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PhD Thesis

GENDER ANALYSIS OF CLIMATE VULNERABILITY AND LIVELIHOOD STRATEGIES AMONG FARMING HOUSEHOLDS IN NORTHERN GHANA

BY

WILLIAM ADZAWLA

SUPERVISOR

PROF. ABOU KANE

APRIL, 2019

DECLARATION

I, William Adzawla, hereby declare that this thesis 'Gender perspective of climate vulnerability and livelihood strategies in northern Ghana' is the result of my own work and that, no part or whole of it has been submitted for the award of a degree of any level in the University or any other university or institution.

ABSTRACT

This study analysed both inter- and intra-households' gender inequalities (climate vulnerability, productivity and welfare) and the effects of climate adaptation through livelihood diversification on gender inequalities in northern Ghana. A total of 619 farmers from 432 farm households were selected through a multistage sampling procedure. The data was analysed using multivariate probit, livelihood vulnerability index, and a self-selection corrected Oaxaca-Blinder decomposition model. From the results, climate responsive livelihood diversification was higher for male heads than female heads and female spouses. The hypothesis that climate responsive livelihood diversification strategies were independent was rejected. Climate vulnerability was highest for females and lowest for male heads. Gendered livelihood vulnerability gap was higher under livelihood diversification than without diversification. There was significant gendered productivity gaps of 394.537 kg/acre (58.8%) and 300.164 kg/acre (44.8%) between male heads and the female heads and between male heads and female spouses, respectively. There was also a significant gendered welfare gap of $45.85 (11.4%) (Equivalent of GH₵211.84) per annum between male and female headed households. The gendered productivity and welfare gaps were largely due to endowment differences. Livelihood diversification and climate change had significant effect on gendered productivity and welfare gaps. The study concluded that although livelihood diversification can reduce climate vulnerability and address productivity and welfare gaps between males and females, but it is not sufficient to address gender inequalities among the farming households. Aside the promotion of livelihood diversification strategies, female farmers must be specifically and deliberately targeted for special purpose programs.

RESUME

Cette étude analyse les inégalités de genre inter et intra ménages (vulnérabilité aux changements climatiques, productivité et bien-être) ainsi que les effets de l'adaptation au changement climatique par la diversification des moyens de subsistance sur les inégalités liées au genre dans le nord du Ghana. Au total, 619 agriculteurs issus de 432 ménages agricoles ont été sélectionnés par la procédure d'échantillonnage multi-étapes. Les données ont été analysées à l'aide d'un probit multivarié, d'un indice de vulnérabilité des moyens de subsistance et d'un modèle de décomposition de Oaxaca-Blinder corrigé du biais de l'auto sélection. D'après les résultats, les stratégies d'adaptation basées sur la diversification des moyens de subsistance sont plus présentes chez les hommes chefs de ménage que chez les femmes chefs de ménage et les épouses. L'hypothèse selon laquelle les stratégies de diversification des moyens de subsistance sensibles au climat étaient indépendantes est rejetée. La vulnérabilité liée au climat est plus élevée chez les femmes que chez les hommes chefs de ménage. L'écart de vulnérabilité des moyens de subsistance selon le sexe est plus important avec la diversification de ces moyens que sans leur diversification. Il existe des écarts de productivité significatifs de 394,537 kg / ha (58,8%) entre les hommes et les femmes et de 300,164 kg / ha (44,8%) entre les hommes et les épouses. Il existe également un écart significatif de 45,85 USD (11,4%) par an en matière de bien-être (équivalent de GH 211,84) par an entre les ménages dirigés par des hommes et ceux dirigés par des femmes. Les écarts de productivité et de bien-être liés au genre sont dus en grande partie aux différences en dotation. La diversification des moyens de subsistance et le changement climatique ont eu un effet significatif sur la productivité et les écarts de bien-être entre les hommes et les femmes. L'étude a conclu que, bien que la diversification des moyens de subsistance puisse réduire la vulnérabilité liée aux variabilités climatiques et réduire les écarts de productivité et de bien-être entre hommes et femmes, elle ne suffit pas pour remédier aux inégalités de genre entre les ménages agricoles. Outre la promotion de stratégies de diversification des moyens de subsistance, les agricultrices doivent être spécifiquement et délibérément ciblées dans le cadre de programmes spéciaux.

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I appreciate the enormous supports from my wife, Mrs Mavis Adzawla, and the entire family. May the Good Lord reward them in His measure. I am also grateful to all my friends and loved ones for their support in diverse ways. A similar appreciation goes to my PhD colleagues for their backing during the entire PhD programme.

DEDICATION

I dedicated this research work to my wife, Mrs Mavis Kpatson Adzawla, and my mother, Mrs Paulina Adzawla.

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CHAPTER ONE

INTRODUCTION

1.1 Background

This study analysed the gender inequalities on one hand and on the other hand, the impact of climate adaptation through livelihood diversification (also a measure of economic empowerment) affects gender inequalities. Generally, gender and development are global concerns and this is reflected in a joint statement by International Fund for Agricultural Development (IFAD), Food and Agriculture Organisation (FAO) and World Food Programme (WFP) on 8th March, 2017(www.fao.org/news/story/en/item/473008/icode/):

"Achieving gender equality and empowering women are crucial ingredients in the fight against extreme poverty, hunger and malnutrition" (FAO Director-General, Jose Graziano da Silva)

"We need to face the fact that we will never overcome poverty and hunger without empowering rural women" (IFAD President, Kanayo F. Nwanze).

Gender and development paradigm requires that the level and sources of inequality are identified and resolved. Globally, climate change has become one of the most developmental challenges not only because of its effects on present livelihoods but also, its impacts are expected to worsen under business as usual; no mitigation, no adaptation or maladaptation. Poverty, food security, energy, coastal cities and all aspects of the ecosystem are currently affected or are expected to be negatively altered due to climate change. Although all economies, systems or persons are or would be affected by climate change, the impacts are unequal and unevenly distributed. In fact, the already existing vulnerable groups are and would be most affected. For instance, evidence (FAO, 2016; Serdeczny et al., 2016; IPCC, 2014) shows that Africa continent is more vulnerable to

climate change than other regions not because of its level of contribution to climate change but due to its high dependence on agriculture, natural resources and weak institutions or governance. Within the continent itself, rural populations, agrarians, women and children are the most vulnerable groups to climate change and variability. Already, addressing gender inequality is a major concern for many development agencies and this has been recognised in the fifth Sustainable Development Goals (SDG5), and this seeks to achieve gender equality and empower women at all levels.

Gender inequality is as a result of several integral components including social, cultural, political and economic factors. Therefore, an important question that arises is whether addressing the economic factors through economic empowerment can reduce gender inequalities or not, and if yes, to what extent? Already, glass ceiling remained a challenge in the labour market, and even when women and men spend the same work-hours, women are often paid less wage than men (UNDP, 2015) while the distribution of resources is unequitable. As recounted by previous studies, Jost et al., (2015) publicised that rural women face high climate risks because their access to resources such as land and institutional services like extension are weak; they engage in agriculture activities than the men; their household responsibilities such as water provision are also affected by climatic conditions; and the fact that social norms and roles limit their adaptive capacity. Jost et al., (2015) maintained that gender difference in Ghana is more pronounced due to public extensions' view of a farmer as a male. As such, almost all agricultural policies are designed with men in view, making it difficult for women to break the inequality shells.

These notwithstanding, women's contribution to development remained vital. For instance, one of the main reasons for the underperformance of the agriculture sector is due to the poor resource access by women (FAO, 2011). In recognition, one of the

policy targets of the fifth SDGs is to undertake reforms that will give women the same rights to economic resources and access to ownership and control over land, financial services, inheritance and natural resources in accordance with national laws. Estimates show that women could increase their farm yields by 20-30 percent given that they have equal resources as their male counterparts and this could lead to a reduction of the number of world's hungry people by 12-17 percent (FAO, 2011). These differences are partly due to resource inequality. By economies of scale, this is undisputable since there is cost saving due to increased level of production or resource usage.

While hundreds of millions of rural families are trapped in a cycle of hunger, poverty and low productivity leading to excessive misery and low agricultural development, climate change has also been projected to reduce yield of most crops. This is an indication of worsening food prices and malnutrition. Although global undernourishment level is on the decline, it is still worrying that as high as 33.7 million people (9.6 percent prevalence) are still undernourished in 2014-16 among West Africans (FAO, 2015b). This raised an important question as to why food insecurity and poverty still remain high despite the various varietal improvement of the dominant crops such as maize in the region. Perhaps, adaptation to climate change within a gendered perspective must be given a prime attention.

From Downing (1993), the ultimate effect of climate change depends largely on the adaptive responses. Broadly, adaptation is the adoption of specific strategies in order to secure livelihoods by using resources more efficiently. Adaptation occurs by reducing exposure to a known threat (Wilby & Dessai, 2010). It is a localised concept as the strategies to adopt depends on the available opportunities in terms of the presence of the strategy and the availability of resources for its adoption. Efforts towards sustainable agriculture requires that actions and inactions of farmers and other actors in the

agriculture sector contribute positively to ending hunger and poverty and ensuring a carbon-neutral world. As such, adaptation to climate change is gaining more prominence. FAO (2016, pp xi) argued that in the absence of adaptation to climate change, "it will not be possible to achieve food security for all and eradicate hunger, malnutrition and poverty". An important and desirable characteristic of adaptation is that its cost of action is a fraction of non-adaptation or inaction. Wossen et al. (2017) argued that with smooth adaptation, climate change impacts can be minimised substantially and adverse effects of food security could be altered.

Generally, the recent literature on adaptation can be classified as following a bottom-up or a top-down approach (scenario-led) (Wilby & Dessai, 2010). Top-down studies examined adaptation in a global perspective and therefore generalised conclusion on the nature and effects of adaptation. Contrarily, bottom-up studies examined adaptation in a local perspective. In bottom-up, the analysis commence with the factors and conditions that enable successful coping with climate related threats at the individual, household or community level (Wilby & Dessai, 2010). Although both provide insights into the need and potential effects of adaptation, there is the need to give much attention to the bottom-up approach in order to identify localised strategies that are required to respond timely to the changes in the environment. Yaro & Hesselberg (2016) noted that understanding adaptation in West Africa is essential since developmental challenges are knotted with the climate. A detailed analysis of adaptation helps to identify which interventions such as diversification are more helpful and to whom it is most helpful (Riede et al., 2016). Economic views and analysis of adaptation are moving from market solutions and cost-benefit to include inequalities and behavioural biases (Chambwera et al., 2014). This is due to the class differences in adaptation and returns from adaptation. For instance in a study by Jost et al. (2015), male farmers in Ghana

mentioned female farmers as primary decision makers in the adoption of new crop varieties since they are responsible for household food supply. On the other hand, the female farmers described their male counterparts as the primary adopters since the males aim mainly at maximising their profits. Similarly, due to control over resources, male farmers adopts strategies such as fertiliser application while female farmers diversify into non-farm jobs (Riede et al., 2016).

Although adoption of sustainable agricultural practices could improve yields and income, the increases in income cannot be sustainable under uncertain climatic conditions, hence the need for diversification to further enhance farmers' resilience (FAO, 2016b). Farmers' understanding of climate variations has preconditioned them to diversify into non-farm and on-farm activities, primarily, to reduce the risks from agriculture sector and maintain household's livelihood. In a focus group discussion in Kanshegu community of Ghana, men's group indicated that 'farming is no longer good so we need to diversify our livelihood' while the female's group indicated that 'every woman now wants to engage in more than one activity as a way of achieving livelihood security' (Yaro et al., 2016, pp.71). Economic empowerment through livelihood diversification have therefore become a strategy used by farmers to improve their livelihoods and also an important strategy to respond to climate change or variability. Therefore, there is the need to understand the role of economic empowerment on livelihood outcomes and its role in addressing gender inequalities and climate vulnerability.

1.2 Problem statement of the study

1.2.1 Evidence of the problem

Poverty and food insecurity reduction continuous to be a global target and it is by no mere imagination that these were respectively placed as first and second goals in the SDGs. Recent estimates suggests that almost a billion of people live in extreme poverty with the majority of the poor residing in rural areas where agriculture, particularly rain fed crop production remain their major or nearly sole source of livelihoods (World Bank, 2015 cited in FAO, 2015a). This vicious cycle of hunger, poverty and low productivity impedes the development of the agricultural sector as well as general economic development of agrarian economies. The widespread of poverty in most SSA economies have placed them into food insecurity even in periods of favourable environmental conditions. Unfortunately, climate change has been observed to affect both income and non-income dimensions of welfare, making the present phenomenon of economies like Ghana more complex and worrying. Poverty intensity is expected to worsen while more households are expected to become poor under the changing climate. Hallegatte et al. (2018) explained that while poverty is a cause of high climate vulnerability in some societies, this high climate vulnerability is also making people to remain in poverty. It is therefore unsurprising that livelihood security and empowerment are recognized as the expected results of climate adaptation and a cause to future changes in climate change vulnerability (Mersha & Laerhoven, 2016).

Two of the strategies to respond to climate change or variability is mitigation and adaptation. Although mitigation to climate change is vital to build resilience to climate change, adaptation provides short term gains and enable systems to recover from environmental shocks. Also, adaptation is crucial because it is mostly stimulated by climate variability such as floods and droughts other than climate change (Berrang-ford

et al., 2011) and location or system specific. Mostly, adaptation strategies are adopted as anticipatory, reactive or proactive measures to climate change. Among others, the primary goal of adaptation is to reduce or spread risks and secure income or resources (Berrang-ford et al., 2011). One reason for Ghana's high vulnerability to climate change is the low adaptive capacity of the country. Berrang-Ford et al. (2011) maintained that there is the need for further scrutiny and learning from current adaptation strategies. As a local context strategy, adaptation remained the most plausible option for farmers and rural dwellers in Ghana. Adaptation allows farmers to harness opportunities and options within their reach to reduce the impacts of climate change on their households. Several adaptation strategies are available, promoted and adopted by farmers (Assan et al., 2018; Denkyirah et al., 2017). One of which is livelihood diversification. Although, diversification is a long-time phenomenon, recent objective of diversification of livelihood is to respond to climate change and variability. For instance, decreases in average rainfall increases diversification (Asravor, 2018). Depending on the strategy, diversification can be a proactive or reactive adaptation strategy, making it a flexible strategy for households to adopt. One of the major advantages of diversification over the other adaptation strategies is its role in reducing household's climate vulnerability and at the same time, improving household's welfare and crop production. Among others, Antwi-Agyei et al. (2014) estimated that Ghanaian farming households adopts adaptation or coping strategies that are linked to livelihood diversification, hence recommend for policies that would promote diversification. Authors in Olsson et al. (2014) indicated that although diversification reduces poverty and future welfare deteriorations due to weather changes, it is less available to or harnessed by the resource poor households. One of such poor households are the rural agrarians, particularly, the female farmers.

Ghana's agriculture is largely rural based, dependent on rainfall and provides employment to about 44.3 percent of the country's workforce (GSS, 2014a). However, poverty and inequality continuous to be higher among the rural areas that hosts these farmers. For instance, while the contribution to total poverty by the rural areas was 89.6 percent in 2005/6, this increased to 93.1 percent in 2012/13 (GSS, 2014b). The implication is that any variation or change in the agricultural environment would worsen rural livelihoods, economic status and developmental paths of the country. In Ghana, women represent 44.3 percent of the total economic labour force in agriculture. Although this value represents less than half of the agricultural labour force, FAO (2011) argued that such values are low because they underestimate the work women do since most of their works are often defined as 'no work'. Giving the recent gender sensitive orientation of programs to empower women and improve their productivity, FAO (2015) holds that it is still inconclusive on the gains from these programmes since gender norms persistently limits their financial decision making. With the obstinate climate change effects on rural households' livelihood, it is important that policies are directed towards minimising the impacts. However as noted by FAO (2011), these developmental projects and policies must not be gender neutral since overcoming the constraints of women warrant considerable efforts than for men. To achieve higher adoption of climate smart agriculture for instance, Jost et al. (2015) argued that directing efforts such as technologies, information and resources towards women is paramount.

