UNIVERSITY OF GHANA

SOCIAL DIFFERNTIATION IN CLIMATE CHANGE ADAPTATION STRATEGIES OF SMALLHOLDER FARMERS IN THE UPPER WEST REGION OF GHANA

BY

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THIS THESIS IS SUBMITTED TO THE UNIVERSITY OF GHANA IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF MPHIL CLIMATE CHANGE AND SUSTAINABLE DEVELOPMENT DEGREE.

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DECLARATION

I, Abass Adam Yidana, do hereby declare that except for the references cited, which have been duly acknowledged, this thesis titled, **"Social Differentiation in Climate Change Adaptation Strategies of smallholder farmers in the Upper West Region of Ghana"** is the product of my own research work in the Climate Change and Sustainable Development Programme in University of Ghana from July 2015 to July 2016. I also declare that this thesis has not been presented either in whole or in part for another degree in this university or elsewhere.

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DEDICATION

I dedicate this work to my mum Mma Rachia, my wife Samata and my wonderful kids Suglo and Sugri for the immense sacrifice they made in the course of this programme.

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ABSTRACT

There is growing attention on socially differentiated stakeholder groups in understanding vulnerability and adaptation to climate change. However, empirical research on smallholder farmers in Ghana have not paid adequate attention to social differentiation among smallholder farmers. This study sought to assess social differentiation in the perception of vulnerability and adaptation strategies of socially differentiated groups' of smallholder farmers to climate change in northern Ghana. Gender and age axis of social differentiation are the major focus of this work. The study employed a mix method study design involving 12 in-depth interviews, 8 FGDs and 160 questionnaire surveys among smallholder farmers in the Lawra district. Kendell's W rank correlation was used to rank constrains identified, descriptive statistics and chi-square was used to determine adaptation patterns among different social groups whiles binary logit regression model was used to determine the effectiveness of adaptation strategies on smallholder farmers' food insecurity. Results suggest that drought/dry spells was identified by all social groups as the most pressing constrain. Sustainable Land Management adaptation strategies were adopted by majority of farmers with the exception of water harvesting. Fertilizer application and improved varieties were reportedly used by most farmers' whiles pesticides and insecticides use were low. Diversification activities were adopted by less than half of farmers. Finally, the study noted high incidence of food insecurity among smallholder farmers. Adaptation strategies found to have significant impact on food insecurity include off-farm employment activities, irrigation and compost use. While irrigation and off-farm employment had a negative impact on household food insecurity, compost and manure use was directly related to food insecurity. Access to credit, ownership of farm land, education, income had significant negative effect on household food insecurity of smallholder farmers. Male were less food insecure relative to females whiles older farmers were more food secure than younger farmers. The results highlights the need for adaptation interventions that pay attention to different stakeholder needs in reducing smallholder farmers' vulnerability. It also emphasizes the need for government and development agencies to prioritize small-scale irrigation development and off-farm income activities in order to reduce food insecurity among smallholder farmers.

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LIST OF ABBREVIATIONS

ASSAR-WA	Adaptation at Scale in Semi-Arid Regions-West Africa
CA	Conservation Agriculture
CCAFS	Climate Change Adaptation and Food Security
CO_2	Carbon dioxide
COTVET	Council for Technical and Vocational Education and Training
CSA	Climate Smart Agriculture
FAO	Food and Agriculture Organization
FGDs	Focus Group Discussions
GMet	Ghana Meteorological Agency
GSOP	Ghana Social Opportunities Project
GSS	Ghana Statistical Service
GIDA	Ghana Irrigation Development Authority
IFPRI	International Food policy Research Institute
INDC	Intended Nationally Determined Contribution
LDA	Lawra District Assembly
MDTDP	Medium-Term Development Plan
MoFA	Ministry of Food and Agriculture
MPMAS	Mathematical Programming-based Multi Agent System
NGO	Non-Governmental Organizations
RDS	Regional Diagnostic Study
SLM	Sustainable Land Management
SPSS	Statistical Package for Social Sciences

SSA	Sub-Saharan Africa
UNFCCC	United Nations Framework Convention on Climate Change
VSLA	Village Savings and Loans Association
WFP	World Food Programme
YEA	Youth Employment Agency

CHAPTER ONE: INTRODUCTION

1.1. Background

Some of the worst impact of climate change will be experienced by the world's 500 million smallholder farms who produce up to 80% of food, provide livelihood for 2.5 billion people and manage about 80% of farmlands in developing countries (IFAD, 2012; IFPRI, 2015). Smallholder farmers generally refers to rural producers, predominantly in developing countries who farm using mainly family labour and for whom the farm provides the principal source of income (Barnett, 2007). The definition of smallholder farmers by scale varies depending on countries and regions (Calcaterra, 2013). Generally, farm size of not more than two hectares is used to define smallholder farms in Sub-Saharan Africa. Beyond farm size, smallholders are defined to include low market participation, low inputs use, location in rural areas, dependent on family labour and largely labour intensive (Kay, 2001; Chamberlin, 2008; Vermeulen & Cotula, 2010).

The smallholder farm production system is generally complex, diverse and risk prone. They constitutes the most vulnerable and marginalised people in rural society, inhabits some of the most marginal landscape and lack land tenure and resource rights (IFAD, 2012). The exposure to climatic stresses contributes to their vulnerability in addition to non-climatic stressors such as small farm size and unfavourable land tenure, low technology, low capitalization, low market participation, high food prices, and poor infrastructure (Nielsen & Reenberg, 2010; Jayne et al., 2010; Holler, 2014; Nyantakyi-Frimpong & Bezner-Kerr, 2015). Especially for Sub-Saharan Africa (SSA) smallholder farmers, increase droughts/dry spells, more unpredictable rain, floods, and increase

temperature resulting in low soil moisture and water stress are the climatic stressors that poses significant threats to their livelihoods (Below et al., 2010).

Ghana produces 51% of its cereal needs, 60% of fish requirements, 50% of meat and less than 30% of the raw materials needed for agro-based industries with smallholder farmers contributing a significant portion (MoFA, 2007). Even though agriculture share of Gross Domestic Product (GDP) has been declining steadily over the years due mainly to discovery and exploitation of oil, it still contribute 22% of the country's GDP and employs about 40% of the labour force (GSS, 2014a).

However, smallholders are not a homogeneous group that should be supported at all costs but are rather a diverse set of households living in different types of economies (IFPRI, 2015), as such vulnerability to climate change is not uniform but differ according to social groups. Social differentiation enabled by both formal and informal institutions accounts for the different vulnerability that people face in their communities (World Bank, 2010). The nature of the inheritance system, governance system and land tenure arrangements are critical factors mediating vulnerability and resulting in adaptation that reinforces social exclusion (World Bank, 2010). Gender and age are a major dimension of social differentiation among farmers in rural areas (Dumenu & Obeng, 2015). Particularly noteworthy is the fact that crop production in Ghana is gendered with males dominating the production of staple and cash crops whiles females emphasise production of subsistence base crops (Carr, 2008; Padmanabhan, 2007).

In Ghana, agriculture is predominantly on smallholder basis with about 90% of farms on smallholdings using rudimentary technologies like hoes, cutlasses and bullock ploughs

(mostly used in the north) (MoFA, 2013). Production is heavily dependent on rainfall and its distribution. This does not only make smallholder farmers the poorest, but also constitutes the most food insecure segment of the population (GSS, 2014b). Smallholder farm households record food shortages during the planting months (Quaye, 2008; WFP, 2012; Rademacher-Schulz, Schraven, & Mahama, 2014). Months of inadequate food provisioning defined as the period between stock depletion and the next harvest is usually used as a measure of food insecurity in a highly subsistence-oriented area where production is primarily for home consumption and households do not make significant sales or purchase in the market. Quaye (2008), in a study in northern Ghana found that periods of inadequate food provisioning range between three (3) to seven (7) months and the average for the Upper West is 5 months.

With climate models predicting a decrease in crop production in Sub-Saharan Africa (Ebi et al., 2011; Vermeulen et al., 2011) and the fact that smallholder farm households are the worst affected in terms of food insecurity (IFAD, 2012) means that some level of adaptation of smallholders' food systems is necessary. Smallholder farmers' adaptation strategies in Ghana generally involves land management practices, varietal and breed improvement, crop diversification, irrigation, agro-forestry and diversification to off-farm income activities and migration (Owusu et al., 2011; Dumenu & Obeng, 2015). A challenge of smallholder adaptation is the lack of empirical research on socially differentiated patterns of adaptation and effectiveness of different adaptation strategies on wellbeing of the different social groups.

1.2. Problem Statement

The arid and semi-arid areas of northern Ghana with their mixed crop-livestock rain-fed system are marked as high risk areas demanding immediate and sustained research and development efforts (Wossen & Berger, 2015). Climate change aggravates the proportion and intensity of poverty and worsens food insecurity among poor farmers in the northern savannah ecological zone (Wossen et al., 2014). In addition to climate change, fluctuations in food price is a significant factor that affects food security of poor farm households in northern Ghana (Wossen & Berger, 2015).

The Upper West Region has the highest (70.7%) incidence of poverty in Ghana (GSS, 2014b) and one of the regions with the highest food insecurity (WFP, 2012). The economy of the area is mainly agrarian, with majority (77%) of the people engaged in rain-fed cultivation of food crops and rearing livestock. The region has a unimodal rainfall regime which comes between May to September with average annual rainfall of 115cm (GSS, 2013). The main crops cultivated are grains such as millet, sorghum and maize; roots and tubers, particularly yams and legumes, including groundnuts and beans. The main livestock raised include poultry, small ruminants and cattle (GSS, 2013). The region falls within the dry sub-humid belt of West Africa that experience moderate to high drought risk and has single growing season with high rainfall intensity and significant risk of dry spells (Padgham et al., 2015).

Attainment of food security in Upper West region is a major problem confronting farming households' especially rural populations due to low productivity in staple crop production, seasonal variability in food supply as well as price fluctuation (GSS, 2014b). Climatic factors including droughts, floods and rainfall variability significantly contributes to poor

agriculture productivity leading to food insecurity in many farm households. Analysis of climate data in northern Ghana shows a combined increase in temperature and decrease in rainfall (De Pinto et al, 2012). Critical for smallholder farmers dependent on rainfall is the exact period it rains and not yearly averages (Nyantakyi-Frimpong & Bezner-Kerr, 2015). This is recognized as the single most important factor accounting for large variation in food security and poverty among smallholder farm households (Hertel et al., 2010).

In response to the challenges pose by these climatic and non-climatic hazards, smallholder farmers are engage in some forms of adaptation. Strategies that have been undertaken by smallholder farmers especially rural farmers in northern Ghana include the use of modern inputs (improved varieties, use of chemical fertilizers, and weedicides and pesticides) (Issahaku & Maharjan, 2014), Sustainable Land Management (SLM) practices (legume intercropping, anti-erosion measures, composting, conservation agricultural practices, changing planting dates and water harvesting (Ndamani & Watanabe, 2015; Nyantakyi-Frimpong & Bezner-Kerr, 2015) and diversification of farming (off farm employment, irrigation, and migration) (World Bank, 2010; Owusu et al., 2011; Rademacher-Schulz et al., 2014; Dumenu & Obeng, 2015). The identification of practicable adaptation options in northern Ghana should be prioritized so as to reduce the impact of climate change on crop production that is important to large food insecure smallholder farmers (Lobell et al., 2008). Government, NGOs and research based institutions are at the forefront of promoting various adaptation strategies in the Upper West region. Jirapa, Lawra and Nandom districts are used by the Climate Change Agriculture and Food Security (CCAFS) as platforms for adaptation research in semi-arid northern Ghana.

Despite the progress made in empirical research on smallholder farmers adaptation to climate variability and change, there are very few studies (Wossen et al., 2014; FAO, 2015) which explores the effectiveness and impacts of adaptation measures in the context of smallholder farmers. Previous works have largely concentrated on the impact of climate change on smallholder farmers (Morton, 2007), the adaptation strategies and coping mechanisms employed (Kuwornu, Al-Hassan, Etwire, & Osei-Owusu, 2013) and determinants of adaptation strategies (Nhemachena, 2008; Mustapha, 2012) Furthermore, existing work on climate change adaptation target smallholder farmers as a homogeneous group masking significant heterogeneity emanating from socio-cultural norms (Padmanabhan, 2007; Carr, 2008), and differences in access to resources, poverty levels and adaptive capacity (Wossen & Berger, 2015). The inherent aggregate nature of these studies makes it difficult to provide insight in terms of effective adaptation strategies at the household level. In view of this, it is unlikely that interventions to improve household food security and general wellbeing of the most vulnerable groups will be met. This study therefore, investigates vulnerability and adaptation of differentiated groups of smallholder farmers to climate variability and change in semi-arid rural Ghana. It focuses on examining the perception of vulnerability and patterns of adaptation and assesses the effectiveness of adaptation strategies on household food security.

1.3. Objectives

The main objective of the study is to assess social differentiation in the adaptation strategies of smallholder farmers to climate change in semi-arid northern Ghana. Specifically the study will;

- Identify the socially differentiated patterns of vulnerability and adaptation of smallholder farmer.
- Examine the effectiveness of adaptation strategies of smallholder farmers in ensuring household food security.

1.4 Hypotheses

Hypothesis 1

H_0**:** There is no significant difference in the adaptation patterns of the different social groups of smallholder farmers.

H_1: There is a significant difference in the adaptation patterns of the different social groups of smallholder farmers.

Hypothesis 2

H_0: Adaptation strategies of smallholder farmers has no significant effect on household food security.

H_1: Adaptation strategies of smallholder farmers has significant effect on household food security.

1.5 Justification

Social differentiation shapes the vulnerability and adaptation response of smallholder farming individual, households and communities in semi-arid regions. Unpacking that complexity through a lens of social differentiation will provide an understanding of adaptation strategies of differentiated groups of smallholder farmers that can lead to more effective and inclusive adaptation processes and sustainable development. The finding will

help inform policy response to adaptation strategies that is inclusive and proactively addresses the needs of very vulnerable groups.

Identifying the impact of various adaptation strategies on the wellbeing of vulnerable groups is essential for planning adaptation intervention by both government and the private sector. The study will therefore inform policy response and programme design of climate change adaptation.

The study will also contribute to addressing research gaps relating to socially differentiated patterns of smallholder farmers adaptation strategies which is largely absent in the existing adaptation literature.

Adaptation strategies of smallholder farmers to climate variability and change in semi-arid regions is well documented (Enete et al., 2015; Howden et al., 2007; John K M. Kuwornu et al., 2013; Nhemachena, 2008). However there are as yet relatively very few studies that assess the effectiveness of these strategies (Wossen et al., 2014; FAO, 2015). The study will therefore contribute to the empirical literature on the effectiveness of adaptation strategies of smallholder farmers.

1.6 Organization of the Study

The study is organized into six chapters. Chapter 1 outlines the background of the study, the problem statement, objectives, research hypothesis and significance of the study, Chapter 2 reviews the relevant literature on adaptation strategies of smallholder farmers to climate change and variability. The chapter also presents the conceptual framework used for the study. Chapter 3 details the methodology used for the study. Chapter 4 presents the

results of the data analysis and Chapter 5 discusses the results. Chapter 6 provides the key conclusions of the study and makes recommendations based on the research findings.

1.7 Conclusion

This introductory chapter established the study background and outlined the basis for the research. The chapter discussed the problem of the study, the study objectives, as well as the hypotheses. Finally, the significance and limitations of the study was presented.

CHAPTER TWO: LITERATURE REVIEW AND CONCEPTUAL FRAMEWORK

2.1 Introduction.

This chapter presents literature on the concept of smallholder farmers, social differentiation, empirical review of vulnerability, adaptation strategies and household food security among smallholder farmers. The focus is to present the theoretical and empirical concepts and extract methods and lessons from existing literature for this study.

2.2 The Concept of Smallholder Farmers

Perhaps the most challenging issue confronting policy makers in targeting smallholder farmers is the issue of accurately defining them. Several definitions have been proposed. The most widely use indicator of smallholder farmer is farm size with substantial variations in the prescribed farm size across countries and sectors (Calcaterra, 2013). Ekboir et al., (2002), define smallholders in Ghana as referring to farm holdings of up to five hectares. According to the Ministry of Food and Agriculture Organization (MoFA, 2007), smallholder farmers refer to farm holding of not more than two hectares and constitute about 90% of farm holdings in Ghana. As simple as this classification based on farm size might seem, it masks significant heterogeneity among smallholders in Ghana and runs the risk of excluding a large portion of subsistent producers who otherwise would pass for smallholders.

Consequently, Chamberlin (2007), in a very elaborate work on the definition of smallholder farmers in Ghana, extends the definition beyond farm size to include low market participation and inputs use and domination by rural poor. In line with this, Kay (2001), and Vermeulen & Cotula (2010), defined smallholder farms as family operated,

subsistence or market-oriented, low inputs use and basically labor intensive. Further, Chamberlin (2008), refined the definition of smallholders to include smaller crop portfolio where smallholder producers have fewer number of crops compared to larger producers.

MoFA (2007), in a social and poverty impact analysis categorize smallholder farmers in Ghana into four groups: small commercial, semi-commercial, non-poor complex diverse risk prone and poor complex diverse risk prone farmers. They emphasize the targeting of the poor complex diverse risk prone category who dominates the smallholder sub-sector for productivity increase in the agriculture sector.

Defining smallholders base on location, vulnerability, commercialization and inputs use better identify smallholders in Ghana compared to definition by farm holding. Against this backdrop, this study adopts the definition of smallholder that goes beyond the commonly use land holding to include location, inputs use and risk conditions.

2.3. Social Differentiation among Smallholder Farmers.

Socio-cultural factors and resource access enabled by both formal and informal institutions accounts for socially differentiated vulnerability and adaptation in communities (World Bank, 2010). Particularly, vulnerability to climatic and non-climatic hazards are determined not only by the severity and magnitude of the hazard but also difference that exist among people. Coirolo & Rahman (2014) in a study on power and climate change vulnerability among poor people in North-East Bangladesh, found that ownership and decision making power over resources upon which one's livelihood depend as central to social differentiation among rural people. Similarly, Dulal & Shah (2014) in their study of social protection and building resilience to climate change identified three groups of vulnerable people based on resources and assets. The study noted that identification of

different adaptive capacity levels based on both tangible and intangible assets was critical in better targeting of social protection interventions like cash transfer. In both cases, the difference forms of capital and resource access are paramount in mediating social groupings.

An important determiner of social differences among vulnerable communities and people is gender. According to Padmanabhan (2007), gender plays a fundamental role in the livelihoods of rural people and provides a clear basis of social differentiation with the gendering of crop production. Males dominate the cultivation of staple and cash crops while females focus on vegetables and other subsistence crops. Similarly, Carr (2008), identified gender as the underlying force in the differentiated production patterns of diversified and undiversified livelihood strategies of rural farmers in response to changes in climatic and socio-economic conditions among rural farmers in the central region. What is noticeable between males and females smallholder farmers regarding production, is the relegation of females to the production of subsistence base crops relative to the staple crops and cash crops cultivation by their male counterparts (Rodima-Taylor, 2012). This culminates into substantial marginalization of females enabled by the patriarchal social structure.

Extending the scope of social differentiation beyond assets and resources, Nyantakyi-Frimpong & Bezner-Kerr (2015), studying vulnerability and adaptation patterns among rural people in semi-arid Ghana noted a striking generational and gender differentiation among rural people. The youth's perception of the vulnerability context and subsequent adaptation response varied significantly from the elderly, likewise between males and females. In a related study, Trang (2010), discovered that older household heads who

established their households before the 1990s were wealthier and less vulnerable to social and environmental changes compared to younger ones who only recently established their households, as such were generally poor.

Ethnicity and migrant status comprise another axis of social differentiation among smallholder farmers in sub-Saharan Africa. Writing on diversification as an adaptation strategy among two ethnic groups in northern Burkina-Faso, Nielsen & Reenberg (2010b), argues that ethnic base cultural practices constrains the *Fulbe* ethnic group from embracing livelihood diversification strategies that have been successfully adopted by the *Ramiibe* ethnic group. Although the *Fulbe* notice the positive impact of diversification strategies including labor migration, irrigation, working for development projects and women small scale commerce, they still hold on to their traditional livelihood strategies that defines their ethnic identity.

In rural Ghana migrants are largely vulnerable as they do not have ownership to production assets and contend with social practices that limit their progress (World Bank, 2010). Consistent with this finding, Antwi-Agyei et al., (2015) using land tenure system identified two major social categories of farmers in rural areas of the middle belt of Ghana; indigenous farmers and migrant farmers. Likewise, males and female social groups emerged as the major social group in the northern savannah. The study noted that indigenous farmers in the middle belt had greater tenure security compared to poor migrant farmers who were considered “outsiders” or “strangers” whiles males in the northern savannah zone had more favorable tenure system relative to women.

According to Yaro (2002), livelihoods of peasant farmers in the Upper West region is best understood from the income and expenditure perspective. Based on this, he categorized

peasant farmers into four main social groups, the rich group, the better off, the moderately poor group and the ultra-poor. The rich group is the most prosperous economically, and the most influential politically, they have large tracks of fertile land, cattle, pioneers in irrigation farming, and includes public sector workers. Those in the better off group can hire labor and also have the benefit of using labor from others in the lower rank, the moderately poor group are active and multi-local and can hire the services of bullock ploughs in the beginning of the planting season whiles the ultra-poor group are the poorest in the communities whose voices are seldom heard by the village authorities are the district assemblies. Many of them live isolated from their families. In a similar study in Tanzania, Lyimo & Kangalawe (2010) used wealth ranking to categorize rural farmers into three socio-economic groups; the well-off, intermediate and the poor based on ownership of certain livelihood assets.

In light of the foregoing discussion, this study seeks to adopt the gender and age axis of social differentiation. This is because, it is the most obvious and basic foundation of social differentiation making the approach appealing in a study with limited information on the other indicators of social differentiation.

2.4 Vulnerability of Smallholder Farmers

Existing literature has thoroughly demonstrated that vulnerability of smallholder farmers range from climatic factors including rainfall scarcity and unpredictability, increased temperature and floods to non-climatic factors like soil degradation, market conditions, policy environment and demography (Morton, 2007; Mertz et al., 2009). Niang et al., (2014) noted that Africa's food system is most vulnerable because of widespread reliance on rain-fed crop production, recurrent droughts and floods and poverty. In addition, Hertel

et al., (2010) posits that poor countries especially sub-Saharan African countries will be adversely affected by changes in the agricultural sector. Low market participation exposes African farmers to production decline induce price increases whereas the reverse will reduce the net value of their produce making them worse off in all scenarios. This emphasize the importance of looking beyond climate induce shocks and beyond simple focus on yield to more nuance socio-economic factors.

An understanding of these climatic and non-climatic stressors is crucial in identifying the complex and location specific climatic stressors and the diverse non-climatic stressors and their contributions to vulnerability of smallholder farmers' in semi-arid areas of Ghana.

