season or livestock for their protein needs, especially during funerals or festive seasons. The average number of months that households experienced food shortage was about three in both districts, usually occurring in June, July and August. This finding has corroborated with that of (Etwire et al., n.d.). Majority of the respondents (98.5%) do reserve the young livestock for the purpose of breeding to increase stockholdings. Farmers in Lawra district are reported to be diversifying into more livestock types than in Nandom district. The average numbers of livestock diversification were found to be three and two in Lawra and Nandom district respectively. Livestock diversification therefore refers to the different types of livestock produce in a particular geographical location. Livestock types common to both districts are sheep, goats, pigs, cattle and poultry. The population of poultry (3840) were found to be more than goats (1623) followed by sheep (888), and then pigs (575) leaving cattle (474) to be the lowest. Unlike men livestock farmers who rear all types of the species above, women livestock farmers mostly rear poultry and goats, hence the high number. When all the four sub-components of food major component were aggregated, Nandom district (0.266) was found to be more vulnerable than Lawra district with an LVI of 0.245.

The fifth major component is water. It is composed of four sub-components as shown in Appendix 1. The aggregate of the four components show that Nandom district (0.623) is more vulnerable water than Lawra district (0.524). Etwire *et al.* (2013) found Upper West region to be the most vulnerable region in terms of water with an index of 0.489, and therefore, based on FANRPAN (2011); Muleta & Deressa (2014); Opiyo et al. (2014) classification, both Lawra and Nandom districts are considered highly vulnerable. The reasons for this are as a result of the fact that, 65% of the respondents in Nandom district are found to be reporting conflicts over water unlike Lawra district which is 41%. Within the study area, as you move up/northwards, the semi-aridity of the location decreases, thus water available for agricultural activities decreases.

This has been corroborated with the fact that 91% of the respondents in Nandom district utilize natural water sources more than their counterparts in Lawra district (84%). Natural water sources considered for this study include rainfall, river/lakes/streams and dams. Man-made sources include boreholes and wells. In all the communities visited, every community has at least one borehole. Except rainfall which is available only in the rainy season, the use of boreholes as sources of water depends on the number of months that these boreholes would have water. More respondents (77%) in Nandom district are reporting inconsistent water supply than in Lawra district (69%). The average time to water source is slightly more (10 minutes) in Nandom district than in Lawra district, about 9.8 minutes, but there is no statistical difference between the average times to water sources.

Health, which is also comprised of four sub-components, is the sixth major component. On foot, the average time to health facility was higher (71 minutes) in Nandom district than in Lawra district which was (54 minutes). This finding is not consistent with Hahn *et al.* (2009) who found the average travelling time to a health facility to be 189.1 and 593.3 minutes respectively. Access to a health facility is a good indicator of an adaptive capacity of any community. Under the same conditions, patients in Lawra district will get access to medical attendants, and eventually get their health dangers averted earlier than patients in Nandom district. Of all the eight communities, only one of the communities in the Lawra district has a health post. Having a health post will reduce the travel time to the district capital to access health care.

On chronic illness suffered by members of farmers' household more people in Lawra than in Nandom district report incidence of chronic illness. More people in Nandom than in Lawra district report missing school or work due to sickness. Households in Lawra district show a higher vulnerability to malaria than households in Nandom district. The aggregation of the four sub-components indicates that, Nandom district (0.260) is more vulnerable to health major component than Lawra district (0.246). The overall health vulnerability value for Moma and Mabote district was estimated to be 0.317 and 0.241 respectively (Hahn *et al.,* 2009).

Natural disaster and climate variability is the seventh and the last major component as far as the determination of community and district level LVI's is concern. The average number of floods occurring in Lawra and Nandom districts from 2004 to 2014 were two and one incidence respectively, whiles that of the average number of droughts for the same districts were seven times each.

Table 4.3: Average Number of Floods and Droughts Occurred from 2004 - 2014

Number of Floods and Droughts	Lawra District	Nandom District	Total Number of Floods/Droughts across districts
Average Number of Floods	2	1	3
Average Number of Droughts	7	7	14
Total Number of Floods/Districts along district	9	8	17

Source: Field Survey, 2016

Sixty-eight percent and 78% of the respondents in Lawra and Nandom districts did not receive warning or information about the floods and droughts before it happened. This has corroborated the finding that majority of the farmers did not receive some form of warning about a likely natural disaster such as floods and droughts (Etwire *et al.,* 2013). Access to information by the respondents is mostly through radio, mobile phone and television. From the results, 60%, 58% and 16% of the respondents own at least a radio set, mobile phone and Television sets respectively in the Lawra district whiles 65%, 59% and 10% own the same equipment respectively in the Nandom district.

Access to information is largely dependent on access to electricity. Out of eight sampled communities visited in both Lawra and Nandom districts, only two communities, one in each district is connected to the national grid. In this regard, farmers do not see the reason for owning a television set in the case of those communities that do not have electricity. This is reflected in the ownership of these sources through which information is received. Radio and mobile phone ownership is above average because majority of the smallholder farmers in the area buy dry cells for their radio sets and those who own mobile phones and do not have electricity in their communities easily carry them to the district capital, especially on market days for charging. Table 4.5 shows the percentage of respondents who owns at least one communication equipment.

Table 4.4: Ownership of Communication Equipment

Equipment Type	Lawra (%)	Nandom (%)
Radio	60	65
Mobile phone	58	59
TV	16	10

Source: Field Survey, 2016

Extreme events of drought and floods lead to poverty, as people would be food insecure. If there are droughts, growing crops will wilt and die-off and livestock will also lose weight and eventually die. If there are floods, crop fields would be washed-off and livestock would not be able to graze on flooded pasture, as grazing fields will be collected by water. As indicated above, from 2004 to 2015, only 2.5% of the respondents (both districts) have been injured. There has not been any case of loss of human life caused by drought and floods. About 22.5% and 33% of the pooled set of respondent reported they had lost at least one livestock and recorded lost in the value of the livestock respectively.

Meteorological data on minimum and maximum temperatures for Nandom district was unavailable, therefore, that of Lawra was used for both districts because, until, 2012, the two districts were one, Lawra-Nandom district. Lawra district however recorded more precipitation than Nandom district. When all the six sub-components were aggregated, Lawra district (0.505) tends to be more vulnerable than Nandom (0.503). However, in terms of Natural Disaster and Climate Variability major component, there is no statistical difference between the means (LVIs) of Lawra and Nandom districts as shown in Table 4.5.

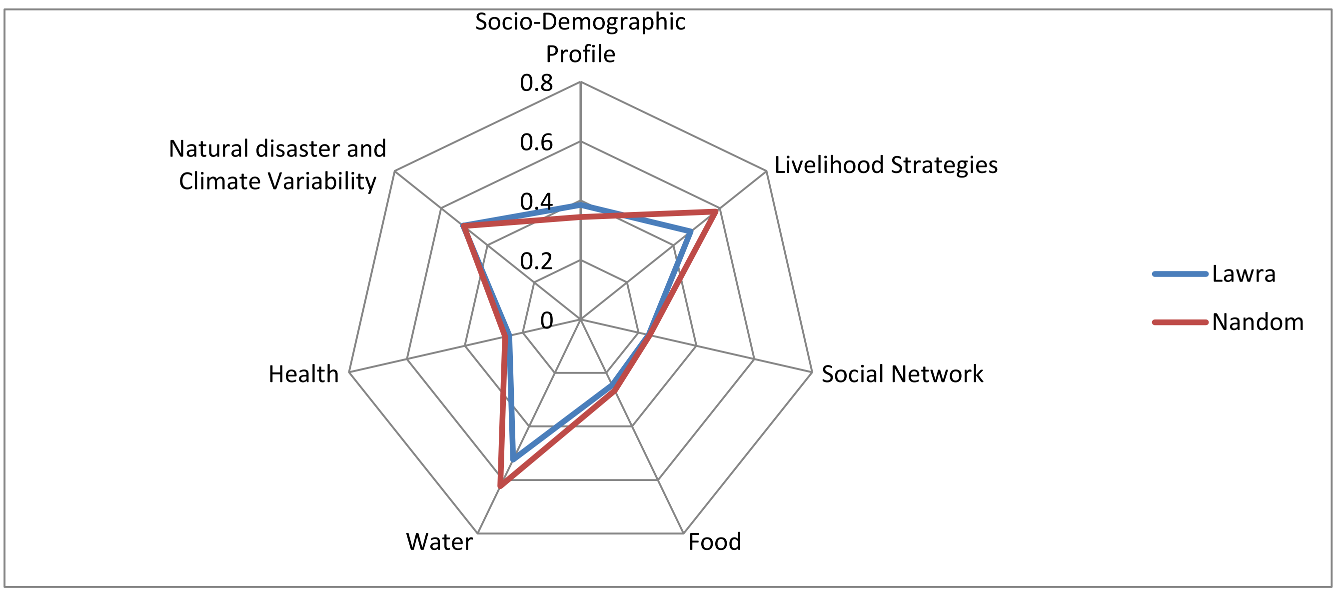
Table 4.5: Difference between Means of Natural Disaster and Climate Variability for both Districts

Variable	Observations	Mean	Std Error	Std Deviation	T-test	P-value	df
Lawra	100	0.5638	0.0033	0.0325	-1.7225	0.0433**	198
Nandom	100	0.5711	0.0027	0.0268			
Combined	200	0.5675	0.0021	0.0299			

Source: Field Survey, 2016

Per the above findings, Nandom district was more vulnerable in five major components compared to two in the Lawra district. It is the reason why the overall aggregate of the seven major components show Nandom district to be more vulnerable to climate change than Lawra district. Figure 4.1 presents a summary of the vulnerability indices of the major components of each district with 0 and 0.7 been least and highly vulnerable respectively.

Figure 4.1: Vulnerability spider diagram of major components of LVI for both Districts



Source: Field Survey, 2016

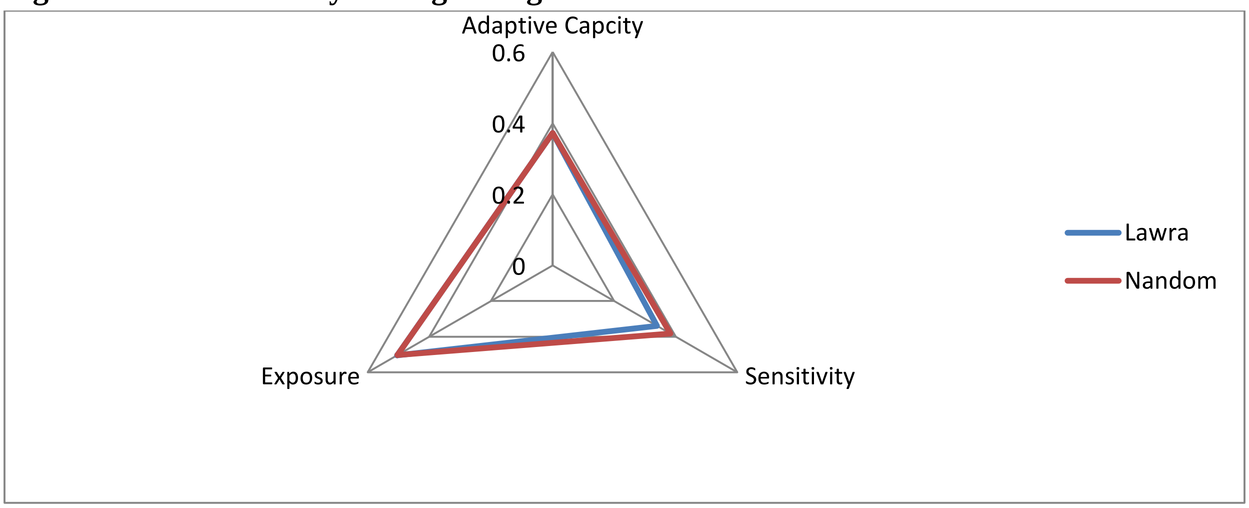
On the grounds of socially differentiated groups for the pooled sample, the results reveal that women livestock farmers were more (0.4831) vulnerable to climatic stressors than men. Vulnerability status were also measured based on marital status, thus widowed livestock farmers were more (0.4864) vulnerable than non-widowed (married and single) livestock farmers with a livelihood vulnerability index of 0.4820. Economically inactive farmers, age sixty-five (65) and above (GSS, 2012), were found to more (0.4839) than smallholder livestock farmers who are economically active, age range of 15-64 (GSS, 2012). Also, engagement in off-farm activities helps farmers to earn additional income, which may be used to take care of certain needs including reducing vulnerability or increasing his/her adaptive capacity. Therefore, the result shows that, farmers who engaged in off-farm activities were found to be less (0.4688) vulnerable to climate extremes and hazards than those who did not engage in any off-farm income generating activities.