Evidence shows that women have positive roles to play in economic and sustainable development. It is not surprising that, one of the main reasons for the inability of most countries to guarantee sustainable development is the underutilisation of the female resources (OECD, 2008). A joint report by UN Women, UNDP, UNEP (2015)

provided that improving gender gaps could lead to increased farm outputs and this would translate into higher spill over effects on other sectors, improve malnutrition, increase Gross Domestic Product (GDP) and reduce poverty.

1.2.2 Diagnosis of the problem and its statement

The green revolution success in Asia provide evidence that integrating environmental sustainability and gender inequality as core policy elements in agricultural development are vital for improving human development outcomes (Conceição et al., 2016). Gender inequalities challenge existing developmental pathways. Therefore, the role of gender studies to identify ways of bridging the gap cannot stand the luxury of time. Considering the implications of climate change on development, climate analysis within a gender framework could be a good starting point. Climate change vulnerability, impacts and adaptation are non-gender neutral. For instance, Alhassan et al. (2018) found that female headed households have lower adaptive capacities and were more vulnerable to climate change than male headed households. Mersha & Laerhoven (2016) also asserted that male headed households have a wider range of adaptation choices such as on-farm and temporal migration than women and that these differences are due to gender barriers but not preference by the gender groups. However, climate vulnerability is a dynamic phenomenon which vary within time and space, therefore, requires a constant search for and an update of knowledge on the subject. The observed gender inequalities is not limited to climate vulnerability or adaptation but also, productivity and welfare.

In SSA, gender productivity gap for instance largely cluster around 20-30% (Kilic et al., 2015). Although gender-gap closing choices could improve societal benefits, evidence to substantiate this potential has been given little attention (FAO, 2011) and seemingly

missing on northern Ghana. Understanding labour roles has become important since prevailing adoption and labour allocations suggest that changes in agricultural practices are occurring alongside the prevailing gender roles while more labour-intensive technologies seems to fall on women. Unfortunately, coupled with the limited technology access by women, the extent to which labour participation and livelihood could vary among male and females is not known. That is to say that although climate and gender discussions especially on their interrelationship are known, the effects of adaptation on the climate vulnerability, productivity and welfare as well as the mechanisms through which the inequality could be reduced have received minimal recognition both at the policy and research levels in Ghana. These have given enough grounds for empirical analysis of these missing information.

The theoretical literature, at least from the sustainable livelihood framework provided that livelihood diversification leads to improved livelihood outcomes such as higher welfare and food security. As discussed earlier, outcomes from empirical studies on this economic relationship (diversification and livelihood outcomes) vary largely based on space dimension. Therefore, this study is anchored on two empirically unresolved issues paramount to policy makers.

Firstly, although women are often described as most vulnerable (both economically and environmentally) and the conclusions that livelihood diversification leads to increased food security, there still unresolved issues on the effect of diversification on gendered productivity and climate vulnerability. As acknowledged by Haji (2006), understanding the directional effect of diversification remained unresolved and of much interest to economist and policy makers. Secondly, there is an increasing emergence of a number of livelihood diversification activities in the rural areas. The empirical results from these livelihood activities shows a net positive effect on welfare. For instance, some scholars

provided that livelihood diversification decisions have a positive impacts on household welfare (Asfaw et al., 2016; Gautam & Andersen, 2016) while others such as Adzawla et al. (2016) estimated a negative effect of off-farm on households' welfare. Tsiboe et al. (2016) provided that engaging in non-farm work increases the dietary diversity score and reduces the monetary food shortfall of households. For Djoudi et al. (2016), diversification is a known vital strategy for reducing household's vulnerability. Ironically, scholars have been silent on the inequality effects from diversification. Thus, there is no literature to suggest the role of diversification on welfare inequality, for instance, among gender groups. In the midst of changing climate, the need for sustainable and all-inclusive development, bringing this class aspects into the body of scientific knowledge is most appropriate and cannot be overemphasised.

Conclusively, the impact of climate change adaptation strategies such as livelihood diversification in closing existing gender inequalities have not received the desired research attention. Therefore, policy options on the ways to reduce inequalities in climate vulnerability, productivity and welfare, at least, through specific livelihood diversification options appears missing in the literature. Thus, the complex connections between climate vulnerability, livelihood dynamics, food production and welfare within different groups or classes are in unknown. Against these milieus, this study analysed climate vulnerability and the effects of climate adaptation (using the case of livelihood diversification) on gender inequality through three indicators as climate vulnerability, productivity and welfare.

1.3 Research questions

The main research question of this study is, what is the effect of climate adaptation through livelihood diversification on gender inequality among maize farming households in northern Ghana? The specific questions include:

1. What livelihood diversification strategies are adopted in response to climate change and variability?
2. What is the level of climate vulnerability of male and female households and the effect of livelihood diversification on climate vulnerability?
3. What is the effect of climate responsive livelihood diversification strategies on maize yield among male and female farmers?
4. What is the effect of climate responsive livelihood diversification strategies on gendered welfare of the farming households?

1.4 Research objectives

The primary objective of this study is to analyse the effects of climate adaptation through livelihood diversification on gender inequality as measured by climate vulnerability, farm productivity and welfare among maize farming households in northern Ghana. Specifically, the aim of the study is to:

1. analyse the livelihood diversification options to climate change as adopted by male and female households in northern Ghana.
2. examine the climate vulnerability of male and female headed households and the effects of climate responsive livelihood diversification strategies on climate vulnerability.

3. estimate the effects of climate responsive livelihood diversification strategies on the productivity gap between male and female maize farmers.
4. estimate the effect of climate responsive livelihood diversification strategies on gendered welfare gap.

1.5 Hypotheses

The following null hypotheses were tested:

1. There are no factors explaining the adoption of climate responsive livelihood diversification strategies among farmers.
2. Climate responsive livelihood diversification have no significant effect on climate vulnerability gaps between male and female farm headed households.
3. Climate responsive livelihood diversification does not improve productivity among male and female farmers.
4. Climate responsive livelihood diversification strategies have zero effect on welfare gap between male and female headed households.

1.6 Significance of the study

Sustainable livelihood outcomes such as food security and welfare are necessary for descent humanity and these are the prime concerns for policy makers across globe. This means that the mechanism through which these outcomes can be attained within the challenging climate change must be at the forefront of research. However, existing group or class differences must be taking into consideration in pursue of this objective, without which efforts may be unsuccessful and unsustainable. For instance, to ensure sustainable development, the most vulnerable groups to livelihood and climate change

needs to be given more attention to raise their status. One of such areas that have gained placement in the recent SDGs is 'gender'. The literature on gender dimensions of climate change, livelihood and welfare provides little and scattered information, making the policy implications less applicable. Methodological approach to gender analysis have been largely qualitative and those which applied quantitative measures seems to be feeble. Therefore, this study is designed to provide quantitative evidence on gender inequalities and how these inequalities could be addressed by climate adaptation through livelihood diversification. This study would also provide basic information to policy makers on the role of economic empowerment in addressing gender inequalities and climate vulnerability.

Although livelihood diversification has been hyped in the literature as suitable for improving welfare, their effects on inequality reduction have not been exploited. With the given assumption that female farmers could reduce the number of hungry people by as high as 17 percent (FAO, 2011) and the recent integration of females in the labour market, understanding the climate vulnerability, crop productivity and welfare differentials among the females and their male farmer counterparts is vital. Therefore, this study offers the mechanisms through which the potentials of the gender groups particularly women can be identified and harnessed, and how gendered gaps could be minimised if not eradicated. This study provides useful policy information that can serve as a turning point for bridging the developmental challenges, especially food security and poverty reduction amidst climate change. Specifically, this study would provide useful policy recommendations to climate change policy makers especially in the Ministry of Food and Agriculture, Ministry of Gender and Social Protection and Ministry of Environment, Science and Technology, and other Non-governmental

Organisations on the policy directions required to address gender inequalities in the region.

1.7 Novelty of the study

To the best of my exploration of the literature, this study is the first to examine the effect of livelihood diversification as climate change/variability adaptation strategy on gender inequality (climate vulnerability, productivity and welfare) in Ghana.

1.8 Organisation of the thesis

The thesis is organised into nine chapters. The first is the introduction chapter. Chapter two provides the theoretical, conceptual and empirical review of relevant literature. Chapter three details the study design, data collection, data analysis while chapter three shows a description of the data. Chapters five to eight provide the empirical findings of each objective outlined in chapter one. The final chapter (chapter nine) provides a summary, conclusions and recommendations of the study.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This section provided literature review relevant to the subject of the present study. The review includes the theoretical analysis (Harvard Gender Analytical Framework) and build into the conceptual framework, the Sustainable Livelihood Framework (SLF), of the study. The SLF also formed the theoretical framework of this study since it provides useful theoretical underpinnings and interrelations relevant to this study.

2.2 Theoretical framework-Harvard Gender Analytical Framework

Gender analysis have become a central component of developmental policies due to the high rate of failure of developmental policies, projects and programs prior to 1970s, partly due to gender-neutral assumption (Warren, 2007). This has led to a number of theories or tools to guide gender analysis. Common among these are Moser Framework, Capabilities and Vulnerability Framework, Social Relations Framework, Empowerment Framework and Harvard Gender Analytical Framework, among others. Although all these theories provide good insights into gender analysis, the Harvard Gender Analytical Framework is more suitable to the context of this study and provide a good merit to enhance the analysis. Hence, this was adopted as the theoretical framework of the study. The Harvard Gender Analytical Framework is also known as the Gender Roles Framework. The theory was developed by Harvard Institute for International Development, Harvard University in the 1980s and was led by James Austin. Thus, the theory was developed during the Women in Development paradigm. The aim of the theory was to enhance the understanding of community-level or household-level gender dynamics and to ensure that both women and men have equal participation and benefit

rights in projects and programs (Wiebe, 1997). Warren (2007) described that the aim of the framework is to 'promote gender-aware developmental practice'.

Primarily, the framework have four broad aims: (a) to demonstrate that there is economic ration in investing in both men and women; (b) to help planners design more efficient projects and to ensure higher productivity from such projects; (c) to emphasize that access to information is crucial to attain efficiency and equality; and (d) to identify the works of men and women and the differences that exist in the work structure of the two groups. The framework also have four interrelated components or profiles. These are the activity profile, access and control profile, analysis of influencing factors and a project cycle analysis. In addition to the profiles, the framework provides a set of checklist to guide in data collection. The activity profile identifies the productive and reproductive tasks of men and women. The access and control profile is based on the resources and benefits, hence identifies the resources used in performing all activities in the activity profile. This profile also highlights the ownership, control and use as well as the benefits derived from the use of these resources. The influencing factors profile identifies the factors that affects differences between men and women as regards to the activity and the access and control profiles.

In this present study, the focus is mainly on the influencing factors profile by highlighting the effects livelihood diversification (clearly observed though the activity and, access and control profiles) on gender inequalities. However, the interrelationship between gender and livelihood outcomes within recent discussions on climate change requires that these theoretical framework is expanded further. This extension best fits into the SLF. Hence, this led to the adoption of the SLF as the conceptual framework of the thesis. In the subsequent sections, a detailed discussion of the SLF and its interlinkages are provided.

2.3 Sustainable Livelihood Framework

SLF form the theoretical framework for this research. Sustainable livelihood (SL) is a manner of thinking about the objectives, scopes and priorities for development to ensure progress in ending poverty (Ashley & Carney, 1999). Ashley & Carney (1999) outlied six core principles of SL. Firstly, it is people centred, thus, eliminating poverty in a sustainable manner can be attainable through emphasizing on peoples' priorities and appreciating existing group differences. Secondly, SL must be responsive and participatory where the poor are key actors in identifying and improving livelihoods. Third, eliminating poverty can be achieved through working at multi-level. Fourth, SL conducted in partnership with local and private sector. The fifth core principle is that SL must be sustainable, where sustainability involves economic, institutional, social and environmental dimensions. Finally, SL must be dynamic to identify and appreciate the dynamics of various livelihood strategies. Therefore, SLF can be described as a pro-poor development planning tool and on the premise that individuals draw on different activities under varying context. The theory highlights the evolutionary means of poverty reduction, the manner of life of the poor and the importance of institutions or structural changes on poverty reduction (Chambers & Conway, 1991).

The framework is complex and integrates various aspects of socioeconomic analysis for examining the status of households. The SLF have being extensively used to understand how specific livelihood options can lead to improved sustainable outcomes or to establish thresholds for which some livelihood actions may be unsustainable. Ellis and Biggs (2001) asserted that SLF is introduced primarily as a respond to the structural opinions on poverty and underdevelopment in the 1970s. One advantage of the framework is that it can be flexibly adapted for a peculiar objective. Although the

framework has been criticised for analytical limitations and over emphases on assets, it still remained the basis

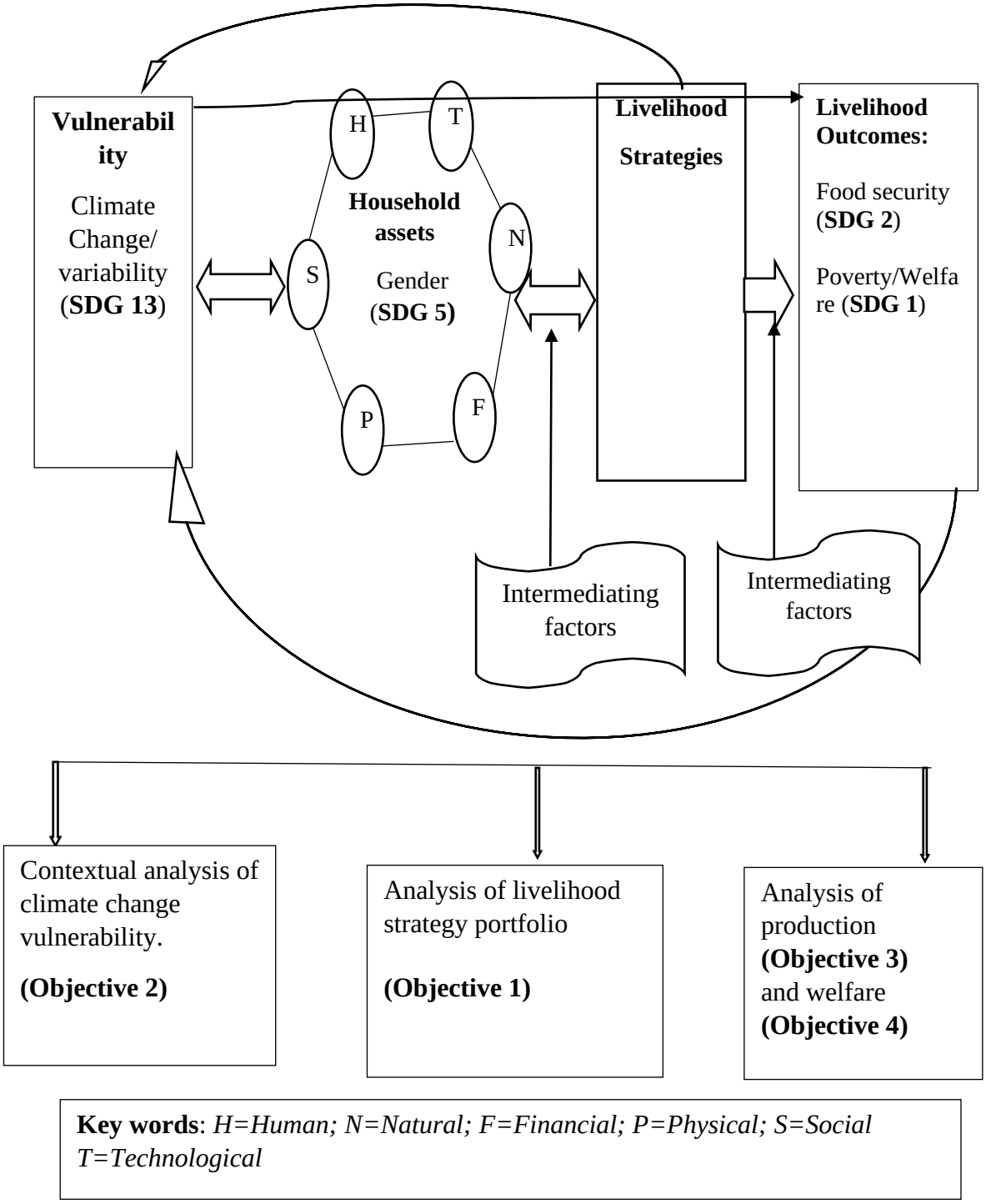


Figure 2.1: Conceptual framework
Source: Adapted from DFID (1999)

for most recent empirical studies. In line with this present study, the framework has four main components that represents different SDGs (See Figure 1). This means that linking these different components in this research would provide holistic findings that can guide policy makers in shaping sustainable rural livelihoods in northern Ghana, and Ghana at large.