The main impact of climate change on agriculture manifests through changes in rainfall, temperature and CO_2 concentration in the atmosphere (Gala Bijl & Fischer, 2011). Thornton et al., (2010), used quantitative projections to estimate climate change impact on smallholder farmers in Africa with emphasis on biological impacts of changing rainfall, temperature and CO_2 concentration. He posited that average yield of maize and beans in mixed rain-fed crop-livestock systems in arid and semi-arid regions of Africa will decline significantly by 2030 and more so by mid-century. This is in line with the projected global trend of decrease in crop productivity even though substantial variations exist across geographic space and across different crops. This analysis recognizes the semi-arid mixed rain-fed crop-livestock systems in Africa as a "hot spot" (Morton, 2007).

Below et al., (2010), in a review of selected literature on micro level adaptation noted that the effects of climate variability and change will continue to challenge vulnerable people. Drought/dry spells will be more frequent, rain will be more unpredictable, and torrential

rainfalls heavier. Higher temperature will lead to the evaporation of soil moisture, and water stress will aggravate worsening the already bad water stress situation in Africa.

Mapping vulnerability of crop production to drought in Ghana, Antwi-Agyei et al., (2012) showed the northern savannah ecological zone to be the most vulnerable to the impacts of drought on crop production in Ghana. With reference to the staple crops in the northern savannah zone, millet was found to be most vulnerable. The study also identified the Bongo district in Upper east region as the most vulnerable among all districts in northern Ghana. In a related study, Issahaku & Maharjan (2014) found both temperature and rainfall to have mix effects on yield of staple crops grown in the northern savanna zone. Increase temperature have significant negative effect on yield of cassava but positive effects on yields of yields of rice, yam and sorghum whiles rainfall increase has significant positive effect on yields maize and sorghum. The study further projected an increase in the yields of cassava, rice, maize and sorghum and a decline in the yields of yam resulting from the allocation of more land to the former a reduction in land allocation to the latter. Elsewhere in Ethiopia, Biazin & Sterk (2013), discovered that livestock farmers were more vulnerable to drought compared to crop farmers resulting in gradual but steady shift in land use from pastoralism to crop farming. This suggests a strong spatial, socio-economic and occupational vulnerability to drought among smallholder farmers.

Following from this, Dumenu & Obeng (2015), studying social vulnerability also found the three regions in northern Ghana to be most vulnerable to climatic factors including erratic rainfall, prolonged drought, and shift in crop season. It nonetheless noted that vulnerability is mediated by social factors including demography, economic and social

factors proxy by illiteracy, climate sensitive occupation and access to climate sensitive information respectively.

Conversely, numerous studies have sought to demonstrate that the major constraints plaguing smallholder farmers are largely non-climatic. Jayne et al., (2010), in an empirical study of challenges confronting smallholders in south and east Africa, identified non-climatic stressors as main challenges confronting smallholder farmers' production. These include declining land holdings, low market participation of majority of smallholders, high food prices, exodus of rural farm labor to urban centers and changing urban consumption patterns. The study concluded that unless government policy on smallholder farmers is changed radically and backed by the required financial commitment, the world will witness progressively, recurrent and severe economic and social crises in sub-Saharan Africa. Elsewhere in Tanzania, Holler (2014), identified multiple stressors (climatic and non-climatic factors) constraining smallholder farmers. He however noted that adaptation to climate change is rarely a priority. More immediate stressors and development goals take precedents.

Similarly, Nielsen & Reenberg (2010a), discovered that farmers in semi-arid regions of northern Burkina Faso have "moved beyond climate" through engagement in non-climate sensitive economic activities including labor migration, gardening, selling livestock, working for development projects and women's small-scale commerce. The study further noted poor health and infrastructure and unstable political and economic structures as the main threats to the sustained wellbeing of people in the area.

Relatedly, Nyantakyi-Frimpong & Bezner-Kerr (2015), posits that farmers, even though well aware of challenges posed by droughts and floods, ranked seed failures, high food

price, poor roads, and lack of credit for smallholding farming as their major constrains. Land tenure is another non-climatic factor identified as a major challenge confronting smallholder farmers in Ghana (Antwi-Agyei et al., 2015).

Although both climatic and non-climatic stressors individually exerts considerable constrain on smallholder farmers, the combine effect of the two is more damning for smallholders especially in sub-Saharan Africa. Following from this, Wossen & Berger (2015), in a model simulation study in northern Ghana using Mathematical Programming-based Multi-Agent Systems (MPMAS) noted that climate and price variability discretely have significant impact on farmers' income and wellbeing. However, the combine effects of both price and climate variability is more profound with household poverty and food insecurity increasing markedly because regional weather and price of agricultural products are strongly correlated. As argued by WFP (2012), challenges faced by smallholder farmers in northern Ghana comprise both climatic and non-climatic factors. Small land size and lack of crop diversity, crop production decline, low soil fertility, lack of agro-chemicals, lack of irrigation, high food prices rainfall variability, droughts/dry spells and flooding were identified.

2.5 Adaptation Strategies of Smallholder Farmers

Smallholder farmers' farm and household level adaptation strategies generally fall into three main categories; sustainable land management practices, modern inputs use and livelihood diversification and irrigation. This section reviews empirical literature base on these classification.

2.5.1 Sustainable Land Management Strategies

Sustainable land management refers to the use of land resource including animal and water for the production of goods to meet changing human needs while ensuring the long term productive potential of these resource and the preserving of their environmental role (Peter, Kelly, Ranjidth, Shibu, & Sougata, 2013). Sustainable land management practices include manure and compost use, water harvesting, legume intercropping, precision farming (including changing planting date), anti-erosion measures and conservation agriculture (minimum or no tillage and permanent organic cover).

Reviewing literature on conservation agriculture for small-scale farmers, Stevenson et al., (2014) discovered that, in the face of low yield, low income and soil degradation of smallholder farming systems in sub-Saharan Africa, Conservation Agricultural (CA) practices have a massive potential to improve productivity, income and soil quality. However, CA codified as a package of three practices (minimum mechanical tillage, permanent organic cover and crop rotation), has generally failed in SSA and it is very unlikely that such an approach will work in SSA. The high initial upfront cost, risk and uncertainty and the delayed benefits of CA (Pannell, Llewellyn, & Corbeels, 2014), do not fit into the low cost, short time planning horizon of the smallholder farmers. Contract farming seem to be the way to ensure widespread adoption of CA among resource poor smallholders in the absence of conditional subsidies.

In Ghana, CA as a complete package of three practices was introduced in the 1970s but adoption was generally low albeit with exceptions in situations where one or two practices were adopted (Kombiok et al., 2008). For instance, Ekboir et al., (2002) reported that newly introduced no till with mulch CA practice responded to smallholder farmers needs leading

to widespread adoption in all agro-ecological zones of Ghana. Farmers reported an increase in uptake of the technology as well as increase in crop output leading to improvement in household food security of adopters. Aside, other benefits identified by farmers include reduced investment in cash and labor, easier weed control which saves a lot of time, expansion of areas farmed and improved soil fertility. The importance of agriculture extension in the spread of no-till among smallholder is underscored in this study. Elsewhere in Mozambique FAO (2012) reported that attempts to introduce CA has not been very successful. Minimal tillage have completely failed with modest gains made in animal manure and mulching and crop rotation adoption.

No-till technology is not new to Africa, evidence of the technology is reported in several parts of the African continent before the recent innovation from the west (Ekboir et al., 2002; Shemdoe et al., 2009). In a study of traditional tillage among smallholder farmers in Tanzania, Shemdoe et al., (2009) observed three types of no-till systems; planting without any soil preparation (*sesa*), digging up to about 10 centimeters using hoe or oxen plough (*kutifua*) and ridging involving the use of hoe to raise soil to make ridges across slopes (*matuta*). Shallow tillage was the most popular system among smallholder farmers. Farmers who prefer using the no-till system mention resource constraints as their prime reason for adopting this practice. Those using shallow tillage indicated improved groundnuts and sorghum yields and reduced weeds as their prime reason whereas adopters of ridging noted soil water retention and penetrability as their major reason for adopting the practice. Contrary to expectation of improve soil fertility on no-land fields, farmers reported a decrease soil fertility and weed infestation. This low soil fertility and high weed

infestation on traditional no-till fields is probably resulting from the non-use of complimentary inputs like weedicides and mulch.

The successful adoption of any innovative technology is contingent on efficiency of the technology itself and its ability to amend itself to local socio-economic and cultural condition of the population. Against this background, Ojiem, De Ridder, Vanaluwe, & Giller (2006), propose a socio-ecological niche under which legume intercropping technology will successfully improve soil fertility and also farm households' income among smallholders in Africa. The adoption of the technology is premised on the production objective of the farmer. Three underlying drivers are identified as central for a legume intercropping socio-ecological niche; i) Local ecological (farm level) factors including soil nutrients deficiency, moisture deficiency, and pests and diseases among others, ii) Economic factors including land, financial capital, labor, inputs and output markets and iii) Institutional factors including inputs dealers, well informed extension service access and access to functional product market. These factors co-determine the niche for a legume technology.

In northern Ghana, intercropping and crop rotation involving cereals and legumes have been widely adopted as they fix substantial amount of nitrogen and can provide large amounts of nitrogen biomass (Kombiok et al., 2008). Farmers use intercropping to improve soil fertility and crop rotation to take advantage of soil heterogeneity (Nyantakyi-Frimpong & Bezner-Kerr, 2015). They also indicated that they use mixed intercropping to take advantage of moisture, outwit pests and to limit the spread of plant disease. Intercropping on any piece of land is informed by soil fertility and moisture retention capacity with sandy soils having low nutrient content planted with millet, groundnuts, sorghum and beans, with

lower planting densities. For relay intercropping, legumes are mostly intercropped among standing maize, millet and sorghum before the cereals harvested. Challenges associated with its adoption include high labor and knowledge requirements.

Adaptation to climate change through changing planting dates can significantly reduce the negative impacts on crop yields (Waha et al., 2013). In SSA information for planting date is often not available. The scarcity of planting information in SSA can partly be explained by the fact that many farmers use indigenous knowledge, particularly non-climatic reasons for sowing (Waongo et al., 2015). An agronomic base scientifically derived optimum planting date yields a higher potential crop yield and reduce inter-annual yield variability (Waongo et al., 2015). However, in the absence of modern technological inputs most smallholder farmers rely on indigenous adaptation strategies noting changing planting date as the most effective adaptation strategy to climate variability and change (Etwire et al., 2013). Delaying or advancing planting dates increases crop yield (Tingem, Rivington, & Bellocchi, 2008). In relay intercropping by farmers in the UWR, the timing of the second crop is not dependent on a calendar date but a combination of factors including moisture content of the soil, how the season unfolds and whether the optimal growth period began too early or too late (Nyantakyi-Frimpong & Bezner-Kerr, 2015).

In northern Ghana, the dominant mode of harvesting water is through reservoirs and dug-outs which collects run-offs for a variety of purpose including agriculture and domestic use. Reservoirs and dug-outs are mostly communally owned in northern Ghana. According to Evans et al., (2012), storing surface water can be very expensive but it is most often the only way to provide water for rural people. They noted that to ensure effective utilization of reservoirs there is the need for coordination and integration of multiple users, facilitate

multiple institutional arrangements, strengthen existing policies and procedures and timely rehabilitation.

The Lawra district assembly place a high priority on water harvesting. In the Medium Term Development Plan of Lawra District Assembly (2014), under the Ghana Social Opportunities Project (GSOP), the district rehabilitated two dug-outs at Boo and Birifo-mangul which have been completed and handed over to the communities whiles two others at Methow-Yipalla and Kalkutuo have been awarded on contract. Other communities with dug-outs are Erimon-Naburenye, Erimon-Bure and Babile. Additionally, The LDA in collaboration with some NGOs have constructed four hand-dug wells and 3 tube wells for some communities which are currently been used for drinking, animal rearing and dry season vegetable gardens in the beneficiary communities.

Manure and compost use is not new to Smallholder farmers in the northern savannah ecological zone. However, Becx et al., (2012) noted a decreasing trend in the use of manure and compost among smallholder farmers in the Upper East and northern regions. The use of compost and manure are higher in the Upper East region compared to the northern region. Similarly, Nyantakyi-Frimpong & Bezner-Kerr (2015) reported a high use of manure and compost among farmers in the Upper West region citing high cost and soil degrading potential of chemical fertilizer as their main reasons for opting for the use of manure and compost. Farms closer to homesteads were more intensively treated to compost and manure compared to distant fields (Kombiok et al., 2008). According to Clay (1998) organic fertilizers use is highest among household with lower non-crop income, smaller farms, more livestock and greater knowledge of sustainable knowledge of sustainable production practices learned from extension services.

Another innovation closely related to compost and manure use is the *zai* pit system adopted from neighboring Burkina Faso. The zai pit technique involve the digging of a pit of 20-40cm diameter and a depth of 10-20cm using a hoe. The excavated soils are ridged half way around the pit to prevent surface run-off, debris and sand. Manure or compost is added to each pit and covered with soil, seeds are then planted with the arrival of the first rain. More than half of farmers were reportedly using the innovation (Hanson Nyantakyi-Frimpong & Bezner-Kerr, 2015). Farmers use the technique to recover degraded land in the semi-arid areas where continuous cropping and soil erosion have depleted large tracks of land and render them unproductive (Zorom et al., 2013).

2.5.2 Modern Inputs Use

Modern inputs are very crucial to agricultural productivity as it makes farmers more productive and more efficient. Adoption of modern inputs vary significantly across the agro-ecological zones of Ghana, with adoption rates highest in the forest area whiles the northern savannah ecological zone records the lowest adoption rates (Asuming-Brempong, et al., 2016). Among smallholder farmers in northern Ghana the commonest modern inputs used in agriculture productivity are chemical fertilizers, improved varieties and weedicides and pesticides. Modern inputs use involve substantive capital investment, high human resource capacity and ability to take risk (FAO, 2011).

According to Kombiok et al., (2008), the recommended rates of chemical fertilizer application for the production of cereals in Ghana are the basal application of compound fertilizer made up of 15% of each of Nitrogen, Phosphorus and Potassium at planting or two weeks after planting of 2 fifty kilograms (50kg) bags per hectare. The use of chemical fertilizer among smallholder farmers in northern Ghana was stimulated by government and

NGOs, but recent price increases has made them inaccessible to many farmers (Becx et al., 2012). The poor fertilizer use and low intensity of use in northern Ghana which currently stands at 15kg per hectare is woefully inadequate culminating in the low output recorded (Chapoto, Darlington, & Collins, 2015). This is attributable to the fact that smallholder farmers are poor and cannot afford the recommended quantities, as such they just purchase the quantity they can afford which are far below the recommended rates (Kombiok et al., 2008). However, chemical fertilizer application was noted to have the highest welfare benefits for smallholder farmers in the Kwabre district of the Ashanti region of Ghana (Asuming-Brempong et al., 2016).

Developing improved varieties of cultivars which is either drought tolerant, early maturing or insect/pests resistance is critical to agriculture adaptation. In developing improve varieties, climatic and other biotic stressors should not be the only focus of breeders, rather attention should be paid to the local and socio-cultural conditions of the targeted farmers (Haussmann et al., 2012). Nyantakyi-Frimpong & Bezner Kerr (2014) reported low adoption of improve varieties among smallholder farmers in Upper West region with the reason that hybrid seeds were sensitive, weak and required extra care. They noted that improve seeds needed to be purchased every planting season and also required high fertilizer use. Socially, improve seeds increase the work load of women and junior men in the households since they have to weed severally and tended intensively to ensure good yield. Farmers however acknowledge improved seeds use as the most effective long-term crop adaptation strategy to climate change in the Upper West region (Ndamani & Watanabe, 2015). In a study of smallholder farmers in Tanzania, Westengen & Brysting

(2014) revealed that the use of drought tolerant varieties was a major adaptation strategy against climatic stresses.

The use of agro-chemicals especially weedicides and pesticides is important for productivity enhancement among smallholder farmers. Pesticides and weedicides are mostly use as complimentary inputs in the application of other agricultural technologies. For instance, the widespread adoption of no-till in Ghana is closely associated with the proper application of weedicides and pesticide (Ekboir et al., 2002). Also, improved variety use sometimes require the application of weedicides and pesticides in order to rip the full benefit associated with the adoption of modern inputs. Asuming-Brempong et al., (2016) observed that pesticides use was identified as the dominant technologies for reducing poverty among smallholder farmers in the Tolon district of the northern region. Also, smallholder farmers in the Lawra district of Upper West region reported the inability of improved varieties to withstand insects/pests and weeds as the major constrain inhibiting the adoption of improved varieties (Nyantakyi-Frimpong & Bezner-Kerr, 2014), underscoring the importance of weedicides and pesticides to productivity of improved varieties.

2.5.3 Livelihood Diversification

Livelihood diversification has traditionally being part of the livelihood strategies of smallholder farmers in the arid and semi-arid regions of Africa. According to Below et al., (2010) diversification includes non-agricultural livelihoods strategies that are carried out on the farm such as the sale of non-timber forest products and activities undertaken beyond the farm such as petty trade and seasonal migration. In a study of rural livelihood diversification in the Sahel, Zorom et al., (2013) extended the scope of diversification to

include engagement in dry season gardening. Nielsen & Reenberg (2010), in a study of rural farmers in Burkina Faso established that rural farmers responded to unreliable rainfall by diversifying their livelihoods through engaging in labor migration, working for development projects, cultivating gardens, women's small scale commerce and selling of livestock.

In a similar study, Nielsen & Reenberg (2010) identified cultural barriers as a major hindrance to adoption of livelihood diversification among two ethnic groups; *Fulbe* and *Rimaiibe*. Despite being just as involve as the *Rimaiibe* in rain-fed agriculture, the *Fulbe* are not able to diversify their livelihoods to the same extent as the *Rimaiibe*. Cultural practices including transhumance, Fulbe preference for living in the bush underpinned by their notion of integrity and personal worthiness (*ndimaaku*), and the notion of appropriate work and ethnic identity limit the ability of *fulbe* to undertake diversification activities including labor migration, working for development projects, cultivating gardens, and women's small-scale commerce.

In a model simulation of adaptation policy response among smallholder farmers in northern Ghana, Wossen & Berger (2015) underscored the importance of off-farm income in reducing poverty and food insecurity under both price and rainfall variability. The impact was profound among the poorest farm households. The study however indicated that, off-farm activities will yield a greater impact if credits facilities are made available alongside off-farm income activities.

Studying smallholder farmers in northern region, Owusu, Abdulai, & Abdul-Rahman (2011) estimated the impact of off-farm work on household food security. The study reported that participation in off-farm income activities by smallholder farmers

significantly improves household food security. Further, male participation in off-farm economic activities improves household food security situation more than female participation. Similar observations have been made by several other studies both within and outside the country (Kuwornu et al., 2010; Beyene & Muche, 2010; Aidoo & Tuffour, 2013; Tefera & Tefera, 2014).

Migration is a livelihood diversification strategy used by rural people to respond to environmental stresses like drought (Jarawura, 2013), a source of capital to finance farm investment (Yilma et al., 2008), introduce new agricultural technology and smoothen household food consumption (Adaawen & Owusu, 2013; Lacroix, 2012). However, climatic stressors do not independently influence migration but interacts with four other drivers: economic, demographic, social and political factors (Black et al., 2011).

For generations, rural households in the dry regions of West Africa have adopted a variety of migration strategies to deal with the seasonality of rainfall and the effects of periodic droughts and dry spells (Mcleman & Hunter, 2009; Jarawura, 2013). According to Rademacher-Schulz et al., (2014) rural farmers in the Upper West region have over the years migrated to southern Ghana, especially rural areas in the Brong Ahafo region where they engage in farming and mining to avoid income losses and also respond to perennial food shortages typical of smallholder farm households. The study made a distinction between two types of migratory patterns prevalent in the area; rainy season migration and dry season migration. Whereas the dry season migration is used as a labor reallocation mechanism for smallholders, the rainy season migration is more of an erosive coping strategy with potential to heighten vulnerability. Migration is commonest among males and assumes a rural-rural patterns contrary to the rural-urban migratory patterns reported by

other studies (Jarawura, 2013; GSS, 2014c; Dumenu & Obeng, 2015). Is also more prevalent among the younger generation relative to the older generation (Nielsen & Reenberg, 2010a; Jarawura, 2013; Rademacher-Schulz et al., 2014).

Similarly, Jarawura (2013) noted a distinction in the migratory patterns of smallholder farmers in the northern region; drought and non-drought related migration. Whereas farmers having more of their farmlands in drought prone areas and less access to irrigation were more likely to engage in drought related migration, farmers with less land in drought prone areas and access to more irrigation fields were not inclined to drought related migration. In terms of gender, more males engaged in drought related migration while non-drought related migration was more popular among unmarried young ladies.

2.5.4 Irrigation

With decreasing rainfall, increasing droughts/dry spells and more variable rainfall pattern, agriculture is becoming more risky for the rain-fed dependent smallholder farmers across SSA. A wide range of traditional and modern technological options are available for use by smallholder farmers. According to Kay (2001), the type of irrigation likely to succeed in the northern savannah ecological zone of Ghana is water harvesting, irrigation of river plains and exploitation of shallow ground water year round cultivation.

Across Ghana, smallholder farmers are finding innovative ways through irrigation to increase yield and income and diversify their cropping and livelihood options (Dumenu & Obeng, 2015). A wide range of irrigation systems initiated by both government and private entrepreneurs can be found across the length and breadth of the country. These systems include; (i) shallow groundwater irrigation using hand-dug wells, mainly for vegetables (ii) seasonal shallow wells mainly in low lying areas, (iii) permanent shallow wells used

throughout the year for vegetables, livestock and domestic purpose, (iv)shallow tube wells (v) communal boreholes for irrigation, (vi) river and stream water lifting system for commercial and out-grower schemes (vii) small reservoirs and dug-outs both communal and private (viii) inland valley water capture for paddy and sometimes dry season vegetables (ix) river diversion and river pumping to gravity fed irrigation, (x) reservoir base gravity fed irrigation and surface water pump and sprinkling irrigation (Evans et al., 2012). With the multiplicity of irrigation types in Ghana however, the northern savannah zone is not adequately covered. The biggest constrain to irrigation development in Ghana is the unreasonably high cost relative to other African countries (Ofori, 2005).

Similarly, three prominent system of irrigation are identified in Nigeria; public irrigation schemes which are under government regulation, farmer owned and operated irrigation scheme and fadama irrigation which utilizes residual moisture and is based on traditional irrigation practices like the *shaduf* (using calabash/bucket to collect water from dug-outs, shallow wells ponds and depressions) (Tijani, Obayelu, Sobowale, & Olatunji, 2014). The farmer owned irrigation schemes was the most prevalent irrigation system, with none of the farmers having formal title to the lands they cultivated. Modern inputs like agro-chemicals was in high use by irrigation farmers.

The impact of irrigation on small farm household food security cannot be overemphasized. A simulation study by Wossen et al., (2014) among smallholder farm households in northern Ghana confirmed that irrigation improves food security and income because of its potential to cultivate at least twice a year and the high productivity associated with irrigation agriculture. The results however noted that, for irrigation to have optimum impact on income and household food security, expansion in irrigation must be

accompanied with access to credit. At the household level, participation in irrigation is significantly determined by labor availability, off-farm income, farm equipment, distance to irrigation facility and distance to market (Yilma et al., 2008).

From the foregoing review, this study refers livelihood diversification to include practices that diversifies from dependence on rainfed agriculture. Specifically, off-farm economic activities, migration and irrigation are addressed under livelihood diversification.