Finally, a smallholder livestock farmer is at an advantageous position of benefiting from resources (capacity building, inputs, equipments, etc) if he/she is a member of a farmer based organisation since most governmental and non-governmental organisations would want to work with farmers who are already into organized groups. In that regard, the vulnerability status of farmers who are members of an FBO were measured to be less than (0.4682) those who were not members of any FBO, as the LVI value were 0.4872.

By considering IPCC definition of vulnerability, which is the product of the sensitivity score and the difference of the exposure and adaptive capacity scores, Hahn et al., (2009) then calculated a new index, which they denote as LVI-IPCC, for vulnerability. Each of the exposure, adaptive capacity and exposure scores are also known as contributing factors. The exposure score is the average score of food, water and health major components. The adaptive capacity score is the average score of socio-demographic profile, livelihood strategies and social network major components. The sensitivity score is equal to the score of natural disaster and climate variability major component.

The contribution factor values shows that, Lawra and Nandom districts have equal levels (0.3723) of adaptive capacity, but Nandom proves to be more (0.3827) sensitive than Lawra district (0.3387). Also Lawra district however shows a marginal higher (0.5045) exposure value than Nandom district (0.5035). The overall effect of the LVI-IPCC values of both districts also shows that, Nandom district is more (0.0502) vulnerable than Lawra district (0.0448). The new index, IPCC-LVI, goes to confirm the earlier findings on LVI when the seven major component values where used. Appendix 3 presents the measurements of vulnerability status and summarized in figure 4.2 as shown below.

Figure 4.2: Vulnerability Triangle Diagram of LVI-IPCC for Lawra and Nandom District



Source: Field Survey, 2016

4.3.1 Categorization of Vulnerability Levels of Livestock Farmers

Many vulnerability assessments identify the most vulnerable systems through ranking or prioritization. The types of ranking systems include categorical (e.g., high, medium/moderate and low), or numerical rankings of vulnerability creating a new index (ICF, 2013). Since the vulnerability levels of smallholder livestock farmers were determine, the study employed the method of classification used by FANRPAN (2011); Muleta & Deressa (2014); Opiyo *et al*. (2014) to classify the vulnerability levels into low, moderate and high vulnerabilities. The minimum and maximum vulnerability levels of a smallholder livestock farmer in the pooled data were found to be 0.3287 and 0.5820 respectively. On this basis, the farmers' vulnerability levels were classified as shown in Table 4.6.

Table 4.6: Categorization of District Level Vulnerability Index

LVI Range	Category	Lawra		Nandom		Combined	
		Freq	%	Freq	%	Freq	%
0.30-0.39	Low	3	3	0	0	3	1.5
0.40-0.49	Moderate	87	87	58	58	145	72.5
0.50-0.59	High	10	10	42	42	52	26

Source: Field Survey, 2016

A household is categorized as low vulnerable if it is able to cope with the effects of climatic hazards whereas moderately vulnerable households are hit hard by a shock and therefore needs urgent but temporary external assistance for it to recover. Also, highly vulnerable households are also known us emergency level household which are described as the equivalent of an intensive care situation, but could be brought back to life only with the best possible expertise.

Table 4.7: Difference between Mean LVIs of Lawra and Nandom Districts

Variable	Observations	Mean	Std Error	Std Deviation	T-test	P-value	df
Lawra	100	0.4611	0.0030	0.0304	-6.333	0.000***	198
Nandom	100	0.4899	0.0034	0.0339			
Combined	200	0.4755	0.0025	0.0352			

***P<0.01 **Source:** Field Survey, 2016

Table 4.7 shows the test of the two-sample t-test. The null hypothesis was rejected due to the fact that the t-statistics obtained from the diagnostics was 6.333 which is greater than the value obtained from the t-statistical table (2.601) with a degree of freedom of 198. The result further shows that, the probability value of 0.000 is less than 1% (0.01) level of significance. Therefore, it can be concluded that, there is significant difference between the mean LVI computed for Lawra and Nandom districts.

4.4 Factors Influencing the Level of Vulnerability

The factors influencing vulnerability of smallholder livestock farmers to climate variability and change emanates from different categories. These categories of the factors are household, institutional and environmental factors. Seven (7) household, six (6) institutional and two (2) environmental factors were considered as determining factors, giving a total of fifteen (15) independent variables. The household factors of the farmer were gender, age, educational level, farming experience, flock size, annual income, which was logged and pen ownership. The institutional factors were member of a Farmer Based Organisation (FBO), access to formal credit, participation in focus group discussion, no of extension contacts, access to veterinary services and access to weather information, and finally, the environmental factors were noticed decreased amount of rainfall and increased intensity of temperature.

The dependent variable is the vulnerability level of each livestock farmer determined in objective one. To estimate the linear relationship among the independent variables, it was important to specify at least one censoring limit, and therefore the vulnerability level of a smallholder livestock farmer was left-censored.

The regression results (Table 4.8) indicate that the chi-square value of 77.97 which is the likelihood ratio statistic and an F test value of 11.82 is highly significant at one percent (1%) level, indicating that the explanatory variables included in the model jointly influenced the level of vulnerability of smallholder livestock farmers. In other words, the variations in the independent variables significantly explained the variations in the dependent variable. The parameter estimates of the Tobit model as shown in Table 4.8 do not directly correspond to changes in the dependent variable brought about by changes in the independent variables. They rather give the direction of the effect.

Table 4.8: Tobit Regression Results of Determinants of Smallholder Livestock Farmers' Vulnerability to Climate Change

Independent variables		Lawra District		Nandom District		Combined/Pooled	
		Coefficient	**P > |t|**	**Coefficient**	**P > |t|**	**Coefficient**	**P > |t|**
Constant		0.3678***	0.000	0.4831***	0.000	0.4358***	0.000
Household Factors	Gender	-0.0048	0.184	0.00001	0.998	-0.0065*	0.083
	Age of farmer	0.0002	0.175	-0.0003	0.201	0.0030**	0.014
	Years of Education	0.0002	0.651	0.0004	0.928	0.0012***	0.002
	Farming Experience	-0.0001	0.420	0.0005**	0.023	-0.0003*	0.051
	Flock Size	0.0017	0.402	-0.0085***	0.010	-0.0001	0.640
	Annual Income (logged)	0.0077*	0.076	0.0053	0.309	-0.0029	0.150
	Pen Ownership	-0.0001	0.896	0.0095***	0.000	-0.0202***	0.000
Institutional Factors	Farmer Based Organisation Member	0.0047	0.404	-0.0010	0.910	-0.0096**	0.033
	Access to Credit	-0.0034	0.364	0.0094*	0.081	0.0067**	0.048
	Participation in Focus Group Discussions	-0.00004	0.748	0.0003	0.272	-0.0078**	0.045
	Number of Extension Contacts	-0.0080**	0.036	-0.0050	0.368	-0.0044***	0.000
	Access to Veterinary Services	-0.0149*	0.072	-0.0318***	0.003	0.0020	0.673
	Access to Weather Information	0.0022	0.527	-0.0075	0.136	-0.0045	0.311
Environmental Factor	Noticed Decreased Rainfall Amount	-0.0022	0.553	-0.0071*	0.078	-0.0054	0.155
	Noticed Increase Intensity of Temperature	0.0029	0.327	0.0085**	0.048	-0.0104***	0.002
/Sigma		0.012059		0.0183736		0.0202	

Where: *, **, and *** denotes statistical significant at *10%, 5%* and *1%* respectively

Source: Field Survey, 2016

After the regression, in the pooled sample, ten (10) of the fifteen factors, five (5) household factors, four (4), institutional factors and one environmental factor, were found to be statistically significant.

Gender of a livestock farmer is significantly associated with a decrease in vulnerability level. As expected, female livestock farmers are more vulnerable to climate change than their male counterparts. Female livestock farmers are therefore less likely to adapt to climate change strategies than the male livestock farmers. The result is consistent with Nabikolo *et al.* (2012) who stated that, female-headed households were less likely to adapt to climate change compared to their male counterparts. The findings however contradicted with that of (Nhemachena & Hassan, 2008), who, in their study on micro-level analysis of farmers' adaptation to climate change in South Africa, posited that female headed households were more likely to take up climate change adaptation methods in the Nile basin of Ethiopia.

Age of a smallholder farmer is significantly associated with an increase in his/her vulnerability level. As farmers grow old, they are more likely to be vulnerable to changes in the climate. This met the a priori expectation, because, ageing farmers become more economically inactive, and would not be able to adopt the adaptation strategies more than before. For instance, feed related strategies need much more income and sometimes energy to be able to buy some specialized formulated ingredients/feed and to cart some feed at the forest for the animals respectively. The findings is in line with FFC & FANRPAN (2013) as they indicate that farming households need physical capital to enhanced their adaptive capacity. However, the findings contradict with Muleta & Deressa (2014) in their study of determinants of vulnerability to poverty in female headed households in rural Ethiopia, found age square to be negative and significant, indicating a decrease in vulnerability to poverty.

Contrary to expectation, the number of years of education attained by the livestock farmers is associated with increase vulnerability. Thus, smallholder livestock farmers who have attained some level of formal education tend to be more vulnerable to climate change. Formal education is expected to enlighten farmers of the ways that they carry out their farm practices in a better way. The situation could be due to the fact that, majority (72.5%) of the farmers did not have at least basic education, and for those educated farmers, only 0.5% of them had up to post-secondary school with no farmer having tertiary education. This findings contradicts with Babatunde *et al.* (2008) who found that education of household heads statistically significant but negatively influences vulnerability to food insecurity among female-headed households.

The number of years of livestock farmer experience in livestock rearing is significantly associated with decreased vulnerability. That is smallholder livestock farmers with more years of farming experience are less likely to be vulnerable to climate variability and change. The reason could be that they are assumed been knowledgeable of the best choice and use of adaptation strategies in order to adapt to the changing climate. This is shown in the results where a significant percentage (35%) of the respondents had 16-30 years of farming experience. This finding is therefore compatible with the a priori expectation of this study. Smallholder livestock farmers’ farming experience is expected to enhance their resilience or adaptive capacity, hence will be less vulnerable. The finding is in line with Hassan and Nhemachena (2008) who reveals that, more experienced farmers are more likely to adopt climate change adaptation strategies.

Farmers owning pens are less vulnerable to climate variability and change effects than those farmers who do not have pens to house their livestock. Ownership and utilization of pens for livestock housing increases their adaptive capacity. That is smallholder livestock farmers who have pens for housing their livestock are less likely to be vulnerable to climate change induce factors like floods, drought, occurrence of strong winds, etc. As shown in the findings of objective 3 below, as much as 88% and 49% of the farmers adopt the indigenous and introduced housing strategies respectively. Indigenous housing strategies are usually not spacious to cater for the farmers' livestock. They also have small entrance with no windows, thereby inducing climate related diseases cause by heat-stress. Introduced housing strategies on the other hand are strategies that build the capacity of the farmers to construct pens which has enough space and yard for animals to move round, and the one with windows or improvised vents for free movement of air in and out of the pens.

Being a member of a Farmer Based Organisation (FBO) is significantly associated with decreased vulnerability. Farmers who belong to at least a Farmer Based Organisation (FBO) are less likely to be vulnerable to climatic stressors. Been a member of an FBO comes with several benefits from having the chance to share information from one farmer to the other, to receiving packages from NGOs and other donors, which will help them (farmers) to increase their resilience to climatic change. This finding is in line with the a priori expectation, which is of the view that, been a member of an FBO enhances your adaptive capacity, hence less vulnerable. This finding contradicts with Amusa *et al.* (2015) who found membership of farmers' cooperative to positively influence vulnerability but was higher in female than at male headed households.