The first component is vulnerability. Vulnerability in this context includes the outcomes of trends such as resource and technology trends; seasonality effects such as seasonality in prices and employment opportunities; and shocks such as natural, environmental, conflict or economic shocks (DFID, 1999). Identifying factors that influences vulnerability are important because it helps determine the assets status of people, provide options available to pursue constructive livelihood outcomes and, enable people to develop positive aspects and build resilience shocks (DFID, 1999). As in Figure 2.1, the focus of this study would be on shocks as related to climate change and variability.

The second component of the SLF is the assets of the households, in this study, an assets hexagon; financial, human, physical, natural, social and technological assets. However, other assets such as political assets are gradually gaining evidence in shaping livelihoods. As such, defining the shape of the assets component depends on the prevailing condition and the objective of the scholar (Ellis, 2000). The asset or resource is an important component because meaningful livelihood can be determined by the level and quality of assets. The principle of the asset shape (hexagon in this study) is that at its core is ‘zero asset’ of households while the perimeters shows maximum assets (DFID, 1999). The implication is that depending on the asset distribution of households, the shape can differ.

The fourth major component of the SLF is the livelihood strategies. These are the diverse economic ways of achieving an outcome, say, well-being. According to DFID

(1999), livelihood approach aims at promoting choices, opportunity and diversity. SFL does not aim to promote a specific livelihood strategy but to identify the underlying factors that influence people's choice in order to enhance the positive factors and mitigate the negative ones. However, more choices are important in providing opportunity for self-determination and flexibility (DFID, 1999).

The last component is the livelihood outcome. These are the outcomes from a livelihood strategy. DFID (1999) outlined a number of livelihood outcomes including increase income, improved wellbeing, improved food security, reduced vulnerability and sustainable use of natural resources. There are however, trade-offs between the livelihood outcomes that the achievement of one outcome can negatively or positively affect another.

In relation to this present study, the SLF can be summarised as follows. Climate change and variability affects household's assets mobilisation and development. On the other hand, the current state of household assets are essential for adaptation, as such, determines households' vulnerability to climate change. However, assets acquisition and utilisation are shaped by gender, and this formed the main basis for the high vulnerability of women to climate change/variability and other external shocks. Therefore, households engage in a set of livelihood options based on the available assets. These livelihood options can directly influence the vulnerability status of the household or indirectly through assets mobilisation. For instance, engaging in crop farming is more vulnerable to climate change than engaging in non-farm activities while engaging in a number of livelihood alternatives improves the assets status of the household, hence a higher adaptive capacity to climate change/variability. In addition to other factors such as socioeconomic, institutional and socio-political factors, different livelihood sources and/or a combination would have different effects on livelihood

outcomes such as household food security and welfare. Improving livelihood outcomes such as lower poverty influences the vulnerability of households to climate change and variability (Hallegatte et al., 2018). Detail explanation on the inter-linkages in Figure 1 are provided in the following sections.

2.4 Climate change and Vulnerability

This section provides a review of climate change and vulnerability concepts, vulnerability difference among groups and climate change within Ghana's context. It also formed the background to the subsequent sections.

2.4.1 Climate change concept

IPCC (2014) defined climate change as the 'change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer'. Since natural variations are expected in the climatic conditions, climate change have largely been attributed to human induced changes. As such, IPCC(2007) in Muller (2013, pg. 1) noted that 'climate change is caused by human activities'. The United Nations Framework Convention on Climate Change (UNFCCC) also distinguish between anthropological causes of the changes in the atmospheric composition and changes due to nature. Schellnhuber et al. (2016) in a similar assessment indicated that unchecked anthropogenic climate change could cause permanent challenges, especially, if viewed at the macro level where a range of ecosystem activities are interrelated. Unarguably, it should take human efforts to reduce climate change

The major reasons why climate change discussions have become a topical issue is its cross-cutting impacts, thus, the impacts on all sectors of the economy, severe future impacts and its unembellished impacts on the existing vulnerable groups (for example, the poor and agrarian systems). Therefore, providing enough information on risks and vulnerability are vital component to enhance the adaptation to climate change (IPCC, 2014). Currently, the warmest five years have occurred since 2010 with 2016 and 2017 being the first and second warmest periods ever, respectively (WMO, 2018). Through Equilibrium Climate Sensitivity (ECS) which describes the mean changes in global temperature at equilibrium if atmospheric carbon dioxide concentration is doubled, IPCC have made a number of projections. For instance, with a 95% probability of occurrence, temperature is expected to be higher than 1.5^0C while at 76% probability, temperature is expected to rise between 2 - 4.5^0C with the most probable occurrence of 3^0C (Rogelj et al., 2012). There is also no rule-out of further increases as a probability of 14% suggests that temperatures could rise above 4.5^0C (Rogelj et al., 2012). It has also been projected that temperatures above 1.5^0C could led to significant climate impacts, especially in the agriculture sector and coastal areas (Huntingford & Mercado, 2016). It is against this backdrop that parties at the twenty-first Conference of Parties (COP21) re-affirmed climate mitigation commitments to ensure that increase in temperatures are held well below 1.5^0C or well below the pre-industrial 2^0C level (Schellnhuber et al., 2016; Huntingford & Mercado, 2016).

2.4.2 The concept of vulnerability

Vulnerability is a complex term with multi-definitions and also applied in different disciplines. Hence, Dunford et al. (2014) describe the concept as an ‘abstract concept’ and not related to only environmental issues but also social, economic, cultural,

development and other related fields. The level of vulnerability also differs across systems and geographical locations. In terms of environmental issues, two broad definitions of vulnerability has been provided in the literature (Gerlitz et al., 2016). Firstly, Wisner et al. (2004) defined vulnerability as the function of internal attributes of a system which is responsible for the level at which it undergoes damages due to their exposure to external events. Secondly as provided by IPCC (2014), vulnerability is viewed on three aspects; exposure, sensitivity and adaptive capacity, and defined the term as the 'propensity or predisposition to be adversely affected' by an external shock. Although both definitions have been used in the literature, the second is most prominent (Gerlitz et al., 2016), especially in empirical studies.

Recent applications of the IPCC definition are based on the multidimensional livelihood vulnerability index or the climate vulnerability index which are able to capture several factors responsible for the level of vulnerability of a system. According to Gerlitz et al. (2016), this method provides policy makers with a complete view of vulnerability that would help to spot specific systems or areas for action towards sensitivity reduction and building an enhanced adaptive capacity. Under this method, vulnerability is viewed as a complex interaction of multiple factors, including socioeconomic, environmental and physical factors, that characterised a household and thereby shaping their adaptive capacity. Sonwa et al. (2016) also indicated that the separation of vulnerability into different components helps to know the level and how each component can be resolved, and also improve the ability of people to react to climate change. In general, this method provides clear evidence on components that can and must be addressed through livelihood or natural resource management. Considering the multidimensionality of this approach and the diversity in gender, this approach provides a useful tool in gender vulnerability studies.

Generally, vulnerability assessment have become an important component of climate change analysis and become a necessary step to addressing climate change and other external or internal shocks in a system. This is because having information on vulnerability improves policy decision making on how to design adaptation and mitigation strategies to build systems' resilience to climate change (Opiyo et al., 2014). In other words, it showcase the efficient interventions needed to be implemented in order to help reduce climate impacts. Marshall et al. (2013) acknowledged that understanding climate vulnerability provides the opportunity to design effective actions to reduce the impacts of climate change. The urgency and prioritisation of adaptation actions can be effectively implemented based on the differences in vulnerability levels among groups (Marshall et al., 2014). Although vulnerability is a broad and global concept, local level vulnerability analysis have being a general recommendation in the scientific literature as this will promote local development planning and the design of resilience and adaptation programs at the local level. This approach also provides the opportunity to identify specific areas necessary for intervention in each locality. This recommendation is upheld in this study.

2.4.3 Vulnerability difference across groups and systems

In the broad sense, vulnerability differs among groups, sectors and regions. Olsson et al. (2014) shows that the identity makers and dimensions of inequality include gender, age, race, dis(ability), ethnicity and class. A review by Binita et al. (2015) provided that the most vulnerable groups to climate shocks include the rural communities due their high dependence on natural resources; the ethnic or racial minority; the poorer households, for instance due to the absence of insurance of assets and economic activities; the less

educated people due for instance to their low socioeconomic status; the elderly population and people with health challenges. Thus, in relative terms, the poorer households are more vulnerable to climate change, especially, due to their weak adaptive capacity and high sensitivity to climate and other environmental shocks. Among others, Brouwer et al. (2007) established a positive relationship between the level of poverty, environmental risks and vulnerability and argued that exposure to environmental shocks is in tandem with income inequality and access to natural resources. Thus, higher inequality and less access to resources leads to higher exposure to environmental shocks. Details on the relationship between climate change and welfare is provided in section 2.7.

Opiyo et al. (2014) concluded in their study that specific social, economic and biophysical factors influence the vulnerability of households to climate induced stresses. On the other hand, the resilience of households to climate events or shocks depends on factors including households' characteristics, institutional capacities, economic capacities and natural settings (Tesso et al., 2012). This means that households with weak economic capacities and/or located at a climate sensitive region would be more vulnerability to climate change. This analysis among others suggest that the north of Ghana that is naturally warmer, having lower mean rainfalls and poorer forest cover is much predisposed to climate change than the middle and southern parts. Nkegbe & Kuunibe (2014) for instance clearly indicated that northern Ghana is more risky to climate shocks than the south.

One of the major vulnerable groups with direct relationship with the previous characteristics that defined higher vulnerability to climate change is gender groups, specifically, the women. Therefore, the next section explained the vulnerability in the

context of gender groups and how asset or economic empowerment influences gender vulnerability and resilience to climate change.

2.4. 4 Climate change and Gender

Generally, climate change and its impacts are not occurring in vacuum, instead, it is occurring together with other non-gender blind issues such as social discrimination. This has largely been the main reason for gender inclusion in climate analysis. Ongoro & Ogara (2012) defined gender as the disparities in socially determined roles and opportunities that is linked to the biologically determined sex difference of man and woman, as well as the relations and social associations that exist between men and women. In this study, Ongoro & Ogara's (2012) definition is adopted. Hence, gender in this study is defined as the differences in contribution of men and women to climate change, the impacts and how they respond to these changes.

While existing gender inequalities do not favour women, it is expected that climate change would worsen these inequalities and predispose women further (UNDP, 2012). The mechanisms through which women are most vulnerable include limited access to land resources, financial or credit market and their home responsibilities (Ngigi et al., 2016; Tibesigwa et al., 2015). Nellemann et al. (2011) therefore asserted that the 'voice, responsibilities and knowledge', which defines the opinions of women on climate change has to be heard. In their study, Ongoro & Ogara (2012) provided that present culturally constructed gender roles leads to higher change vulnerability of women, even though women easily adapt using efficient strategies that helps them to effectively cope with the situation. In a review of why gender dimensions are vital in vulnerability analysis, Djoudi et al. (2016) cited a number of reasons including women's higher sensitiveness to health impacts due to household fuel led air pollutions; food provision

roles of women even in the midst of risks and conflicts; non-participation of women in planning of development and adaptive strategies; as well as the general triple roles of women.

Despites women's high climate vulnerability, UNDP (2012) and Huyer (2016) among other studies described them as important agents for change, and that women have special knowledge that can lead to effective and sustainable adaptation to climate change. Thus, while women are most climate vulnerable, they are also most virtuous to the environment. In other words, Arora-jonsson (2011) noted that while women in the tropics are most climate vulnerable than men, women in the temperate zones are most virtuous to the environment than the men. But in both locations, women are less considered in decision making, including climate decision processes. Therefore, the role of addressing gender issues in environmental stability cannot be underemphasized. A gender analysis of climate vulnerability could provide insights into the dynamics and conditions that leads to and perpetuates the gender inequality (Morchain et al., 2015) and identify strategic options to resolve the gaps. Thus, to achieve the global objective of keeping an increase in temperature below 2^0C and reduce its impacts on households, gender inclusive analysis is paramount.

Although women are most vulnerable to climate change, they are not intrinsically attributable to vulnerability but as a result of their systematic marginalisation (Morchain et al., 2015). The implication is that, the social construction of gender has led to their high climate vulnerability and could be resolved through women empowerment, equity, justice and freedom. Such steps include assets development, providing livelihood opportunities and listening to the 'voice' of women on climate and other developmental issues. From Djoudi et al. (2016), female headed households are particularly vulnerable to climate change due to low formal education, absence of reliable non-farm income and

poor social networks. While assets accumulation and maintenance shapes individual's ability to cope with risks and overcome external shocks, women often have low asset levels.

Doss et al. (2011) indicated that assets are a store of wealth, important instrument for higher well-being, enhance the opportunity to generate income, and improves the coping capacities of a household. They further argued that accumulation of productive assets helps the poor out of poverty and reduces women's marginalisation. For instance, financial assets such as income or income sources help households to move from focusing on mere survival to empowerment and improvement of wellbeing (Nazari et al., 2015). Differences in assets exist between men and women even at the same household, leading to gender asset gaps and low adaptive capacities. Evident in Ghana, women are often observed to be holding fewer and less valuable assets than men (Doss et al., 2011). For instance, Doss et al. (2011) found men to have higher ownership of lands, agriculture implements and household durables than women. Opiyo et al. (2014) opined that empowering women, promoting livelihood diversification as well as providing information on early warning are essential to enhance households' resilience to climate change. Beyond doubt, removing gender-based constraints could provide a greater opportunity to reduce food insecurity, poverty and climate vulnerability.

Although the general conclusion that women are most vulnerable, local context analysis of the dynamics is missing (Djoudi et al., 2016), especially the extent of the vulnerabilities and the impact of existing climate response strategies on climate vulnerability. Ghana is not exceptional, especially, northern Ghana where women and children are often observed for instance, walk for several distance in search for water for household consumption. In the next section, a further description of Ghana's climate vulnerability is provided.