2.6 Household Food Security

2.6.1. Concepts

Food security has been variously defined and has undergone substantial transformation over the years (Clay, 2002). The most widely accepted definition is the World Food Summit's definition of food security as "Food security, at the individual, household, national, regional and global levels [is achieved] when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life" (FAO, 1996 cited in MoFA, 2007 pp. 24). It is important to note that, the emphasis on individual and household access to food resonates with the work of Sen (1981), and pales the concentration on global and national production into insignificance in the food security discourse. Pinstrup-Andersen (2009) draws attention to "food preference" in the definition stating that foods that are socially and cultural acceptable and consistent with religious and ethical values are as important as any other indicator of food security. In Ghana, the Ministry of Food and Agriculture (MoFA) defines food security "as good quality nutritious food, hygienically packaged and attractively presented, available in sufficient quantities all year round and located at the appropriate places at affordable prices" (MoFA, 2007, pp. 24). In addition to physical and

financial availability and nutritive components espoused in the world food summit definition, packaging is included as a component of food security.

In his foundation work on hunger and deprivation, Sen (1981) used entitlement approach to explain food security in terms of access to food. He posited that access to food is mediated by a person's ownership of resources informed by the set of entitlement(s) available to them. A claim to any asset(s) is premised on the following types of entitlements; trade base entitlement obtained true purchases, production based entitlement obtained by using one's own resources or hired resources in a production process, own labor entitlement acquired through trading one's labor power and inheritance and transfers acquired through transfers from a legitimate owner. Therefore a person's entitlement is determined by employment, sales of non-labor assets, ability to produce with one's labor power, the cost of purchasing resources and the social security benefit he/she is entitle to and taxes he/she must pay. Food security is therefore determined by ownership and entitlements available to an individual or a household. This exposition has shifted the attention on aggregate food production to the real issue of food security with the emphasis on the basic unit of food consumption.

2.6.2. Dimensions of Food Security

From FAOs definition of food security, four dimensions of food security is identified:

1. Food availability deals with supply side of the food security and expects sufficient quantities of quality food from local agriculture production or import.
2. Food access addresses access by individuals to adequate resources (entitlements) for acquiring appropriate foods for a nutritious diet. It deals with both economic and physical access.

3. Utilization of food through adequate diet, clean water, sanitation and health care to reach a state of nutritional well-being where all physiological needs are met. This brings out the importance of non-food inputs in food security
4. Stability encompasses access to adequate food at all times. Risk of losing access to food as a consequence of sudden shocks (e.g. an economic or climatic crisis) or cyclical events (e.g. seasonal food insecurity) should not be present. The concept of stability can therefore refer to both the availability and access dimensions of food security (de Ridder, 2006).

2.6.3. Types of Food Security.

FAO (2008) classified food insecurity into the following;

Chronic food insecurity: it is longer term/persistent and occurs when households are unable to meet their minimum food requirement over a sustained period of time.

Transitory food insecurity: it is short term and temporary and occurs when there is a sudden drop in the ability to produce or access enough food to maintain a good nutritional status. It results from short term shocks and fluctuation in food availability and food access, including year to year variation in domestic food production, food prices and household income

Seasonal food insecurity: it occurs when there is a cyclical pattern of inadequate access and availability of food. It is similar to chronic food insecurity as it is usually predictable and follows a sequence of known events. This type of food insecurity underpins the definition adopted in the study.

2.6.4. Smallholder farm household's food security in Northern Ghana.

In Ghana, poverty and food insecurity is highest in the three regions of the northern savannah ecological zone and disproportionately concentrated among food crop farmers (GSS, 2014c). In a study on food security in northern Ghana, WFP (2012) reported that even though the country has made substantial progress, the three regions in northern Ghana continue to record higher incidence of poverty, food insecurity and mal-nutrition. Food insecurity was found to result from low agricultural output and seasonal nature of production coupled with food price volatilities. Consistent with this, a simulation study revealed that rainfall and price variability significantly increases poverty and food insecurity among smallholder farmers in northern Ghana (Wossen & Berger, 2015).

In a study of food security among smallholder farm households in Central region using household caloric intake, Kuwornu et al., (2010) found 60% and Aidoo & Tuffour (2013) found 72% to be food insecure. Similar studies in Ethiopia made consistent estimates on smallholder food security with Beyene & Muche (2010) reporting 64%, Tefera & Tefera (2014) 62% whiles Leza & Kuma (2015) reported 65.5% of households being food insecure. However, the WFP (2012) studying food security in northern Ghana used a combination of two indicators; the food consumption score (FCS) and wealth index and found only 26% of households to be food insecure. In Zimbabwe, Mango et al., (2014) revealed that only 26.7% of households have been completely without food in the last 30 days. However majority expressed misgivings about their household's food security status relative to some important food security indices including anxiety on food security (69.2%), inability to eat their preferred food (84.2%), and limited variety of food (81.7%). Several factors are found to influence food security among smallholder farmers. In northern

Ghana, smallholder farmers' are food insecure because of limited non-farm income opportunities, low soil fertility, lack of agro-chemical inputs, lack of irrigation, drought/dry spells, floods, and high food prices (WFP, 2012). Marital status, gender, farm size, non-farm income, credit access, total annual income and dependency ratio were found to be significant determinants of household food security in the Central region (Kuwornu et al., 2010; Aidoo & Tuffour, 2013). In Zimbabwe, access to labor, education, remittances, market information and livestock ownership significantly influenced household food security (Mango et al., 2014).

Farm households adopt diverse strategies to cope with household food insecurity ranging from very erosive coping mechanisms to sustainable adaptation strategies. Rademacher-Schulz et al., (2014) posits that, in addition to selling of assets, smallholder farmers in the Upper West region engage in rainy season migration as a respond to household food shortages during periods of crop failures. Studies in Ghana and elsewhere in SSA have identified reducing the size and frequency of food, eat vegetables and fruits, sell livestock, sell other household assets, labor for food, seek food from relatives and friends and send children to leave with other relatives as the coping strategies adopted by food insecure households among smallholder farmers (Quaye, 2008; Kuwornu et al., 2010; Aidoo & Tuffour, 2013; Otunaiya & Ibidunni, 2014; Tefera & Tefera, 2014; Leza & Kuma, 2015).

2.7 Conceptual Framework

The conceptual framework focuses on drawing linkages and explaining how climatic and non-climatic stressors affect differentiated groups of smallholder farmers and the resulting adaptation response of the differentiated groups and their effectiveness in ensuring household food security.

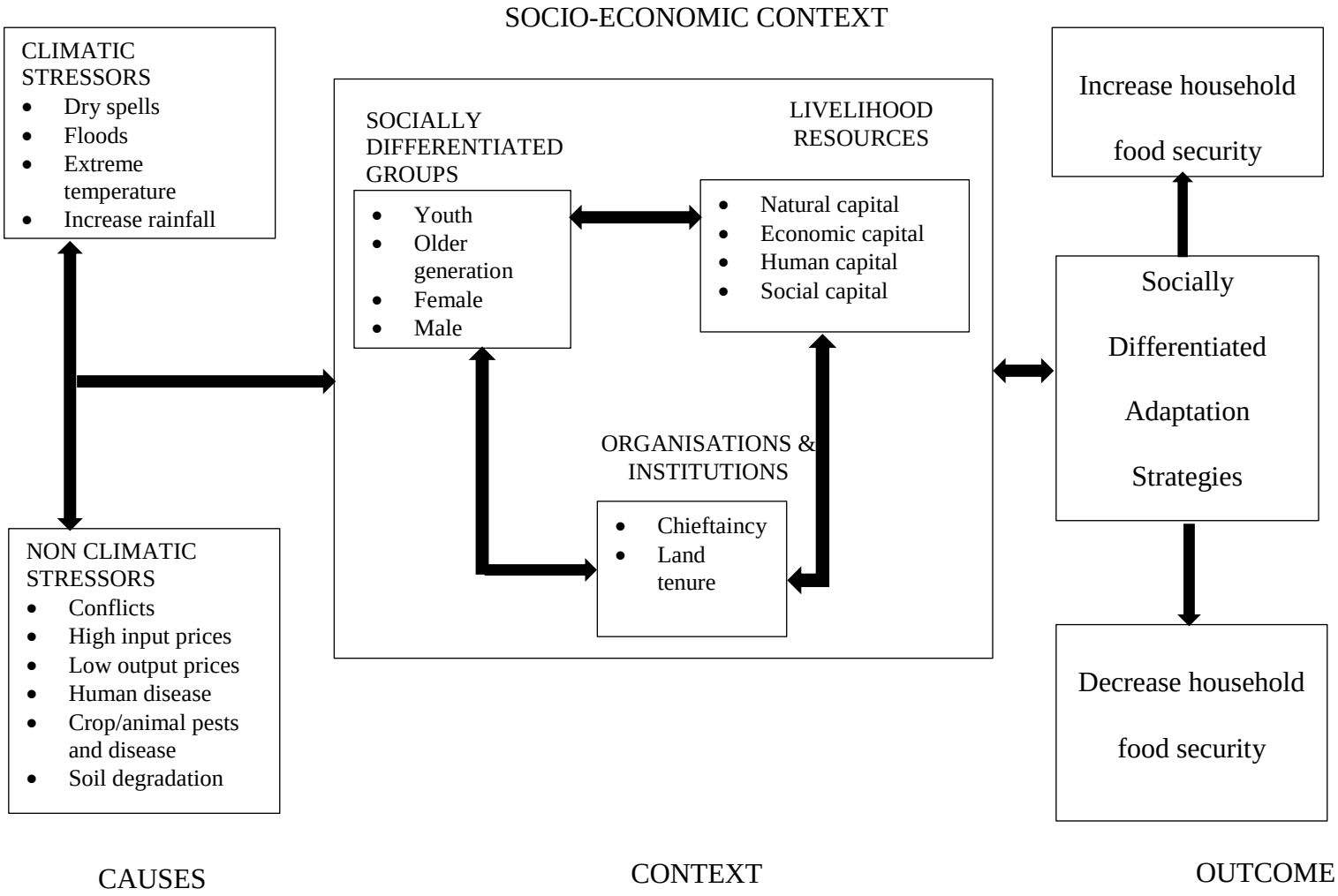
Smallholder farmers in the Lawra district are faced with climatic risks including droughts, floods, increased rainfall variability and increased temperature and non-climatic stressors such as high input prices, low output price, conflicts, soil degradation, and pests and diseases. These factors acting individually and in combination with one another serves as major causes of food insecurity among smallholder farmers as shown in Figure 2.1.

The impact of both climatic and non-climatic risks in the Lawra district depends on the smallholder farmers' vulnerability which is a function of the level of exposure, sensitivity and adaptive capacity. However, vulnerability among smallholder farmers is not homogenous but is socially differentiated (World Bank, 2010; Padgham et al., 2015). Some dimensions of social differentiation include gender, socio-economic status, ethnicity, and age. These differences influences access to livelihood resources including physical, economic, social and human capital. In addition, both formal and informal institutions and organizations mediates the vulnerability level of smallholder farmers as depicted in Figure 2.1.

In order to reduce the impact of climatic and non-climatic risks and enable them cope with and recover from stresses and shocks, smallholder farmers adopt strategies to maintain or increase productivity. Just like vulnerability, adaptation strategies of smallholder farmers are also socially differentiated. Adaptation strategies at the household level are generally clustered into three main categories; Adaptation practices related to the use of modern agro inputs including chemical fertilizer use, improved seeds, and use of weedicides and pesticides, sustainable land management practices involving composting, water harvesting, conservation agricultural practices, anti-erosion measures and legume intercropping, and livelihood diversification comprising off-farm income activities, migration and irrigation.

Unravelling the nuanced patterns of adaptation by the differentiated groups is critical for designing well targeted adaptation interventions. Adjustments made by farmers to cope with or recover from stresses are key to smallholder farmer resilience. The study determines the impact of the various adaptation strategies employed in ensuring household food security.

Figure 2. 1. Conceptual Framework



Source: Authors construction base on literature

2.8 Summary

This chapter provided a review of relevant literature in the study. The chapter began with a review on the definition of smallholder farmers. A discussion on social differentiation among smallholder farmers is presented. Vulnerability of smallholder farmers to both climatic and non-climatic stressors was presented. Adaptation strategies used by smallholder farmers was also presented. The concept of food security and food security among smallholder farmers was presented. Finally, the conceptual framework underpinning the study was discussed in the chapter.

CHAPTER THREE: METHODOLOGY

3.1 Introduction

This chapter discusses the methodology used for the study. First, a profile of the study area is provided, followed by study design, data collection method and data analysis accordingly.

3.2 Study Area

The Lawra district, which is the focus of the study is one of the eleven districts that make up the Upper West Region of Ghana. It lies in the north-western corner of the region. It is bounded to the north by Nandom district, to the east by Lambussie-Karni district and to the south and west by the Republic of Burkina Faso (Figure 3.1). The total area of the district is 1,051.2 square km. This constitutes about 5.7% of the Region's total land area, estimated at 18,476 square km.The district is estimated to have 157 communities with 95% of the inhabitants in the rural areas (GSS, 2013). The population density is about 89 per square km, making it the most densely populated district in the region. The population of Lawra district, according to the 2010 Population and Housing Census, was 54,889 representing 7.8 percent of the region's total population. Males constitute 48 percent and females represent 52 percent. The district is comprised predominantly of the Dagaaba ethnic group with dialectical variations. There are other minor tribes such as Akans, Hausas and Dagombas (GSS, 2013).

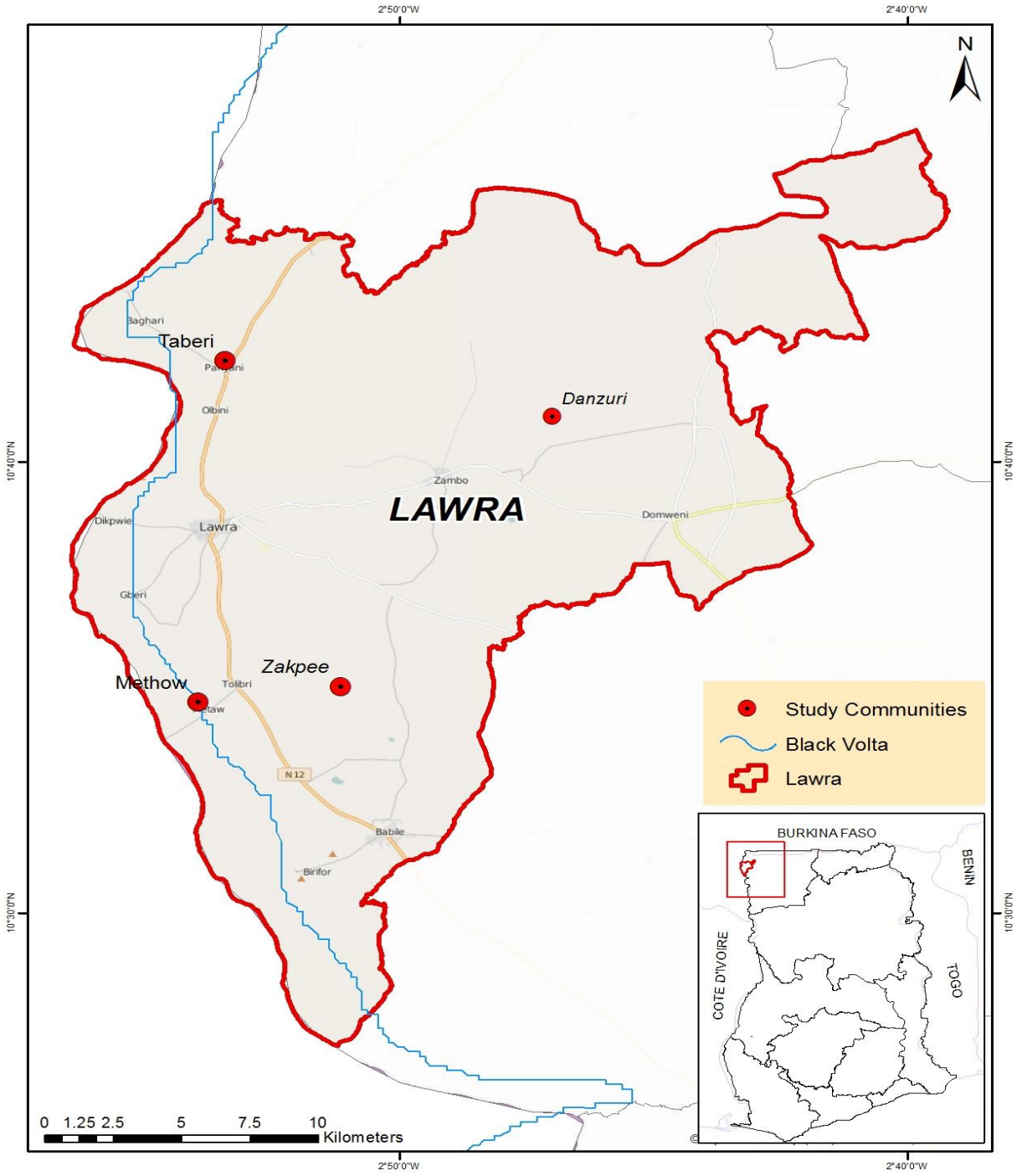
The District is mainly drained by the Black Volta to the west which lies very close to the boundary between the District and the Republic of Burkina Faso (Figure 3.2). The Black Volta has several tributaries in the District; notable amongst them are the Kamba/Dangbang, Nawer, Duodaa. The Lawra district lies within the Guinea Savannah

agro ecological zone which is characterized by short grasses and few woody plan. Common trees in the District consist of drought and fire resistant trees such as baobab, dawadawa, Shea trees and acacia. The greatest influence on the vegetation is the prolonged dry season. The mean annual rainfall ranges between 1016mm and 1270mm and is concentrated in one season - April to October (Lawra District Assembly, 2014). The mean annual temperature range between 27° C to 36° C. The period between February and April is the hottest (Lawra District Assembly, 2014).

The majority (78%) of people in the Lawra district are farmers producing small quantities of maize, millet, groundnuts, soya beans and cowpea. Animal rearing is also undertaken by most farmers to supplement crop production. The local agricultural sector is confronted with depleting soil fertility, unreliable rainfall pattern, limited capital investment and skills, pests and disease, inadequate access to extension services and low access to market (Lawra District Assembly). Food insecurity is a major challenge to many households within the district especially during the lean season (WFP, 2012). The harvest season is usually characterized by abundance, particularly to crop farming households. However, due to low income levels, farmers usually sell their produce to provide their non-food needs leaving them with insufficient food for the rest of the year (Lawra District Assembly, 2014).

Four rural communities including Methow-Yipala, Zagkpee, Tabier and Erimon-Dazuuri were chosen as the study locations in the district (Figure 3.1).

Figure 3. 1 Map of study area showing study locations



Source: Remote Sensing/GIS Laboratory, Department of Geography, University of Ghana, 2016

3.3 Study Design

The mixed method study design was used for this study. The findings of the study seeks to achieve both nomothetic (generalization) and ideographic (sympathetic understanding) objectives. While quantitative survey data enabled the study ascertain the general patterns of vulnerability and adaptation practices of smallholder farmers across the study area, qualitative exploration provided more depth by proffering reasons underpinning vulnerability and adaptation strategies of differentiated groups of farmers. Qualitative responses also provided further clarification on household food security of smallholder farmers.

3.4 Reconnaissance Survey

A reconnaissance visit was made to the study area in August 2015 to enable the researcher familiarize with the study area and establish rapport with the study participants. The visit was also aimed at firming up the research questions and better situating the research in the context of the participants.

3.5 Data Collection Methods

The study used both primary and secondary data. Secondary data comprising rainfall and temperature data was obtained from the Ghana Meteorological Agency (GMet). Primary data was collected through; Focus Group Discussions (FGDs), in-depth interviews and semi-structured questionnaire survey. FGDs preceded the questionnaire survey and key informants' interview

FGDs comprising a cross section of farmers in the communities was conducted to understand livelihood strategies of farmers, hazards confronting smallholder farmers, and

local perceptions on food security. Eight FGDs were conducted; two in each community disaggregated by gender. Disaggregation of FGDs discussants according to gender was informed by the fact that socio-cultural consideration in the study area constrained females from expressing themselves in the midst of their male counterparts (Yiridoe, 1995). The focus of the work on social differentiation partly accounted for the gender disaggregation for the community FGDs. Particular attention was paid to other social factors including age, marital status, migratory status, disability and social class in ensuring inclusiveness in the discussions. The composition of groups ranged between 9 and 12 people. Discussions in all communities were held at the community meeting grounds. Additionally, FGDs were used to validate major hazards confronting smallholder farmers that were identified from literature. Further, adaptation response of farmers to these hazards were also explored.

Key informants' interviews was used to further explore differentiated social groups to better understand their perceptions on the vulnerability context, why distinct perceptions exist, and how these perceptions shape individual decisions to play the livelihood roles they do. The patterns of adaptation of the different social groups and the effectiveness of the adaptation strategies on wellbeing was further explored. A total of twelve in-depth interviews were conducted; three in each community disaggregated into the differentiated social groups of men, women and youth. Respondents of questionnaire survey whose response were considered to reflect the identified social groups (males and females and youth and older generation) were identified and included for in-depth interviews where the relevant social group was explored to more depth. Key informant's included community leadership like a community secretary and a chief. The Lawra district zonal coordinator of agriculture extension was also interviewed for the study.

Interviews from both FGDs and key informants' interviews were digitally recorded and transcribed. Permission of discussants and interviewees were sought before recording took place. Permission was also sought before pictures were taken during interviews or discussions.

Questionnaire surveys: Data was collected from individual farmers by the use of semi-structured questionnaires aided by a face to face interview. Two research assistance from the University for Development Studies were trained and engaged during data collection process. They served as interpreters during FGDs, in-depth interviews and questionnaire administration. They also conducted interviews during the questionnaire administration process. These people had prior experience with community engagement and data collection.

3.6 Sample Size and Sampling Approach

The target population for the study was smallholder farmers (farmers who lived in rural areas and engage in agriculture as the main source of livelihood relying solely on family labor in their production process). Even though farm size of not more than two hectare is usually used to define smallholders in Ghana. This study adopted Chamberlin (2007), definition of smallholder to focus on location rather than farm size. As such farmers located in the rural areas were targeted for this study.

Data on population of the four communities studied was obtained from community secretaries and chiefs. The population of the four communities was estimated at 2,614 people. A sample size of 160 representing 6% of the total population was used for the study. This sample size was considered partly for statistical reason and partly for logistical consideration. Statistically, the sample size is large enough to study and make

generalization of the population under study. Time and resource limitations constrained the use of sample size proportionate to the population under study. Besides, survey data was coupled with focus group discussions, in-depth interviews and key informants' interview.

A multi stage sampling procedure was adopted for this study. The multi stage procedure was three-stages; purposive, cluster and non-proportionate random sampling approach. The Lawra district was purposively selected from the districts in the Upper West region data obtained from the regional coordinating council indicated that the district has the highest climate change interventions in the region. Besides, a good number of communities in the district are located along the Black Volta which makes them prone to both drought/dry spells and floods.