A smallholder livestock farmer having access to credit is more likely to be vulnerable to climatic stressors. Therefore, the a priori expectation was not met. This occurs if the farmers adversely selected, that is, if after accessing the credit, he/she does not use the money for the intended purpose of adopting climate change strategies to reduce his/her vulnerability. This finding corroborated with Amusa *et al.* (2015) who found access to credit to positively influence vulnerability of male and female headed households.

Usually, information on good agricultural practices may come out of meetings among researchers and farmers. In line with expectation therefore, participation in focus group discussion is associated with decreased vulnerability. Thus, smallholder livestock farmers who participate in focus group discussion are less likely to be vulnerable to climate change effects. During meetings, farmers are likely to learn new ways of farming practices which when implemented will help them to reduce their vulnerability to climatic extremes such droughts and floods.

There exists an associated decreased vulnerability due to the number of contacts a farmer has with an extension officer. This agrees with the a priori expectation of this study. This means that, as the smallholder's livestock farmer number of times in contact with extension officers increases, he is less likely to be vulnerable to climatic effects. This could be possibly due to the fact that as much as 81% of the respondents did receive extension services annually. Extension officers, who serve as a conduit between researchers and farmers, are known to transfer livestock related technologies to farmers to adopt.

Increased intensity of temperature has a significant associated decrease in vulnerability level of smallholder livestock farmers. Thus, a farmer who noticed increase intensity of atmospheric temperature is more likely to be vulnerable to climate change effects. The findings therefore met the a priori sign. An increase in temperature may reduce or eliminate diseases of livestock cause by increased humidity. This invariably reduces the vulnerability of the livestock farmers since he may not or spend less amount of money to treat or vaccinate his animals.

To ascertain the district level effect of the independent variables on the dependent variable, regressions of Tobit model were also performed for each of the districts. The results in the Lawra district reveals that, membership to a farmer based organisation, participation in focus group discussion and pen ownership were found to influence the vulnerability of smallholder livestock farmers. In the Nandom district, the factors that were found to influence the vulnerability of the farmers were farming experience, annual income of the farmer, number of extension contacts, access to weather information, pen ownership, noticed decreased rainfall amounts and noticed increased temperature. The result of the Nandom district has provided additional evidence to the fact that, Nandom district were more vulnerable to climatic stressors than Lawra district. For instance, it is shown that, among other influential factors, decreased rainfall amounts and increased temperature are the two main environmental/ climatic factors that dictate the vulnerability status of a society. In Lawra district, these two factors were not significant. For each district, the overall model was found to be statistically significant at one percent level.

4.5 Indigenous and Introduced Climate Change Related Adaptation Strategies

Eight indigenous and thirteen introduced adaptation strategies were identified. The strategies identified are all related to four main sectors of livestock production system. These sectors include the provision of feed for livestock management, access to affordable and quality health services, the choice of breed type for optimum production and the type of housing system to use. Based on these, both the indigenous and introduced strategies are classified into feed, health, breed and house related strategies. On this score, we have indigenous feeding, health, breeding and housing related strategies, and also the introduced feeding, health, breeding and housing related strategies.

The indigenous feeding strategies include; adjustment of the quantity of feed given to animals as a way of feed management, planting of certain tree species for livestock feeding, the use of agricultural by-products such as yam and cassava peels, groundnut haulms, soyabean haulms, leaves of fic tree, use of thorns tree (goat biscuit tree), maize stovers and stalks and storing of feed on top of locally constructed sheds for dry season feeding (Konlan *et al.,* 2014). On the other hand, the introduced feeding strategies identified are pelleted feed as a way of reducing feed wastage during feeding, growing or cultivation of pasture grasses/forages, establishment of grazing reserves, fodder production, hay and sillage production, a mixture of rice straw/husk with salt solution and shade drying of leaves (Lukuyu *et al.*, 2007).

The indigenous health strategies refer to the use and application of traditional medicine for the treatment and vaccination of animals. Wounds of livestock can be treated by using barks of certain tree species (Khan *et al.,* 2013). Wounds are also treated by applying a solution of "duulang". Duulang is a local name given to accumulated smoke. The accumulated smoke is usually harvested from the walls of the kitchen. Since the source of energy for cooking is usually from firewood, smoke can easily gather on the kitchen walls. Also, certain types of leaves of trees (locally called bagna) when pounded into a paste and mix with water can control diarrhoea among livestock. More to these, leaves of "gorgor", a type of tree, is use as a dewormer to deworm livestock.

The research further shows that the sources of the introduced health strategies are self-medication from the farmer, services from the formal veterinary officer and services from the community livestock officer. All of these three different sources have to do with the use of orthodox medicines. With self-medication, the farmer buys the drugs from the recommended veterinary drug store and use or applies it himself without contacting the veterinary officer or the community livestock officer. Depending on the species of livestock, the use of the veterinary officer demands outright payment per head of livestock, since it is the veterinary officer who brings his/her own drugs (Kwadwo, 2013). In other instances, instead of the farmer doing self-medication, they seek the help of the community livestock officers to appropriately help them to medicate. On breeding strategies, the indigenous ones were best identified as local breeds and the introduced as improved (Fulani type) breeds. No further distinction was made within these breeds.

The characteristics of an indigenous house include; a pen without a yard, with no window or opening to allow for ventilation as well as the one with small entrance. However, a house which has a yard, window or openings at the back and a bigger entrance is considered as an introduced house related strategy (Nghonyuji *et al*., 2014). Another remarkable introduced house related strategy is the consideration of wind direction before building the pen. According to the farmers, with increasing temperatures, the wind mostly flow from east to west, so it is good to build across (North-south) this direction in order to harvest enough air into the animal pens (Zhang, Y. and Funk, 2000).

Appendix 9 presents a comparison of some of the indigenous and introduced climate related strategies.

4.6 Adoption of Adaptation Strategies

Five (5) categories of adaptation strategies were identified. These were feeding, health, housing and breed related strategies. The fifth (5) category was the non-adopters. These adaptation strategies were further classified into indigenous and introduced strategies. In all, 96% of the respondents adopt at least one strategy. Non-adopters of climate change adaptation strategies do not feed their livestock, animals are left to fend for themselves, they do not also provide any form of health care when the animals are sick, and neither do they provide any form of housing for the animals. They are also unaware of the type of breed they rear.

The study reveals that for a particular strategy, it is not uncommon to find a smallholder livestock farmer adopting both indigenous and an introduced strategy. In other words, the adoption of climate change adaptation strategy is not a mutually exclusive event. For instance, it is common to find a smallholder livestock farmer using both the indigenous and introduced health strategy to cure the disease of his sick livestock at the same time. The Adoption of the adaptation strategies are discussed in three broad areas namely: (i) the level of adoption of at least an adaptation strategy, expressed as a percentage (ii) the intensity of which a particular strategy is adopted, which is expressed as a percentage and (iii) the perceived effectiveness of these adaptation strategies.

4.6.1 Level of Adoption of Adaptation Strategies

The percentage of farmers adopting a particular strategy is presented in figure 4.4. Whiles about 86% of the respondents did indicate that they adopt different forms of indigenous feed related strategies (FRS) in order to adapt to their environment, 87% of them are reported to have done same for the case of the introduced feeding strategies. Among all the strategies identified, feed related strategies are the most important. The high rates of adoption of the indigenous and introduced feeding strategies could be as a result of inadequate feed grown at pasture for livestock all year round. So all sought of feeding options available are considered by the livestock farmer to feed his animals. In this regard, farmers have always taken indigenous measures to harvest some quantity of crop residue during the ending part of the rainy season which they store and use as feed to feed animals during the dry/lean season (Konlan *et al.*, 2014). That aside, this practice do not sometimes solve their annual feed shortage, so they resort to finding other options such as the introduced strategies; which include the formulation of feed from agricultural products and by-products, hay and silage production, a mixture of salt solution and rice straw and husk for livestock feeding. Because these types of introduced feeding still come with some little cost, the intensity of adoption (Figure 4.5) by farmers is higher (58%) for the case of the indigenous than the introduced feeding strategies.

Since the adoption rates for the indigenous and feeding strategies are almost the same level, a test for significance was conducted using the student two-sample t-test and the results reveal that the null hypothesis is not rejected because the t-statistics obtained from the t-test was 0.1448 which is less than the value obtained from the t-statistical table (1.966) at a degree of freedom of 398. Therefore, there is no significant difference between the mean level of adoption of the indigenous and introduced feeding strategies as indicated in Table 4.8. This findings is contrary to that of Bawa and Ani (2014) who found a significant difference between the mean level of adoption of improved maize technologies in Nigeria.

Table 4.8: Difference between Mean Level of Adoption of Indigenous and Introduced Feeding Strategies

Variable	Observations	Mean	Standard Error	Standard Deviation	t	P value	Df
Indigenous Feeding	200	0.860	0.025	0.348	0.1448	0.4425	398
Introduced Feeding	200	0.865	0.024	0.343			
Combined	400	0.863	0.017	0.345			

Source: Field Survey, 2016

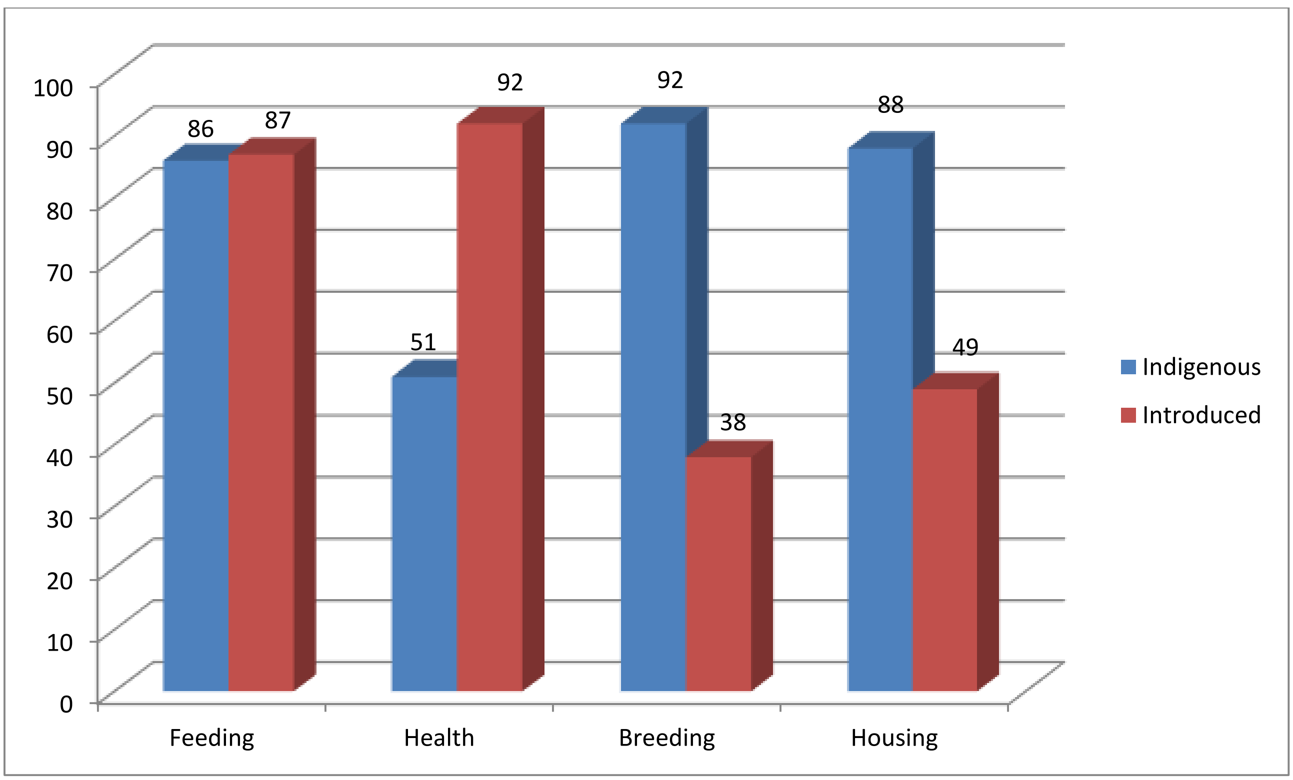
The second important adaptation strategy is the health related strategies. Majority (92%) of the respondents adopt the introduced health strategies because, though more costly to adopt, it is the most effective means of treating their animals as compared to the indigenous health strategies. This findings is further corroborated by the fact that majority (57%) of the respondents intensely adopted (Figure 4.5) the introduced health strategies. Farmers report that their animals are better treated with the use of the formal veterinary officer than relying on concoctions prepared from herbs and barks of trees. Except for complex cases, some farmers avoid the service cost of the veterinary officer by buying and applying the orthodox veterinary drugs by themselves. To them, the amount they will use to pay for treating or vaccinating their animals could be used to buy more drugs. This increases their economies of scale.