2.4.4 Ghana's vulnerability to climate change

As is the case of most African economies, Ghana is highly vulnerable to climate change. Ghana is located at the intersection of the Inter-Tropical Convergence Zone (ITCZ) and the West African Monsoon. Since 1960, Ghana's temperature have increased by 1^{o}C and expected to rise by 1.5^{o}C to 3^{o}C by 2080s (EPA, 2010). However, although there are observed decrease in precipitation, it is still inconclusive on the changes due to its complexity. Twerefou et al. (2015) observed that Ghana have experienced long periods of drought and erratic rainfalls, particularly in the arid areas. Also, see levels are expected to rise in Ghana's water bodies from 0.13-0.60m by the late of 21st century with negative implications on maritime and coastal activities (Stanturf et al., 2011).

Generally, Ghana's vulnerability to climate change is due to three factors and these are high dependence on agriculture; high dependence on hydropower for electricity supply; and high infrastructure deficits such as poor rural road networks, public services and low access to market (Arndt et al., 2015). Thus, the high economic dependence on the agriculture, energy and forestry sectors accounts for Ghana's economic reaction to external shocks (Asante & Amuakwa-Mensah, 2015). In vulnerability mapping study of selected districts in Upper east region of Ghana, Yiran et al. (2016) estimated that the agriculture sector is most vulnerable to drought and increase temperatures, followed by the water and health sectors. Similarly, Yiran et al. (2016) estimated that the agriculture sector is most vulnerable to flood and heavy rains, followed by the health, housing and road sectors. Thus, irrespective of the climate shock analysed, agriculture sector remained the most vulnerable.

Unfortunately for Ghana, the agriculture sector has been the major contributor to the country's Gross Domestic Product (GDP) until 2006 but continues to employ a

significant proportion (42%) of the total workforce. In the rural areas, agriculture continuous to be the major, if not the only source of livelihood for the households. Unfortunately, both the growth rate of crop yields and actual yields of the country are expected to reduce with the changing climate. Arndt et al. (2015) found that climate change could lead to 1.9% reduction of agriculture share to Ghana's GDP by 2050. And this reduction was found to be very high in cocoa sector, the major agriculture export commodity of the country. In addition to cocoa which will record reduction (Arndt et al., 2015; Asante & Amuakwa-mensah, 2015), rice, maize and root crop yields, fish catch are declining over the years as a result of climatic factors.

Despite the poor road infrastructure development of the country (Arndt et al., 2015), existing roads are expected to be negatively affected by climate change. While higher temperatures will lead to cracks, higher precipitation would lead to worsening potholes on the roads (Arndt et al., 2015). This would worsen the challenge of transporting food products from the rural areas to the urban areas. This would lead to high post-harvest losses at the rural areas and higher food prices and shortage at the urban areas. This is an implication of a waning future welfare in the country. Twerefou et al. (2015) estimated that, from 2020-2100, Ghana would need a collective amount of $473 million in maintaining and repairing damaged roads due to climate change. Generally, improving roads would lead to efficient transportation of agriculture products and emergency services and enhance the adaptive capacities of households and the country (Yiran et al., 2016).

Although the country as a whole is vulnerable, there are differences based on the location of the households. Thus, due to the agro-ecological and climatic differences across the country, climate vulnerability is not or expected to be the same all over the country. While the coastal cities are especially prone to the impacts of sea level rise, the

northern parts of the country are prone to increasing temperatures, drought, windstorm and heavy rainfalls which occurs interactively (Yiran et al., 2016). Health related implications of climate change are also observed over the years across the country. The occurrence of cerebrospinal meningitis and malaria may worsen due to increase temperatures and heavy rainfalls, respectively. However, Yiran et al. (2016) argued that the health sector is most vulnerable to higher temperatures and droughts than floods and other climatic hazards. These health implications may worsen wellbeing of the individuals, increase household's health expenditure and put pressure on the government to provide logistic and other health facilities. Fundamentally, agrarian households would realise loss of labour and efficiency of production due to health challenges.

2.5 Theoretical approaches to vulnerability analysis

As indicated from the previous section, there is no universal definition for vulnerability, hence, there is also no universal method for measuring the level of vulnerability of a system. As noted by Hahn et al. (2009), vulnerability assessment is a wide range of methods to systematically incorporate the relationships that exist between human and their physical and social environment. However, from the literature, climate vulnerability assessment can be under two broad methods, the indicator and the econometric methods. The indicator method involves the use of socioeconomic, biophysical and integrated approaches, while the econometric method involves the use of vulnerability as expected poverty (VEP), vulnerability as expected utility (VEU) or vulnerability as uninsured exposure to risk (VER). Depending on the objective and data, different studies have used different approaches to determine the vulnerability of a system. These methods are described in the following sections.

2.5.1 Econometric Approach

Vulnerability and poverty or welfare are directly related. And this observable relationship form the basis for the econometric approach to vulnerability measurement. Klasen & Povel (2013) noted that vulnerability analysis has become prominent due to three reasons. Firstly, vulnerability have negative impacts on the welfare of households; secondly, it is not short term phenomenon but can also lead to long-term deprivation; and thirdly, it shifts focus from ex-post poverty outcomes to ex-ante poverty risks.

The three econometric measures of vulnerability (VEP, VEU and VER) share the same characteristics of building a model to determine the welfare of a system. However, VEP and VEU also share the characteristics of classical poverty measures such as the headcount index. This is because they also involve the determination of a welfare benchmark (referred to as poverty line in poverty analysis) and the individual's probability of falling below this benchmark (Hoddinott & Quisumbing, 2010). The implication is that these two approaches measure vulnerability at the individual or household level. On the other hand, VER do not construct probabilities, therefore, it is only used to measure whether or not observed shocks leads to a deviation in expected household welfare. From Hoddinott & Quisumbing (2010), vulnerability can be defined in all three approaches as $V_h(C_h, I, z_h)$ where V_h is the vulnerability of a household as, , z is the welfare reference point, I is the welfare indicator, and C is the measure of welfare.

2.5.1.1 Vulnerability as Expected Poverty

Ravallion's (1988) work inspired the VEP approach. Ravallion (1988) defined vulnerability as the risk of an economic unit's welfare reducing below a standard level

of living or for those already below the poverty threshold to remain unchanged or further fall below the poverty line. VEP measures the probability that a household's consumption ($C_{h,t+1}$) in the next period will fall below the poverty line. From Klasen & Povel (2013);

$$VEP_{ht} = \Pr(C_{h,t+1} \leq z) \qquad (2.1)$$

Since uncertainty increases with time, the level of vulnerability would also increase with time. Therefore, the extended future period can be given as (Pritchett et al., 2000);

$$V_h(n,z) = 1 - \left[1 - \left(Pr\left(C_{h,t+1}\right) < z, \ldots, 1 - \left(Pr\left(C_{h,t+n}\right) < z\right)\right)\right] \qquad (2.2)$$

However, this neglects the effect of risk sensitivity and do not take into account the severity of the expected poverty. Hence households would exhibit the same degree of vulnerability once they have the same VEP. To resolve this, VEP can be combined with the Foster-Greer-Thorbecke measure of poverty[1] (Hoddinott & Quisumbing, 2003). Assuming $\sum_{i=1}^{N_h} P_{hi}$ is the sum of probabilities of all possible future scenarios faced by household *h*, and an indicator $I_{hi}(.)$ which is defined as one if $C_{hi,t} \leq z$ and zero if otherwise, VEP can be redefined as;

$$VEP_{h,t} = \sum_{i=1}^{N_h} P_{hi} * I_{hi}\left(C_{hi,t+1} \leq z\right) * \left(\frac{z - C_{hi,t+1}}{z}\right)^{\alpha} \qquad (2.3)$$

Hoddinott & Quisumbing (2003) argued that the VEP approach provides three main strengths. Firstly, it estimates a measure that is analogous to poverty severity or incidence. Secondly, it provides the ability to capture more precise information on

[1] The Foster-Greer-Thorbecke (1984) measure of poverty is given as $P_\alpha = \frac{1}{N}\sum_{i=1}^{H}\left(\frac{z - Y_i}{z}\right)^{\alpha}$. Where Y_i is an individual's observed income, *N* is the population, *H* is the number of households below poverty line, z, and α is the sensitivity level. Depending on the value of α, the P_α index can take on different forms. If α = 0, the numerator is equal to *H*, and we get the headcount ratio. If α = 1, we get the normalized poverty gap. If α = 2, the impact on measured poverty of a gain in income by a poor person increases in proportion to the distance of the person from the poverty line.

households. This is because in situations where the poor and the vulnerable to shocks do not share similar characteristics, relying on poverty measures could result in the neglect of a significant proportion of households. Thirdly, data challenges are minimal as cross-sectional data are applicable in VEP analysis.

2.5.1.2 Vulnerability as Expected Utility

The VEP method is deficient in measuring the shortfall below the poverty line and risk-aversion. The work of Ligon & Schechter (2003) have been cited as one that addressed this weakness of the VEP method. Ligon & Schechter (2003) defined vulnerability as the difference between the utility derived from a certainty-equivalent consumption, Z_{CE}, below which a household is vulnerable, and the household's expected utility derived from actual consumption, C_h. Thus;

$$VEU_h = U_h(Z_{CE}) - EU_h(C_h) \qquad (2.4)$$

Where U_h is assumed as a weakly concave and strictly increasing function (Hoddinott & Quisumbing, 2010). Klasen & Povel (2013) noted that this condition makes the VEU approach to account for risk preferences, hence, a better method to capture shock induced welfare loses. Similarly, the VEU_h can be decomposed into three components as the poverty component, the covariate-risks component and the idiosyncratic-risk component. While the first component measures the difference in utility at Z_{CE} and the utility at expected consumption, C_h, the last two components are measures of risks that the household faces. Mathematically;

$$\begin{aligned} VEU_h = {} & [U_h(Z_{CE}) - EU_h(C_h)] && \text{(Poverty compoenent)} \\ & + \{U_h(EC_h) - EU_h[E(C_h|X_t)]\} && \text{(Covariate} - \text{risk component)} \\ & + \{EU_h[E(C_h|X_t)] - EU_h(EC_h)\} && \text{(Idiosyncratic} - \text{risk component)} \qquad (2.4) \end{aligned}$$

Where $E(C_h|X_t)$ is the expected value of consumption that is conditioned on a vector of covariate variables, X_t. Since measurement error may affect the idiosyncratic risks, Ligon & Schechter (2003) reformulated the decomposition to provide vulnerability in utility terms as;

$$\begin{aligned} VEU_h = \; & [U_h(EC) - U_h(EC_{ht})] && \text{(Poverty compoenent)} \\ & + \{EU_h(EC_h) - EU_h[C_{ht}|X_{vt}]\} && \text{(Covariate} - \text{risk component)} \\ & + \{EU_h[E(C_{ht}|X_{vt})] - EU_h(EC_{ht}|X_{vt}, X_{hvt})\} && \text{(Idiosyncratic} \\ & - \text{risk component)} \\ & + EU_h[E(C_{ht}|X_{vt}, X_{hvt})] - EU_h(EC_{ht}) \quad unexplained\ risk && (2.5) \end{aligned}$$

The aggregate measure of vulnerability can be estimated as;

$$\begin{aligned} VEU = (\frac{1}{N}) \sum_h^N \Big\{ & [U_h(z_{CE}) - U_h(EC_h)] \\ & + \big\{[U_h(E(C_{CE})) - EU_h(E(C_h|X_t))] \\ & + \{EU_h(E(C_h|X_t)) - EU_h(E(C_{CE}))\}\big\}\Big\} \end{aligned} \qquad (2.6)$$

The advantage of the VEU measure is that it clearly define the effects of risks, the likelihood and the severity of shocks on household welfare (Klasen & Povel, 2013). Nonetheless, VEU does not also focus on vulnerability to deprivation.

2.5.1.3 Vulnerability as uninsured Exposure to Risk (VER)

Unlike VEP and VEU, VER does not attempt to construct an aggregate measure of vulnerability. Instead, it is an ex-post assessment that measures whether negative shocks on income will affect consumption. The VER can be given as (Hoddinott & Quisumbing, 2010);

$$\begin{aligned} \Delta InC_{htv} = & \sum_i \lambda_i S(i)_{tv} \\ & + \sum_i \beta_i S(i)_{htv} + \sum_{tv} \delta_v (D)_v + \sum_i \delta X_{hv} + \Delta \varepsilon_{hvt} \end{aligned} \qquad (2.7)$$

Where ΔInC_{htv} is the change in log of consumption of a household *h* in community *v* and at time *t*, $S(i)_{tv}$ is the covariate shocks, $S(i)_{htv}$ is idiosyncratic shocks, D_v is community identifiers, X_{hv} is a set of household or individual characterises and $\Delta\varepsilon_{hvt}$ is an error term. The parameter estimates of λ, β and δ provides policy information on the major risk sources that must be considered. The notations $S(i)_{tv}$ can be redefined as the mean rate of average community income growth rate, $\Delta(\overline{Iny})_{tv}$, and $S(i)_{htv}$ as the household income growth rate, ΔIny. Therefore from Hoddinott & Quisumbing (2010), VER involves the use of any of the following four equations;

$$\Delta InC_{htv} = \sum_{tv} \delta_{tv}(D)_{tv} + \sum_i \beta_i S(i)_{htv} + \gamma X_{hv} + \Delta\varepsilon_{hvt}$$

$$\Delta InC_{htv} = \sum_{tv} \delta_{tv}(D)_{tv} + \beta\Delta Iny_{htv} + \delta X_{htv} + \Delta\varepsilon_{hvt}$$

$$\Delta InC_{htv} = \propto + \sum_i \beta_i S(i)_{tv} + \beta\Delta Iny_{htv} + \delta X_{htv} + \Delta\varepsilon_{hvt}$$

$$\Delta InC_{htv} = \propto + \beta\Delta Iny_{htv} + \gamma\Delta(\overline{Iny})_{tv} + \delta X_{htv} + \Delta\varepsilon_{hvt}$$

2.8

Although the four notations include the socioeconomic characteristics of the households, they differ in the particular shocks that are introduced. The challenge of this method is largely about data since it requires panel data and information on both income and consumption.

2.5.2 The Indicator method

The indicator method of vulnerability assessment has been widely applied in the literature. This method includes socioeconomic, biophysical or integrated approaches.

The genesis of socioeconomic vulnerability can be traced to the work of O'keefe and others in 1976 (Stafford & Abramowitz, 2016). This approach considers vulnerability as a starting point analysis and considers sensitivity, exposure and adaptive capacity of the system (Nguyen et al., 2016). It is based on the social, economic and political conditions of the system and measures adaptation based on the internal capacities of the system (Nazari et al., 2015). Generally, the necessary step for climate risks mitigation and emergency preparedness to environmental shocks is to identify the socioeconomic characteristics of the population in order to create vital information. This means that evaluating a system's social vulnerability to an environmental stress is an important component of adaptation. Stafford & Abramowitz (2016) outlined several methods of measuring social vulnerability, although principal component analysis and cluster analysis are two of the widely applied methods. Marshall et al. (2014) for instance used the cluster analysis method and classified primary resource users into different typologies and found specific factors responsible for the vulnerability of each type of producer. In an empirical analysis, Shukla et al. (2016) observed higher social vulnerability for communities with no local institutions, poor infrastructure and high dependence on agriculture. Similarly, Brouwer et al. (2007) used this approach and found that the level of vulnerability differs across economic levels, hence recommended the need for policies that could reduce economic inequality. One advantage, also a limitation, to this approach is that the selection of indicators for adaptive capacity and sensitivity is context based, thereby, allowing greater flexibility to analysts.