A non-proportionate random sampling technique was used to select farmers for inclusion in the study. With emphasis of the work on social differentiation, deliberate efforts were made to maintain a balance in gender and age. To achieve a balance among the social groups of interest (males, females and youth), stratified sampling procedure was used to create three strata of the population based on the social groups. Selection of respondents in the field was very challenging as a result of lack of comprehensive list of farmers disaggregated by age and gender. An improvised list was developed and used in the field. This involved the division of communities into four blocks and a vantage point identified. People within each block were asked to provide names of farmers within that block. The lottery method was then used to randomly select respondents. Table 3.1 shows of respondents from the communities according to age and sex.

Table 3. 1. Sample Respondents

Name of community	Males	Females	Ages 15-35	Above 35
Methow-Yipalla	23	17	21	19
Zakpee	19	21	23	17
Tabier	19	21	15	25
Erimon-Dazuuri	23	17	11	29
Total	84	76	70	90

Source: field survey data, 2016

Interviewees and discussants selected for FGDs and in-depth interviews were purposively selected based on specialized knowledge of the subjects under study. Selection of participants FGDs was based on interaction with community leaders and other identified people to ensure inclusiveness. Interviewees for key informants was based on depth of knowledge in relation to the subject matter. Some interviewees were selected for in-depth interviews from survey questionnaires base on the socio-economic features and response patterns.

3.7 Data Analysis

Qualitative data from focus group discussions, in-depth interviews, field notes were transcribed, summarized, coded and grouped into major themes. Direct quotations were used to give voice to participants' own views on livelihoods strategies, vulnerability and adaptation practices of rural farmers. Quotes were selected based on archetypal views conveyed by many respondents and the depth or clarity the idea was expressed.

Objective one (Identify the socially differentiated patterns of vulnerability and adaptation of smallholder farmers) was addressed using descriptive statistics. The SPSS version 20 software package was used to analyze the data. The data were presented in tables, graphs and charts. The chi-square ($\chi 2$) was used to estimate the statistical difference among the social groups (males, females, youth and older generation) in the adoption of adaptation strategies. The Kendell W ranking was also use to rank constrains faced by farmers.

3.7.1 Identification and Ranking of Constraints faced by smallholder farmers

The identification of hazards faced by smallholder farmers in the Upper West region was done through literature review and validated with community focus group discussions. The profile of the Lawra district and the medium-term development plan for the 2013-2017 planning year were also vital in identification of challenges faced by farmers in the Lawra district. Twelve (12) major constrains were identified and presented to farmers for ranking. The hazards were then presented to respondents for ranking from the most pressing constraint to the least pressing one using numeric scales 1, 2, 3….12. The total rank score of each constraint was calculated and the constraint with the least score ranked the most pressing one while the constraint with the highest score was ranked the least.

The Kendall's Coefficient of Concordance (W) was used to determine the level or degree of agreement among the rankings of the constraints by the respondents using the rank scores (Legendre, 2010). The coefficient of concordance (W) is a positive value ranging between zero (0) and one (1). A Kendall's concordance coefficient of one suggests maximum agreement among rankers while zero coefficient means maximum disagreements among rankers on the rankings of the constraints.

Given that T = the sum of ranks of each constraint being ranked, the variance of the sum is given by;

$$Var_T = \frac{\sum T^2 - (\sum T^2)/n}{n} \quad (1)$$

And the maximum variance of T is then given by

$$\frac{m^2(n^2-1)}{12} \quad (2)$$

Where, m = Number of sets of ranking by the farmers and n = the number of specific constraints being ranked.

The Kendall's coefficient of concordance (W) is therefore given as,

$$W = \frac{[\sum T^2 - (\sum T^2)/n]/n}{m^2(n^2-1)/12} \quad (3)$$

Equation (3) is further simplified to the computational formula as;

$$W = \frac{12[\sum T^2 - (\sum T^2)/n]/n}{nm^2(n^2-1)} \quad (4)$$

The coefficient of concordance (W) may be tested for significance using the F-statistic. This is given by,

$$F = \frac{[(m-1)w_c]}{(1-w_c)} \quad (5)$$

The F-statistics has $V_i = \frac{(n-1)-2}{m}$ Degree of freedom for the numerator

$V_2 = (m-1)[(n-1) - 2/m]$ Degree of freedom for the denominator.

Decision rule: If $F_{cal} > F_{cri}$ from Fisher's F-statistics distribution, the null hypothesis is rejected; otherwise, it is not rejected.

Objective two (examine the effectiveness of adaptation strategies on smallholder household food security) was analysed with the binary logit model with (cumulative) logistic distribution function. Stata version 12 software package was used for the analysis.

According to Gujarati (2004) binary response regression model are qualitative response regression models appropriate when the response for the dependent variable can take only two variables, it is thus considered a binary or dichotomous variable. There are three approaches to developing a probability model for a binary response variable; the Linear Probability Model (LPM), the logit model and the probit model.

To determine the effectiveness of different adaptation strategies used by smallholder farmers in the Lawra district on their household food insecurity, this study employed the binary logit model. This is possible because household food insecurity is not ordinal, farmers were either food insecure or not. The outcome of the dependent variables for this study is household food insecure and household food secure. The predictor variables for this study include sustainable SLM practices; mix cropping/legume intercropping, composting, conservation agriculture, anti-erosion measures and changing planting dates; modern inputs use; improved varieties use, use of chemical fertilizer and pesticides and weedicides use; and diversification; off-farm employment and migration. Other socio economic variables that influence household food insecurity were added to the predictor variables.

3.7.2 Theoretical Model.

The logit model is a probability model most suitable for measuring the likely occurrence of a dichotomous response variable which takes the range of values of 0 - 1. The logit model is specified as:

$$E(Y=1|X_i)=\frac{1}{1+e^{-(\beta_1+\beta_2 X_I)}} \quad (1)$$

Where $E(Y=1|X_i)$ is the expectation of observing the endogenous variable, Y, given the exogenous variable X_i, β_1 and β_2 are parameters to be estimated.

If $Z_i=\beta_1+\beta_2 X_i,$ (2)

Then equation (2) can be written as

$$P_i=\frac{1}{1+e^{-z}}=\frac{e^z}{1+e^z}, \qquad 0<P_i<1 \quad (3)$$

Where P_i denotes the probability of a smallholder farm household been food insecure.

If P_i, the probability of a household been food insecure is given by equation (3), then, the probability of a household not been food insecure (1 – Pi) can be expressed as:

$$1-P_i=\frac{1}{1+e^{z_i}} \quad (3)$$

Therefore, we can express the odd ratio in favour of a household been food insecure ($\frac{P_i}{1-P_i}$) as the ratio of the probability that a smallholder farmer is food insecure to the probability that a smallholder farmer household is not food insecure:

$$\frac{P_i}{1-P_i} = \frac{1+e^{z_i}}{1+e^{-z_i}} = e^{z_i} \quad (4)$$

Taking the natural logs of equation (4) gives

$$L_i = \ln\left(\frac{P_i}{1-P_i}\right) = Z_i \quad (5)$$

But, from equation (2), $Z_i = \beta_1 + \beta_2 X_i$

Hence, $L_i = \ln\left(\frac{P_i}{1-P_i}\right) = \beta_1 + \beta_2 X_i$ (6)

For the purpose of estimation, equation (6) is rewritten as:

$$L_i = \ln\left(\frac{P_i}{1-P_i}\right) = \beta_1 + \beta_2 X_i + \mu_i \quad (7)$$

Where $-\infty \leq L \leq +\infty$, and $0 \leq P_i \leq 1$.

Regressing the exogenous variables (Xs) given in the Table 3.2, on the endogenous variable (the smallholder farm households' food insecurity), the empirical logit model can be specified thus:

$$Y_i = \beta_0 + \beta_1 Age + \beta_2 Sex + \beta_3 Inc + \beta_4 Edu + \beta_5 Comp + \beta_6 landT + \beta_7 CreAcc + \beta_8 ConA + \beta_9 ImpV + \beta_{10} CheF + \beta_{11} OffF + \beta_{12} Mig + \beta_{13} Irrg + \varepsilon_i \quad (8)$$

Table 3. 2. Description of Exogenous Variables for the Binary Logit Model

STRATEGIES	EXOGENOUS VARIABLES	MEASUREMENTS	EXPECTED SIGN
Socio-demographic variables	Age (Agegrp)	Dummy: 1=15-35 years, 0=otherwise	+/-
	Sex (S)	Dummy:1=male, 0=otherwise	
	Income (FY)	GH₵	+
	Education (Edu)		+
	No formal education (1)	Dummy: 1=yes, 0=otherwise	
	Primary education (1)	Dummy:1=yes, 0=otherwise	
	JHS/Middle school (2)	Dummy:1=yes, 0=otherwise	
	SHS/vocational (3)	Dummy:1=yes, 0=otherwise	
	Tertiary (4)	Dummy:1=yes, 0=otherwise	
Institutional variables	Access to credit (AccCr)	Dummy:1=yes, 0=otherwise	+
	Land tenure (Land T)	Dummy:1=yes, 0=otherwise	+
Sustainable land management practices	Composting (Comp)	Dummy:1=Yes, 0=Otherwise	+
	Conservation Agriculture (ConAg)	Dummy:1=Yes, 0=Otherwise	+
Modern inputs	Improved Varieties (IV)	Dummy:1=Yes, 0=Otherwise	+
	Chemical Fertilizers (CheFu)	Dummy:1=Yes, 0=Otherwise	+
Diversification	Off-Farm Employment (Off-FE)	Dummy:1=Yes, 0=Otherwise	+
	Migration (Mig)	Dummy:1=Yes, 0=Otherwise	-/+
Irrigation	Irrigation (Irrg)	Dummy:1=Yes, 0=Otherwise	-/+

Where the slopes, βs are parameters to be estimated and μ_i is the error term associated with the model regression estimated. The parameters were estimated using the maximum likelihood method. Stata software was used for the analysis. The count R^2, given by $\frac{Number\ of\ correct\ predictions}{Total\ number\ of\ observations}$ was used to test for the overall significance (goodness of fit) of the logit model while the (standard normal) z statistic was used to test for the statistical

significance of the individual exogenous variables. Since the regressand (Household food insecurity) in the logit model takes a value of 1 or 0, if the predicted probability is greater than 0.5, it is rounded up to 1; but if it is less than 0.5, it is approximated to 0. The number of correct predictions were then counted and divided by the total number of observations to ascertain the count R^2. A higher R^2 is always preferred to a lower one.

If the logit, L is positive, it means that when the value of the regressor(s) increases, the odds that the regressand equals one (1) (meaning becoming more food insecure) increases as the exogenous variable, X increases and if L is negative, the odds that the regressand equals one (1) decreases as the exogenous variable, X increase (Gujarati, 2004, pp. 596). In short, the logit becomes negative and increasingly larger in magnitude as the odds ratio decrease from 1 to 0 and becomes increasingly larger and positive as the odds ratio increase from one to infinity.

The slopes, βs measure the change in L for a unit change in an exogenous variable, X. Thus, the βs tell how the log odds in favour of a smallholder farm household been food insecure changes as an exogenous variable changes by a unit, holding other factors constant.

3.7.3 Predictor Variables Considered for the Model.

Adaptation Strategies

Use of improved varieties

Use of improved seed is hypothesized to have positive impact on the probability of being food secure among the farm households because of its potential to increase farm productivity. Tefera & Tefera (2014) found that farmers who use improved varieties to be more food secured relative to farmers who do not use it.

Use of Chemical Fertilizer

Chemical fertilizer use improves the productivity of farms, as such households using chemical fertilizer are expected to have a better food productivity and household food security than non-users (Beyene, 2010).

Conservation Agriculture

Soil conseravation measures increases productivity of farmlands and lead to a better food security for adopters of the practice. Beyene (2010) found soil conservation measures to be statistically signifcant and positively correlated to household food security in Ethiopia.

Composting

Composting is hypothesized to be inversely related to household food security. Composting and manure use is the major intensification pathways adopted by poor farmers in northern Ghana (Yaro, 2002). Also, most smallholder farmers in northern Ghana possess few livestock reared on the free range system making it impossible to get the amount of manure and compost required to increase productivity (Kombiok et al., 2008).

Off-farm employment

Off-farm employment is predicted to have a significant positive impact on household food security. Smallholder farmers engaged in off-farm income activities are more food secure relative to farmers who do not engage in off-farm income activities (Kuwornu et al., 2010 ; Owusu et al., 2011; Aidoo & Tuffour, 2013; Mango et al., 2014; Tefera & Tefera, 2014).

Migration

Migration is hypothesized to have a positive impact on household food security of farmers. Household food security are enhanced through remittance of food and money (Nielsen &

Reenberg, 2010a; Lacroix, 2012; Mango et al., 2014; Generoso, 2015) and also the reduction in demand on household food (Rademacher-Schulz et al., 2014).

Irrigation

Irrigation has been reported as a widespread adaptation strategy against climate variability in developing countries (Deressa et al., 2009). Farmers with access to irrigation are expected to be more food secure than those without access because they can produce at least twice a year (Nkhata et al., 2014; Wossen et al., 2014).

Farmer Socio-Demographic Characteristics

Age

Age could have a positive or negative impact on household food security. Household with older and more experience household heads are likely to be more food secured compared to households with younger household heads (Trang, 2010; Tefera & Tefera, 2014). However, Leza & Kuma, (2015) found that age of the farmer is negatively related to the food security situation, implying older farmers are more likely to be food insecure compared to younger ones.

Gender

Gender is a major determinant of households' food security in developing countries especially sub-Saharan African countries. Men are expected to be more food secured than women among smallholder farmers because of factors such as access to resources, nature of inheritance system and socio-cultural practices that discriminate against women. In terms of gender, there is robust evidence that women are more food insecure than men (FAO, 2015).

Education

Education measures the level of human capital of farmers. Literate farmers are therefore expected be more food secured because of ease of access to information and the ability to diversify from farming into other non-farm activities. FAO (2015) found food security to be significantly higher for households with literate household heads.

Farm income

Total annual Farm income is hypothesized to have a positive correlation with household food security. Leza & Kuma (2015) found that a higher total annual farm income resulted in better food security situation for the farmer.

Institutional Factors

Access to credit

Access to credit is one of the central factors in the farm activities of smallholder farmers. Short term credit targeting smallholders is expected to enhance food security both in the short and long run by reducing their capital constrains. It was found to be a very effective poverty alleviation and food security instrument among smallholder farmers in northern Ghana (Yilma et al., 2008). Leza & Kuma (2015), Aidoo & Tuffour (2013) and Generoso, (2015) found households with access to credit to stand the chance of being more food secured than households without access to credit in Ethiopia, Ghana and Kenya respectively.

Farmland Ownership

Farmland ownership is predicted to have a positive effect on the food security of smallholder farmers. Ownership of farmland was found to have a positive impact on household food security in Ethiopia (Tefera & Tefera, 2014).

3.8 Limitation of the study

The background of the researcher as a student from the University of Ghana in the national capital possibly produced a wide gap between the researcher and the study participants who were mostly rural dwellers. This gap was hightened by the geographic distance between Accra and Lawra, located in extreme south east to extreme north west of the country. Consequently, respondents tried to adjust their responses and behavior to meet their percieved expectation of the researcher. This was aimed at projecting the community in a positive light to the researcher and by extension the research report to be produced.

3.9 Summary

This chapter presented the methodology of the study. The study area was first presented. This was followed by the study design, methods of data collection, sampling and data analysis. Empirical specification of the Kendell's Coefficient of concordance and theoretical binary logit model employed in the analysis were discussed. Finally, limitation of the study was presented.

CHAPTER FOUR: RESULTS

4.1 Introduction

The results emanating from the study are presented in this chapter. Findings on the socio-economic characteristics of smallholder farmers included in the study are presented in section 4.2. Smallholder farmers' perception of long-term temperature and rainfall changes are presented in 4.3. Perception on incidence of floods and droughts are presented in section 4.4. Assets ownership of smallholder farmers are presented in section 4.5. Section 4.6 contain vulnerability context and adaptation patterns of participants to both climatic and non-climatic factors. Section 4.7 focus on diversification. Finally, section 4.8 presents the household food insecurity among smallholder farmers.

4.2 Basic Statistics of Socio-economic Variables

The socio-demographic profile of study respondents include gender, age, education, types of farming, income, farm size, years of farming, household members employed and household size. Institutional factors included are credit access, formal extension service access, and land tenure. They are grouped into categorical and continuous variables.

4.2.1 Categorical variables

Table 4.1 indicates that about three quarters (74.4%) of respondents did not have any form of formal education, while minority (13.1%) of respondents who had formal education had some JHS/Middle school education (4.2%). Very few (1.9%) had tertiary education whereas 6.9 percent and 3.8 percent had primary and SHS/O/A level education respectively. Formal education measures the level of human capital and it is expected to improve the ability of farmers to access information, services and resources needed to improve their farm activities and reduce hazards.

The dominant farming method among respondents is mixed farming (63.1%) involving the cultivation of cereals including maize, rice, millet and sorghum, legumes; groundnuts, beans, bambara beans, soya beans and cowpea and vegetables comprising okra, pepper, pumpkin, tomatoes, and amaranthus spps. Animals reared by respondents include cattle, pigs, sheep, goats, and poultry (Table 4.1). The practice of sole animal husbandry is virtually non-existent (0.6%) among respondents. Crop farming is second most dominant farming method with 36.3% of the responding engaging in crop cultivation alone.

Also, access to credit is very low (23.1%) among respondents. Access was defined by farmers' proven record of securing both cash and input credits from both formal and informal source. Out of the 38 respondents who had access to credit, majority (51.2%) of them obtained it from Village Savings and Loans Associations operated in their various communities. Banks (Lawra Rural Bank) were the least (4.7%) source of credit cited by respondents in line with the general trends in access to commercial credits by the agriculture sector in Ghana. Other sources of credit included Non-Governmental Organizations (NGOs) (25.6%) and the Ministry of Food and Agriculture (18.6%).

Table 4. 1. Categorical Variables

Variable	Category	Frequency	Percentage	Total
Gender	Male	86	53.8	160
	Female	74	46.3	160
Type of farming	Crop farming	58	36.3	160
	Animal husbandry	1	0.62	160
	Mix farming	101	63.1	160
Access to credit	Yes	37	23.1	160
	No	123	76.9	160
Source of credit	NGO	11	25.6	40
	VSLA	22	51.2	40
	Rural bank	2	4.7	40
	MoFA	8	18.6	40
Access to formal extension services	Yes	116	72.5	160
	No	44	27.5	160
Educational level	No formal education	119	74.4	160
	Primary education	11	6.9	160
	JHS/Middle School	21	13.1	160
	SHS/O/Alevel	6	3.8	160
	Tertiary	3	1.9	160
Farmland ownership	Yes	105	65.6	160
	No	55	34.4	160

Source: Computed from field survey data, 2016

Additionally, most respondents (72.5%) indicated they had some form of contact with formal extension services from the district agriculture development unit and some NGOs. This implies that extension contact in the district is very high. Information obtained from extension contacts were reported to include terrace farming, compost preparation, chemical

fertilizer application, weedicides and pesticides use and row planting. Other kinds of information obtained included improved seeds use, basic veterinary skills, dry season tomatoes farming and information on rainfall.

4.2.2 Descriptive Statistics of Continuous Variables

Table 4.2 presents results on continuous variables of study respondents, the mean household size (measured as the number of individuals in a household) is 8.5 persons per household. This is more than double the national average of 4.0 and significantly higher than the regional figure of 6.5 (GSS, 2014b). The standard deviation for household size is 4.5 and indicates a large variation in household with most households' sizes falling below the mean household size. The Sreason for this disparity could be attributed to the focus of the study on smallholder farmers who are predominantly located in rural areas and known to have large household sizes.

The average number of household members who are employed is 3.8. With an average household size of 8.5, implies an economic dependency ratio (measured by the actual number of dependence on each household member) of 1:2.2.

The median income of farm households is Gh₵1,240.00 (Table 4.2). This is above the extreme poverty income level of Gh₵792.05.00 but a little below the absolute poverty level of 1, 314.00 (GSS, 2014b).

The mean farm size of respondents is 3.2 acres with a minimum of 0.5 acre and a maximum of 12 acres. The mean farm size is below the average land holding of five acres for smallholders in Ghana. The mean farm size of study respondents is 3.3063 acres indicating a fairly small average land holdings among respondents. It also indicates that the study population is a typical reflection of a smallholder define by farm size of not more than five

acres. The data also indicate that the average number of years respondents have engaged in farming is 14.7 years with a minimum of one year and a maximum of 60 years (Table 4.2).

Table 4. 2. Continuous Variables

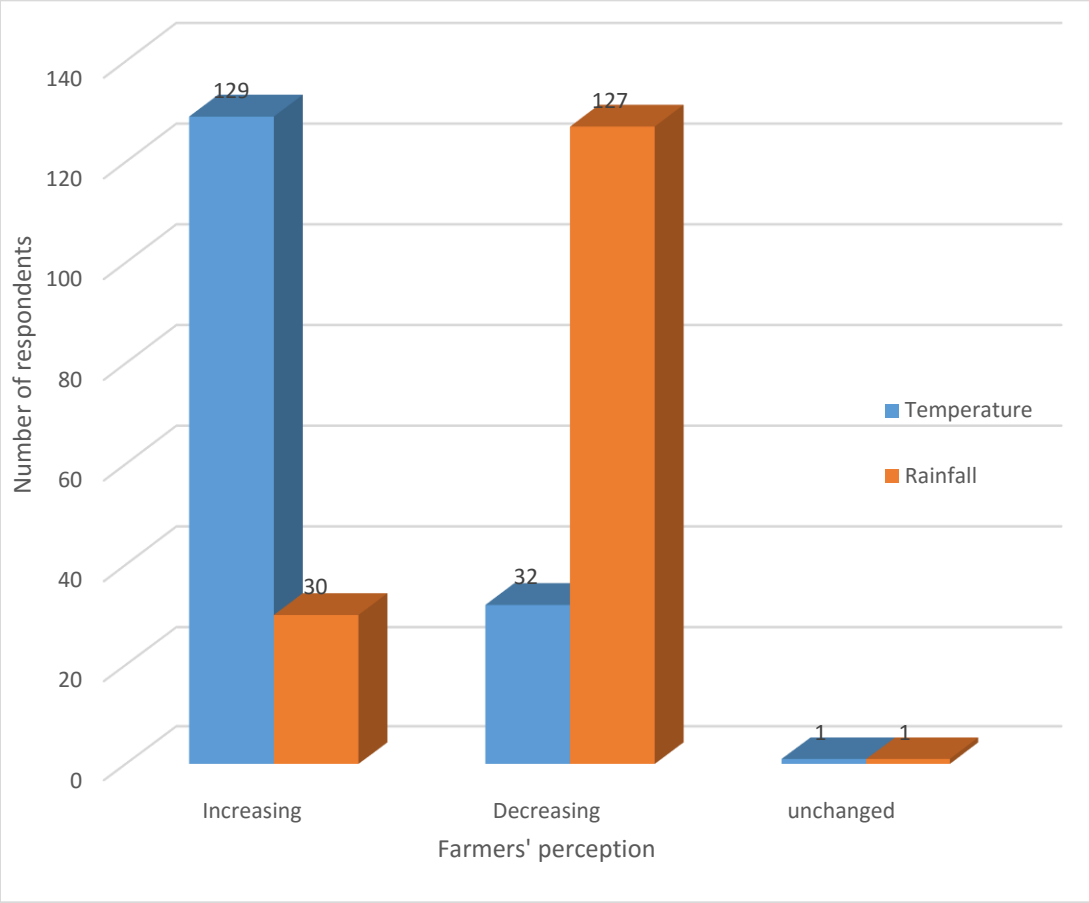
	Minimum	Maximum	Mean/ Median	Std. Deviation
Age of respondent	17	90	40.5750	15.43481
Income	95	81900.00	1240.00	9160.98774
Farm size (hectares)	0.2	4.9	1.3	0.963
Years of farming	1	60	14.4125	13.01928
Household members employed	1	17	3.8688	2.70597
Size of household	1	27	8.5813	4.54948

Source: Computed from field survey data, 2016

4.3 Farmers' Perception of Long Term Temperature and Rainfall Changes

The majority (80.6%) of farmers perceived an increase in temperature over the past 10 years (Figure 4.2). About 0.6% of respondents perceived no change, 18.8% perceived a decrease in temperature. However, in the case of rainfall, 79.3% of respondents claimed that the rainfall amount has been decreasing over the past 10 years, 0.6% perceived no change, and 21.1% perceived an increase (Figure 4.1).