The finding of this study is consistent with the findings of Amadou *et al.* (2012) where majority (85%) of the respondents stated to have provided prophylactic vaccination or treatment to their animals in the case of the introduced health related strategies. Contrary to this finding is the case where an overwhelming majority (89%) of the respondents did indicate they use ethnoveterinary medicines, an indigenous health strategies, to treat their sheep (Getahun *et al.*, 2013).
The breed related strategies is the third adaptation strategy options used by farmers. The study further reveals that majority (92%) of the respondents adopt the indigenous Breed Related Strategies (BRS) such as the local types whiles 38% of the respondents adopt the introduced Breed Related Strategies.

The reasons could be that even though farmers perceived the introduced breeding strategies to be more effective (able to fetch higher prices) than the local types, they lack the skills in managing them. Managing the introduced breeds are more costly than the local types. More frequent vaccinations and specialized feed such as the commercially prepared types sold at veterinary stores are needed to manage the introduced breeds. However, the indigenous breeds are able to thrive well on the climate of the study area, thus they do not easily fall sick, and when they do mortality rates are much lower than the case of the introduced breeds. These are also the reasons why the intensity of adoption (Figure 4.5) by farmers is higher (89%) among the indigenous breeds than in the introduced breeds.

The housing related strategy is the fourth important adaptation options that farmers rely on when it comes to providing shelter for their livestock. Like the breed related strategies, adopting the housing related strategies come with cost. Building expanded housing system (an introduced strategy) with the provision of windows, doors and sometimes roofing with alluminium roofing sheets (zinc) as well as yard is more costly than building without a yard and either no or small outlets created at the front and back of the building which serves as entrance and windows. More to this is because farmers' livestock holding are in small quantities, a possibility that discourages them from adopting the introduced strategies. This is reflected in the intensity of adoption (Figure 4.5) by farmers, thus majority (78%) of them intensely adopted the indigenous strategies. However, farmers allude to the fact that the introduced housing strategies (Table 4.9) are more effective than the indigenous types. Figure 4.4 indicates the percentage of respondents who adopts these adaptation strategies.

Figure 4.4: Level of Adoption of Adaptation Strategies

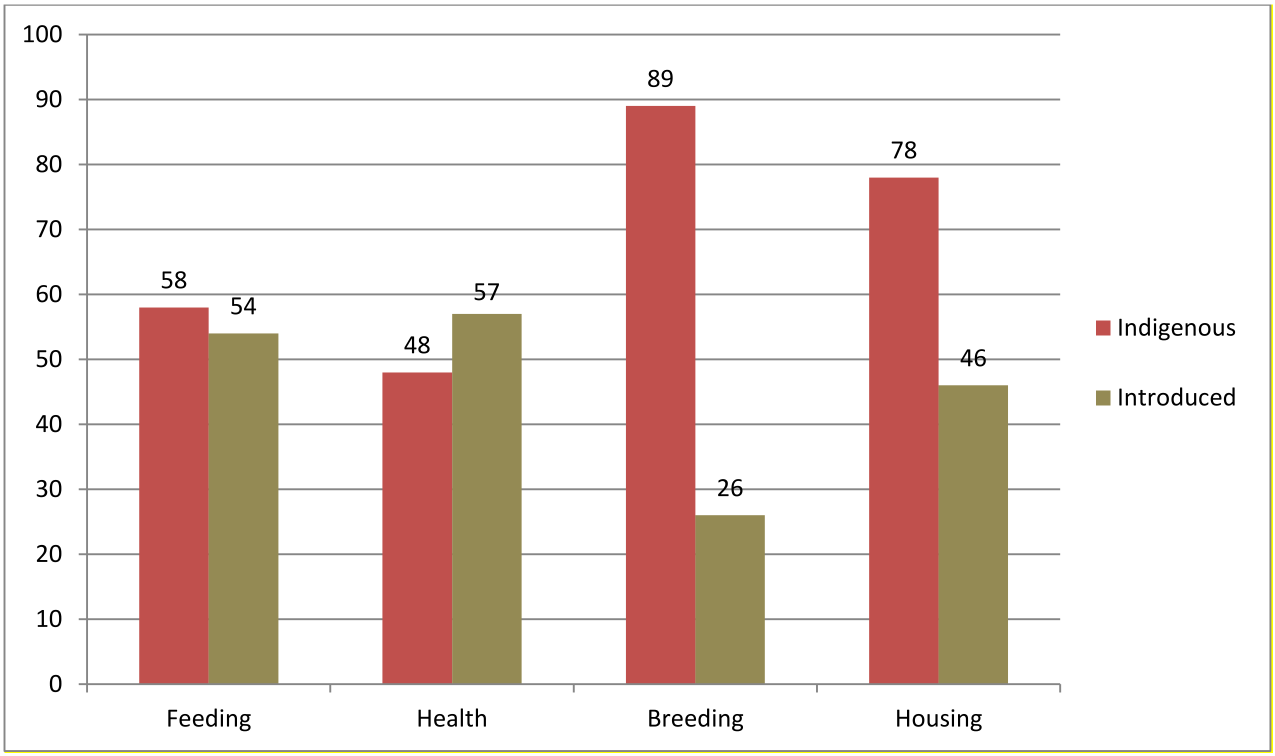


Source: Field Survey, 2016

4.6.2 Intensity of Adoption of Adaptation Strategies

The respondents were made to indicate the extent to which they adopt a particular strategy. As indicated, in this study, intensity of adoption, expressed as a percentage of farmers who adopt a particular strategy, refers to the degree at which a particular adaptation strategy is being used. Figure 4.5 indicates the various intensities of adoption.

Figure 4.5: Intensity of Adoption of the strategies



Source: Field Survey, 2016

4.6.3 Perceived Effectiveness of Adaptation Strategies

This section presents the results of assessment of effectiveness of the adaptation strategies. Depending upon the degree of effectiveness of an adaptation strategy, it is categorized into four (Table 4.9) namely; not effective, somewhat effective, moderately effective and very effective. The dominant category under each strategy could have influence the levels of adoption discussed in section 4.5.1. The dominant category is that category of effectiveness which has the highest percentage.

Under the feeding strategies the dominant category of effectiveness is the moderately effective. The statistics show that 34.87 and 37.08% of the respondents reported the indigenous and introduced feeding strategies are both moderately effective. The possibility is that, though slightly higher under the introduced feeding strategies, both strategies provide the nutrient requirement that the animals need for their metabolic activities.

Under the indigenous health strategies, the dominant category is somewhat effective, and moderately effective under the introduced health strategies. The reason could be the strong conviction hold by farmers that the introduced health strategies are a better way of having animals treated and vaccinated than the indigenous health strategies.

The dominant category under the indigenous breeding strategy is moderately effective and very effective for the case of the introduced breeding strategies. In terms of reproduction and net returns on investments, the introduced breeds and able to easily reproduce and give higher returns than the indigenous breeds.

Under the indigenous and introduced housing strategies, somewhat effective and very effective categories constitute the dominant category.

Table 4.9: Categorization of Effectiveness of Climate Change Adaptation Strategies

	Feeding Strategies		**Health Strategies**		**Breeding Strategies**		**Housing Strategies**	
	Indigenous (%)	Introduced (%)	Indigenous (%)	Introduced (%)	Indigenous (%)	Introduced (%)	Indigenous (%)	Introduced (%)
Not Effective	15.93	16.97	14.14	5.78	2.22	0	25.57	1.06
Somewhat Effective	25.41	22.71	33.33	20.23	30.93	3.95	41.48	2.10
Moderately Effective	34.87	37.08	29.29	49.71	50.27	35.53	19.32	23.16
Very Effective	23.79	23.24	23.24	24.28	16.58	60.53	13.64	73.67
Total Percentage	100	100	100	100	100	100	100	100

Source: Field Survey, 2016

4.7 Factors Influencing the Adoption of Introduced Adaptation Strategies

Prior to running the regression, multicollinearity among the exogenous variables was tested to ascertain that there was no near or perfect collinearity among the independent variables, as shown in appendix 4, that the tolerance and the VIF values of each of the exogenous variables was not less than 0.4 and more than 2.5 respectively (Allison, 1999). Also, to establish an independence of the presence of the strategies, for example, the odds of feeding strategies versus health strategies does not depend on the presence or absence of the other strategies, the Hausman's test of independent of irrelevant alternatives (IIA) assumptions test was conducted on each adaptation strategy as shown in Appendix 6. With this test, a significant test is evidence against the null hypothesis (H_0), and this is detected if the chi square (χ^2) value is less than zero, it means that, the estimated model does not meet asymptotic assumptions. The Hausman test result could not reject the null hypothesis of independence of irrelevant alternatives meaning that the use of the multinomial logit in this model was justified.

There were five (5) dependent variables that were considered in this multinomial logit model and these are feed, health, breed and house related strategies. The fifth category known as non-adopters (base category) was also taken into account since not all smallholder livestock farmers are able to adopt the new introduced strategies. Results of the coefficients of the regression are indicated in appendix 5.

Following Muleta & Deressa, (2014), this study discusses the pooled sample of the marginal effects of the factors that influenced the use of climate change introduced adaptation strategies with the individual district marginal effects indicated in appendix 7.

A unit increase in the age of a farmer decreases the probability of adopting the feed, health and breed related strategies as against not adopting any of the other strategies by 0.3%, 0.2% and 0.55% respectively. The plausible reason could be that as the farmers' ages, a time will reach when he will become economically and physically inactive to take up an adaptation strategy. Due to old age, a farmer may not be able to farm the way he use to do, to earn extra income that can enable him to buy a recommended feed, access livestock health need from a veterinary officer or purchase and improve breed of livestock. This is however a contradiction of the finding of Deressa *et al.* (2010) who stated that, age has a positive effect on the choice of livestock sale as an adaptation strategy by farmers during extreme climatic events, but in line with the findings of Anley *et al.* (2007) who found that age is significantly and negatively related to farmers' decisions to adopt. The apriori expectation of this study were expected to be either negative or positive, as hypothesized by Mutsvangwa-Sammie *et al.* (2013) that, age of the household head has both positive and negative impacts on adaptation measures, but however stated that, old age is associated with more experience and expect older farmers to adapt to changes in climate. However, young farmers are more likely to adopt measures such as irrigation and mixed crop-livestock systems that enhance farm productivity.

The difficulty in accessing veterinary drugs by a farmer reduces the probability of adopting the breed and house related strategies as against not adopting any of the strategies by about 21 and 24% respectively. Most smallholder livestock farmers in the Upper West region adopt less of the introduced breed and house related strategies. Adopting a breed or house related strategies come with an associated cost to the farmer. That is, the farmer may have to buy improved breeds which need regular vaccination unlike the local breeds or build the livestock pen with concrete blocks and roof with zinc, and on a regular basis has to fumigate the house and also give medications associated with possible overcrowding by the animals. However, none of the study communities and the districts in the region has a veterinary drug store where farmers could easily access drugs for their animals. This therefore make most of them (farmers) depend on the local breeds and also house their livestock only in the farming season, usually from May – September to prevent growing crops from been eating by the animals. The finding is consistent with Adams & Ohene-Yankyera (2015); Heffernan and Misturelli (2000) as they indicated that veterinary services are not affordable and are not easily accessible.

A unit increase in years of farming experience by the farmer decreases the probability of adoption of the health related strategies as compared to not adopting any of the strategies by 0.5%. The reason could be the same as explained in the age variable above, since an increase in farming experience by the farmer can be directly proportional to farmers' age. The finding is in line with Mutsvangwa-Sammie *et al.* (2013) as they noted that an experienced farmer who has stayed in a community for a long time has better knowledge of the climatic history of the area, and thus is more likely to adapt better to the changing environment compared to a farmer with less farming experience in his/her area.