The second approach is the biophysical vulnerability approach which is largely centred on the degree and exposure to natural hazards, and how human settlements are distributed along these hazardous areas and their response strategies. This approach captures vulnerability as an end-point analysis and based on exposure and sensitivity

(Nguyen et al., 2016). The approach measures the extent of damage caused by an environmental stress. Therefore, this has become the major limitation of the biophysical approach (Nazari et al., 2015).

The third approach is the integrated approach and this combines both the socioeconomic and biophysical approaches. The approach addresses the separate limitations of the two and provide a more policy relevant vulnerability assessment (Nazari et al., 2015). However, this approach is not without a limitation as there is no standard for combining the socioeconomic and biophysical approaches to form the vulnerability level of the system. This present study relies on the integrated approach to measure the vulnerability of the households.

The essential steps in the indicator method is the selection of indicators to be included in the analysis, normalisation and aggregation. This procedure also includes weighting of the indicators, using equal weights, expert judgement or statistical methods. Due to the influence of each weighting method on the calculated vulnerability index, this study used both the equal weighting and the statistical method to cross-validate the vulnerability index and provide more policy relevant results. However, beyond aggregation, the vulnerability indices can be mapped for visualisation.

2.5.2.1 Construction of indicators for vulnerability

Under the indicator approach, one essential step is the selection of 'indicators' to be used in constructing the vulnerability index. This selection process is either data driven or theory driven. However, any indicator selected can be placed under the adaptive capacity, sensitivity or the exposure of the household to a climate shock.

The adaptive capacity is the ability of a system to adjust to climate change, variability or shocks in order to reduce the potential negative consequences associated with the changes; take opportunity of the changes in order to improve the system; or the ability to cope with the changes (Maiti et al., 2017; Nguyen et al., 2016). In general, lower adaptive capacity leads to higher vulnerability and vice versa. Adaptive capacity is an essential component as it provides policy makers with strategies suitable for enhancing the system's resilience towards climate change (Nguyen et al., 2016). In their study, Maiti et al. (2017) constructed adaptive capacity based on livelihood assets (physical, human, natural, social and financial assets). In a review, Nguyen et al. (2016) outlined a number of indicators used in constructing adaptive capacity and these includes demographic structure such as education, age and dependency ratio; socioeconomic characteristics such as employment, poverty (or GDP at macro studies) and human development index; technology and other assets such as natural resources. A number of other indicators have also been outlined in other studies (Shukla et al., 2016; Gerlitz et al., 2016; Nazari et al., 2015; Panthi et al., 2015; Opiyo et al., 2014).

Sensitivity is the degree to which a system is adversely or beneficially affected by climate change or variability (Nguyen et al., 2016). This is defined largely by the ecological and socioeconomic conditions of the system and the effects can be direct or indirect. Vulnerability is directly related to system's sensitivity, therefore, systems that are highly sensitive are more like to be highly vulnerable. Maiti et al. (2017) noted that sensitivity can best be measured as changes in income or livelihood although largely due to climate change. Livelihood activities that directly depend on natural resources such as crop production and livestock rearing are more sensitive to climate change than others such as salary jobs, remittance and non-farm skilled jobs. In a study by Panthi et

al. (2015), water, food and health sector specific variables were used to construct the sensitivity of households; and this is adopted in this present study.

Exposure is the presence of a system in an area that could be adversely affected by climate change (Nguyen et al., 2016). It is the extent to which a system encounter with changes in an environmental stress, either in terms of frequency, intensity, magnitude or a combination. In empirical analyses, changes in variables such as precipitation, minimum and maximum temperature, flood and droughts or perceptions at micro levels have being used to construct the exposure of a system to climate change.

2.6 The concept of livelihood and interlinkages with food security

The concept of livelihood is widely used in the literature. It is the way to achieving a well-being. Livelihood strategies are the diverse activities people engage in for a livelihood outcome. According to Chambers & Conway (1991), livelihood is the set of capabilities, assets and activities that are needed for a living. Therefore, a livelihood is sustainable if a livelihood is able to recover or withstand stress, maintain or improve assets, provides livelihood for future generations and leads to net benefits on other livelihood activities in the short to long term. In other words, sustainable livelihoods are the activities that can avoid, resist, cope or reignited after a shock or a stress (Chambers & Conway, 1991). Livelihood can also be described as a private response to reducing vulnerabilities. These definitions shows that livelihood is not merely an outcome (income) but the ways to attaining the outcome. Chambers & Conway (1991) put livelihood sustainability under two categories as environmental and social sustainability. The authors defined environmental sustainability as livelihoods that provides a net positive effect on the entitlements and access that are required by other people. Social

sustainability requires that livelihoods do not only lead to a gain to only the households but also, are able to maintain an adequate and a decent living for the larger community. A number of factors determines the specific livelihood that a person engages. These factors include environmental factors such as climate change, variability and shocks or socioeconomic factors such as the education and prevailing livelihood opportunities in a locality.

Climate change affects the livelihood of both the rural and urban households but more prevailing on the rural population. Rural livelihoods depend on natural resources for agricultural activities which have high possibility to alter due to changing climate (IPCC, 2014). Thus, livelihood is dynamic and households change their livelihood as a way of adaptation to both internal and external stressors. These stressors are in multiples (climate, socioeconomic and environmental) and interact with each other to influence livelihood decision making (Olsson et al., 2014). Olsson et al. (2014) indicated that climate change affects the poor directly through the impacts on their livelihoods and that this leads to shifts in rural livelihood with mixed outcomes. Asfaw et al. (2016) distinguished between push and pull factors that drives livelihood diversification. Push factors refers to constraints that force households into diversification while the pull factors are those existing opportunities for diversification. Other authors cited in Asfaw et al. (2016) provided that livelihood diversification is a thoughtful approach that households used in smoothening their incomes and or managing risks and shocks; hence climate risks push household into diversifying their livelihoods. Therefore, uunderstanding the complex drivers of livelihood strategies would enable policy makers assess how people are pushed into worse or better well-being.

IPCC (2014) report indicated that, to determine the impacts of climate change/variability on rural households, the economic heterogeniety that exists among

farm household's and social relations have to be examined. For instance, livelihood diversification differs among males and females, which means that the associated impacts or gains from these different livelihoods may also be different within the groups. Rahman & Akter (2014) argued that women are most vulnerable in the labour market since they are less likely to engage in agricultural, wage and non-agricultural livelihood choices, leading to their significantly lower incomes. However, the literature have less analysed the specific factors that influence males and females decision into each livelihood strategy and the impacts thereof on gender inequalities, particularly, climate vulnerability, crop production and welfare.

2.7 The concept of Food security

One of the main sustainable livelihood outcomes is food security. Food security is a complex concept that goes beyond food production. Food security is defined as 'a situation that exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life' (FAO, 2015b, p.53). Hence, food security is defined based on four dimensions as food availability, economic and physical access, food utilisation and stability of food over time (FAO, 2015b). On the flipside, food insecurity occurs when 'people lack secure access to sufficient amounts of safe and nutritious food for normal growth and development and an active healthy life'(FAO, 2015b, p.53).

Although global undernourished population decreased from 18.6 percent in 1990-92 to 10.9 percent in 2014-16, progress have being slow in SSA (FAO, 2015b). Food insecurity can be chronic or transitory. Chronic food insecurity implies a persistent

inability of a household to access adequate food and generally arise due to inadequate access to resources (assets). On the other hand, transitory food insecurity is temporal and as a result of shocks, economic failures and human induced or natural disasters. This means that climate change may induce transitory food insecurity and if unchecked, would lead to chronic food insecurity. As in FAO (2015b), increasingly extreme weather events and natural disasters, political instability and civil strife are hampering efforts to achieve food security in areas such as SSA.

2.7.2 Gender (in)equality in agriculture

The literature on gender and development provides compelling evidence that enough information cannot be provided if men and women in agriculture are considered as a single unit (Carr, 2008). Women proportion in agriculture varies from country to country but averagely contributes 43 percent to global agricultural labour force. Unfortunately, the average output per land area is generally lower for women than for men. But this cannot lead to the conclusion that women are less productive. This is because gender productivity differences are not based on the ability or inability of women to operate farms, instead, due to a number of factors including resource discrimination (Croppenstedt et al., 2013). Also, women engages in less productive and low earning activities such as small farms or farming on marginal lands (C. R. Doss, 2018). These phenomena among others describe the productivity trap of women that results in welfare loses, and low economic empowerment of the women. Gender differences in productivity are not systematic but persistent and arise mainly due to time use, access to productive resources and market and institutional factors (Campos et al., 2016; Ali et al., 2016; Aguilar et al., 2015). Nonetheless, women are not worse farmers than men, therefore, productivity gaps vanish when access to land, productive inputs

and scale of production of women are addressed. A review on SSA pointed out that gendered productivity gap ranges between 4-40%, but centered around 20-30% (Kilic et al., 2015). In Ghana for instance, productivity (yield) gap in cocoa production is around 17 percent.

Although women's involvement in agricultural activities is improving, this is occurring at a slower pace as women are still observed cultivating staple crops while men cultivate more cash crops (Doss, 2002). In most areas where cash crops are less distinctive from staples, men's production (output) often sold in the market while women's output are directly used for home consumption. Doss (2018) explained that since women have less access to the market, it is rational for them to produce lower value crops for domestic consumption. This suggests that correcting market conditions may not necessarily eliminate gender gaps in food production. Carr (2008) argued that men and women cultivate different crops or same crops for different purposes and this leads to differences in their vulnerability to climate change and changes in global crop markets. Generally, the differences in the types of crop grown by men and women is due to social and cultural norms, differences in access to information, technology, market and production inputs (C. R. Doss, 2018).

2.7.3 Relationship between climate change, food production and food security

Food security remained a global concern and has been given recognition in the SDGs, SDG 1. Current figures shows that 33.7 million people are undernourished in West Africa (FAO, 2015b). Although Ghana ranked third to South Africa and Botswana on the Global Food Security Index among SSA countries, food security still remain a developmental priority especially in the northern parts of the country (Osarfo et al., 2016). One out of every five persons live in food insecurity in these parts of the country

(Biederlack and Rivers, 2009 cited in Nyantakyi-frimpong & Bezner-kerr, 2015). In any case, ensuring sustainable provision of food is a 'precondition for sustainable human development' since it strengthens human capabilities (Conceição et al., 2016). Aside capabilities, Conceição et al. (2016) also indicated that entitlement or command over resources and production possibilities influences the state of food security. Several challenges limit the country's ability to meet a food secured world. One of such challenges is climate change and this has been stated by scholars over the past decades (Haile et al., 2017; Ye et al., 2013). The net effect of climate change on food production is negative. Therefore, climate change have become a developmental challenge due to its effect on crop production and general food security. Haile et al. (2017) projected that climate change could reduce crop production by 9% in 2030 and as high as 23% in the 2050s. Earlier studies such as Parry et al. (2005) also observed that food security risks in Africa are worsening under changing climates and that natural variability induced changes in global food production could be over 50% in 2080s. The challenge is how to reduce the risks of climate change on food security since the projections of climate impacts shows a worsened future (Campbell et al., 2016). In most economies, especially, developing economies like Ghana, crop production is predominantly rainfed. This imply that changes in rainfall patterns (timeliness, intensity or duration) have a direct effect on production outcomes while the prevalence of poverty reduces the adaptive capacity of the farmers (Wossen et al., 2017).

The overall food system is or can be disrupted by climate variability and food access and utilisation are all affected by the climatic condition (Wheeler & Braun, 2013). In addition to the supply side effects, climate change and variability have effects on demand side through price mechanisms such as volatility (Wossen et al., 2017; Haile et al., 2017) and income levels of the farmers. These price changes could alter production

or consumption behaviour of households. Therefore, the ability of the market to regulate food demand and supply is negatively affected. Relatedly, deteriorating agricultural activities could worsen rural-urban migration that will worsen urban challenges (Serdeczny et al., 2016) and increase food unavailability and prices. Nonetheless, the review of Wheeler & Braun (2013) showed that climate change effects on food security is largely on food availability.

Generally, climate change is expected to affect agriculture in four major ways as directly through increased carbon concentration, changes in climatic averages, altered weather and weather events; and secondary effects on social and economic systems (Downing, 1993). These effects of climate change on food security is manifested through changes in rainfall, temperature, sea level rises and wind storms that manifest themselves into shocks such as drought, flood, and pests and diseases prevalence (Figure 2.1). Precipitation changes results in floods or droughts and this can prevent farmers from cultivating the lands or reducing their crop yields (Haile et al., 2017). On the other hand, temperature changes increased evapotranspiration, reduce soil moisture and increase agricultural pests and their resilience, thereby, affecting crop yields. However, the relationship between crop production and increased temperatures assume bell-shape, therefore, temperature only affects crop production after a critical level (Haile et al., 2017). This is not the case for rainfall, therefore, rainfall is a major climate determinant in agriculture.

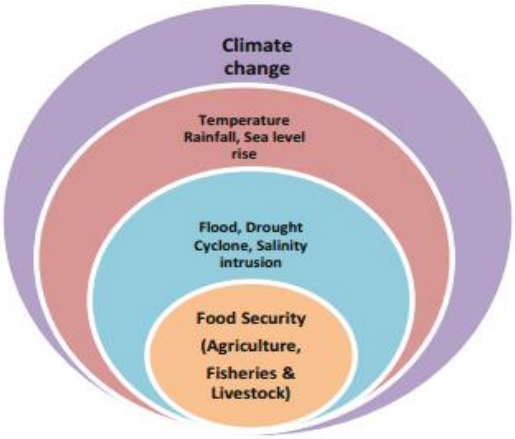


Figure 2.2: Effects of climate change on food security
Source: Habiba et al. (2015)

2.7.4 Livelihood diversification and food security

Rural livelihood is centered on producing to first meet household's food needs. Therefore, households would achieve this by a combination of strategies that can maximise their objective. As a response to environmental and economic changes, agrarians engage in diverse livelihood activities to ensure constant ability to obtain food. The effect of livelihood diversification have being established in the literature (Makate et al., 2016; Osarfo et al., 2016; Tsiboe et al., 2016). The effects of livelihood diversification on food security can be seen through risk distribution among alternative crops, effective labour allocation and financing of crop production through off-farm activities. Nonetheless, the most vital aspect of food security to analyse when dealing with rural households are the means by which they produce food to feed themselves and generate income for other consumption purposes. Empirically, Osarfo et al. (2016) noted that diversification is one way of reducing food insecurity among households in northern Ghana and also estimated that non-farm diversification have a positive significant effect on household's food security. However, the authors argued that policies aiming at ensuring food security should not only emphasize on food production

measures but also, livelihood diversification opportunities should be created for the households to generate supplementary incomes.

Different livelihood diversification options have varying effects on improving crop production. Similarly, the drivers and effects of diversification are not gender neutral. For instance, women were found having a higher chance of engaging in non-farm work, while, food availability is improved for farm households with non-farm businesses but worse-off for those farm households who engage in non-farm wage employment (Tsiboe et al., 2016). The fallouts from low yield as a result of climate change are largely experience by women, therefore, to build climate resilience, social differentiation factors needs to be considered (Nyantakyi-frimpong & Bezner-kerr, 2015). Generally, Campbell et al. (2016) concluded that researches that can provide ways of reducing food insecurity should be enhanced. One of such measures (research area) is to focus on livelihood outcomes in line with climate vulnerable groups.