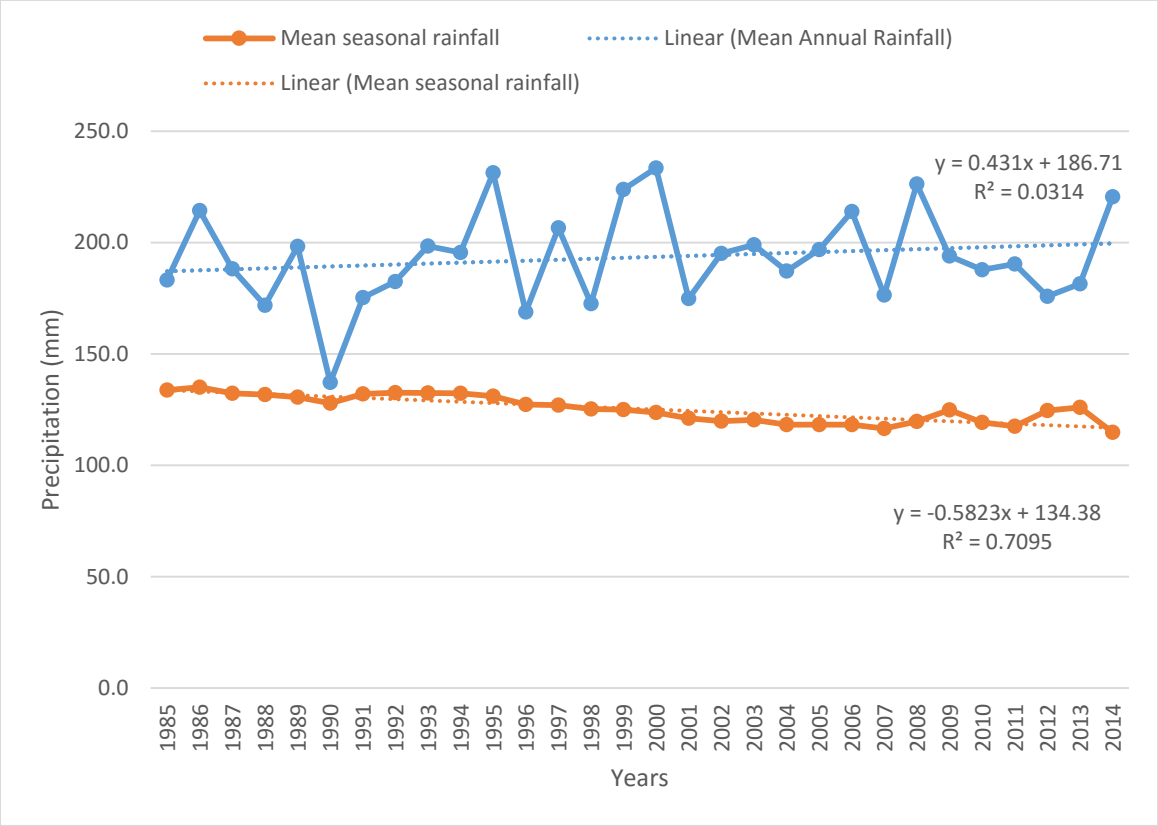
Figure 4. 1. Farmers' perceptions of long-term changes in temperature and precipitation in the Lawra district.



Source: Computed from field survey, 2016

Figure 4.2 shows that annual rainfall pattern indicates a high temporal variability with trend line establishing a slight increase in rainfall amount across the 30 year period between 1985 and 2014. However, mean seasonal rainfall indicates a clear and consistent decline across the period.

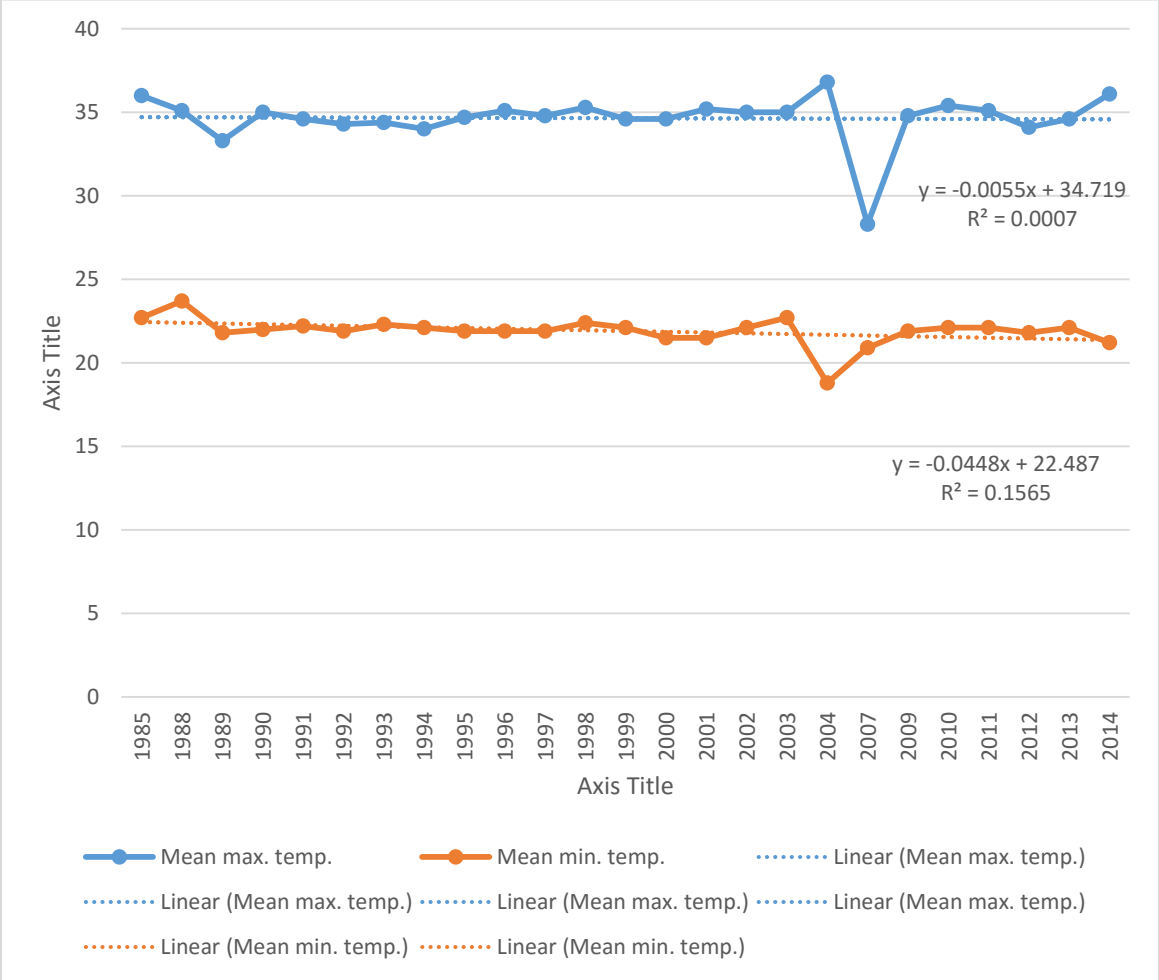
Figure 4. 2. Annual and seasonal rainfall (mm) in the Lawra district, 1985-2014.



Source: Computed from rainfall data from GMet

The long-term temperature trends illustrates a relatively stable mean annual minimum and maximum temperature (Figure 4.3). The trend lines however depicts a slight decline in mean maximum and minimum temperature trends.

Figure 4. 3. Mean Annual Minimum and Maximum Temperatures (℃) in the Lawra district, 1985-2014.

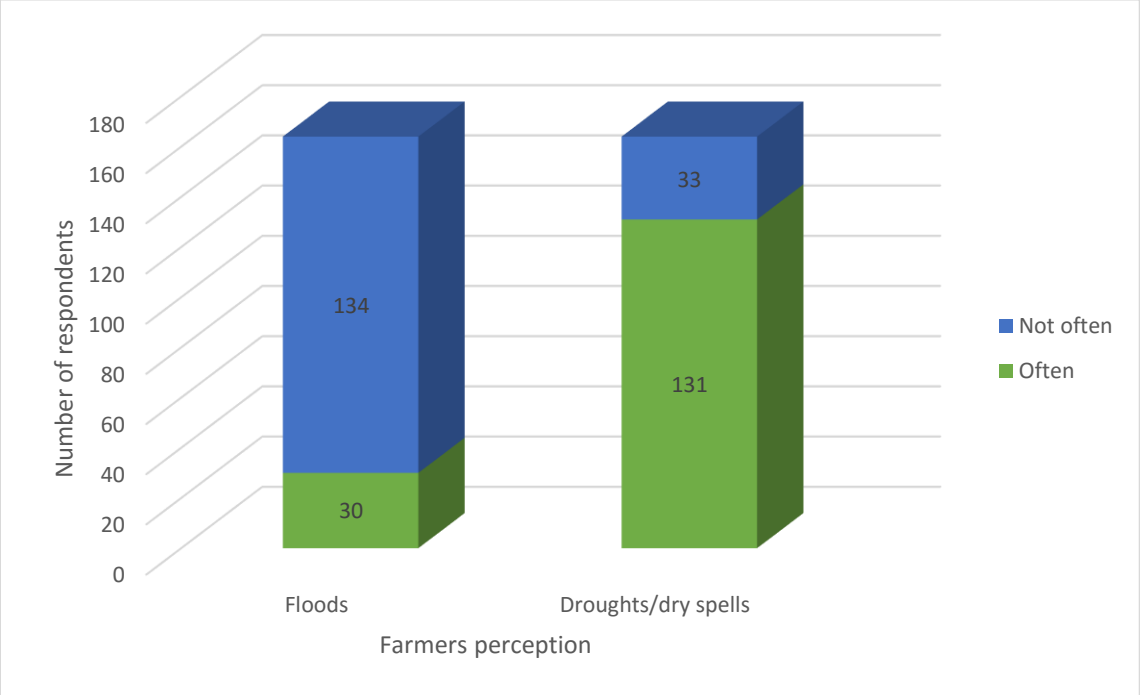


Source: Computed from temperature data from GMet

4.4 Farmers' Perception on Incidence of Floods and Droughts/Dry Spells.

The incidence of drought/dry spells in the Lawra district was perceived by most (79.4%) farmers to be more frequent. Conversely, fewer (18.1%) farmers perceived the incidence of floods to be often while majority (81.9%) perceived it be infrequent.

Figure 4. 4. Farmers' perception on incidence of drought/dry spells and floods in the Lawra district.

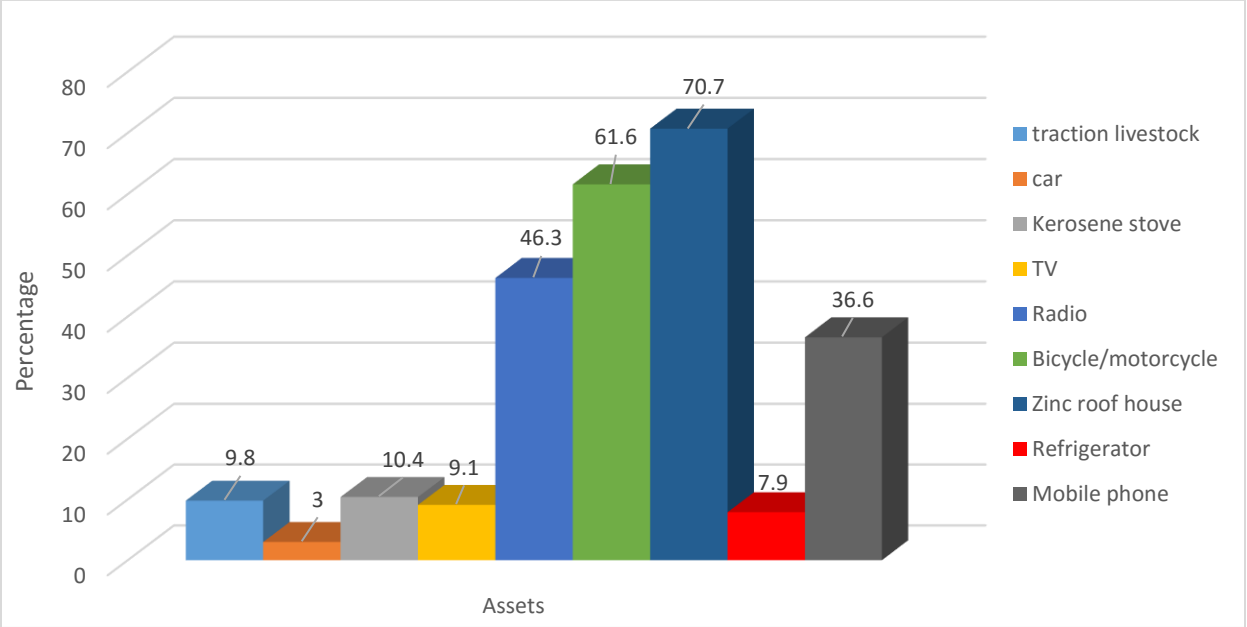


Source: Computed from field survey, 2016

4.5 Assets Ownership of Smallholder Farmers.

From figure 4.3 it is shown that majority of (70.7%) farmers resided in houses roofed with zinc. Ownership of car, refrigerator, TV and traction livestock is negligible (3%, 7.9%, 9.1% and 9.8% respectively). Less than half (46.3%) of respondents owned a radio set. The proportion of respondents who had mobile phone is 36.6%. Ownership of TV is low (9.1%) of respondents while gas/kerosene stove ownership is 10 percent.

Figure 4. 5. Asset ownership of smallholder farmers in Lawra district.



Source: Computed from field survey, 2016

4.6 Vulnerability and Adaptation Patterns of Differentiated Groups of Smallholder Farmers

The livelihood approach is a method for studying complex rural development issues like adaptation to climate change. It is therefore used in this study as a lens to understand what factors smallholder farmers in the Lawra district are vulnerable to and the subsequent adaptation measures adopted by these farmers. Smallholder farmers in the Lawra district are faced with a variety of hazards in their farming activities ranging from climatic stresses like drought/dry spells, floods, increased temperature to non-climatic stressors including water stress, farm input prices, sales of farm produce, high food prices and decrease soil fertility among others. To moderate the impact of these hazards, various adaptation strategies have been adopted by smallholder farmers. Vulnerability to and adaptation to the hazards are not uniform across different social groups. This section of the study ranks the

hazards faced by smallholder farmers and also identify the patterns of adaptation among the different social groups both by gender and age.

4.6.1 Ranked Vulnerability of Smallholder Farmers to Climatic and Non-Climatic Hazards

The identification of hazards faced by smallholder farmers in the northern savannah zone was done through literature review and validated with community focus group discussions. The profile of the Lawra district and the medium-term development plan for the 2013-2017 planning year were also vital in identification of challenges faced by farmers in the Lawra district. Twelve major constrains were identified and presented to farmers for ranking. The hazards were presented to all respondents to rank them in other of importance from the most pressing to the least pressing one.

The Kendall's Concordance Coefficient was used to test for the level of agreements of the rankings among smallholder farmers. Results of the Kendall's Test showed that the Chi Square value for the pooled sample ($\chi 2$=487.563) was significant at 1 percent with a Kendall's concordance coefficient of 0.277 as presented in Table 4.3. This means there is a 27% agreement level among smallholder farmers on the ranking of hazards faced by smallholder farmers. With the exception of conflicts, there is an overwhelming consensus among farmers that threats posed by hazards have increased over time (Table 4.4).

Drought/dry spells

Drought/dry spells hazard was ranked by respondents as the most pressing hazard confronting farmers in the Lawra district. The different social groups of males, females, youth and older generation do not differ in ranking dry spells/drought as the most pressing problem. Smallholder farmers were unanimous in the perception that dry spells/drought

hazards have become more threatening now than in the past. Thus, the problem of drought/dry spells are considered worse than socio-economic and biotic stressors.

Water stress

The females and youth social groups both ranked water stress second with a mean rank of 4.18 and 5.16 respectively. However, the males' social group ranked water stress as the seventh most pressing hazard with a mean rank of 6.25 whiles the older generation ranked it third with a mean rank of 5.40. The findings also indicate that a greater chunk of farmers perceive water stress to be more prevalent today compared to the past.

Decrease soil fertility

Males ranked decrease soil fertility hazard second most pressing hazard whereas females ranked it fourth. Similarly, youth ranked decrease soil fertility fourth most pressing hazard whiles older people ranked it second. The mean rank of the groups did not however show significant differences (5.32, 5.53, 5.51 and 5.37 for males, females, youth and older generation respectively). Farmers are overwhelmingly unanimous in their perception that decrease soil fertility has become more threatening today than in the past.

Problems with inputs purchase

The males group ranked it third with a mean rank of 5.70 whereas females ranked it fifth with a Kendell mean rank of 5.82. The youth ranked it fourth and the older generation ranked it sixth. The perception that problems with inputs purchase have increased over time is very conclusive among all social groups.

Table 4. 3. Ranking of hazards by smallholder farmers.

No	Hazards	Kendell W Mean Rank				Rank			
		Male	Female	Youth	Older generation	Male	Female	Youth	Older generation
1	Dry spells	3.61	2.69	2.98	3.39	1	1	1	1
2	Water stress	6.25	4.18	5.16	5.40	7	2	2	3
3	Floods	7.42	9.05	7.90	8.33	11	11	11	11
4	Extreme temperature	6.85	8.27	7.46	7.59	9	10	10	10
5	Human disease	5.97	6.77	6.41	6.19	5	8	6	7
6	Crop pests and disease	6.23	7.26	7.15	6.39	6	9	9	8
7	Animal pests and disease	5.94	6.41	6.54	5.81	4	7	7	4
8	Decrease soil fertility	5.32	5.53	5.51	5.37	2	4	3	2
9	Problems with inputs purchase	5.70	5.82	5.55	6.02	3	5	4	6
10	Problems with output sales	7.09	5.91	6.69	6.41	10	6	8	9
11	High food prices	6.80	4.66	5.70	5.88	8	3	5	5
12	Conflicts	10.82	11.45	10.95	11.22	12	12	12	12

Kendall's Test Statistics

N	Male	Female	Youth	Older generation
	86	74	70	90
Kendall's W[a]	0.2162	0.414	0.279	0.282
Chi-square	204.253	337.283	214.903	278.806
Df	11	11	11	11
Asymp. Sig.	0.000	0.000	0.000	0.000

Source: computed from field survey data, 2016.

Table 4. 4. Perception of Increase in Threat of Hazard over Time.

No	Hazard	Male (%)	Female (%)	Youth (%)	Older generation (%)
1	Drought/dry spells	89.8	98.7	95.7	92.2
2	Water stress	78.4	81.6	82.1	77.8
3	Floods	45.5	28.9	48.6	28.9
4	Extreme temperature	73.9	57.9	70	64.4
5	Human disease	68.2	39.5	54.3	55.6
6	Crop pests and disease	87.5	71.1	81.4	80.0
7	Animal pests and disease	90.9	84.2	90	86.7
8	Decrease soil fertility	97.7	92.1	95.7	94.4
9	Problems with inputs purchase	94.3	94.7	98.6	92.2
10	Problems with output sales	87.5	96.1	95.7	86.7
11	High food prices	92	98.7	100	91.1
12	Conflicts	30.7	15.8	27.1	20.0

Source: computed from field survey, 2016

High food prices

Males ranked high food prices as the eighth most pressing hazard whiles females ranked it third. Both youth and older generation ranked high food prices as the fifth most pressing hazard. All social groups are unanimous in their perception that threat in the hazard of high food prices have increased over time.

Animal pests and disease

To the males, this hazard is ranked fourth with mean rank of 5.94 while females with a mean rank of 6.41 ranked it seventh. Similarly, the youth ranked it seventh whereas the older generation ranked it fourth. Animal pests and disease hazard is perceived to be more threatening now than in the past.

Human disease

The hazard was ranked fifth and eighth respectively by males and females whereas the youth and older generation ranked it sixth and seventh accordingly. The perception of human disease hazards being more threatening today than in the past is not quite

conclusive. A little over half (54.9%) of respondents are of the view that human disease has become more threatening now than in the past while 45.1% thinks otherwise.

Problem with output sales

Males ranked problems with output sales as the tenth most pressing hazard, females ranked it sixth. Youth on their part ranked it eighth whiles older people ranked it ninth. Farmers were equally unanimous (90.9%) in their perception of the hazard increasing over time.

Crop pests and disease

Males ranked this hazard as sixth and females ranked it ninth most pressing hazard facing smallholder farmers. The youth equally ranked it ninth while the older people ranked it eighth. Majority of farmers perceive the occurrence of crop pests and diseases to be more threatening now than in the past.

Extreme temperatures

Males ranked extreme temperatures ninth and females ranked it tenth most pressing hazard faced by smallholder farmers. Both the youth and the older people ranked extreme temperature hazards tenth. A significant number of farmers (66.5%) thinks extreme temperatures have become more threatening today in the past.

Floods

There is absolute agreement among all social groups that floods are the eleventh ranked hazards faced by farmers. Farmers were unanimous (95.1%) in their assertion that floods have become threatening now than in the past.