Also, the difficulty of accessing veterinary service is another factor that influences the adoption of the introduced feed and health related adaptation strategies. As against not adopting any of the strategies, it decreases the probability of adopting the feed and health strategies by 9.5% and 4.9% respectively. The reason could be that there are inadequate veterinary officers available to provide veterinary services to livestock owners. It is expected from veterinary officers to provide extension services such as sources of good feed for livestock use and how farmers should keep their animals to prevent an outbreak of diseases. To prevent other farmers from waiting for their turn for their animals to be treated, the veterinary officer may not have enough time to provide such education to the farmers, thus he (veterinary officer) will quickly treat or vaccinate the animals and moves to the next farmers' farm. The finding agrees with Adams & Ohene-Yankyera, (2015); Getahun *et al*. (2013) who argues that, veterinary offices are far from farms as one of the reasons why smallholder farmers do not participate in veterinary services.

Table 4.10: Marginal Effects of Influencing Factors of Introduced Adaptation Strategies

Independent Variables	**Feed Related Strategies**	**Health Related Strategies**	**Breed Related Strategies**	**House Related Strategies**
Gender	-0.1964 (0.641)	0.0085 (0.644)	0.1774 (0.115)	0.1817** (0.029)
Age of farmer	-0.0026*** (0.009)	-0.0023** (0.023)	-0.0055*** (0.002)	0.0007 (0.330)
Access to Veterinary drugs	0.1755 (0.514)	0.1308 (0.367)	-0.2124* (0.094)	-0.2443** (0.025)
Farming experience	0.0030 (0.732)	-0.0050** (0.012)	-0.0008 (0.374)	-0.0005 (0.391)
Access to veterinary services	-0.0947** (0.027)	-0.0490* (0.054)	-0.0517 (0.103)	-0.0055 (0.198)
Access to community livestock worker	-0.1159 (0.699)	-0.0531 (0.726)	0.2084* (0.096)	0.0920 (0.140)
Noticed decrease rainfall amounts	-0.0492* (0.071)	0.0121 (0.459)	-0.1451** (0.013)	0.0084 (0.366)
Noticed increased temperature	-0.0324 (0.285)	0.0148 (0.749)	-0.1637* (0.078)	0.0414 (0.833)
FBO member	0.1964** (0.017)	0.0394 (0.205)	-0.1742 (0.382)	0.0025 (0.689)
Access to weather information	0.0309 (0.143)	0.0397* (0.094)	-0.0179 (0.316)	0.0992** (0.025)
LVI	-0.3088 (0.364)	0.3936 (0.408)	0.4586 (0.912)	-0.9903** (0.015)
Base outcome: Non-adopters of the introduced strategies				
Number of observations: 200				

***, ** and * denotes statistical significance at 1%, 5% and 10% respectively
*Figures in parenthesis are the coefficients of the explanatory variables
Source: Field Survey, 2015

The ease of accessing a community livestock officer increases the probability of adoption of breed related strategies by about 21% as against not adopting any of the introduced strategies. In the livestock health delivery system in Ghana, formal veterinary officers are usually inadequate to cater for most farmers' livestock. To increase livestock health delivery system during either vaccination or treatment, enlightened individuals from the communities are trained on how to handle some first aid cases of livestock health needs. These people are referred to as Community Livestock Officers (CLWs) or Community Animal Health Workers (CAHWs). A smallholder livestock farmer in the region will not hesitate to adopt any livestock breed if he/she can get access to livestock health care. This is possible because, the CLW, who is a member of the community and a livestock farmer as well, is usually part of the first people to adopt a newly introduced strategy, given the fact that, his capacity is being built to provide health care services. He can also serve as a source of extension service delivery. His (CLW) success in adopting the strategy, especially breed and the house related strategy can lure other farmers to adopt such strategies. In analyzing factors influencing the adoption of livestock production technologies (eg breeding strategies), farmers access to extension services, probably through community livestock worker, was found to be significant and negatively relates to the adoption of improved livestock technologies Ansah *et al.* (2015), a finding which is contrary to that of this study.

There is about 4.9% decrease in the probability of adopting the feed related strategies if the smallholder livestock farmer in the region noticed decreased rainfall amounts. The rainfall system in recent times has been very erratic, in that, the expectations of farmers are usually unmet, as the rains sometimes stop as early as September. During these periods, farmers are still busy with their crop activities and do not have enough time to harvest feed for livestock to feed-on during the dry season.

A livestock farmer noticing decreased rainfall amount reduces the probability of adopting the breed related strategies by about 14.5% as compared to not adopting any strategy. Decreased rainfall amount, to some extent, increases the temperature. Some livestock breeds are not able to withstand increased temperature. So, as temperature increases and rainfall amount reduces, the likelihood of adopting a variety of livestock breeds reduces. The smallholder livestock farmer will rather adopt those breeds that are drought resistant. The finding of this study agrees with Apata, (2011) who opine that the negative relationship between average annual precipitation and adaptation could be due to the fact that increasing precipitation does relax the constraints imposed by increasing temperature on crop growth.

Contrary to expectation, as temperature increases, the probability of adopting the breed related strategies as compared to not adopting any strategy reduces by about 16%. This contradicts the finding of Apata, (2011) who found increasing temperature to be directly related to the adoption of climate change adaptation strategies.

Smallholder livestock farmers who are Members to a Farmer Based Organisation (FBO) in Upper West region are more likely to adopt the feed related strategy rather than not adopting any strategy. There is high chance of a farmer capacity been built through these FBO's, because FBO's usually wins the attention of development change agents/workers. In this regard, the farmer have the chance of been introduced to different climate change adaptation strategies including that of feed related strategies, thus increasing the likelihood of adopting the feed related strategies by that proportion (19.5%). This is in line with the findings of Okuthe *et al.*(2013) who found a farmer being a member of a farmer group to significantly influenced the adoption of improved sorghum varieties and technologies in Kenya.

As expected, farmers' accessing weather information is more likely to adopt the health and housing related strategies versus not adopting any of the strategies. Information on temperature and rainfall dynamics could have influence the adoption of the health and housing related strategies. An increase in temperature which could lead to heat-stress related infections could influence farmers to build expanded houses and also make sure that they clean and fumigate the house regularly. The livelihood vulnerability level of farmers reduces their likelihood of adopting the housing related strategies versus not adopting any form of adaptation strategy by about 10%.

CHAPTER 5

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This concluding chapter presents a summary of the findings of this study, from which relevant conclusions are derived from the findings. Based on the findings, it has also recommended some relevant policies for stakeholders. The chapter also presents some suggested research gab(s) for future research.

5.2 Summary and Major Findings

The study seeks to assess climate change adaptation strategies used by smallholder livestock farmers in the Upper West region of Ghana. The objectives of the study were to: measure the vulnerability level of smallholder livestock farmers, determine the factors influencing the vulnerability levels, measure the levels of adoption of adaptation strategies used by livestock farmers to adapt to climate change effects and to determine the factors influencing the adoption of the adaptation strategies.

The study made use of relevant tools like the Livelihood Vulnerability Index to measure vulnerability levels, the tobit model to determine vulnerability influencing factors, descriptive statistics such as percentages, tables, frequencies and bar chart to measure adoption rates and finally the multinomial logit model to determine adoption rate influencing factors.

Using a multistage sampling technique involving purposive sampling technique to select study region and districts, stratified and simple random sampling technique to identify study communities and respondents, 200 smallholder livestock farmers was interviewed.

The findings of the study show the dynamics of the socioeconomic characteristics of the farmers, which included gender, age, educational status, farming experience, household size, and involvement in off-farm activities and among others. The results show that, 67% and 33% of the respondents were males and females respectively. The mean age of farmers interviewed were about 48 years with 22 and 90 years been the minimum and maximum age of farmers' respectively. The educational status of the respondent show that, 72.5% had no basic education whiles 27.5% of the respondents had at least basic education. A respondent had an average of about 19 years of livestock rearing experience.

Measurements of vulnerability of smallholder livestock farmers were estimated by three methods- in terms of major components, overall LVI and the LVI-IPCC approaches. The results show that, Lawra district is more vulnerable in terms of socio-demographic status and natural disaster and climate variability whiles Nandom district is more vulnerable in terms of livelihood strategies, social network, food, water and health. Overall, the smallholder livestock farmers in Nandom district are more vulnerable than those in Lawra district and the difference is statistically significant.

The categorization of the LVIs shows that in Lawra district, majority of the smallholder livestock farmers are moderately vulnerable, but highly vulnerable in Nandom district. The pooled sample indicates moderately vulnerable livestock farmers.

Being a male farmer, experience in farming, owning pens, being a member of an FBO, number of extension contacts, noticing increase intensity of temperature and participation in focus group discussions are associated with lower vulnerability. Also, the age of the farmer, number of years of education and accessing credit are associated with higher vulnerability.

Adoption of indigenous breeding and housing strategies is much higher than adoption of introduced strategies. The reverse is true for health strategies. While more farmers adopted the introduced feeding and health strategies, the adoption of the indigenous and introduced feeding strategies are at par.

The result on the intensity of adoption shows that, 58%, 48%, 89% and 78% of the indigenous feeding, health, breeding and housing strategies are being intensely adopted. The same goes for the introduced strategies where 54%, 57%, 26% and 46% of the feeding, health, breeding and housing strategies are been intensely adopted. Furthermore, the aggregations of the categories of effectiveness indicate that the introduced health, breeding and housing strategies are more effective than the indigenous health, breeding and housing strategies. The reverse is true for the feeding strategies.

The factors that were found to influence the adoption of the introduced strategies varied depending upon the type of strategy adopted. If a smallholder livestock farmer is a female, then she is more likely to adopt the house related strategies. Except for house related strategies, a unit increase in the age of a farmer reduces the likelihood of adopting the feed, health and breed related strategies. The difficulty in accessing veterinary drugs was more likely to reduce the adoption of breed and house related strategies. Also, a unit increase in years of farming experience by the farmer decreases the probability of adoption of the health related strategies. The difficulty in accessing veterinary services reduces the likelihood of adopting the feed and health related strategies. However, the ease of accessing the community livestock worker and being a member of a farmer based organisation increases the adoption of the breed and feed related strategies respectively. The results further reveals that noticing decreasing rainfall amount by the farmers reduces the probability of adopting the feed and breed related strategies.

Whereas noticing increased temperature and a farmer with a certain level of LVI reduces the probability of adopting the breed and house related strategies respectively, the ease of access to weather information increases the adoption of health and house related strategies.

5.3 Conclusions

Farmers in Nandom district were more vulnerable to climatic stressors than farmers in Lawra district when the LVI and LVI-IPCC were computed. This is because there were more ageing women livestock farmers in Nandom than in Lawra district. Women livestock farmers were found to be more vulnerable to climatic stressors than men, due to the fact that women have less access to economic resources such as ownership of land for farming and livestock. They are also, in many cases not consulted when it comes to decision making, such as the number of livestock or crop produce to sell. This could have been the reason why Nandom district were more vulnerable in five of the seven major components that were used to compute the LVI.

Factors that enable smallholder livestock farmers to be highly vulnerable to extreme situations of droughts and floods include; the age of the farmer, being a woman, number of years of formal education and access to credit. Since an increase in the age of the farmer influences an increase in vulnerability, introduction of new technologies should target young farmers instead of adult farmers. When young farmers take-up an adaptation strategy, they will consider and use it for a number of years before they abandon it.

Also, adult education can be introduced to improve the educational standard of livestock farmers. A literate young farmer will be better able to accept an introduce strategy than an illiterate adult farmer.

Under the indigenous strategies, majority of the farmers adopted the feeding, breeding and housing strategies. It implies that farmers are yet to understand the advantages/benefits of adopting the introduced breeding and housing strategies. Under the introduced strategies, majority of the respondents adopted the feeding and health strategies. The reason could be that they were more conscious about the feed and health of their animals. Furthermore, farmers' levels of adoption of the indigenous and introduced feeding strategies are about the same as proved by the t-test result. The possibility could be that, the indigenous feeding strategies still help them to minimize cost whiles maximizes profit in their livestock production activities.