2.8 Concept of poverty and welfare

Poverty is a multidimensional concept. Poverty and welfare are flipsides. The higher the poverty, the lower the welfare and the lower the poverty, the higher the welfare. Therefore, the poor have less welfare and the rich have higher welfare. Poverty has been defined in several contexts. However, World Bank's definition of poverty as the 'pronounced deprivation in well-being'(Haughton & Khandker, 2009, p.1) and Sen's argument that the status of a person either poor or rich is defined by the persons 'capability to function' (Todaro & Smith, 2012, p.6) are common. Therefore, combining these two definitions, the poor are those who lacked the capabilities to live a meaningful life. Measuring poverty is a good exercise as it helps to identify the poor and the

appropriate interventions required to ameliorate their plight. Similarly, recent changes in global poverty indices requires that inequality, shared prosperity (the distribution of welfare over population) and vulnerability (the risk of falling into poverty in the future) are given attention in poverty analysis and poverty policy making.

Due to the complexity and wide application in different contexts, there is no universal method for measuring welfare or poverty. However, the two broad methods are the monetary (welfarist) and nonmonetary (nonwelfarist) methods. Under monetary methods, income or consumption expenditure are widely used while a set of indicators are constructed to form the nonmonetary welfare index. Each approach has its merits and demerits. Therefore, the choice of one method over another in empirical analysis should be given justification.

For the monetary approach, consumption expenditure and income are often used. However, the consumption expenditure is more realistic to income. Often, income understates welfare since people tend to forget or unwilling to provide their income in order to invade taxes or due to illegal nature of activities, difficulty of calculating income in situations such as farm income (Haughton & Khandker, 2009a) and the possibility of zero income during survey periods (World Bank, 2016). World Bank (2016) noted that consumption varies less and displays smoother patterns, as such, a better measure of welfare in developing countries. This study therefore used consumption expenditure to measure the welfare of the households. In the following sections, the effects of livelihood diversification and climate change as well as gender differences in welfare are discussed.

2.8.1 Livelihood diversification and welfare

Diversification involves providing other alternatives to full-time employment or engaging in multiple economic activity portfolios. Primarily, the aim of diversification is to provide a well-meaning and sustainable survival for individual or households. Thus, diversification have implications on poverty reducing policies (Ellis, 2000). Lama (2014) provided that diversification can be as a result of the need to invest surpluses from existing activities. From Ellis (1998), while some scholars describe diversification as a transient phenomenon, others hold the view that diversification cannot be so transient but connected with livelihood security realisation. There is also difference in views on diversification as a deliberate strategy (choice) versus diversification as an involuntary (necessity) response to negative events. Others differ on diversification as having positive gains on farm productivity versus diversification having negative effects on farm production. This study would provide evidence on the latter controversy in northern Ghana. Similarly, various studies in Ellis (1998) provided that livelihood diversification involves a number of 'self-bounded arenas' which can overlap. These arenas include rural poverty, household risks strategies, household coping strategies, rural nonfarm activities and rural-urban migration.

Livelihood diversification provides welfare insurance to households against shocks. Also, households engage in diversification to accumulate more capital, income or welfare. Similarly, distressed households, either due to poverty or vulnerability to environmental shocks, could engage in multiple livelihoods to lift-up themselves from these distresses (Kassie et al., 2017). Therefore, different diversification strategies may be pursued for specific purpose. But the general implication is that any purpose of diversification satisfied welfare improvement objective; hence the primary objective of livelihood diversification.

From Gautam & Andersen (2016), diversification improves household's coping capacities to environmental stress, enhance household's income as well as ensuring that income or consumption are sustainable. Osarfo et al. (2016) estimated that nonfarm diversification leads to increasing welfare and smoothens the income or consumption of households in Ghana. The authors concluded that although non-farm activities cannot be a substitute to farming, the former provides a reliable compliment to the latter. Similar findings were obtained by Zereyesus et al. (2017) where non-farm activities were found to lead to higher future expected food consumption expenditure and reducing vulnerability to food poverty. These justified the need to enhance non-farm opportunities among households and reduce diversification entry barriers (Zereyesus et al., 2017; Osarfo et al., 2016). Intuitively, non-farm diversification does not only provide direct effect on welfare through income mobilisation but also, through effects on resource mobilisation for agricultural activities and improve technology adoption. The absorption of unemployed people into the non-farm sector also reduces unemployment, providing income for these individuals, reducing poverty and fostering economic growth. Lama (2014) argued that the rural non-farm sector is viewed as solving the twin problem of unemployment and poverty, easing income inequalities and moving rural dwellers from merely subsistence levels. These demonstrate the macroeconomic benefits from households' diversification decisions. Non-farm activities provide the opportunity for structural transformation of the economy from agriculture base to industrial base (Lama, 2014).

The effects of non-farm activity on household welfare is not an isolated finding as Birthal et al. (2015) also estimated that crop farming households who diversify into high valued crops are able to escape poverty. Therefore, aiming at interventions that offer opportunity for diversification would ultimately lead to improved welfare (Asmah,

2011). Nkegbe & Kuunibe (2014) recommends that in order to enhance the welfare of households, livelihood diversification options that are not directly affected by climate change should be promoted.

The mixed effects of different diversification options on wellbeing still remained an issue to be addressed. This was recounted by Perz (2005) where they argued that agricultural diversification options may lead to unique level of effects on wellbeing from diversification into non-agricultural strategies. Therefore, it is unclear whether different diversification strategies would lead to same welfare outcome. Depending on which diversification strategy is pursued by the household agent, outcomes from such strategies could be invested into other forms of livelihood opportunities available to the agent. Asfaw et al. (2016) argued that although diversification is a welfare increasing strategy, the final effect of diversification on welfare depends on the weight of push and pull factors since diversification from push factors leads to lesser welfare while diversification due to pull factors leads to improved welfare.

2.8.2 Climate change impacts on welfare

Globally, poverty levels are on the decline since the last three decades. However, almost a million remained extremely poor and over one billion are poor (FAO, 2015a). Global progress has not been even as nearly half of SSA population, particularly in the rural areas are extremely poor (FAO, 2015a). Unfortunately, the pathways out of poverty are not smooth, and many non-poor (in addition to the poor) households are vulnerable to poverty in events of shocks (FAO, 2015a). Climate change affects both the income and non-income components of welfare. These effects can be direct or indirect. The effects of climate change on income are largely due to productivity loss and decline or loss of

assets. On the other hand, non-income components of welfare such as health and education are affected through diseases, death and loss of labour. In addition, climate induced conflicts and migration affects education and peace among households.

Building resilience to all forms of shocks is negatively affected with increasing climate change and shocks. Climate change exacerbates existing levels of poverty, inequality and wellbeing; hence, climate change is described as a 'threat multiplier' (Olsson et al., 2014, p.802). Inequality and wellbeing are also described as the most salient conditions that determines climate vulnerability (Ribot, 2010 in Olsson et al., 2014). Similarly, Asfaw et al. (2016) concluded that climate variables are important factors that affects expected per capita consumption as well as its variance. In northern Ghana, climate variability has been found to negatively influence household welfare and farm income (Nkegbe & Kuunibe, 2014) and this impacts are worst in the north savannah zones (Arndt et al., 2015). Arouri et al. (2015) also estimated that natural disasters, specifically, floods, droughts and storms have negative effect on household income and consumption expenditure and increases the probability of becoming poor.

The high dependence of rural households on agriculture and their high poverty levels provide increasing concern on the impacts of climate change on household's welfare. The negative implications of climate related shocks on household welfare and economic growth are gaining more prominence. Unlike idiosyncratic shocks that are individual related, covariate shocks such as droughts and floods have effects on entire communities and have long lasting impacts on the poor. There are increasing evidence suggesting that climate variability and change would worsen the vulnerability of the poor households, thereby worsening incidence, severity and persistence of poverty in developing countries and hindering global poverty reduction efforts (Skoufias et al., 2011). The impacts of climate change on welfare are particularly pronounced among the

poor since their adaptive capacities are low, and they highly depend on natural resources for agricultural activities and spends large share of their income on food. These explains why the agrarian communities are more vulnerable to poverty under the changing climate. However, the urban and industrial sector also suffers through productivity loss of farmers as food and raw materials become scarce and expensive.

Macro level analyses such as Elshennawy et al. (2016) shows that economic growth and poverty reduction prospects in the developing countries are at risk considering the potential threats of climate change. On their part, Skoufias et al. (2011) indicated that information on climate-output and poverty-output elasticities needs to be first obtained in order to address the impacts of climate change on poverty.

2.8.3 Gender welfare gap (inequality), growth and development

Gender inequality exists globally, although more pronounced in poor countries than rich countries (Jayachandran, 2015). It is a major concern for most developmental organisations. The paradigm of gender in global discussions have changed over the years with recent connotation such as gender and development. Thus, gender issues do not only affect growth but also development. The discussions in recent gender paradigm can be summarised under two considerations (Kabeer & Natali, 2013). Firstly, the negative implications of gender inequality in resource distribution and opportunities on women's welfare and human rights. Secondly, other developmental goals can best be achieved through addressing gender inequality. While some scholars document the existence of gender inequality, others also provided evidence that poverty reduction, agricultural productivity and general welfare can be improved through gender equality (Cuberes & Teignier, 2014; Kabeer & Natali, 2013). There are valid concerns on the role of gender inequality on economic growth and effect of economic growth or

underdevelopment on gender inequality (Jayachandran, 2015; Kabeer & Natali, 2013). The effect of gender inequality on economic growth is valid due to its implications on changes in per capita output through market participation on one hand and on the other hand, its effects on fertility and capital accumulation that influences long term equilibrium of per capita output (Cavalcanti & Tavares, 2015). Labour market discrimination have remained a central reason for gender welfare differences. Historically, this discrimination does not only lead to lower income for the vulnerable group but also leads to higher income for the majority group (Oaxaca & Ransom, 1994). Glass ceiling, occupational differentiation, less working hours of women due to reproductive duties as well as characteristic differences such as education explain bits of this gender welfare inequality.

Empirically, Cavalcanti & Tavares (2015) conducted a benchmarked and counterfactual analysis and indicated that, in a steady state, 50 percent increase in gender gap can lead to 35 percent decrease in per capita output. This implies that, per capita output can be improved by addressing gender barriers in labour markets. FAO (2011) also reported that over 100 million people could be distant from poverty by providing equal access and control of resources to women. CARE (2014) argued that gender inequality is the root cause of poverty and that sustainable development can only be achieved through resolving climate change impacts while climate change cannot be resolved without addressing poverty. Thus, addressing gender inequality is focal for sustainable development in the midst of environmental changes. Similarly, authors in Arouri et al. (2015) argued that households with inappropriate redistribution of income suffers high welfare losses due to natural disasters and these losses may occur for several years.

2.9 Literature conclusions and potential literature gaps

Climate change is real and evidence on the phenomenon is increasing. Similarly, vulnerability and impacts are not universal as such, agrarian communities and women are some of the most vulnerable groups to climate change impacts. These differences are not systematic, hence, can be resolved. From the review also, it has been observed that empirical studies on agrarians should consider households as social units and not economic units since vast differences exist among households in the latter and observed differences in the former also perpetuates the latter. The consideration of households as social units implies that the economic considerations are included. The SLF provide a comprehensive conceptual and theoretical analysis of the social units with implicit integration of economic units. It also offer a tool for identifying the pathway for improving standards of living in a changing climate.

Although women have been reported as most vulnerable to climate and economic shocks, the effect of climate adaptation for instance through livelihood diversification have not being studies. Considering the importance of climate adaptation, this lack of information may have a negative implication on effective gender climate policy formulation.

The literature provided that the net effect of climate change on food security is negative. More generally, achieving food security (or higher yields) and improved welfare are the prime concerns for development, especially, rural development. But these are negatively related to climate change. To offset these losses, there is the need for climate adaptation. One of the major climate adaptation identified in the literature to improve food production (food security) and the welfare of households is livelihood diversification. The research on the effect of livelihood diversification on welfare abounds. However,

these studies have failed to consider gender differences in their analysis. Hence, there is no information on the role of livelihood diversification on gender inequality (food production and welfare) among the households. Clearly, policy decision making on steps to achieving sustainable development without availing to this information may failed or less successful. In conclusion, the reviewed studies generally appeared to be interested in knowing whether or not there exist gender inequalities with no interest on how climate adaptation strategies could influence the identified inequalities. Therefore in this study, the gender inequalities were first identified and the impact of livelihood diversification on these inequalities estimated. This is believed to provide a more complete information to policy makers and improve the literature on gender inequality especially within climate change context.

CHAPTER THREE

METHODOLOGY

3.1 Introduction

This chapter provides information on the study area, sampling design, data collection and data analysis.

3.2 Study area

The study was conducted in Ghana, particularly the guinea and sudan savannah zones of the country. These zones largely stretched the Upper East, Upper West and Northern regions of the country, accounting for 41% of the total land mass of the country (Figure 1) (as at the time of study design, there are ten regions in Ghana although there are sixteen regions currently). The area is located within latitude 8^0-11^0N and longitude 0^0-3^0W. As at the last general housing and population census in 2010, the three regions had a total population of 4,228,116, representing 17.1% of Ghana's total population. The average population growth rate of the region is 2.0%, lower than the national population growth rate of 2.5% (GSS, 2012a). Using these information, the expected population of the region by 2019 is 5,061,974[2].

Unlike the southern and middle zones of Ghana, the northern zones experiences a unimodal rainfall pattern. The rainfall in the regions range between 916mm to 1,169 mm. The soil pH is within 4.5-6.8 with about 0.5-2.5% organic matter (MoFA, 2013). Agriculture is the main economic activity, employing 71.9% of the economically active group; the three northern regions has the highest proportion of agricultural households and far above the national average of 45.8% (GSS, 2014a). The region produces a wide

[2] *Calculated using* $P = P_0 e^{rt}$,
where P is current population, Po is population at 2010, t is years (6) and r is population growth rate (2%)

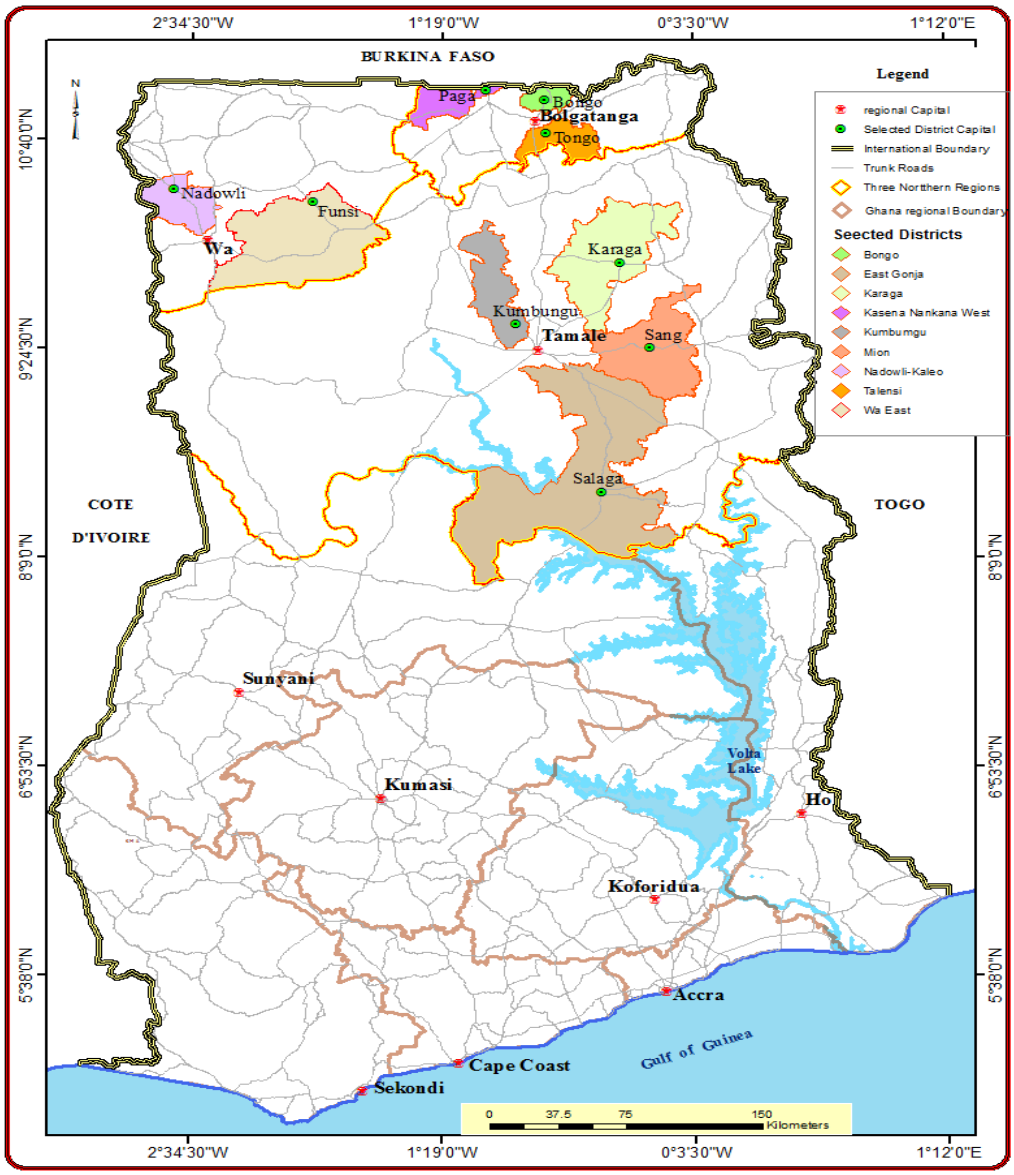
range of food crops, notably, maize, rice, millet, groundnut, sorghum and yam. Unlike in the forest belt where cocoa and palm trees are major cash crops for farming households, shea nut trees which is the main cash tree crop in the north is less developed. However, its location as the gateway to the Sahel region provides opportunity for international trade of food and non-food commodities.