Conflicts

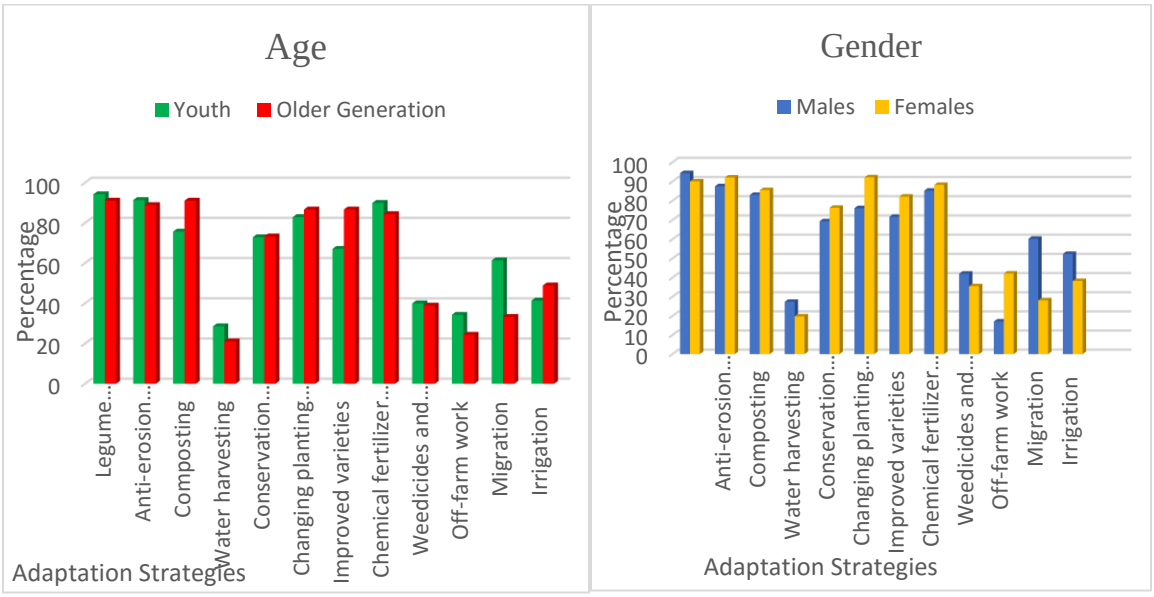
Likewise, all social groups strongly agree to conflicts as the least ranked hazard. This hazard was not perceived as being more threatening now compared to the past as only 23.8% perceived the hazard to increase over time.

4.6.2 Patterns of Adaptation

Figure 4.5 shows the results on adaptation strategies of smallholder farmers in the study area. Generally, there is overwhelmingly high adoption of adaptation strategies related to SLM practices including mix cropping/legume intercropping (92.5%), anti-erosion measures (90%), composting (84.4%), changing planting dates (85%) and CA practices (73.1%). The only SLM strategy which was found not to be used by majority of farmers was water harvesting which was adopted by 24.4 percent of respondents.

Further, Table 4.5 indicates the patterns of adaptation of the differentiated groups of males and females and between youth and the older generation. With regards to sustainable land management adaptation strategies, compost use and changing planting dates have a 1 percent statistically significant difference in terms of gender and age group respectively. This implies, a significant difference exists between the youth and the older generation in their use of compost. Also, significant difference exists between males and females in the use of changing planting dates as an adaptation strategy. The other adaptation strategies related to sustainable land management practices including mix cropping/legume intercropping, anti-erosion measures and water harvesting do not have a statistically significant difference between them either by age group or by gender.

Figure 4. 6. Patterns of Adaptation of Differentiated Groups of Smallholder Farmers.



Source: Constructed from field survey, 2016

Adaptation strategies related to modern inputs use including improved seed varieties and chemical fertilizer application were equally adopted by majority of respondents (78.1% and 86.9% respectively) as shown in Figure 4.6. Weedicides and pesticides use was found to be relatively low (39.4%) among respondents.

Table 4. 5. Patterns of adaptation

Adaptation Strategy	Social Group	P. Value
Mix cropping/Legume intercropping	Gender	0.451
	Age	0.500
Anti-erosion measures	Gender	0.205
	Age	0.595
Composting	Gender	0.806
	Age	0.008***
Water harvesting	Gender	0.262
	Age	0.279
Conservation Agriculture	Gender	0.500
	Age	0.946
Changing planting dates	Gender	0.007***
	Age	0.503
Improved varieties use	Gender	0.108
	Age	0.003***
Chemical fertilizer use	Gender	0.421
	Age	0.302
Weedicides and pesticides use	Gender	0.488
	Age	0.887
Off-farm employment	Gender	0.001***
	Age	0.172
Migration	Gender	0.000***
	Age	0.000***
Irrigation	Gender	0.129
	Age	0.347

Source: computed from field survey data, 2016

Note: *** =1% significant level.

Table 4.5 reveals that the difference between males and females in their use of improved varieties is statistically significant at 1 percent. The difference between males and females and between youth and the older generation in chemical fertilizer application and weedicides and pesticides use are not statistically significant.

The use of diversification strategies including off-farm work and migration, and irrigation is relatively low with less than half of respondents adopting any one of these strategies (Figure 4.6).

The social groups of males and females and youth and older generation differ in their use of off-farm employment and migration as adaptation strategies (Table 4.5). With regard to off-farm employment activities, there is a statistically significant difference between males and females at 1 percent significance level (Table 4.5). In the case of migration, males and females as well as youth and the older generation significantly differ at a 1 percent significance level (Table 4.5). This implies, a significant difference between males and females as well as between youth and the older generation in their use of migration.

Irrigation is adopted by 45 percent of respondents. However, there is no statistically significant difference between males and females and also between the youth and the older generation in the adoption of irrigation.

4.7 Livelihood Diversification

4.7.1 Irrigation

Qualitative interviews and field observations showed two forms of irrigation are noticeable in the Lawra district; traditional dry season gardening and improved irrigation. The traditional dry season gardening is done along the Black Volta and near community dams and dug-out wells. It involves the manual drawing of water from the water source using buckets and watering cans. The zai system of planting is used on this type of irrigation fields. This type is considered very cumbersome and labor intensive but less expensive in terms of the initial capital investment. Along the Black Volta River, farms are constructed right on the banks of the river to facilitate easy access to water.

The improved irrigation system is not widespread in the district. Methow-Yipalla was the only community among the four study communities where this irrigation is undertaken.

Fields are constructed at a reasonable distance away from the Black Volta River and pump machines are used to draw water from the river to water the fields using well laid pipes. Farmers cited heavy capital requirement as the reason for their non-adoption of this kind of irrigation. During interview with staff of district agriculture development unit, it was disclosed that, renewed interest in irrigation was instigated by the 2007 flood disaster which swept most farmlands in the area away. The ministry of food and agriculture in collaboration with Food and Agriculture Organization provided pump machine, pipes and seeds to facilitate dry season farming to forestall the looming food crises caused by the floods. A total of 18 pump machines were provided to affected communities along the banks of the Black Volta River. With the exception of the ones in use in Methow-Yipalla, none of the other pump machines is in use now. He cited lack of funds to fuel the pump machines as the main reasons for community members' non-use of the machines.

Figure Figure 4. 7. Types of irrigation in Lawra district.

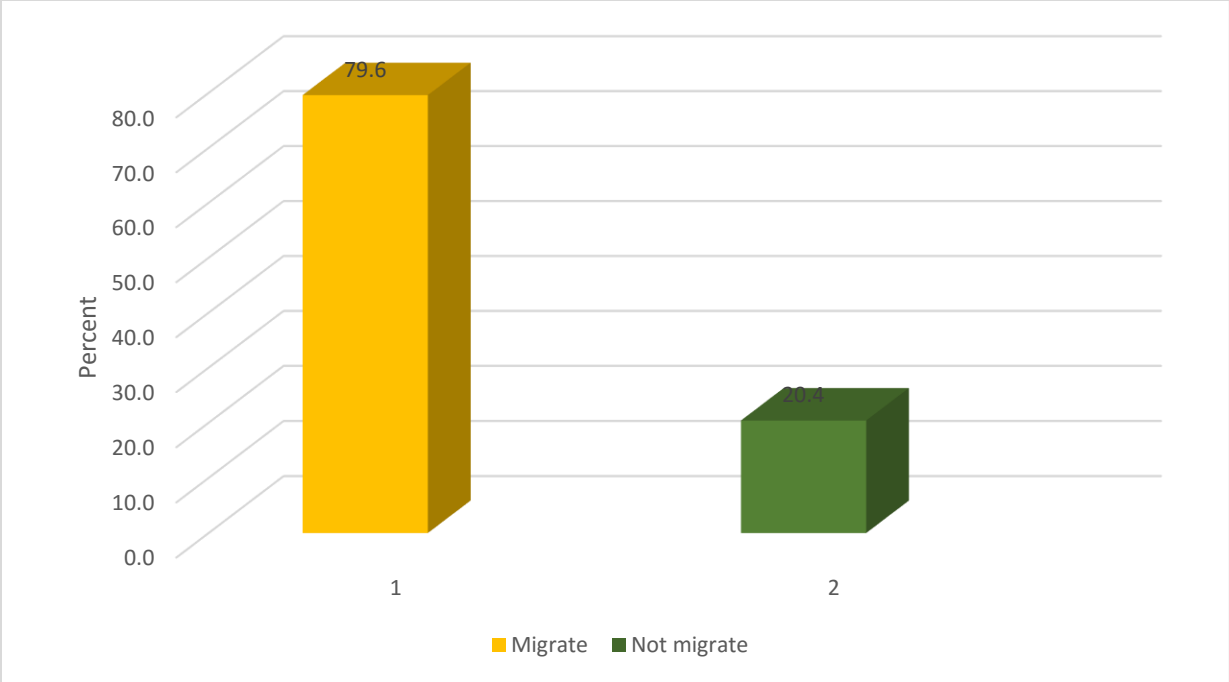
Improved irrigation field in Methow-Yipalla. Traditional dry season gardening at Tabier

Source: From field survey, 2016

4.7.2 Migration among Smallholder Farmers.

Figure 4.8 shows that majority (79.4%) of farmers have migrated or have a household member migrating in the last 5 years whereas 20.6 percent of farm households have not migrated or have household member migrating in the last five years.

Figure 4. 8. Migration in farm households.

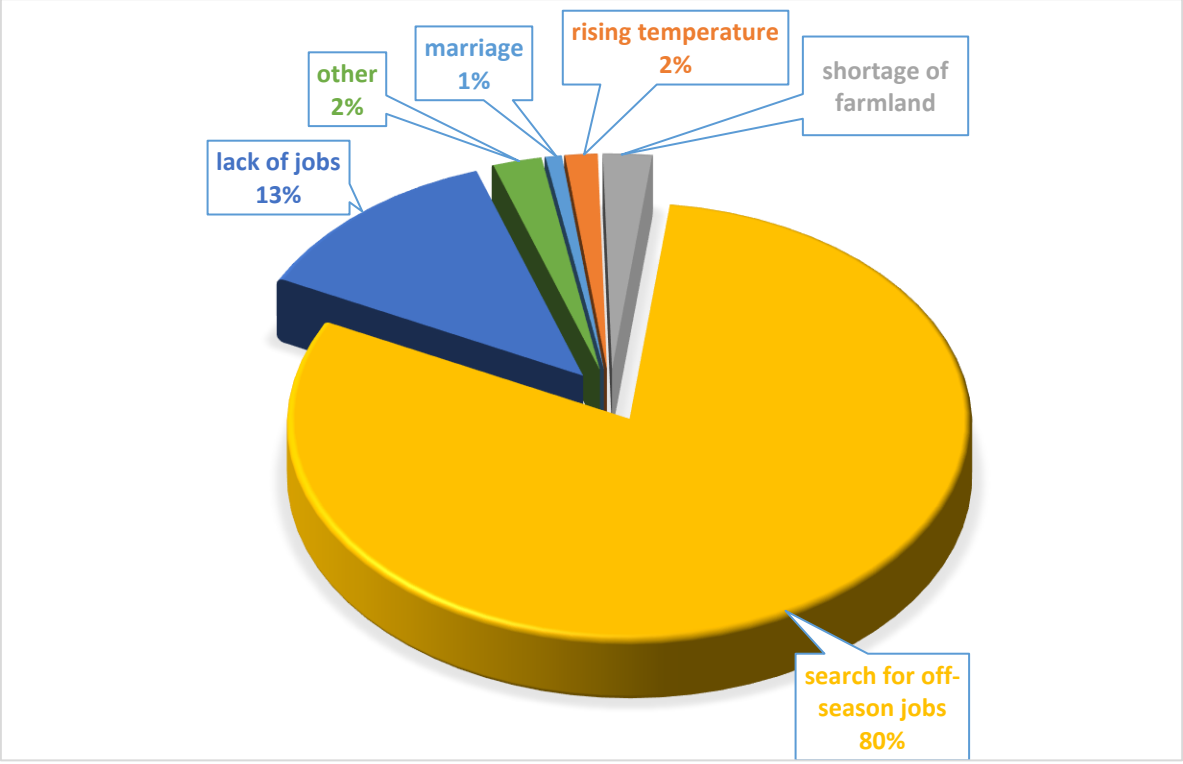


Source: computed from field survey data, 2016

From Figure 4.8, majority (80.5%) of farmers cited the search for off-season jobs as the reason for migrating. Interestingly, rise in temperature accounted for only 1.2 percent of migration among respondents in the area. The other mainly socio-economic factors that stimulated migration among respondents include, lack of jobs in the communities (12.5%), shortage of farmland (2.3%) and marriage (0.6%). Other factors including visiting family members, education, and seeking medical attention accounted for 3 percent of migration among respondents.

Majority (87.50%) of migrants were engaged in seasonal migration, 10.9% in permanent migration and very few (1.6%) were engage in return migration. The mean age of migrants is 33 years.

Figure 4. 9. Reasons for migration

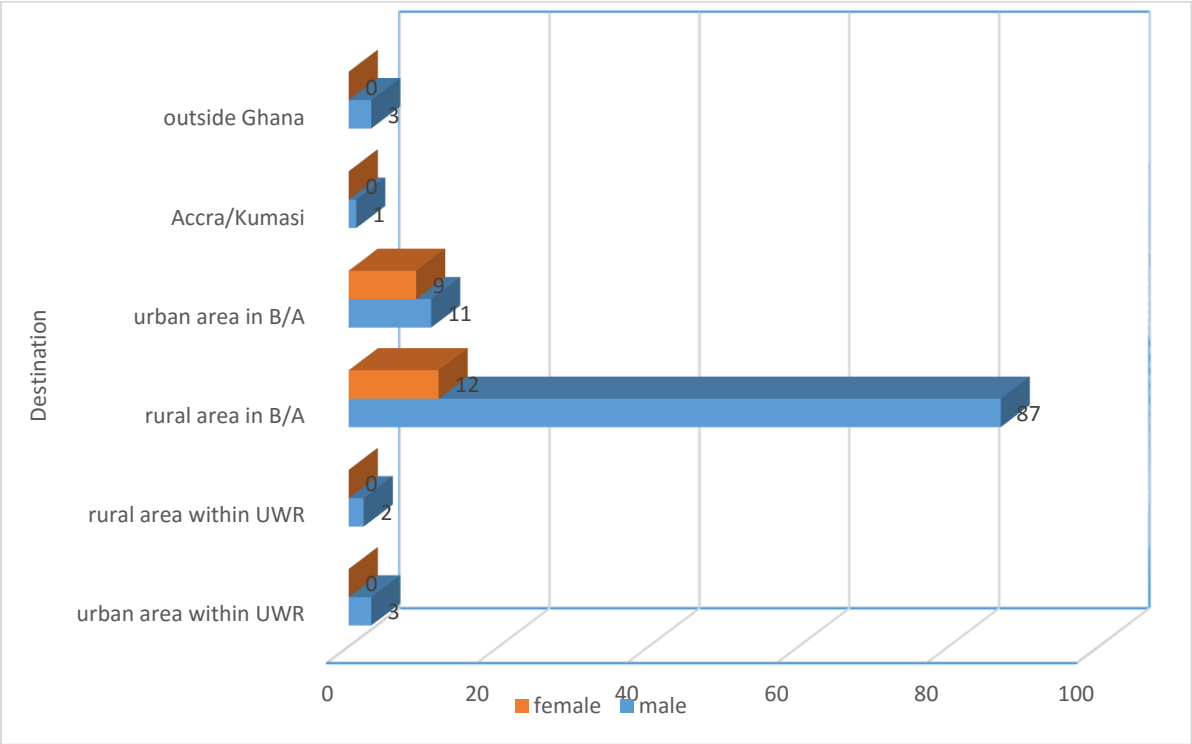


Source: computed from field survey data, 2016

Figure 4.10 reveals that, the migration pattern in the Lawra district is largely rural-rural migration. The study found that rural areas in the Brong Ahafo region are recipients of majority (77.3%) of migrant famers from the Lawra district. A substantial amount (87 out 99) are males whereas only a few (12 out of 99) are females. Urban areas in Brong Ahafo region recorded the second highest number (15.6%) of migrant farmers from Lawra district with 11 males and 9 females reportedly migrating to urban areas in the Brong Ahafo. The Brong Ahafo region accounts for 93 percent of migrant destination from the Lawra district.

Internal migration within the Lawra district and the Upper West region at large is very low. There was no migration recorded within the district with migration to both urban and rural areas within the Upper West region accounting for 5% of migration of farmers from the Lawra district.

Figure 4. 10. Destination of migrants by gender.



Source: computed from field survey data, 2016

4.8 Household Food Insecurity among Smallholder Farmers

The period of households' food shortages in the course of the preceding year was used to determine households' food insecurity. From Table 4.5, the percentage of food insecure and food secure households were found to be 79.3 and 20.7 percent respectively. Majority (63%) of food insecure household recorded food shortage between the periods of two months and below while 36.2% recorded food shortages above 2 months (Table 4.6).

Table 4. 6. Household food insecurity

Household food insecurity		Frequency	Percentage	Total
Food insecure		130	79.3	160
Food secure		30	20.7	160
Period of HH food insecurity	1-2 months	83	63.8	130
	Above 2 months	47	36.2	130
Coping strategies	Sale of livestock	56	43	130
	Migrate to do labour work	26	20	130
	Reduce quantity/skip meals	3	2.3	130
	Sale of farm produce	12	9.2	130
	Sales of firewood/charcoal	12	9.2	130
	Borrow	13	10	130
	Other	6	4.6	130

Source: computed from field survey data, 2016

Farm household adopt a variety of coping strategies to deal with household food shortages. Majority (43%) of respondents sell livestock, 20% migrate to do labor work, 10% borrow from family and friends and also from Village Savings and Loans Associations (VSLA), 9.2% sell farm produce including seeds for the next farming season, and another 9.2 engage in the sales of firewood (Table 4.6). A few (6%) engage in other coping strategies including selling *moringa* leaves, harvesting wild fruits and plants. The youth especially, travel to southern Ghana for two reasons; 1. To work and remit food and money to household members 2. To reduce the consumption of the little food left for the weaker members of the household.

4.8.1 Effectiveness of Adaptation Strategies on Household Food Insecurity

The goodness of fit of the model was established by using the wald chi^2 (χ2=40.66) which was found to be significant at 1 percent (Prob >chi ^{2}=0.0006) indicating that the variation in household food insecurity is significantly explained by variations in the independent variables considered in the model.

Adaptation strategies related to sustainable land management practices included in the model are compost use and conservation agricultural practices. Of the 2 variables only compost use is statistically significant at 5 percent with a marginal effect of 0.1042585. Thus, the study suggest that farmers who use compost, all other things being equal, are 10 percent more likely to be food insecure relative to farmers who do not use compost. CA practice is not statistically significant, the negative sign however suggest that its adoption results in farmers more likely not to be food insecure.

In this study, adaptation strategies related to modern inputs use involving fertilizer application and improved seeds variety typically associated with high agriculture productivity and by extension food security was found not to be statistically significant, implying that they are not a key determiner of food insecurity in the study area.

Off-farm employment and irrigation was found to have an inverse but statistical significant relationship at 10 percent and one percent significance level respectfully. The marginal effect for off-farm work and irrigation is -1491779 and 1450772 implying that Farmers who engage in off-farm income and irrigation were both 15 percent likely not to be food insecure relative to farmers who do not engage in off-farm work and irrigation. Migration is the only diversification strategy found not to wield statistically significant influence on

household food insecurity. The positive sign of the marginal effect however depicts a positive relationship between migration and food insecurity. This means that migration actually makes farmers who engage in it worse off in terms of food security.

Certain socio-demographic and institutional factors exerts considerable influence on household food insecurity of smallholder farmers and are thus included in the regression model.

The variable age is found to be one of the significant factors that determine food security situation of a smallholder farmer. It is significant at 5 percent and has a negative relationship with food insecurity situation of smallholder farm households. The results indicate that, an older farmer (Above 34 years) is 10 percent more likely not to be food insecure.

Sex is another human capital variable found to exercise positive influence on food insecurity situation of smallholder farmers at a significance level of 5 percent with a marginal effect of 0.119762. This implies that a female farmers is 12 percent more likely to be food insecure.

The findings also reveal that some educational level variables have significant influence on food insecurity of farmers. Primary, JHS/middle school and tertiary education levels have significant influence on farmers' food insecurity at a probability level of 10 percent for both primary and JHS/Middle school education and 5 percent for tertiary education. With regards to primary education there is an inverse relationship with the dependent variable with a marginal effect of -0.180936. This indicates that farmers with primary school education is 18 percent more likely not to be food insecure relative to farmers with no formal education. However, there is a direct relationship between JHS/middle school education and food insecurity with a marginal effect of 0.08217. This shows that a farmer

with JHS/middle school education is 8 percent more likely to be food insecure relative to farmers without formal education. Tertiary education has an inverse relationship with the dependent variable with a marginal effect of -0.3764099 revealing that farmers with tertiary education is 38 percent more likely not to be food insecure relative to farmers without formal education. SHS/vocational education is the only level of education variable not statistically significant.

As expected, income of farmers is significant at 1 percent and has an inverse relationship with the dependent variable with a marginal effect of -0.0000722. The implication is that an increase in farmers' income by a cedi, means they are 0.007 percent more likely not to be food insecure other related things being equal.

Table 4. 7. Binary Logistic estimates of impacts of adaptation strategies on food insecurity.

Variable	Marginal effects	P. Values
Age	-.1093523**	0.022
Sex	.119762**	0.031
Farm Income	-.0000722***	0.000
Education		
2	-.180936*	0.081
3	.08217*	0.086
4	-.167002	0.578
5	-.3764099**	0.024
Compost	.1042585**	0.042
LandT	-.1102375*	0.097
CreAcc	-.1614637***	0.001
ConA	-.0891111	0.149
ImpV	.0624966	0.526
CheF	.0404855	0.664
OffY	-.1491779*	0.055
Mig	.0006461	0.988
Irrg	-.1450772***	0.001
Number of observations	160	
Wald chi2 (16)	40.66	
Prob >chi 2	0.0006	
Pseudo R^2	0.4874	

Note: significance levels are *** p< 0.01 **p<0.05 *p<0.10

Dependent variable (HH Food insecurity): Farmer subjective perception of having faced a situation where there was inadequate food to feed the household. As a binary outcome variable, 1 is, farmer faced a situation of inadequate food to feed the household in the last 12 months and 0 otherwise.

The study also established that the institutional factors variables, land tenure and credit access, are statistically significant at 10 percent and 1 percent respectively with a corresponding -0.1103275 and -0.1614637 marginal effects. It also showed an inverse relationship between the two variables and the dependent variable. This implies that farmland ownership and access to credit results in an 11 percent and 16 percent likelihood of a farmer not being food insecure correspondingly.

4.9 Summary

This chapter presented the results of the study. First, results of socio-demographic characteristics of respondents was presented. Second, farmers' perception on long term changes in climatic variables (temperature and rainfall) and climatic hazards (drought/dry spells and floods) were presented. Results from the socially differentiated ranking of hazards faced by farmers and patterns of adaptation was presented. Results of further exploration of migration and irrigation was presented. Finally, results from smallholder household food security and effectiveness of some adaptation strategies in ensuring household food security in the study area concludes the chapter.