Adoption of the feed related strategies could be increase if farmers are made to form and or join farmer based organisations. These organisations can provide a platform where farmers will learn other new or existing use of possible feed related strategies. To enhance the adoption rate of the health and house related strategies, farmers should have frequent access to weather information. Knowledge about weather information can make them to prepare for the impending natural disaster. More community livestock workers should be recruited and trained on basic veterinary practices to complement the few and inadequate number of formal veterinary officers. This can stimulate the adoption of the breed related strategies.

5.4 Policy Recommendations

To reduce vulnerability of farmers, the climate change unit of the Ministry of Environment, Science, Technology and Innovation (MESTI) should collaborate with appropriate organizations by providing funding to build the capacity of farmers for increased adoption of introduced breeding and housing strategies. This can be achieve by providing some improve livestock breeds, building recommended housing and requisite training on these strategies to some selected farmers. This can enable other farmers to emulate from the others. The effect of this will increase their adaptive capacities, reduce their sensitiveness and exposure to climatic stressors.

Policies should gear towards establishing early warning systems to affect natural disasters. One way of establishing early warning systems is by directing the Ghana Meteorological Agency (GMA) to collaborate with radio stations in the districts to broadcast in local dialect the possible climate change hazards (floods and droughts) that may occur. When this initiative is taken into consideration, farmers would be informed early enough, and that will enable them to prepare for the possible disaster, thus increasing their adaptive capacity.

Given the effectiveness of housing livestock, educational programmes that will increase the facilitation and use of improved pens to house livestock, an effective way of introduced housing strategy, should be intensified since more than half of the sample farmers considered are not adopting the introduced housing strategy.

Also, government should consider the recruitment of more Agricultural Extension Agents (AEAs) to reduce the deficit of extension worker to farmers' ratio since majority of the farmers did not have access to extension services.

Since women are more vulnerable to climate stressors than the men, women should be supported with livestock and livestock inputs to increase their adaptive capacities.

Given the levels of adoption of the strategies, District Assemblies (DA) of the Ministry of Local Government and Rural Development (MLGRD) should collaborate with local authorities in the various districts and communities to help enforce the governance of land use systems in those districts and communities. Unregulated land use systems in a society leads to siltation of water bodies, deforestation, bush-burning, absence or poor identification of pasture fields from arable lands, improper use of fishing equipments and agro-chemicals to mention a few are land use systems which when not well regulated can lead to increased vulnerability of any society.

In order to enhance the adoption of the introduced strategies, more Community Livestock Workers (CLWs) should be trained on basic veterinary practices to help provide first aid services to sick livestock in various communities across the district before the veterinary officer arrives. Smallholder livestock farmers should be encouraged to join and participate actively in FBOs. Being a member and participating actively in an FBO have the potential of increasing the knowledge of the farmer, since he/she may get the opportunity to learn from other experience farmers. It even shows that, membership to an FBO increase the probability of a farmer adopting the house related strategies.

There is the need for private investors, especially those in the regional capital, Wa to consider expanding their business (sale of livestock drugs and other inputs) to the districts or community levels so that smallholder livestock farmers can easily access these drugs either by themselves or through the services of a veterinary officer or community livestock officer.

5.5 Suggestions for Future Research

First, future research on assessing climate change adaptation strategies by smallholder livestock farmers should be based on particular livestock species. Secondly, the indices used in the computation of the livelihood vulnerability index could be increased to establish the effect of using different number of indices on the vulnerability status of farmers in a particular location

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APPENDICES

Appendix 1: Indexed Sub-Components, Major Components for Lawra and Nandom Districts

Sub-Components	**Districts**		**Major Components**	**Districts**	
	Lawra	**Nandom**		**Lawra**	**Nandom**
Dependency ratio	0.16	0.18	Socio-demographic Profile	0.385	0.344
% of Female Headed Households	0.21	0.10			
% of Household head with no education	0.88	0.69			
% of Household with orphans	0.20	0.31			
% of Households with mud walls	0.99	0.93			
% of Households with earth floor	0.14	0.14			
% of Households with thatch roof	0.16	0.04			
Average number of persons per room	0.35	0.37			
% of Household with members working outside the community	0.42	0.65	Livelihood Strategies	0.474	0.581
% of Household earning income solely from Agriculture	0.74	0.80			
Average Livelihood Diversification Index	0.26	0.29			
Average Receive : Give	0.31	0.31	Social Network	0.236	0.239
Average Borrowed : Lend money	0.38	0.38			
% of Households with no assistance from local assembly	0.02	0.02			
% of Household solely family livestock	0.74	0.84	Food	0.245	0.266
Months Household struggle to find food	0.11	0.07			
Average Livestock diversification index	0.11	0.13			
% of Households not reserving some young animals for breeding purposes	0.01	0.02			
% of Households reporting water conflict	0.41	0.65	Water	0.524	0.623
% of Household that fetch from natural water source	0.84	0.91			

Average Time to Water Source	0.16	0.16			
% of Household with inconsistent water supply	0.69	0.77			
Average time to health facility	0.22	0.29			
% of Household member/s with chronic illness	0.11	0.04			
% of Household member missing work/ school	0.28	0.41	Health	0.246	0.260
Average Malaria exposure	0.37	0.30			
Total floods and Droughts	0.29	0.25			
% of Household with no warning about any pending disaster	0.68	0.78			
% of Households member with injury/death	0.01	0.02	Natural Disaster and Climate Variability	0.505	0.503
Average Maximum Temperature	0.73	0.73			
Average Minimum Temperature	0.72	0.72			
Average Rainfall	0.60	0.52			

Source: Field Survey, 2015

Appendix 2: Calculating the Socio-Demographic Profile and Livelihood Strategies Major Component of the LVI for Lawra district

Sub-components for Socio demographic Profile	Sub-component value for Lawra	Max in Combined data	Min in Combined data	Index Value for Lawra	Socio – demographic profile major Component for Lawra
Dependency ratio	0.84	5.33	0	0.16	
% of Female headed of Household	21	100	0	0.21	
% of Household head with no school	88	100	0	0.88	
% of household with orphans	20	100	0	0.20	0.344
% of household with mud houses/walls	99	100	0	0.99	
% of household with earth floor	14	100	0	0.14	
%of household with thatch roof	16	100	0		
Average Number of persons per room	2.07	6	0	0.35	
Sub-components for Livelihood Strategies	**Sub-component value for Lawra**	**Max in Combined data**	**Min in Combined data**	**Index Value for Lawra**	**Livelihood Strategies major component for Lawra**
% of household member working outside	42	100	0	0.42	
% of household income solely from Agric.	74	100	0	0.74	0.581
Average Livelihood diversification index	0.32	0.5	0.25	0.26	

Source: Field Survey, 2015

Appendix 3: Calculating LVI – IPCC for Lawra and Nandom Districts

Contributing Factors	Major Components for Lawra and Nandom	Major Component Value		Number of Sub-components	Contributing Factors Value		LVI – IPCC Value	
		Lawra	Nandom		Lawra	Nandom	Lawra	Nandom
Adaptation Capacity	Socio-demographic profile	0.385	0.344	8	0.3723	0.3723	0.0448	0.0502
	Livelihood Strategies	0.474	0.581	3				
	Social Network	0.236	0.239	3				
Sensitivity	Food	0.245	0.266	4	0.3387	0.3827		
	Water	0.524	0.623	4				
	Health	0.246	0.260	4				
Exposure	Natural Disaster and Climate Variability	0.505	0.503	6	0.5045	0.5035		

Source: Field Survey, 2015

Appendix 4: Variance Inflation Factor Test for Multicollinearity among the Explanatory Variables used for the Introduced Adaptation Strategies

Variable	Tolerance	VIF	1/VIF
Age	0.914	1.094	0.9141
Access to veterinary drugs	0.975	1.025	0.9756
Farming experience	0.990	1.010	0.9901
Access to veterinary services	0.940	1.064	0.9398
Access to community livestock worker	0.916	1.092	0.9158
Noticed decreased rainfall amount	0.938	1.066	0.9381
Noticed increased temperature	0.933	1.072	0.9328
FBO member	0.934	1.071	0.9337
Access to weather information	0.981	1.020	0.9804
Dependent variable: Gender			

Source: Field Survey, 2015

Appendix 5: Coefficients of the Factors that Influence the use of Climate Change Introduced Adaptation Strategies

Independent variable	Coefficients	Standard Error	P>│z│
Feed Related Strategies			
Gender	-0.4331	0.9286	0.641
Age of farmer	-0.0438	0.0169	0.009
Access to Veterinary drugs	0.5980	0.9163	0.514
Farming experience	0.0050	0.0145	0.732
Access to veterinary services	-1.2038	0.5432	0.027
Access to community livestock worker	-0.3319	0.8588	0.699
Noticed decrease rainfall amounts	-0.7949	0.4407	0.071
Noticed increased temperature	-0.6842	0.6400	0.285
FBO member	1.5086	0.6318	0.017
Access to weather information	0.6577	0.4493	0.143
LVI	-3.0091	3.3142	0.364
Constant	3.0910	2.0098	0.123
Health Related Strategies			
Gender	0.6463	1.4005	0.644
Age of farmer	-0.0573	0.0252	0.023
Access to Veterinary drugs	1.3872	1.5362	0.367
Farming experience	-0.0703	0.0281	0.012
Access to veterinary services	-1.2664	0.6567	0.054
Access to community livestock worker	-0.3616	1.0315	0.726
Noticed decrease rainfall amounts	-0.3797	0.5123	0.459
Noticed increased temperature	-0.3321	1.0363	0.749
FBO member	0.7336	0.5786	0.205
Access to weather information	0.9521	0.5692	0.094
LVI	3.2783	3.9645	0.408
Constant	0.9506	2.1244	0.655
Breed Related Strategies			
Gender	1.3106	0.8318	0.115

Age of farmer	-0.0506	0.0163	0.002
Access to Veterinary drugs	-1.3576	0.8110	0.094
Farming experience	-0.0139	0.0156	0.374
Access to veterinary services	-0.9416	0.5771	0.103
Access to community livestock worker	1.1169	0.6715	0.096
Noticed decrease rainfall amounts	-1.0951	0.4310	0.013
Noticed increased temperature	-1.0308	0.5842	0.078
FBO member	-0.3980	0.4556	0.382
Access to weather information	0.4248	0.4237	0.316
LVI	0.3376	3.0571	0.912
Constant	4.5893	1.5838	0.004
House Related Strategies			
Gender	2.1341	0.9757	0.029
Age of farmer	-0.0245	0.0252	0.330
Access to Veterinary drugs	-2.0935	0.9345	0.025
Farming experience	-0.0148	0.0172	0.391
Access to veterinary services	-0.7948	0.6180	0.198
Access to community livestock worker	1.0519	0.7127	0.140
Noticed decrease rainfall amounts	-0.4619	0.5113	0.366
Noticed increased temperature	-0.1718	0.8157	0.833
FBO member	0.2174	0.5423	0.689
Access to weather information	1.1878	0.5312	0.025
LVI	-8.7024	3.5899	0.015
Constant	3.8186	2.3773	0.108
Base outcome: Non-adopters			
Test statistics			
Number of observations	200		
Wald chi2 (44)	100.78		
Prob > chi2	0.0000		
Pseudo R2	0.1446		
Log pseudolikelihood	-265.50148		

Source: Field Survey, 2015

Appendix 6: Hausman's Tests of Independence of Irrelevant Alternatives Assumption

Omitted	Chi2	df	P>Chi2	Evidence
Feeding strategies	2.85	22	1.00	For Ho
Health strategies	-2.57	22	1.00	For Ho
Breeding strategies	3.68	22	1.00	For Ho
Housing strategies	1.74	22	1.00	For Ho
Non-adopters of introduced strategies	-3.75	22	1.00	For Ho

H_0: Odds are independent of the other alternatives

Source: Field Survey, 2015

Appendix 7: Marginal Effects of the Factors that Influence the use of Introduced Adaptation Strategies (District Sample)