Although the region has less forest cover, its biodiversity especially in terms of tree population is decreasing over the years especially due to logging and charcoal burning. The region is much risky to climate change than other regions of Ghana. Evidence suggests that there are increasing periodic floods, droughts and wind storms that continue to destroy properties and lives in the region. Nkegbe & Kuunibe (2014) explained that although climate change affects the entire country, the physical and economic vulnerability of the northern part makes households in these area most vulnerable to climate change. The high climate vulnerability of northern Ghana is based on the following:

1. The region has weak infrastructure and development than the other regions;
2. Poverty levels and inequality have always been higher in the three northern regions (55.17%) than all other regions and the country as a whole (24.2%) (Lu & Horlu, 2017; Osei-Assibey, 2015; GSS, 2014a).
3. The region has the largest rural population. Relatedly, agriculture employs more people in the region than elsewhere (GSS, 2014a).
4. The region is located farther from the southern hemisphere, which means that the region is naturally warmer than the southern parts. The implications are long dry season associated with difficulty in food and water access (Osarfo et al., 2016). Similarly, unlike the southern parts where there is

bimodal rainfall, the northern regions have a unimodal rainfall, thereby creating a lot of idled agricultural labour periods.

5. Although statistical evidence is less available, it is observed that gender discrimination is much higher in the northern part of Ghana than in the south. By culture, household assets belong entirely to the males. Although this is similar across the country, the trend seems changing faster at the middle and s



an the northern part.

Figure 3.1: Map of Ghana showing the study area (the three northern regions)

3.3 Population and Sampling

3.3.1 Target population

The study population is maize farming households who cultivated maize in the 2016 cropping season and located in the three northern regions. The data on maize farming population is unavailable. However, 71.9% of active workers in the region are into agriculture. Since maize is the primary staple crop produced in the region, it is assumed that all these households formed the proportion of households into maize farming.

3.3.2 Sample determination and sample size

Sample size determination is pivotal for any survey research. An adequate procedure to obtain the required sample is therefore an essential component for a research. The limitation in this study however is that the population of maize farming (or general farming) households of the northern region is unknown. However, relying on the approximately 72% agricultural households' proportion and calculating the sample through single population proportion approach (Cochran, 1977; Tessema, 2017), the sample for this study was determined by:

$$n = \frac{z^2 * \hat{p}(1-\hat{p})}{\varepsilon^2} \tag{3.1}$$

Where z is the z score, ε is the margin of error, $\hat{p}$ is the population proportion. Given a proportion of approximately 72% of farming households in the three northern regions of Ghana; a 95% confidence level that the estimated sample reflects the true sample if the actual population was known (given a Z score of 1.96); and a 5% margin of error, the sample was obtained as follows:

$$n = \frac{1.96^2 * 0.72(1-0.72)}{0.05^2} = 307 \quad (3.2)$$

Therefore, a minimum of 307 maize farming households must be selected for this study. However, this was adjusted to 432 farm households to offset the lack of actual data on the maize farming population. Also, a wife of 57% of the sampled male household heads, given 187 female spouses were considered into the sample. Therefore, the total sample becomes 619.

3.3.3 Sampling design

From the population, the sampling frame of the study are the maize farming households but the sampling unit are the maize farmers who cultivated maize in the 2016 cropping season and have also reside in the community for at least ten years. The study used a multi-stage sampling procedure in the selection of the respondents. A multistage sampling procedure as the name suggest, involves the combination of different forms of sampling procedures. Thus, it involves a step-by-step procedure of obtaining the sample. This method is flexible and mostly used for cross sectional survey.

Firstly, the three northern regions out of Ghana's ten (at the time of sampling) administrative regions were selected purposively due to their high climate vulnerability, high poverty levels and gender differentials (as described in the study area). Also, maize crop farmers who have resided in the region for ten years or more were purposively selected due to the high impact of climate change on their livelihood, the fact that it is the first staple crop cultivated and consumed by almost every household in the country and the need for farmers to tell historical changes in climatic conditions of their communities. In the second stage, stratified sampling was used to put all districts in each of the three regions into three strata. Stratified sampling allows for the division of

the sampling frame into homogenous and non-overlapping sub-groups and then a sample is drawn from each stratum. Using poverty maps from GSS (2015), the strata for this study includes the poor, middle and rich class districts. The poverty maps were used because poverty status is a primary determinant of the socioeconomic of the households and their respond to climate change. Simple random sampling was then used in selecting one (1) district from each stratum in each region. However, an additional one district was selected in the rich class stratum of the Northern region to replace that in Upper West region. The selected districts include East Gonja (poor class stratum), Mion (middle class stratum), Kumbungu (rich class stratum) and Karaga (rich class stratum) in Northern region; Bongo (poor class stratum), Talensi (middle class stratum) and Kassena Nankana East (rich class stratum) in Upper East region; and Wa East (poor class stratum) and Nadowli-Kaleo (middle class stratum) from Upper West region. Also, using simple random sampling approach, three communities from each district were selected, given a total of 27 communities from the three regions. In the third and also the final stage, stratified sampling was used to put the sample frame from the selected communities into two groups; female and male headed household. From the 2010 population census, 23% of the household in the three northern regions were headed by females while the remaining 77% households were headed by men. Although this does not indicate maize farming households' distribution, it is the best available information to guide the sample proportion determination. Given that 432 households were sampled and using proportion allocations, a total of 324 male heads and 108 female heads were selected. As indicated earlier, 187 female spouses were also selected from 57% of male headed households to account for intra-household gender differences. The sample distribution is shown in Table 3.1.

Table 3.1: Sample distribution

Sample category	Sample per		Total
	District	Community	
Male Heads	36	12	324
Female heads	12	4	108
Female spouse	21	7	187
Total	69	23	619

3.4 Data type and data collection

The study used primary data. However, to understand the climatic pattern of the study area, a secondary data was collected at the meteorological department of the various regions. The secondary data spans from 1960 to 2012. This data includes the mean annual precipitation, minimum and maximum temperatures.

The primary data for this study was collected using questionnaire. The questionnaire was designed through a comprehensive process with input from other scholars and policy makers. A pilot study was also conducted on the questionnaire to examine its validity in providing the relevant information needed for the study. The questionnaire was therefore reviewed using results from the pilot study. The questionnaire was administered by a minimum of four Research Assistants in each region. The Research Assistants were selected based on their experience in questionnaire administration, fluency in English and local dialects. A training workshop was held for the Research Assistants to ensure that they have common understanding of every component of the questionnaire and are able to translate the questions into local languages without losing relevant information. In addition to the individual questionnaire administration, focus

group discussions were organised in each district. This involved randomly selected participants from the study sample.

3.5 Data analysis

The data was analysed based on objectives and these basically involved quantitative methods. The data analysis procedure is discussed in the following sections. However, the discussions are largely theoretical while the empirical models were reserved and presented under the results of each analysis. These was done to ensure that the empirical models are not too far from the results to enable easy linkages between the empirical models and the results.

3.5.1 Household's vulnerability to climate change

In recent times, sustainable livelihood approach has been used in designing development programs at the community levels. These approaches are limited as they do not include the climate exposure of households or communities. This limitation is addressed using the livelihood vulnerability index (LVI) by Hahn et al. (2009). The LVI method provides local context evidence for development planning and also address the shortcomings of relying on secondary data and climate models. Following IPCC's definition, vulnerability to climate change is measured based on three main indicators as exposure, sensitivity and adaptive capacity. While adaptive capacity is a positive function of vulnerability, exposure and sensitivity are negative functions of climate vulnerability.

In this study, vulnerability was measured as multidimensional LVI (Hahn et al., 2009; Gerlitz et al., 2016). The vulnerability was analysed using equal weighting and weighting through Principal Component Analysis (PCA). The sub-major components

considered for the LVI determination are natural disasters, climate variability, water, food, health, socio-demographic profile, livelihood strategy and social network.

Due to the multidimensional nature of the indicators of LVI calculation, a number of steps were followed under this study. Firstly, in analysing the livelihood vulnerability of the respondents, specific factors were identified under each minor component and normalised as:

$$Index(X_i) = \frac{S_d - S_{min}}{S_{max} - S_{min}} \qquad (3.3)$$

Where S_d is an observed or reported value of the indicator, S_{min} is the minimum observed value and S_{max} is the maximum observed value. The normalisation of each variable to a range of zero and one was to discount the units of measurement of the individual factors. In other words, in order to ensure that the units of measurement do not influence the overall LVI result, the values of each factor were converted to values from zero to one, a unitless measure.

Secondly, two weighting methods were used to calculate the index values of each minor component. Under equal weighting, the normalised values were aggregated and divided by the number of indicators under the specific minor component as:

$$M_j = \frac{\sum_{I=1}^{n} X_i}{n} \qquad (3.4)$$

Where *n* is the number of indicators considered and M_j is the index of the *jth* minor component. For instance, there are five specific factors under livelihood strategies; household size between 15-35 without economic activities, household size between 36-65 without economic activities, household size solely engaged in agriculture, diversification index and number of emigrants who remits. Therefore, livelihood

strategies minor component was obtained by adding the normalised values of these five specific factors and the result divided by five.

In the final stage, the LVI was determined by:

$$LVI = \frac{\sum_{i=1}^{n} w_{mi} M_j}{\sum_{i=1}^{n} w_{mi}} \quad (3.5)$$

Where w_{mi} is the number of indicators in each minor component. Using the LVI by Intergovernmental Panel on Climate Change (LVI-IPCC) approach, instead of combining all factors (minor components), they were first put into major components (exposure, adaptive capacity and sensitivity) from equation 3.4 as:

$$MC_i = \frac{\sum_{i=1}^{n} w_{mi} M_j}{\sum_{i=1}^{n} w_{mi}} \quad (3.6)$$

Where MC_i is the major component. Once these are determined, the LVI-IPCC is determined by:

$$LVI - IPCC = (e - a) * s \quad (3.7)$$

Where *e* is exposure, *a* is adaptive capacity and *s* is the sensitivity to climate change. The LVI-IPCC is scaled between -1 and +1.

For the unequal weighting, the normalised values from equation 3.3 were analysed using PCA in two steps. In the first step, the result from the first components of PCA were retained as weight and multiplied with their respective normalised values. Thus,

$$M_j = \sum_{i=1}^{N} a_m X_i \quad (3.8)$$

Where a_m is the weight and X_i is the normalised value. In the second step, M_j were again analysed using PCA to determine the contribution of minor component to the

major components. The weights from the first principal component were again retained and equation 3.8 applied as:

$$MC_j = \frac{\sum_{i=1}^{N} a_m M_j}{n} \qquad (3.9)$$

Where MC_j is the *jth* major component (adaptive capacity, sensitivity and exposure). These values were then aggregated and used in the calculation of the vulnerability scores, using equation 3.7.

3.5.2 Livelihood diversification strategies to climate change

Descriptive statistics was used to provide qualitative information on the livelihood diversification options engaged by the male and female households. These livelihood diversification are climate responsive strategies, hence livelihood diversification was conceptualised as a risk sharing arena by the farmers. It is obvious that a number of livelihood diversification strategies are simultaneously engaged by a farmer. Therefore, a multivariate probit was used to estimate the factors influencing farmers' decision under each option, simultaneously. The advantage of the multivariate analysis is that it allowed the estimation of farmer's choice of one or more livelihood activities simultaneously and also provided the opportunity to demonstrate the joint decision making processes of the farmers (Rahman & Akter, 2014). Following Greene (2012), this is discussed below.