CHAPTER FIVE: DISCUSSION

5.1 Introduction

This chapter discusses the results of data analysis presented in chapter four. Section 5.2 discusses the socio-economic characteristics of smallholder farmers. This is followed by a discussion of farmers' perception of long term temperature and rainfall changes in the study area in section 5.3. Perception of farmers on the occurrence of droughts and floods incidence are discussed in chapter 5.4. Assets ownership of smallholder farmers are discussed in section 5.5. Section 5.6 discusses vulnerability and adaptation patterns of smallholder farmers. The chapter concludes with a discussion of results on effectiveness of adaptation strategies on household food insecurity among smallholder farm households.

5.2 Basic Statistics of Socio-economic Characteristics of Smallholder Farmers

From Table 4.1, majority (74%) of smallholder farmers did not have any kind of formal education suggesting high illiteracy rate among smallholder farmers. Most (20%) farmers who had formal education had some basic education, 3.8 percent had secondary level education. Only 1.9 percent of farmers reported accessing tertiary education. This high illiteracy rates and low educational attainment among farmers in northern Ghana have been widely reported (Al-hassan, 2008; Mustapha, 2012; Abu et al., 2014). Results of qualitative interviews revealed that formal education also afford farmers the opportunity to engage in other activities to earn more income to improve household food security situation.

The results of the study indicates that household size among smallholder farmers are relatively high with a mean household size of 8.5. This is more than double the national average of 4.0 and significantly higher than the regional figure of 6.5 (GSS, 2014c). The

standard deviation for household size is 4.5 and indicates a large variation in household with most households' sizes falling below the mean household size. In a related study, Nyantakyi-Frimpong & Kerr (2014) found household size among rural farmers in the Upper West region to be 7.8. Other studies have noted smallholder farming households in the savannah agro-ecological region of Ghana to be associated with large household (Kuwornu et al., 2010; Abu et al., 2014). Elsewhere in Kenya, Margaret (2015) found smallholder farming household be large (5.6) and higher than the national average. The main reason smallholder farming households maintain large household size is to ensure adequate supply of family labor (S. Al-hassan, 2008).

Table 4.2 shows total household members employed to be 4 on the average. This implies an economic dependency of 1:2.2. This indicates a higher dependency ratio and provide a more accurate measure of dependency level among farmers relative to the age dependency ratio of 93.6% (GSS, 2013).

In relation to income, the study showed average annual household income to be Gh₵1,240.00 and ranges between Gh₵95.00 and Gh₵81,900.00 (Table 4.2). This is consistent with the findings of Abu et al., (2014) who discovered the average income of smallholder farmers in the Upper West region to be Gh₵1,129.00. This implies smallholder farmers in the Lawra district falls between extreme poverty level (Gh₵792.05) and absolute poverty level (Gh₵1314.00) (GSS, 2014b). However, Martey et al., (2012) reported the average annual income of smallholder farmers in Efutu municipality in southern Ghana as Gh₵1772.00, well above both the national extreme poverty and absolute poverty levels. This reflects the general poverty dichotomy between the northern and southern Ghana.

Overall, land holding of smallholder farmers in the Lawra district is small (1.3 hectares) (Table 4.2). This finding resonates with Martey et al., (2012) who related average landholding for smallholder farmers in Efutu municipality in southern Ghana as 1.2 ha as well as in Kenya where Margaret et al., (2015) found smallholder farmers landholding to be 1.8 ha. In contrast, the average landholding of smallholder farmers as established by Chamberlin (2008) is 3.2 with the estimate for Upper West region being 2.7 ha.

Results from the study show the dominance of rain-fed mix crop livestock agricultural activities in the area. This is a reflection of the fact that agriculture is the dominant economic activity in the rural savannah area of Ghana with about 93% of households involved (GSS, 2014b). This is consistent with the finding of Nyantakyi-Frimpong & Bezner-Kerr (2015).

The main purpose of credit in rural savannah is to invest in agriculture through the acquisition of equipment and inputs (GSS, 2014b). However, lack of access to credit is one of the key factors limiting agriculture productivity in Ghana (MoFA, 2007; Yilma et al., 2008). The study found access to credit to be very low (23.1%) among smallholder farmers. Other studies (Abu et al., 2014; Al-hassan, 2008; Anaglo et al., 2014; Martey et al., 2012) reported similarly low credit access by smallholder farmers in the Upper West region. Interestingly, Anaglo et al., (2014) observed that females had more access to credit than males. Access was defined by farmers' proven record of securing both cash and input credits from both formal and informal source. The informal sector dominates smallholder credit market in the study area. Of the smallholder farmers who had access to credit, majority (51.2%) obtained it from Village Savings and Loans Association (VSLA) operated informally at the community level. Interviews with study participants revealed

that community based VSLA are mostly financed with income from off-farm activities including petty trading, labor work, and sales of fuelwood. This supports the finding of Yilma et al., (2008) that lack of agricultural credit leads to a dependence on off-farm income activities as a critical source of agricultural financing. The only formal financial institution in the area that advance credit to smallholder farmers, the Lawra rural bank, accounted for only 4.7 percent of credit. NGOs and MoFA are also significant players in the credit market for smallholder farmers accounting for 25.6 percent and 18.6 percent of credit to smallholder farmers respectively. Other studies in the Upper West region have reported that the informal sector account for majority (68.4%) of credit to smallholder farmers whiles formal financial institutions reported low (3.8%) advancement of credit to smallholder farmers (Abu et al., 2014).

Better access to extension have a positive influence on the adoption of high productivity practices and abandoning relatively risky measures (Nhemachena, 2008). The results shows majority (72.5%) of smallholder farmers have access to formal extension services consistent with the findings of Anaglo et al., (2014) who indicated 65% smallholder farmers in the Upper West region reportedly have access to formal extension service. Conversely, low formal extension access by smallholder farmers in northern Ghana has been reported by several studies (Etwire et al., 2013; Abu et al., 2014; Martey et al., 2012). Information obtained from extension contacts included terrace farming, compost preparation, chemical fertilizer application, weedicides and pesticides use and row planting. Other kinds of information obtained included improved seeds use, basic veterinary skills, dry season tomatoes farming and information on rainfall.

5.3 Farmers Perception on Temperature and Rainfall

Ghana has witness an increase in temperature and decrease in rainfall in all agro ecological zone in the last four decades (MESTI, 2013). Farmers perceive climate through climate related variables that directly influence their livelihood activities (Lyimo & Kangalawe, 2010). The study therefore focus on perception of rainfall and temperature to assess perception on climate change. Consistent with this, majority of smallholder farmers perceive that the temperature has become hotter and rainfall has decrease in the Lawra district (Figure 4.2). This results conforms to several other studies who reported increase temperatures, decrease and more variable rainfall pattern in northern Ghana (Teye, 2014; Ndamani & Watanabe, 2015; Nyantakyi-Frimpong & Bezner-Kerr, 2015). During interviews, farmers noted that increase temperature is a major problem because of wilting of plants and drying up of water bodies from which livestock drink. Generally, they believe that the increasing temperature trend was associated with the changes in precipitation. Even more worrying to farmers than temperature increase and rainfall decrease is the high irregularity in the onset and cessation of rainfall during the growing season (Nyantakyi-Frimpong & Bezner-Kerr, 2015). This was amply captured by a focus group discussant in Erimon Dazuuri:

The rain is making things difficult for us. In the past we had time for sowing, time for transplanting and time for weeding because the rainfall pattern was regular. Now it is not the same.

During in-depth interview with an elderly man in Methow-Yipalla, similar sentiments was expressed

Everything used to be very balance. The crops and animals got enough sunlight and water to produce their best. Everything has changed now. Growing up as a young man we could easily predict rain and even predict how fruitful the season's harvest would be. When clouds formed from the east, we had no doubt that it will rain, but when it formed from the north, south or west, we had doubts. That was then! Everything has changed.

To verify farmers' perception regarding rainfall and temperature trends, available historical annual rainfall and temperature data from the period 1985-2014 were obtained from the GMet head office in Accra and plotted on a chart (Figure 4.3). The results of mean annual rainfall trends gave a contradictory impression to farmers' perception, with trend showing an increase in rainfall across the 30 year period. To comprehend this obvious contradiction between the mean annual rainfall trend and the popular perception, evaluation of mean seasonal rainfall is done. The rainy season for the Upper West region has shifted from (early April) around the 1980s and early 1990s: to a late start (mid-April) in the last two decades (Nyantakyi-Frimpong & Bezner-Kerr, 2015). Similarly, Ndamani & Watanabe (2013) noted the planting season for the Lawra district to fall between May to August. This study therefore use the period of May to August to depict the annual rainfall season for the Lawra district. The seasonal rainfall data conforms to the perception of farmers by depicting a clear decrease trend in seasonal rainfall over the period. Apart from indicating a decreasing trend, the results also showed high intra-annual variability in rainfall patterns.

Similar to the results of the rainfall trend, results of mean annual minimum and maximum temperature data revealed a subtle decrease in temperature in contrast to farmers' perception of increasing temperature (Figure 4.4). The mean annual maximum temperature

for the period 1985-2014 was 34.6℃, however analysis of the temperature data reveal that temperature has consistently been higher than the long term average since 2000 with the exception of 2012. The years 2004 and 2007 had very scanty available temperature data accounting for the sudden deep in temperature within the period. This high temperature above the long term mean in the last one and half decade may likely account for the perception of increase temperature among smallholder farmers in the Lawra district.

5.4 Farmers' Perception on incidence of Floods and Droughts/Dry Spells.

Majority of farmers perceive increase in the incidence of droughts/dry spells and decrease in the frequency of floods (Figure 4.5). Consistent with this results Nyantakyi-Frimpong & Bezner-Kerr (2015) and Teye (2014) found that smallholder farmers in the Upper West region perceive an increase in both the incidence of drought/dry spells and floods whiles Dumenu & Obeng (2015), found similar trends for all ecological zones of Ghana. Farmers in the Guinea and Sudan savannah ecological zone characterized by low levels of social, economic and physical assets are the most vulnerable to the impacts of droughts in Ghana (Antwi-Agyei et al., 2012).

5.5 Assets Ownership

Ownership of information and communication technological assets including radio, television and mobile phone among farmers is low (Figure 4.6). Digital technology assets provide a unique opportunity to overcome isolation and bridge knowledge gaps creating new opportunities for smallholder farmers and transforming rural communities (Rose, 2016). The low number of farmers who own bicycles/motorcycles and cars imply high transaction cost for farmers because of the limited availability and high cost involve in engaging the services of commercial transportation (Margaret, 2015). The high number of

farmers who dwell in structures roofed with iron sheets is consistent with the national estimates of rural houses roofed with iron sheets (GSS, 2014b).

5.6 Vulnerability and Adaptation Patterns of Differentiated Groups of Smallholder Farmers

Drought/dry spells

Drought and dry spells was identified by all social groups of males, females, youth and older generation as the most pressing hazard confronting smallholder farmers (Table 4.3). They are equally overwhelmingly unanimous in their perception that drought and dry spells hazards have become more threatening now than in the past consistent with the finding of Teye (2014). Climatic factors including drought and dry spells are noted to pose significant threat to crop yield and food security of farmers in the northern savannah zone (Dumenu & Obeng, 2015). Elsewhere in Tanzania, Westengen & Brysting (2014) posits that farm households ranked drought, conflict/competition over water and the unreliable onset of rain as the three worse stress factors. In opposition, Nyantakyi-Frimpong & Bezner-Kerr (2015) identified non-climatic factors including land tenure, lack of credit, poor roads, labor and access to granaries as more pressing challenges to smallholder farmers in the Lawra district and also indicated significant variations among social groups of females, males and youth in the ranking of hazards faced by smallholder. Nyantakyi-Frimpong & Bezner-Kerr (2015) revealed that the unpredictable occurrence of dry spells and Optimum Growth Period (OGP) during planting season in Lawra district amplifies the predicaments of rural farmers and makes their livelihoods more precarious. This is because an overwhelming majority of farmers in the Upper West region depends solely on rainfall for productivity (GSS, 2013).

Water stress

Water stress ranked as the second most pressing hazard and it's perceived by majority of farmers to have become more threatening now than in the past (Table 4.4). Rainfall decrease, droughts and dry spells have led to a significant reduction of water resources in semi-arid and arid areas (Mertz et al., 2009). The significance of water stress as major challenge to smallholder farmers is highlighted by Douxchamps et al., (2015), who found that rural farmers in Ghana spend more time and efforts in water related activities compared to Burkinabe rural farmers. Males however, found water stress to be less threatening evidenced by the seventh ranking. During qualitative interview sessions, it was noted that variation of the males from the other social groups is explained thus; women and the youth has the burden of providing water for household use in rural areas, as such they are likely to perceive the problem with water stress to be more threatening than males.

Decrease soil fertility

Soil in the Upper west region is associated with poor fertility level with low organic matter content, high pH, low percentage total nitrogen, and low available phosphorus and calcium content (MoFA, 2013). Poor soil fertility was identified among the top three most pressing hazards and ranked third by smallholder farmers (Table 4.3). A similar observation is made by Becx et al., (2012), reporting declining soil fertility as one of the major factors that constrain agriculture productivity of smallholder farmers in northern Ghana, noting continuous cropping, bush burning, poor application of both organic and inorganic fertilizer and poor rainfall as the main reasons for the declining soil fertility.

Problem with input purchase.

Problem with inputs purchase was identified as one of the major constrains plaguing farmers. Agriculture inputs including, fertilizers, insecticides, improved varieties are

readily available in the market (Anaglo et al., 2014). In qualitative interview sessions, high price of inputs and lack of funds to acquire farm inputs were cited as a major problem to farmers. Unavailability of traction livestock (donkeys) and tractor services were identified as major input challenges during community discussions.

High food prices

In Africa smallholder farmers in rural areas constitute net buyers of grains, as such are directly hurt by increase in food prices (Jayne et al., 2010). High food prices was identified as one the major constrains faced by smallholder farmers by all social groups (Table 4.3), with most farmers perceiving the threat to have increased over time (Table 4.4). Farmers usually sell some of their produce to meet other household needs including payment of school fees for their wards and other educational expenses, health needs, and performance of funeral rites. This depletes the food stock of most household compelling households to make substantial purchases in the market. Consistent with this, Al-hassan & Poulton (2009) found that smallholder farmers in northern Ghana are most vulnerable and constitute net food buyers.

Animal Pests and Diseases

FGDs revealed that livestock and more especially pigs, sheep and cattle are predominantly owned by males. It was further discovered that recent outbreaks of diseases especially swine fever that has led to high livestock mortality in the area. Another worrying trend plaguing the livestock sector, perhaps more than animal pests and disease, is the issue of animal theft which has become so rampant and pervasive that animals can hardly roam freely outside the confines of the community without being stolen. A combination of these

factors likely explains the perception that animal pests and disease is more threatening now than in the past (Table 4.4).

Other hazards identified in the study including human disease, crop pests and diseases, problem with output sales, extreme temperature, floods and conflicts even though cause substantial damage to farmers when they do occur, were lowly ranked by farmers. This is primarily because other factors were considered more pressing relative to those ones.

5.6.1 Patterns of Adaptation

Figure 4.5 indicates high adoption of strategies related to sustainable land management practices. Only water harvesting was found to be relatively unpopular with farmers. This holds a huge potential for climate change mitigation and adaptation. The finding contradicts Ndamani & Watanabe (2015) who suggest that, the use of sustainable land management practices including mulching, mix cropping, and changing planting dates is low among farmers in the Lawra district. Response from focus group discussions revealed that most of the sustainable land management strategies conforms to the traditional farming practices of the Dagaaba people. Besides, the upfront financial cost involve in the use of these strategies is relatively less compared to other strategies. Key informant's interview also indicated that these strategies were vigorously pursued by the district office of the MoFA as part of their strategies to promote climate smart agricultural practices in the district.

The results show a statistically significant difference between the youth and the older generation in the use of compost (Table 4.5). The difference in terms of compost use is explained by the fact that livestock are mostly owned by the older generation, as such they have access to manure compared to the youth. Also the construction of compost pits is

done at the household level, and since the older generation are invariably heads of the households, they reserve ownership of these compost pits. Males and females also differ significantly in the use of changing planting dates. This could be explained by the fact that most females do not own separate farmlands but rather intercrop their crops on their husbands' field thereby constraining their ability to take independent decisions relative to the crop field. This results corroborate studies suggesting that males and females significantly differ in the use of conservation agricultural practice (Ekboire et al., 2002). Conversely, Etwire et al., (2013) found no significant difference between males and females in the use of recommended agricultural practices strategies including changing planting dates, composting, row planting and conservation agriculture among smallholder farmers in northern Ghana.

Modern inputs including improved varieties and chemical fertilizer application are used by majority (78.1% and 86.9% respectively) of farmers whiles relatively fewer (39.4%) farmers use weedicides and pesticides (Figure 4.5). However, Nyantakyi-Frimpong & Bezner Kerr (2014) in a similar study in the Upper West region indicated that majority (76%) of farmers did not use improved varieties because they perceived it to be weak, sensitive and required extra care. It also needed stricter timing of cultural practices especially weeding and fertilizer application. This buttresses the claim that farmers' seed use is more complex than a simple choice between different varieties (Issahaku & Maharjan, 2014). Westengen & Brysting (2014) reported a high uptake of improved maize variety and a low uptake of improved sorghum variety among smallholder farmers in Tanzania.

In terms of modern inputs use, there is a statistically significant difference between males and female in the use of improved varieties (Table 4.5). The difference in the use of improved seeds is probably explained by the activities of some NGOs in the area (Result project and PRUDA) supporting female farmers through the distribution of improved seed varieties. The study results showed no significant difference by age and gender in relation to chemical fertilizer application and weedicides and insecticides use (Table 4.5). In Malawi, Chirwa (2005), found no significant difference between males and females in the use of chemical fertilizer and improved varieties but noted a significant difference in age with respect to improve variety use with older farmers less likely to adopt improved varieties. Contrasting results were found in other studies in Upper West region and elsewhere in Africa where males and female farmers have a statistically significant difference in the use of modern technological inputs, with males having more access than females (Ragasa et al., 2012; Anaglo et al., 2014; Mukasa et al., 2015). FAO (2011), identified a number of constraints that lead to male dominance in modern inputs use: financial capital requirements, risk taking behavior, and human capital requirement.

With rainfall becoming progressively less predictable whiles droughts and dry spells become more frequent, exclusive dependence on rain-fed agriculture is becoming risky (Van Aelst & Holvoet, 2016). A common adaptation strategy among smallholder farmers is diversifying one's income stream through off-farm activities and migration (Below et al., 2010). Following from this, smallholder farmers in northern Ghana participate in livelihood diversification including off-farm jobs and migration. The study indicate a relatively low participation in diversification activities including off-farm economic activities (28.8%), and migration (45.6%) (Figure 4.5). However, Dumenu & Obeng (2015)

observed that though the range of diversification portfolio available to smallholder farmers in the Guinea and Sudan savanna zones is limited, the use of the strategy as an adaptation is relatively high. Similarly, Yilma et al., (2008) noted that 68% of agricultural households in the Upper East region have at least a family member engaged in off-farm income generating activities.

Further, the study reported significant difference in gender and age relative to off-farm employment and migration. In particular, significant difference was found between males and females in engagement in off-farm economic activities with more females than males participating in non-farm income activities. In keeping with this finding Owusu et al., (2011), reported a statistical significant difference between males and females, with more females than males participating in non-farm work in northern Ghana. Also, Van Aelst & Holvoet (2016) identified significant difference between men and women in terms of participation in non-farm economic activities with more males undertaking off-farm income activities and also marked difference between the youth and the older generation with the youth 60% more likely to engage in non-farm work. Owusu et al., (2011) suggests that participation of males in off farm work increases the probability at which a farm household becomes food secure in northern region.

In terms of migration, both gender and the age show manifest difference at 1 percent significance level (Table 4.5). By gender, migration is essentially a male affair whiles in terms of age, the youth dominates. Consistent with this finding, Rademacher-Schulz et al., (2014) reported a similar results in the Nadowli district where migration is usually a male undertaking and predominantly a youth affair. In Burkina Faso, Nielsen & Reenberg

(2010a), made similar observation of migration embarked on by men and most especially the youth below 35 years.

Declining and unpredictable rainfall pattern coupled with emphasis of development projects on irrigation, have made irrigation more popular among smallholder farmers in semi-arid areas (Nielsen & Reenberg, 2010a). Results from the current study, however revealed low (45.6%) participation of respondents in irrigation (Tale 4.5). Dumenu & Obeng (2015) reported that 34.6% and 61.5% of farmers in the Guinea and Sudan savanna agro-ecological zones of Ghana engage in irrigation as an adaptation. Qualitative interviews noted inadequate capital to invest in high mechanized irrigation and tedious nature of traditional irrigation methods as the major constrains affecting respondents' participation in irrigation. The result further illustrates no significant difference between farmers both by age and gender in the use of irrigation (Table 4.5). Consistent with this results, Yilma et al., (2008) reported that gender of household head was not statistical significant in using irrigation in the Upper West region, but the sign of the coefficient indicated a higher probability of irrigation in female headed households. However, away in Tanzania Van Aelst & Holvoet (2016), reported that significantly more men than women use irrigation. Irrigation significantly improves income of the most marginalised groups including female headed households, youth and poor in society (Nkhata et al., 2014).

The significant differences showed between the differentiated groups of smallholder farmers with respect to the use some of the adaptation strategies imply that the null hypothesis is rejected.

5.7 Household food insecurity

The results showed majority (79.3%) of farmers faced situation where their households did not have enough food in the preceding 12 months, and were thus food insecure. This conforms to the findings of WFP (2012) who reported that 81.4% of people in Lawra district were food insecure. Similar observation was made by other studies in the country and elsewhere in Africa (Beyene, 2010; Aidoo & Tuffour, 2013; Leza & Kuma, 2015).

Diverse strategies have been adopted by farm households to deal with food shortages including sales of livestock (43%), migrate to do labor work in southern Ghana (20%), borrow from family, friends and VSLA (10%), and sell grains including seeds for the next season (9.2%). Others include sales of firewood (9.2%) and other activities including harvest and sale of *moringa*, and harvesting of wild fruits and plants for home consumption. Quaye (2008) identified the following strategies as the main coping strategies used by food insecure households in northern Ghana; reduce meals, sales of livestock, eat wild vegetables and fruits, sell durable assets, seek food from family and friends and household members work and get paid in food. Similar food insecurity coping and adaptation strategies are widely reported among smallholder farmers in Ghana and elsewhere in sub-Saharan Africa (Kuwornu et al., 2010; Tefera & Tefera, 2014; Leza & Kuma, 2015). Farmers recognize that most of the strategies including sales of livestock and other household assets adopted may reduce food insecurity temporarily but ultimately increase vulnerability (Rademacher-Schulz et al., 2014). This is not surprising because an increase livestock holding is found to significantly improve household food security under the combine effect of price increases and climate variability (Wossen & Berger, 2015).