Exogenous variable	**Lawra District**				**Nandom District**			
	Feeding Strategies	**Health Strategies**	**Breeding Strategies**	**Housing Strategies**	**Feeding Strategies**	**Health Strategies**	**Breeding Strategies**	**Housing Strategies**
Gender	-0.6833**	0.0012	0.3369**	0.3293	0.9881***	-0.0477	-0.2220	0.0059***
Age	-0.0026**	-0.00002	-0.0083***	0.0016	-0.0010	-0.0031**	-0.0019	0.0001
Access to Vet. Drugs	0.3272**	0.0058	-0.1893*	-0.2796	-0.9801***	0.1549	0.1872	-0.0185***
Farming Experience	0.0048**	-0.0004	0.0011	-0.0009	-0.00004	-0.0027**	-0.0038	-0.00005
Access to vet. Services	-0.0986	-0.0110*	-0.0540	0.1216	-0.0149	0.0017	-0.3066*	0.0002
Access to CLW	-0.0979	0.0001	0.2207	0.0055	-0.0310	-0.1010***	0.2196	-0.0024***
Noticed decreased rainfall amounts	-0.0521	0.0056	-0.1021	0.1752	-0.0878**	-0.0007	-0.2683**	-0.0016**
Noticed increased temperature	-0.0261	0.0322***	-0.1389	0.1139	-0.0254	-0.0650	-0.1832	0.0082***
FBO membership	0.1831*	0.0037	-0.1767	0.0571	0.1754**	0.0331	0.1196	0.0001
Access to weather information	0.0217	0.0063*	-0.1573	0.2705**	-0.0078	-0.0038	0.2185*	0.0028
LVI	-0.9410	0.0838**	1.6141	-1.2385	-0.0007	0.0215	-0.1236	-0.0028

Source: Field Survey, 2016

Appendix 8a: Focus Group Discussion Guide

Project Title: *Assessing Climate Change Adaptation Strategies used by Smallholder Livestock Farmers in the Upper West Region of Ghana*

Guide for Focus Group Discussion

November 2015

Purpose: to obtain information on livestock related climate change adaptation strategies in this community and the district as a whole

Preliminary activities before the FGD session will include:

- Training of FGD teams (facilitator and a note taker)
- Meeting with key people in the community to inform them the purpose of the research
- Community mobilization for the FGD
- Collection of preliminary information on the community

Criteria for selection of FGD participants:

- The team will invite about 15 participants with a good gender balance and good knowledge of the community.
- The FGD will compose of key social groups (Both male and female livestock farmers who will be group into three (3) according to their ages, livestock traders and assemblers, ethnic groups, etc).

1. General Information on the FGD

Country: Ghana			
District			
Name of Community			
GPS coordinates			
Altitude			
Date of FGD		Duration of FGD	
Venue for the FGD		Language of FGD	
Number of participants (Males)		Number of participants (Females)	

Name of Facilitator	
Names of note takers	
Names of observers	
Special conditions that may affect FGD on that day (weather, local activities, etc)	

2. Information on the community

Name of community	
Total population	
Total number of households	
Number of female headed households	
Proportion of households growing crops and keeping livestock	
Proportion of households growing crops only	
Proportion of households keeping livestock only	
Proportion of households engaged in non-agricultural activities only e.g. commerce	
Average size of farm per household	
Dominant crops grown in the village	
Dominant livestock species in the village	
Average livestock number per household for the dominant livestock type	

3. Community profiling

Mapping issues	**Detailed information**
Natural resources	
Water resources	
Location of crop fields	
Rangelands (composition)	
Livestock corridors(where the livestock pass seasonally)	
Forest resources	
Infrastructure	
Road Network	
Commodity markets (including agricultural and livestock markets)	
Vet Clinic	
Water sources (eg.Stand pipes, boreholes, wells, small reservoirs, etc)	
Social services	
Health	
Schools	

Mosque/Church	
Local administration	
Role of traditional Authorities	
Extension offices	
Types of NGO's and their activities	
Electricity (national grid)	

4. How are you aware of climate change? (eg. Decreasing rainfall totals, increased rainfall variability, Increasing temperature, increasing intensity of sunshine, seasonal changes in rainfall patterns, prolonged rainfall shortages)
……………………………………………………………………………………………………
……………………………………………………………………………………………………

5. What are the different livestock-related social groups in the community? (multiple responses possible) [ ][ ][ ][ ][ ][ ] 1=Male livestock farmers 2=Female livestock farmers 3=Livestock traders 4=Livestock assemblers 5=Other ethnic groups 6=Other
(Specify)……………………………………………………………………………

6. Are different social groups in the community adopting different climate change adaptation strategies? [ ] 1=Yes 2=No

7. What indicators do the community members observed that influences a change in the climate? What are the attributes of these indicators, by local perceptions, to change in climate? (Local knowledge or perceptions that indicates or will give a forecast of future climate)

S/N	**Indicator of change**	**Attributes on rainfall (high or low), beginning of rainy season or imminent of dry season, livestock diseases, crop failure, etc**
1	Thunder and Lightning	
2	Germination or disappearance of certain grass species	
3	Appearance or disappearance of certain insect species	
4	Appearance ,timely movement and sound of certain bird species	
5	Nature and direction of the moon	
6	Appearance of rainbow	
7		

8. How do the changes affect your livestock and how livestock owners respond to these changes?

Effects on livestock	**Responds by livestock farmers to these changes**

9. How many flood situations have been observed in this community since 2004? [ ]

10. Indicate those years in which these floods were observed? [ ][ ][ ][ ] [ ][ ][ ][ ] [ ][ ]

11. In this area, about how many droughts have occurred since 2004?

12. Indicate those years in which these droughts were observed? [ ][ ][ ] [ ] [ ][ ][ ][ ] [ ][ ]

13. Have you observed any changes about the weather from 2004-to date? If yes what are they?

    (a)……………………………………………………………………………………

    (b)……………………………………………………………………………………

    (c)……………………………………………………………………………………

14. In the following table, indicate the names of organisations/institutions and their purpose of implementing climate change and livestock related projects in this community

Name of Organisation	**Purpose**	**Specific recommendations for climate change and variability adaptation strategy**	**Are they Still implementing ? 1=Yes 2=No**

15. Seasonal Calendar of climate hazards that affects livestock production (Tick in the boxes where applicable)

Climate Harzards	**Month**											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Drought												
Floods												
Strong winds												

16. Identify the adaptation strategies into indigenous and introduced strategies, and use proportions to indicate the extent of its use by livestock farmers (For each strategy, 10 stones will be used to distribute to the various strategies, where 1 stone will represent 10%)

(a) Indigenous adaptation strategies

S/No	Strategies	Proportion of farmers who use them
1		
2		
3		
4		
5		

10 stones=All farmers, 6-9 stones=Most farmers, 5stones=Half of the farmers, 4-1 stones= Less than half, 0 stone= None

(b) Introduced adaptation strategies

S/No	Strategies	Proportion of farmers who use them
1		
2		
3		
4		
5		

10 stones=All farmers, 6-9 stones=Most farmers, 5stones=Half of the farmers, 4-1 stones= Less than half, 0 stone= None

Appendix 8b: Questionnaire

Smallholder Livestock Farmers' Questionnaire
Adaptation at Scale in Semi-Arid Regions (ASSAR) Project
Institute for Environment and Sanitation Studies (IESS)

Title

Assessing climate change adaptation strategies used by smallholder livestock farmers in the Upper West region of Ghana

Informed Consent

Dear respondent, you have been randomly recruited to participate in this survey. For this survey to be successful, I would want to take about 30-40 minutes of your time. The information you will give me will be treated as anonymous and will not be associated to your name in any of my work or in my further interviews with other people working in this and other communities.

My contact address and numbers:
Shaibu Mohammed Tiyumtaba
mohammedtiyumtabas@gmail.com
0203905609/ 0264521199

Questionnaire Code:	Date:
District:	District code:
Community:	Community code:
Name of Enumerator:	Enumerator signature:

A. General Information

1. Name of respondent:____

2. Gender of respondent: 1=Male[_____] 0=Female[_____]

3. Age of respondent: [_____] years

4. Respondents' highest level of formal education: 0=None[____] 1= Basic (Primary/JHS/Middle school) [____] 2= Secondary (Secondary/Vocational) [____] 3=Post-Secondary (Teacher & Nursing Training college/polytechnic) [____] 4= Tertiary (University) [____] 5=Other (Specify) ______________________________

5. Number of years spent in school by respondent _________

6. Which tribes do you belongs to? 1=Dagaati[____] 2=Waala[____] 3=Dagomba[____] 4=Fulani[____] 5=Ashanti[____] 6=Other (specify) __________________

7. Respondents' marital status: 0=Single[____] 1=Married[____] 2=Divorced/Separated[____] 3=Widowed[____]

8. Years of experience in rearing livestock by respondent: ______________________

9. (a) Is the respondent the head of the household? 1=Yes[____] 0=No[____]

   (b) If Yes to 9(a), skip to question 16

   (c) If No to 9(a), provide name of the head: _________________________________

10. Gender of head: 1=Male[____]0=Female[____]

11. Age of head: __________________years

12. Household head highest level of formal education: 0=None[____] 1=Basic (Primary/JHS/Middle school) [____] 2= Secondary (Secondary/Vocational) [____] 3=Post-

Secondary (Teacher & Nursing Training college/polytechnic) [____] 4= Tertiary (University) [____] 5= Other (Specify)______________________

13. How many years has the household head spent in school?__________________________

14. Heads' marital status of head: 0= Single[____] 1=Married[____] 2=Divorced/Separated[____] 3=Widowed[____]

15. Years of experience in rearing livestock by the head____________________________

B. Assets

16. Indicate the assets own by the farmer with their corresponding prices?

Asset	Number	Unit Cost	Amount
Farm assets			
Livestock			
Wheel barrows			
Hoes			
Axe			
Machetes			
Spraying pumps			
Spade			
Communication assets			
Radio			
TV			
Mobile phones			
Transportation assets			
Motor Bike			
Bicycles			
Salon vehicles			
Trucks			
Other assets			
Mosquito nets			

17. Is your house made of mud or concrete? 1=Mud [____] 2= Concrete[____] 3=others (Specify)____

18. What is the floor of your house made of? 1=Earth[____] 2=Cement[____] 3=Tiles[____] 4=Others (Specify) _______________________

19. What is the roof of your house made of? 1=Grass/thatch[____] 2=Mud [____] 3=Iron sheets/asbestos[____] 4=others (Specify)____________________________

20. How many rooms does this household have?____________________

C. Household Composition

21. What is the mean numbe of persons sleeping in a room?___________________

22. How many people live in this hous? Total:________ Male:________ Female__________

23. How many orphans are there in this household (<18 & have lost 1 or both parents)? ______________

24. How many persons are below 15 years? Total:________ Male:________ Female________________

25. How many persons are 15 to 65 years? Total:_______ Male:_______ Female:____________

26. How many persons are above 65 years? Total:__________ Male:_______ Female:____________

D. Income Sources of Farmer

27. What is the main occupation of the farmer: 1= More crops-Less on livestock[____] 2=Less on crops-More on livestock[____] 3=Only crops[____] 4=Only livestock[____] 5=Petty trading[____] 6=Craftsmanship[____] 7=Formal sector salary worker [____] 8=Other (specify)_____________________________

28. Do you involved in any off-farm activities that earn you some additional income? 1=Yes [____] 0=No [____] Skip "Off-farm activities" in Q29 if respondents answered "No".