The results also indicated that a majority (63.8%) of food insecure households experience food shortage between one to two months whiles 36.2 percent record food shortages above two months (Table 4.5). A similar observation was made by Barahona (2015) who reported that many smallholder farmers across Africa struggle to feed their households for one or more months of the year. Qualitative interviews revealed that food insecurity is prevalent in the planting season within the months of June to September. It further noted that, food insecurity is not static and peculiar to particular households but vary considerably between households and is largely determined by the farm outputs of any year. Also, the youth and females who have limited resources and social capital are more food insecure.

5.8 Effectiveness of Adaptation Strategies on Household Food Insecurity

In a highly subsistent economy where the principal aim of farm production is for home consumption, strategies aimed at increasing farm production and reducing impact of production volatilities are central to household food security and livelihood sustainability. Farmers who have adapted their farm activities in the face of climatic and non-climatic stressors have a better food production output compared to farmers who have not adapted (Di Falco et al., 2012). This section assess the effectiveness of some adaptation strategies on smallholder farm household food insecurity. The effectiveness of adaptation strategies related to sustainable land management practices, modern inputs use and diversification away from the traditionally rain-fed dependent farm production are assessed. Socioeconomic and institutional variables that have an impact on household food insecurity are included in the model to enhance its explanatory power.

The goodness of fit of the model was established by using the wald chi^2 ($\chi 2$=40.66) which was found to be significant at 1 percent (Prob >chi ^{2}=0.0006) indicating that the variation

in household food insecurity is significantly explained by variations in the independent variables considered in the model. We therefore reject the null hypothesis.

As hypothesized, compost and manure use was found to be associated with food insecurity (Table 4.6). Consistent with this results Mukasa et al., (2015) reported that the use of inorganic fertilizer has a negative effect on yield values of smallholder farmers. This is attributable to the fact the major intensification pathway for poor smallholder farmers is through application of manure (Yaro, 2002). Also, most farm households in northern Ghana possess few livestock who are mostly reared on the free range system making it difficult to get sufficient quantities to fertilize even an area of one acre (Kombiok et al., 2008).

Conservation agriculture is found not to be a significant determiner of household food insecurity. The negative sign of the marginal effect however shows adoption of the strategy has a negative effect on household food insecurity making it a desirable strategy. The common conservation agricultural practice adopted in the area is leaving crop residue on farm (mulching) and to a very limited extent minimal tillage. Identifying one or more components of conservation agriculture which is adoptable to local farmers is more productive than wholesale promotion of the strategy (Pannell et al., 2014). Elsewhere in Ethiopia, FAO (2015) argued that Climate Smart Agricultural (CSA) practices is not significantly correlated to household food insecurity even though the relationship is inverse implying a decrease in household food insecurity.

Further, the study found that modern technological inputs variables; chemical fertilizer application and improve variety use have no significant effect on household food insecurity (Table 4.6). The positive sign of the marginal effects however shows that, the use of these

inputs is directly related to household food insecurity. This corroborate the findings of FAO (2015) and Mukasa et al., (2015) in selected countries in East and West Africa, that chemical fertilizer and improved seed use have no significant effect on farm productivity and food security and notes that, the situation is reflective of the low application of the inputs. In Kenya, Ochieng, Kirimi, & Mathenge (2016) also found that fertilizer application has no significant effect on productivity of maize and tea. Most smallholder farmers are poor, as such are unable to apply the recommended quantities of modern inputs and are therefore unable to increase productivity thereby remaining poor (Kombiok et al., 2008). The results is also indicative of the fact that adoption of modern technological inputs alone does not automatically solve food insecurity problems (FAO, 2015).

Off-farm employment has a significant effect on household food insecurity with the marginal effect revealing that off-farm income has a 15 percent likelihood effect of a household not being being food insecure (Table 4.6). Consistent with this finding, Owusu et al., (2011) reported that participation in off farm work has a negative and statistically significant impact on household food insecurity among farm households in northern Ghana. Similarly, in a model simulation, Wossen & Berger (2015) hypothesize that off farm income generating activities coupled with a well targeted credit will substantially improve the food security situation of smallholder farm households in northern Ghana.

Similarly, irrigation has a negative and statistically significant effect on household's food insecurity (Table 4.6). In conformity with this finding, Nkhata et al., (2014), irrigation has a significant positive effect on household food secuirty among smallholder farmers in Malawi. Irrigation coupled with well targeted credit facilities is expected to exert significant positive effect on income and poverty levels among smallholder farmers in

northern Ghana (Wossen et al., 2014). Even though irrigation has significantly improved household food secuirty of smallholder farmers in Upper West, it comes at a cost to the leasure and social cohesion previously enjoyed by the people in the dry season before the introduction of irrigation (Bagson & Kuuder, 2013). Irrigation programmes should therefore be set in the socio-cultural context of the locality.

Migration does not have statistically significant effect on household food security but the positive sign associated with the marginal effects imply migration increases household food insecurity (Table 4.6). Inline with this, Yaro (2002) suggest that migration has a low correlation with increasing poverty and the attendant food insecurity in the Upper West region. Farmers in the Upper West region resort to migration in the lean season when households are running out of food stocks and in the rainy season when crop failure is imminent (Rademacher-Schulz et al., 2014). It is thus considered a response to food insecurity. In Zimbabwe, migrants remittances was reported to have a significant positive relationship with household food security among smallholder farmers (Mango et al., 2014).

It is interesting to note that, diversification strategies dominated by males and females (irrigation and off-farm employment respectively) have an inverse but a statistical significant impact on household food insecurity whiles migration, dominated by the youth, has a positive but a statistical insignificant impact on household food insecurity.

In this study, we find the institutional factor variables typically associated with food security such as land tenure and credit access to be statistically significant and negatively correlated with household food insecurity in line with conventional expectation (Table 4.6). This finding is partially consistent with Kuwornu et al., (2010) who found that access to credit has a positive influence on household food security because of its consumption

smoothening mechanism which gives households temporal relief against food insecurity, it however found land tenure to be statistically insignificant even though the positive sign of the marginal effects is indicative of positive effect on household food security. Leza & Kuma (2015) and Tefera & Tefera (2014) both found credit access to have a significant and positive effect on household food security in Ethiopia.

Household demographic structure also explains the variation of food insecurity status of households. Food insecurity is higher for females than for males (Table 4.6). Consistent with this finding, WFP (2012) confirmed that food insecurity is higher among female headed households relative to male headed households in northern Ghana. In Ethiopia, FAO (2015) reported that male headed households were more food secure compared to female headed ones. The finding also support Barahona (2015) who reported a statistically significant difference between male and female headed households in some countries in East and West Africa, revealing that female headed households tended to experience five or more hunger months more frequently than male headed households. Females farmers in Africa generally lack access to productive resources required to engage in more productive agriculture (Mukasa et al., 2015).

Also, the results showed that older farmers (above 35 years) were more food secure than the youth (below 35 years) (Table 4.6). This is consistent with the finding of Tefera & Tefera (2014) and Trang (2010) who found older farmers to be more food secure relative to younger farmers. This is because of older farmers' access to land and other production resources, stable economies, more experience and therefore accumulated more wealth, making them more food secured than younger ones. However, Aidoo & Tuffour (2013)

and Kuwornu et al., (2010) did not fine a statistically significant difference between the youth and the older generation in the central region.

Education access has a mix effect on household food insecurity (Table 4.6). Primary, JHS/middle school and tertiary education have a statistically significant effect on household food security whiles SHS/Vocational/Technical schools have no significant effect on household food security. Primary and tertiary education both associated with household food insecurity whereas JHS/middle school education increase household food insecurity. WFP (2012) found household heads in northern Ghana with higher level of education to be less vulnerable to food insecurity. Elsewhere in Ethiopia, FAO (2015) found that households with literate household's heads have a significantly higher food security status.

The results also indicated a higher food security status for farmers with higher income (Table 4.6). This is attributable to the consumption smoothening potential of high income which allows farm households to make purchases in market when the households run out of food stock. Similar results were reported by WFP (2012) in northern Ghana where households with higher incomes were less vulnerable to food insecurity. The study further noted that low income households do not only have limited means of purchasing food, they have smaller harvest and more vulnerable to climatic and non-climatic shocks. Similar outcomes of a higher food security for households with higher incomes were observed elsewhere in Ghana and East Africa (Beyene, 2010; Kuwornu et al., 2010; Ragasa et al., 2012; Aidoo & Tuffour, 2013; Leza & Kuma, 2015).

5.9 Summary

This chapter presents discussion of the study results. Discussion of socio-economic and demographic characteristics of the study respondents was presented. Smallholder farmers' perception on weather variables (rainfall and temperature) and climatic hazards (drought/dry spells and floods) was discussed. Ranking of socially differentiated vulnerability to both climatic and non-climatic hazards, socially differentiated adaptation patterns, food security among smallholder farm household in the study area as well as effectiveness of some adaptation strategies on household food security were discussed.

CHAPTER SIX: SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

6.1 Introduction

This chapter presents the conclusions from the study. The first section presents the major findings of the study. The second section covers recommendations based on findings. The final section presents the conclusion of the study.

6.2 Summary of Key Findings

A combination of climatic and non-climatic hazards substantially constrain the livelihood of smallholder farmers. Drought/dry spells, water stress and decrease soil fertility are the three worst stress factors facing smallholder farmers in the Lawra district. The Kendells ranking is however not consistent across the social groups both by gender and age. Males ranked drought/dry spells, decrease soil fertility, and problems with inputs purchase whiles females ranked drought/dry spells, water stress and high food prices as the top stress factors facing farmers. The youth on their part ranked drought/dry spells, water stress and decrease soil fertility whereas older generation ranked drought/dry spells, decrease soil fertility and water stress as the three worst stress factors facing farmers. Farmers are overwhelmingly unanimous in the perception that threats posed by these hazards have increased over time and this is consistent across all social groups.

Adaptation strategies related to sustainable land management practices including mix-cropping/legume intercropping, compost use, changing planting dates, anti-erosion measures, and conservation agriculture were adopted by majority of farmers. Water harvesting is the only sustainable land management strategy which is not adopted by most smallholder farmers. In terms of modern inputs use, chemical fertilizer application and

improved seed variety use was commonly used by farmers. Weedicides and pesticides use were however not prevalent among farmers in the study area. Diversification strategies related to off-farm income activities and migration and were adopted by less than half of farmers. Irrigation was also adopted by less than half of the respondents.

Statistically significant difference was found among the different social groups in the use of some of these strategies. In relation to sustainable land management, compost use and changing planting date were statistically significant. The youth differ significantly from the older generation in the use of compost whiles males differ significantly from females in changing planting dates. Regarding modern inputs use, there is a significant difference between males and females in the use of improve varieties with more females than males adopting improved varieties. In terms of diversification, there is significant difference between males and females in undertaking off-farm income activities. Males varies significantly from females whiles the youth also vary significantly from the older generation in the use of migration as an adaptation strategy by smallholder farmers. Interestingly, no statistical significant difference could be established between the social groups in the use of irrigation as an adaptation.

Majority of farm households were found to be food insecure. Most food insecure households experience food shortages during the planting season between the months of June to September. The youth and females with limited economic resources and social capital are the most food insecure. Strategies adopted by households to deal with food shortages include sales of livestock, migrate to do labor work, borrow from family, friends and VSLA and selling of grains.

All the sustainable land management practices does not have a significant effect on household food security with the exception of compost use which was positively related to food insecurity. Modern technological inputs comprising chemical fertilizer use, improved variety use and weedicides and pesticides use does not have a significant effect on household food security. In terms of diversification, off-farm income had a significantly positive effect on household food security, migration had no significant effect on household food security. Irrigation also had a significant and positive effect on household food security.

Institutional factors including land tenure and credit access have a significant positive effect on household food security of smallholder farm households. Households with higher incomes were more food secure. Male farmers' household were more food secure relative to female farmers' households whiles older farmers' households were also more food secure than younger farmers' household.

6.3 Recommendations

Based on the above findings, the following recommendations are made by the study;
To reduce vulnerability of smallholder farmers in the Upper West region, policies and programmes should target smallholder farmers at the disaggregated social groups' levels of males and females and youth and older people instead of the current approach of targeting them as a homogeneous group.

MoFA and other development organizations should focus on reducing vulnerability to drought and dry spells through the provision of accurate and timely rainfall information. Also the Savannah Agricultural Research Institute should develop drought resistant crop

varieties that is suitable to local conditions and also addresses the socio-cultural aspirations of farmers.

To reduce vulnerability of male farmers to hazards, MoFA and development organizations should prioritize, in addition to drought/dry spells measures, soil fertility enhancement strategies including precise application of agro-chemicals. Also, these organizations should improve access to credit to eliminate or reduce problems associated with inputs purchase.

The Community Water and Sanitation Agency and NGOs working in the water and sanitation sector should provide potable water in the study area. This will reduce vulnerability of both the females and the youth.

In line with Ghana's Intended Nationally Determined Contribution (INDC) to the UNFCCC, to promote CSA in the northern savannah agro-ecological zone, policy measures should be targeted at improving the efficiency and effectiveness of the sustainable land management strategies so as to sustain and improve adoption. Specific interventions should be targeted at improving water harvesting techniques among smallholder farmers in the Lawra district. This will reduce vulnerability to drought/dry spells identified by all social groups as the most pressing hazard faced by farmers. With findings showing low adoption of compost and manure use among the youth relative to older folks, focus should be placed on the youth to increase its adoption.

The national Youth Employment Agency (YEA) should develop a model that targets smallholder farmers in the savannah zone. This model will provide off-farm income to young smallholder farmers crucial to improving household food security and stemming the tide of labor migration in the region. Also the Council for Technical and Vocational

Education and Training (COTVET) should put in place special skills development programmes targeting smallholder farmers in the Upper West region. These programme will give employable skills to farmers most of whom are unemployed or under employed during the lean season.

The district departments of agriculture should collaborate with the Ghana Irrigation Development Authority (GIDA) to promote irrigation in the area. The intervention should deviate from the current approach of provision of mechanized irrigation equipment. Existing traditional irrigation as practiced in the area should serve as a launchpad to develop a low cost, socially and culturally applicable technology. The promotion of irrigation should be a complete package which include well targeted credit facilities for farmers.

The government should put in place a food aid programme targeting the most distressed farm households in Ghana. The national buffer stock system could be used to this effect.

6.4 Conclusion

Based on the findings, the following conclusions are drawn;

The study has demonstrated empirically that smallholder farmers are not homogenous. Rather, males and females and youth and older people differ in their perception of vulnerability and subsequent adaptation strategies. This means that, efforts to improve the wellbeing of smallholder farmers should be targeted at the individual disaggregated social groups.

The study also concluded that, on farm productivity enhancement adaptation strategies comprising both SLM practices and modern inputs use as currently use by farmers, do not significantly improve household food security.

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APPENDICES

Appendix A1: Questionnaire on smallholder farmer adaptation

Introduction

My name is Abass Adam Yidana I am a graduate student from the University of Ghana working towards my Mphil degree in Climate Change and Sustainable Development. As part of my studies, I am interviewing farmers in Lawra district to learn more about the challenges they face and how they deal with those challenges. The answers given during the interview will be kept absolutely confidential and anonymous and will be used to help me learn more about the lives and needs of smallholder farmers. Further, the answers will also add to a larger study working toward ensuring better policies and programs for helping farmers as they face a variety of problems. Participation is voluntary and you can stop at any time, but we would really appreciate it if you could spare some of your time for this interview

To be completed by interviewer
ENUMERATION COMMUNITY……
RESPONDENT CODE…….
RESPONDENTS NAME……..
HOUSE CODE…….

Background Characteristics

1. Age: ……
2. Gender: 1. Male 2. Female
3. Relation of respondent to household head: 1. Household head 2. Wife of household head 3. Son/daughter of household head 4. Other (specify)……..
4. Size of Household (this include those away): ……
5. Level of education of respondent: 1. No formal education 2. Primary 3. JHS/Middle 4. SHS/'O'level/'A'level 5. Tertiary

6. What type of farming are you engage in? 1. Crop farming 2. Animal husbandry3. Mix farming 4.Other(specify)……
7. Which crop and or livestock do you grow or rear?.....
8. How many acres of land do you farm?.....
9. How many years have you being farming?.....
10. List any other sources income……

b. Wellbeing and Livelihood Assets

11. Do you own a farm land in this community? 1. Yes 2. No
12. If no, please indicate how you acquire your farm land…….
13. Do you receive any information or advice from extension workers? 1. Yes 2. No
14. What kind of information?.....
15. Do you receive credit from any organization for your farm activities?.....

Major items owned (Tick as many as applicable):

Items Owned	Assets owned	
	Yes	No
1. Traction livestock (e.g. mule, horse, oxen)		
2. Car		
3. Plough		
4. Gas/kerosene stove		
5. Television		
6. Radio		
7. Bicycle/moped		
8. Iron roofed house		
9. Refrigerator		
10. Cellphone		

16. In the last 12 months, did your household face a situation where there was not enough food to feed the household?
(1) Yes (2) No IF NO SKIP 16 and 17
17. In the past 1 year how often did your household face food shortage?
(2)1-2 months (4) above 3 months

18. What did you do when your household did not have enough food?.....

Vulnerability Context and Perceptions of Climate Change

19. Has the temperature in this area changed over the past 10 years?.....

20. Has the rainfall in this area changed over the past 20 years?

21. Is the Climate Changing? 1. Yes 2. No 3. Don't know

IF YES, PROCEED TO 20 OTHERWISE SKIP TO 22

22. How is it changing?.....

23. What is responsible for the changes in climate?
…….

24. How often does this area get flooded?
……

25. How often do you experience droughts and dry spells during the farming season?

……
……..

26. How does changes in temperature affect your farm activities?.....

27. How does changes in rainfall affect your farm activities?…….

28. How does flooding affect your farm activities?……

29. How does dry spells affect your farm activities?……...

30. Based on your experience in this community, rank the hazards given below from the least serious (1) to most serious (12). Also, indicate whether or not the hazards have become more threatening in the last 10 years than the years before.

Hazard	Rank	Hazard more threatening today than in the past?	
		Yes	No
Dry spells			
Water stress			
Floods due to excessive rainfall			
Extreme temperatures			
Human diseases			
crop pests and diseases			
Animal pests and diseases			
Decreasing soil fertility			
Problems with input purchase			
Problems with output sales			
High food prices			
Conflicts			

Adaptation Strategies

31. What adjustments in your farming system have you made to changes in temperature and rainfall?

……

32. Which of the following adaptation strategies did you adopt to cope with climate related hazards? For each strategy adopted, state whether it was able to improve HH food security or not.7

Adaptation Strategy	Strategy adopted? 1. Yes 2. No	Did strategy ensure food availability for all HH members throughout the last year? 1. Yes 2. No	If NO, how many months did your household face food shortages? 1. 1-2months 2. Above 3 months
Mix cropping/legume Intercropping			
Anti-Erosion Measures			
Composting			
Water Harvesting			
Conservation Agriculture			
Changing Planting Date			
Improved Varieties			
Chemical Fertilizers			
Weedicides and Pesticides			
Off-Farm Employment			
Migration			
Irrigation			

33. Have you or any member of your household ever migrated from this village in the last 10 years? 1. Yes 2. No

34. If you or a member of your household has migrated from this village in the last 10 years, complete the table below for the migrant.

Name of migrant (indicate as many as applicable)	Type of migrant (use codes1.Permanent 2 Seasonal; 3.Returned	Age	Gender (1. Male; 2 Female)	Destination (1.urban area within U/W/R; 2 Rural area within U/W/R 3.Kumasi/Accra 3.Rural area outside U/W/R 4. Outside Ghana (specify)	Reasons for Migration (multiple allowed) 1. Education 2. Marriage 3. Declining/unreliable rainfall 4. Rising Temperatures 5. Shortage of farming land 6. Floods 7. Lack of jobs here 8. Other (specify)	Has migrant ever remitted money/Food home? 1. Yes 2. No

Appendix A2: Focus Group Discussion Interview Guide

A. **Background**

Date:	Number of Participants:
Community:	Number of HH:
Population:	Duration:
No of Compounds:	

B. Introduction of participants/Personal Data on FGD Participants

No	Initials	Name	Gender	Age	Main crops grown	Farm size (acres)	Highest education level

C. Discussions

Vulnerability context	
1. What are your major challenges in your livelihood activities? (IDENTIFY BOTH CLIMATIC AND NON CLIMATIC STRESSORS). Probe for economic, environmental, social and economic stressors. 2. How have these challenges changed over time?	
Adaptation response	
3. What adjustments have you made in your livelihood activities to adapt to climatic and non-climatic hazards? Probe for a. Agriculture intensification (composting, conservation agriculture, legume intercropping, water harvesting, use of improved varieties, chemical fertilizer etc.) b. Livelihood diversification c. Migration.	
4. Do you receive any external assistance to enable you adapt?	
HH Food Security	
5. What is food security? b. what is the food security situation in this community? c. how often did households and individual face food insecurity in the last one year? 6. d. what do you do when HH does not have enough food? 7. What impact does various adaptation strategies have on HH food security?	

Appendix A3: Key Informants' Interview Guide

Date:	District:
Community:	Moderator:
Note-Taker:	Name of Respondent:
Sex	Social Group:
House number:	Respondents Code:

Interviewer	**Interviewee**
Vulnerability context	
1. What livelihood activity do you undertake?	
2. Why do you undertake this particular livelihood activity?	
3. Why don't you undertake other livelihood activities/opportunities available?	
4. Which activities are clearly acceptable and which are unacceptable?	
5. How are your livelihood choices and actions enabled and by whom?	
6. What factors constrains your livelihood activities? Probe for climatic and non-climatic factors	
Adaptation Response	
7. How do you deal with factors constraining your livelihood activities?	
8. How do you access the resources you need to undertake your livelihood activity?	
9. Who grants this access?	
10. Who makes decisions about money or resources in your household?	
11. Why do they make these decisions?	
12. What would happen to someone who tend to ignore or contradict these decisions?	

Appendix B: Binary logistic regression output

	dy/dx	Delta-method Std. Err.	z	P>|z|	[95% Conf. Interval]	
Aggrp	-.1093523	.047648	-2.30	0.022	-.2027408	-.0159639
Sex	.119762	.0556592	2.15	0.031	.010672	.228852
Inc	-.0000722	.0000104	-6.91	0.000	-.0000927	-.0000517
Edu						
2	-.180936	.1035365	-1.75	0.081	-.3838638	.0219919
3	.08217	.0478134	1.72	0.086	-.0115426	.1758826
4	-.167002	.3001865	-0.56	0.578	-.7553567	.4213528
5	-.3764099	.1666572	-2.26	0.024	-.703052	-.0497678
Comp	.1042585	.0512389	2.03	0.042	.0038321	.2046849
LandT	-.1102375	.0663722	-1.66	0.097	-.2403246	.0198497
CreAcc	-.1614637	.0504673	-3.20	0.001	-.2603779	-.0625496
ConA	-.0891111	.0617257	-1.44	0.149	-.2100913	.0318692
ImpV	.0624966	.0986705	0.63	0.526	-.130894	.2558873
CheF	.0404855	.0932271	0.43	0.664	-.1422363	.2232074
OffY	-.1491779	.0779002	-1.91	0.055	-.3018595	.0035038
Mig	.0006461	.0430347	0.02	0.988	-.0837003	.0849924
Irrg	-.1450772	.0435116	-3.33	0.001	-.2303583	-.0597961