29. Please, give an estimates of your annual income from these farm and off-farm activities (if any) in the last 12 months

ACTIVITIES	**QUANTITY**	**UNIT PRICE**	**AMOUNT**
A. Livestock Farm Activities			
Sheep			
Goats			
Pigs			
Cattle			
Poultry			
Sub-total (A)			
B. Crop Farm Activities			
Maize (in bags)			
Millet (in bags)			
Sorghum (in bags)			
Rice (in bags)			

Bambara beans (in bags)			
Others (specify)			
Sub-total (B)			
C. Off-farm Activities			
Pito brewing (Number of pots per day)			
Handicrafts making (e.g basketry) (No. sold per day)			
Charcoal burning (in bags)			
Rice processing (in bags)			
Shea butter processing (in Kg)			
Dawadawa processing (in Kg)			
Other (specify)			
Sub-total (c)			
GRAND TOTAL			

*For the crops, usually, a bag ranges between 85-100kg. This is yet to be identified for the specific crops

E. Availability and Access to Services

30. Does any member in your house work outside this community? 1=Yes[____] 0=No[____]

31. What sources of water is available for your household for drinking and other chores? 1=Pipe borne[____] 2=Dam[____] 3=Rain[____] 4=River/Lake/Stream[____] 5=Wells[____] 6=Boreholes[____] 7=Other (specify) [____]

32. How many minutes does it take to get to the source of water? ___________on foot/___________by bicycle

33. Have you experience water shortages in this locality before? 1=Yes[____] 0=No[____]

34. Each day, how many buckets (size 34) of water do you store? (probe)__________________________

35. Have you experience or heard about any form of conflict probably due to water shortage? 1= Yes[____] 0= No[____]

36. How many minutes will it take to get to a health centre? __________on foot /____________by bicycle

37. Do any of the household members have a chronic illness? 1=Yes[____] 0=No[_____]

38. (a) Has any member of your house been very sick in the past 6 months such that she/he has to forgo going to work or school? 1=Yes[____] 0=No[____]

(b) If Yes to 38(a), what are the common diseases in this community? 1=Malaria 2= Skin Disease & Ulcers 3= Diarrhoea 4= Acute Eye Infection 5= Urinary Tract Infections (UTI) 5=Others (Specify)_______________________________________

39. (a) If malaria is common, how many months in a year is it particularly common? ____________________

(b) Name the months: 1=Jan[____] 2=Feb[____] 3=Mar[____] 4=Apr[____] 5=May[____] 6=Jun[____] 7=Jul[____] 8=Aug[____] 9=Sept[____] 10=Oct[____] 11=Nov[____] 12=Dec[____]

40. How many mosquito nets does the household have?___________________

41. (a) Does this community have a market? 1=Yes[____] 2=No[____]

(b) If No to Q41 (a), how many minutes does it take you to get to the nearest market? by foot_____ by bicycle___________ and by motorbike____________________________________

F. Livestock Composition and Housing Information

42. Indicate the number of the following livestock species

1	**Sheep**						
Category	Ewe	Gimmer	Ewe Lamb	Ram	Young Ram	Ram Lamb	Sheep Castrate
Number							
2	**Goats**						
Category	Doe	Female goatling	Female kid	Billy	Male goatling	Male kid	Goat castrate
Number							
3	**Pigs**						
Category	Sow	Gilt	Piglet	Boar	Young Boar	Piglet	Barrow/Stag
Number							
4	**Cattle**						

Category	Cow	Heifer	Female Calf	Bull	Young bull	Male calf	Bullock/Steer
Number							
5	Poultry						
Category	Hen	Point-of-lay pullet	Pullet	Cock	Cockerel	Young cockerel	Capon
Number							

43. Will some of the young livestock species in the table above be reserved for breeding purposes? 1=Yes[____] 2=No[____]

44. (a) Do you have a pen for housing the livestock? 1=Yes[____] 2=No[____]

    (b) If Yes to Q44 (a), do you have it for the different species of livestock? 1=Yes[____] 2=No[____]

45. Which periods do you not house your livestock? 1=Jan-Mar[____] 2=April-Jun[____] 3=July-Sept[____] 4=Oct-Dec. [____] 5.Other (Specify the months) [____]

G. Livestock Medication

46. (a) Do you have access to veterinary services? 1=Yes[____] 2=No[____]

    (b) If No to 46 (a), what practices do you adopt to treat your livestock when they are sick? 1=None[____] 2=Local practices[____] 3=Use of human related medicines[____] 4=others (specify)____

    (c) If Yes to 46 (a), which sources do you access your veterinary services (multiple responses possible) 1=Services from traditional healer[____] 2= Services from community livestock worker[____] 3=Services from professional veterinary officer[____] 4=other (specify) [____]

(d) If Yes to 46 (a), how much did it cost you to vaccinate and/or to treat a unit of livestock specie in the last 12 months?

Livestock Species	Medication Type		Total Cost (GHC)
	Vaccination (GHC)	Treatment(GHC)	
Sheep			
Goats			
Pigs			
Cattle			
Poultry			
Grand Total			

47. (a) Do you have access to veterinary drugs? 1=Yes[____] 2=No[____]

(b) If Yes to 47 (a), estimate the cost of veterinary drugs bought in the past 12 months?

Type of drug bought	Number/Volume	Unit Cost	Total Cost

H. Mortality and Consumption records

48. Estimate the value of livestock that has died and consumed over the last 12 months

	Total production (Retrieve from Q 42)	Number died	Unit Price	Amount	Number consumed	Unit Price	Amount	Total value of livestock that died and consumed (GHC)
Sheep								
Goats								
Pigs								
Cattle								
Poultry								

49. (a) Does your household have enough food throughout the year from own produce? 1=Yes[____] 0=No[____] If Yes, skip to Q50

(b) If No to Q49 (a), how many months in a year does your household experience food shortage? [______]

(c) Name the months: Jan=1[____] Feb=2[____] Mar=3[____] April=4[____] May=5[____] June=6[____] July=7[____] Aug=8[____] Sept=9[____] Oct=10[____] Nov=11[____] and Dec=12[____]

I. Access to Credit

50. (a) In the past 12 months, has any member of your house obtained any help from relatives/friends? (e.g. remittances, payment of school fees, care during sickness or medicines, sale of crops or livestock, etc)? 1=Yes [____] 0=No[____]

(b) If Yes to Q50 (a), list the type of help obtained:

____
____
____

51. (a) In the past 12 months, have you borrowed any money from your relatives or friends? 1=Yes[____] 0=No[____]

(b) If Yes Q51 (a), What did you use it for?

____
____
____

52. (a) In the past 12 months, have borrowed any money from formal credit source/sDid you borrow any money from formal credit sources in the past 12 months? 1=Yes[____] 0=No[____]

(b) If Yes to Q52 (a), what did you use it for?

____
____
____

53. In the past 12 months, has any member lend money from you? 1=Yes[____] 0=No[____]

54. (a) Has any member in this household gone to your community leader for assistance in the past 12 months? (e.g., Member of Parliament, Assemblyman, chief etc)? 1=Yes[____] 0=No[____]

(b) If Yes to Q54 (a), what type of assistance did you obtained?

____
____
____

J. Climate Change

55. (a) In recent years, have you observed any form of changes in the weather pattern?
1=Yes [____] 0=No[____]

(b) If Yes to Q55 (a), what notable changes have been observed?
1=Increasing temperature [_____] 2=Increasing intensity of sunshine [_____] 3=Seasonal Changes in Rainfall pattern[_____] 4=Prolonged Rainfall Shortages[_____] 5=Stronger Winds[_____] 6=Others (specify)____

56. What changes have been particularly noticed in the changes of rainfall?
1=Unpredictable[____] 2=No change[____] 3=Decreased[____] 4=Increased[____]

57. What changes have been particularly noticed in the temperature pattern?
1= Unpredictable[____] 2=No change[____] 3=Decreased[____] 4=Increased [____]

58. (a) Has this community been affected by any drought or flood since 2004? 1=Yes[____] 0=No[____]

(b) If Yes, to Q58(a), how many times of flood? __________and drought?_______________

59. Before the flood/s occurred, did you receive any warning about it? 1=Yes [___] 0=No [____]

60. (a) Has any member of your household suffered from any injury or lost their life due to the flood/s or drought/s? 1=Yes[____] 0=No[____]

(b) If Yes to Q60 (a), indicate the number that got injured _______ / lost life__________

61. (a) Has there been any case of lost of livestock due to the flood/s or drought/s? 1=Yes[____] 0=No[____]

(b) If Yes to Q61 (a), how many livestock did you lose to the flood/s or drought/s_____________

62. Did you record any loss in the value (due to ill health or weight loss) of your livestock due to the flood/s or drought/s? 1=Yes [____] 0=No[_____]

63. Do you adopt any form of measures to adapt to climate change? 1=Yes [_____] 2=No [_____]

64. If Yes to Q63, identify by classifying those measures into indigenous and introduced strategies, and use proportions to indicate the extent of its adoption by livestock farmers (For each strategy, 10 stones will be used to distribute to the various strategies, where 1 stone will represent 10%)

(d) Indigenous adaptation strategies

S/No	Strategies	Proportion of strategy being adopted by farmer
1	Application of traditional medicine	
2	Adjustment of the quantity of feed given to animals as a way of feed management	
3	Planting of certain tree species for livestock feeding	
4	Use of agricultural by-products as feed	
5	A mixture of rice straw/husk with salt solution and used as feed for livestock	
6	Fencing of an area by planting shady tree species	
7	Others (specify)	

1 stone=Least adopted

(e) Introduced adaptation strategies

S/No	Strategies	Proportion of strategy being adopted by farmer
1	Reliance on the services of a community livestock officer	
2	Use of pelleted feed as a way of reducing feed wastage	
3	Growing of pasture grass/forage for livestock feeding	
4	Establishment of grazing reserves for livestock feeding	
5	Formulated feed from agricultural products and by-products for livestock feeding	
6	Fodder production	
7	Hay and silage production	
8	A mixture of boiled sheabutter and kerosene to control ectoparasites (eg ticks)	
9	Provision of bedding and warmth during cold days	
10	Provision of cold water and shed during warm days	
11		

1 stone=Least adopted

65. Adaptation strategies based on effectiveness in adapting to climate change (obtainable from Focus Group Discussion). Use 10 stones as a local measure, to indicate the degree of effectiveness.

(a) Indigenous strategies

Indigenous strategies ever used	**Still Using (1=Yes, 0=No)**	**Effectiveness**
Application of traditional medicine		
Adjustment of the quantity of feed given to animals as a way of feed management		
Planting of certain tree species for livestock feeding		
Use of agricultural by-products as feed		
A mixture of rice straw/husk with salt solution and used as feed for livestock		
Fencing of an area by planting shady tree species		

0-1 stones=Not effective, 2-4 stones=Somewhat effective, 5-7 stones=Moderately effective, 8-10 stones=Very effective

(b) Introduced strategies

Introduced Strategies	**Still Using (1=Yes, 0=No)**	**Effectiveness**
Reliance on the services of a community livestock officer		
Use of pelleted feed as a way of reducing feed wastage		
Growing of pasture grass/forage for livestock feeding		
Establishment of grazing reserves for livestock feeding		
Formulated feed from agricultural products and by-products for livestock feeding		
Fodder production		
Hay and silage production		
A mixture of boiled sheabutter and kerosene to control ectoparasites		
Provision of bedding and warmth during cold days		
Provision of cold water and shed during warm days		

0-1 stones=Not effective, 2-4 stones=Somewhat effective, 5-7 stones=Moderately effective, 8-10 stones=Very effective

66. For introduced strategies, indicate source, how long ago and cost (per animal) of applying the strategy

S/N	**Introduced Strategies**	**Source of strategy**	**How long ago (years)**	**Cost of applying strategy**
1				
2				
3				

4				
5				
6				

K. Access to Agricultural Extension Services

67. (a) In the past 12 months, have you accessed any formal agricultural extension services? 1=Yes[_____] 0=No[_____]
(b) If Yes to Q67(a), how many number of times in the past 12 months?_____________________

(c) If Yes to Q 67 (a), what are these extension services (Multiple choices possible):
1=Administration of medications[_____] 2=Dry season feed preparation[_____] 3=Delivering of young animals[_____] 4=Awareness creation[_____] 5=Facilitates access to inputs[_____] 6=Facilitates access to credit[_____] 7=Advice on livestock management[_____] 8=Introduced new livestock breeds[_____] 9=Others (Specify)_______________________

L. Membership in an Organization

68. (a) Are you a member of a Farmer Based Organization (FBO) or any agricultural related group? 1=Yes[_____] 2=No[_____]
(b) If Yes to Q68 (a), what does the organization do to build your capacity and other forms of support towards rearing livestock?
____
____

69. How many of such groups do you currently belong to? [______]

70. Do you participate in focus group discussions and community workshops in relation to climate change adaptation issues? 1=Yes[_____] 2=No[______]

71. What is/are your final comment(s) based on the interview?
____
____

We have come to the end of the interview. Thank you very much

Appendix 9: Plagiarism Result

Originality Report

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