The basis of the multivariate probit is the bivariate probit. In situations where there are two binary response variables, the bivariate probit model is applicable to resolve the covariance between the two response functions. For instance, if the objective of this study was to examine the factors influencing farmers' crop diversification and crop-

livestock diversification, the bivariate probit model would have been more appropriate. Generally, the bivariate probit model is given by (Greene, 2012);

$$\begin{aligned} y_1^* &= \mathrm{X}_1^*\beta_1 + \varepsilon_1, \quad y_1 = 1 if\ y_1^* > 0,\ and\ 0 if\ otherwise \\ y_2^* &= \mathrm{X}_2^*\beta_2 + \varepsilon_2, \quad y_2 = 1 if\ y_2^* > 0,\ and\ 0 if\ otherwise \end{aligned} \tag{3.10}$$

Therefore;

$$\begin{pmatrix} \varepsilon_1 \\ \varepsilon_2 \end{pmatrix} | \mathrm{X}_1, \mathrm{X}_2 \sim N\left[\begin{matrix} 0 \\ 0 \end{matrix}, \begin{pmatrix} 1 & \rho \\ \rho & 1 \end{pmatrix} \right] \tag{3.11}$$

This also means that;

$$E\left[\varepsilon_1 \mid \mathrm{X}_1, \mathrm{X}_2\right] = E\left[\varepsilon_2 \mid \mathrm{X}_1, \mathrm{X}_2\right] = 0$$

$$Var\left[\varepsilon_1 \mid \mathrm{X}_1, \mathrm{X}_2\right] = Var\left[\varepsilon_2 \mid \mathrm{X}_1, \mathrm{X}_2\right] = 1 \tag{3.12}$$

$$Cov\left[\varepsilon_1, \varepsilon_2 \mid \mathrm{X}_1, \mathrm{X}_2\right] = \rho$$

Using maximum likelihood estimation, the bivariate normal cumulative distribution unction (CDF) can be given as;

$$\Pr ob\left(X_1 < x_1, X_2 < x_2\right) = \int_{-\infty}^{x_2}\int_{-\infty}^{x_1} \phi_2\left(z_1, z_2, \rho\right) dz_1 dz_2 = \Phi_2\left(x_1, x_2, \rho\right) \tag{3.13}$$

Therefore, the density function is given by;

$$\Phi_2\left(x_1, x_2, \rho\right) = \frac{e^{-\left(1/2\right)\left(x_1^2 + x_2^2 - 2\rho x_1 x_2\right)/\left(1-\rho^2\right)}}{2\pi\left(1-\rho^2\right)^{1/2}} \tag{3.14}$$

To derive the log-likelihood, the following notations are used;

$$\begin{aligned} q_{i1} &= 2y_{i1} - 1 \\ q_{i2} &= 2y_{i2} - 1 \end{aligned}$$

Thus, $q_{ij} = 1 if\ y_{1j} = 1 and -1 if\ y_{1j} = 0;\quad j = 1,2$. Now assuming that $z_{ij} = \mathrm{X}_{ij}^{'}\beta_j$, $w_{ij} = q_{ij} z_{ij}$ *and* $\rho_{i*} = q_{i1} q_{i2} \rho$. Where the subscript 1 and 2 indicates a bivariate normal distribution of the density ϕ_2 and Φ_2. The probabilities that enters the likelihood functions can be given as $\Pr ob\left(Y_1 = y_{i1}, Y_2 = y_{i2} \mid \mathrm{X}_1, \mathrm{X}_2\right) = \Phi_2\left(w_{i1}, w_{i2}, \rho_{i*}\right).$

Therefore the log-likelihood function is;

$$InL = \sum_{i=1}^{n} In\Phi_2\left(w_{i1}, w_{i2}, \rho_{i*}\right) \tag{3.15}$$

Taking the derivatives of the log-likelihood functions are;

$$\frac{\partial InL}{\partial \beta_j} = \sum_{i=1}^{n}\left(\frac{q_{ij}, g_{ij}}{\Phi_2}\right)x_{ij} \text{ and } \frac{\partial InL}{\partial \rho} = \sum_{i=1}^{n}\frac{q_{i1}, q_{i2}\phi_2}{\Phi_2} \tag{3.16}$$

Where $g_{i1} = \phi\left(w_{i1}\right)\Phi\left[\frac{w_{i2} - \rho_{i*} w_{i1}}{\sqrt{1-\rho_{i*}^2}}\right]$. This can be done for g_{i1} be replacing the subscript 1 with 2. The maximum likelihood can be obtained by setting these derivatives to zero. Having obtained the maximum likelihood estimates, the marginal or partial effects were obtained by evaluating;

$$\Pr ob\left(Y_1 = 1, Y_2 = 1 \mid \mathrm{X}\right) = \Phi_2\left(x^{'}\gamma_1, x^{'}\gamma_2, \rho\right) \tag{3.17}$$

For a change in X can be given as;

$$\frac{\partial \Phi_2}{\partial X} = g_1\gamma_1 + g_2\gamma_2 \tag{3.18}$$

Given the above information, the multivariate probit model is expressed as;

$$y_m^* = X_m^* \beta_m + \varepsilon_m,\ y_m = 1\ if\ y_m^* > 0,\ and\ \ 0\ if\ \ otherwise,\quad m = 1,...,5 \qquad (3.19)$$

Where m are the diversification strategies. From equation 3.19, the variance covariance matrix is given as;

$$\begin{aligned} &E[\varepsilon_{\mathrm{m}} \mid \mathrm{X}m....\mathrm{X}_{\mathrm{m}}] = 0 \\ &Var[\varepsilon_{\mathrm{m}} \mid \mathrm{X}_{\mathrm{m}}...\mathrm{X}_{\mathrm{m}}] = 1 \\ &Cov[\varepsilon_{\mathrm{m}}...\varepsilon_{\mathrm{m}} \mid \mathrm{X}_1...\mathrm{X}_{\mathrm{m}}] = \rho_{jm} \\ &(\varepsilon_{\mathrm{m}}...\varepsilon_{\mathrm{m}}) \sim N_m(0, \Re) \end{aligned} \qquad (3.20)$$

The log-likelihood function is;

$$L_{\mathrm{m}} = \Phi_{\mathrm{m}}(\mathrm{q}_{\mathrm{i1}}\mathrm{X}_{i1}^{'}\beta_1,...,\mathrm{q}_{\mathrm{im}}\mathrm{X}_{im}^{'}\beta_m, \Re^*)..\varepsilon_{\mathrm{m}} \qquad (3.21)$$

Where $\mathrm{q}_{\mathrm{im}} = 2y_{im}^{'} - 1$ and $\Re^*_{jm} = q_{ij}q_{im}\rho_{jm}$.

The empirical model estimated for livelihood diversification and their definition is presented in chapter 5.

3.5.3 Analysis of gender productivity and welfare gaps

This section outlined the analytical procedure for objectives three and four that respectively sought to estimate the gender productivity gap among farmers and gender welfare gap among households. In addition, the focus of these objectives is to analyse the effects of climate change and livelihood diversification on these gaps. Thus, to estimate gender productivity and welfare inequalities and the effects of climate responsive livelihood diversification on these inequalities. Practically, the gender gap can simply be estimated using mean difference or the headcount index and its equivalence. However, a set of predictor variables differ in the contribution to productivity or welfare among males and females, hence, the need to identify the contribution from factor or resource endowments and gender discrimination. One of the

economic models used in gender inequality analysis is the Oaxaca-Blinder (OB) decomposition model. This model was independently proposed by Oaxaca (1973) and Blinder (1973) and has gained wide applications in gender productivity analysis (Kilic, Winters, & Carletto, 2015; Palacios-López & López, 2015; Aguilar et al., 2015; Ali et al., 2016) and gender wage gap analysis (Madden, 2008; Lee, 2014; Kaiser, 2015). In recent applications of the OB model, efforts were made to integrate selectivity bias correction in the models (Choe & Oaxaca, 2016).

Given the gender groups as male (M) and female (F) and the outcome difference, productivity/welfare (W), then the gender gap (G) was estimated as:

$$G = E(W_M) - E(W_F) \tag{3.22}$$

where $E(.)$ is the expected value of productivity or welfare. Under an assumption of linear prediction, the productivity/welfare function was given as:

$$W_i = X_i\delta + u_i,\ E(u_i) = 0\ and\ i \in (M, F) \tag{3.23}$$

Where X is a vector of predictors, β is vector parameters including the intercept and u_i is an error term. The aim is to separate the observations into its group constituents as males and females and then estimate the mean difference. Therefore, at the group specific means, G was redefined as:

$$G = E(W_M) - E(W_F) = E(X_M)^I \beta_M - E(X_F)^I \beta_F \tag{3.24}$$

This provide the gender productivity/welfare gap. However, we have to identify the sources of the differences the gaps. In this case, a detailed decomposition of the factors contributing to productivity or welfare are required. The aggregate decomposition is categorised into characteristics effects (I), which measures the contributions by X; the

coefficient effect (II) which measures discrimination between the gender groups; and an interaction component (III) which measures the interaction between I and II (Oaxaca, 1973; Blinder, 1973; Madden, 2008; Lee, 2014; Kaiser, 2015). Thus:

$$G = \{E(X_M) - E(X_F)\}\beta_F + E(X_F)^I(\beta_M - \beta_F) + \{E(X_M) - E(X_F)\}\beta_F{}^I(\beta_M - \beta_F) \quad (3.25$$

Simply, equation 3.25 can be put as:

$$G = I + II + III \quad (3.26)$$

Equation 3.25 provided an aggregate contribution of the endowment and pure discrimination to G. However, the prime objective is to estimate the contribution of climate change and livelihood diversification to G. Therefore, a further decomposition of equation 3.25 was required. The coefficients from the decomposition measures the extent to which climate change and diversification contributes to the productivity/welfare gaps via the endowment (characteristics effect) and discrimination components (Madden, 2008).

From the above description, the productivity or welfare function can be given as:

$$W = \beta_0 + \beta_1 X_i + \delta_i D_i + \gamma_i C_i + e_i \quad (3.27)$$

Where X_i is a vector of socioeconomic characteristics, D_i is a vector of climate responsive livelihood diversification strategies, and C_i is a vector of climatic factors. The limitation of the equation 3.27 is that the D_i are endogenous and this may lead to possible selectivity bias, hence, inefficient estimates. Therefore, this must be corrected and in the next section, the correction for selectivity bias in the OB model is provided.

3.5.3.1 Addressing selectivity bias in Oaxaca Blinder decomposition

From equation 3.27, there is potential presence of selectivity bias due to two reasons. Firstly, the returns from diversification are different from non-diversification and secondly, the decision to adopt a particular diversification strategy or not depends on individual's decisions with differences in entry barriers by the gender groups. In such circumstances, Heckman (1979) suggested that a diversification function (equation 3.19) is defined and estimated simultaneously with the productivity/welfare function (equation 3.27). Farmers irrespective of their diversification strategy, they have positive values for productivity and welfare. Heckman (1979) suggested that after estimating the diversification model (equation 3.19), the predicted values of diversification should be estimated and used to construct an Inverse Mills Ratio (IMR) and included in the outcome model as an additional variable to correct the selectivity bias. Therefore, redefining equation 3.19 with a latent value for diversification:

$$D_m^* = Z_i^* \beta + \varepsilon_i \qquad (3.28)$$

Where Z_i^* is a vector of factors that influence farmer's decision into livelihood strategy *m*, D_m^* is a latent for diversification which is unobservable, instead, a dummy that is defined as is D_m. Hence, $D_m = 1 \;\; if \; D_m^* > 0$ and $D_m = 0$ if otherwise. Therefore,

$$\Pr ob(\varepsilon_i > 0) = \Pr ob(\varepsilon_i > -Z_i = \Pr ob\,(D_m = 1/Z_i) = \Phi(Z_i \beta) \qquad (3.29)$$

Given the productivity/welfare function in equation 3.27 and redefining this by the diversification function (equation 3.28) gives;

$$E(w_i / D_i^* = 1) = X_i \delta + E(u_i / \varepsilon_i > -Z_i^{'} \beta) = w_i = X_i \delta + \rho \sigma \lambda_i = X_i \delta + \theta \lambda_i \qquad (3.30)$$

Where $\lambda_i = \frac{\phi(-Z_i'\beta)}{1-\Phi(-Z_i'\beta)}$. This is the IMR that is estimated using the predicted values from the diversification. Φ is the cumulative density function and ϕ is the standard normal function. Since D_i is a vector, λ_i is also a vector with the same dimension.

Combining the two-stage treatment effect model with OB decomposition model;

$$\begin{aligned} W_M - W_F &= (\bar{X}_M \hat{\delta}_M + \theta_M \hat{\lambda}_M) - (\bar{X}_F \hat{\delta}_F + \theta_F \hat{\lambda}_F) \\ &= \bar{X}_F(\hat{\delta}_M - \hat{\delta}_F) + (\bar{X}_M - \bar{X}_F)\hat{\delta}_M + (\hat{\theta}_M \hat{\lambda}_M - \hat{\theta}_F \hat{\lambda}_F) \end{aligned} \quad (3.31)$$

The first two terms in equation 3.31 are the discrimination and endowment components while the last is the gender difference due to selection bias. Therefore, the welfare model is defined as:

$$W = \delta_0 + \delta_i Z_i + \delta_i C_i + \delta_i D_i + \delta_i \lambda + u \quad (3.37)$$

Where Z_i is a vector of socioeconomic variables, C_i is a vector of climate variables, D_i is a vector of livelihood diversification strategies and δ_s are the parameters to estimate. The estimated empirical models are discussed under chapter 7 for gender productivity gap and chapter 8 for gender welfare gap.

CHAPTER FOUR

DATA DESCRIPTION AND PERCEPTIONS OF FARMERS

4.1 Overview of chapter four

This chapter presents the descriptive statistics of the socioeconomic characteristics, assets ownership and the livelihood diversification strategies of the respondents. The perceptions of the farmers were also examined on climate change, sources of gender inequality and the effects of diversification on livelihood outcomes. The main aim of this chapter is to provide qualitative information of the farmers on their socioeconomic characteristics and gender inequality. It also allowed to understand the data for the analysis in subsequent chapters.

4.2 Demographic characteristics of respondents

The mean statistics of the sampled respondents are shown in Table 4.1. From the result, the female heads recorded a higher mean age of approximately 52 years while male heads and female spouses recorded nearly 50 and 40 years, respectively. The mean ages were significantly different from between gender groups. This was expected since the probability of a female been recognised as a family head is usually related to the age of the female and usually when there is no adult male in the home. The educational level is generally low since all gender groups had mean values less than 6, thus, primary education. While male heads averagely had up to five years of formal education (primary five), the female farmers had averagely primary four education; a year difference in formal education. These mean educational values were statistically different at 5%.

The household size of the sampled respondents were adjusted to adults equivalent [1+0.7(No. of adults-1)+0.5(No. of children)] (Haughton & Khandker, 2009b). The

results showed that while there were averagely 7 people in male headed households, there were 6 people in female headed households. However, there were more dependents in female headed households (1.15) than in male headed households (0.91). This high dependency on female heads could exacerbate their vulnerabilities. Both the household size and dependency ratio are statistically different between male and female headed households at 1%.

Table 4.1: Mean statistics of socioeconomic characteristics of farmers

Variable	Male heads	Female heads	Female spouse	Bartlett's test
Age	49.90	51.73	39.76	20.808***
Education	4.51	3.28	3.45	7.316**
Household size	6.82	6.22	6.82	18.530***
Dependency ratio	0.91	1.15	0.91	71.110***
Daily home keeping hours	2.54	4.01	3.37	12.729***
Daily farm hours	6.01	4.73	5.16	2.379

Expectedly, female heads spend more daily hours in home keeping (4.01 hours) than female spouses (3.37 hours) and male heads (2.54 hours). This is because, unlike male heads and their spouses who may share home duties, female heads do not have such marital partners to share household activities with. Nationally, while males spends an average of 1.15 hours on activities that do not reflect in national income determination such as cooking, females spend an average of 3.48 hours on these activities daily (GSS, 2012b). This have also reflected in the low daily farm hours by the female heads (4.73 hours) as opposed to 6.01 and 5.16 hours by the male heads and their spouses, respectively. The high productive work hours for males than females is consistent with the national estimate of 5.15 hours and 4.10 hours, respectively (GSS, 2012b). The low farm hours of females is a reflection of the labour market since females have to use the fixed hours for both economic activities and domestic or reproductive schedules. They

sometimes had to wake up early from bed for morning chores and also had to return early from farms for evening home chores. Although there was a statistical significant difference in the mean home keeping hours between the sample groups, the difference in daily work hours was not significantly different.

4.3 Assets index of households

Table 4.2 shows the assets distribution of the households. Since some assets can be jointly owned, these assets were first normalized to determine the relevant proportion of assets to individuals. For instance, both husband and wife can jointly contribute to own a motorbike, and in this case, the number of motorbikes owned by a husband or a wife is 0.5. Also, the asset quantity is divided by 3 if three people jointly owned the asset[3]. These observed values were then normalized and weighted through PCA. Except technological assets, there are statistically significant differences (at 1%) between the mean asset values of males and females (Table 4.2).

Table 4.2: Mean asset indices of households

Asset	Male heads	Female heads	Female spouse	Bartlett's test
Financial assets	15.43	10.71	8.22	54.271***
Physical assets	1.19	0.98	0.83	42.390***
Social assets	1.64	1.65	3.32	57.289***
Human assets	0.59	0.44	0.02	18.355***
Technological assets	0.44	0.37	0.39	2.922
Political assets	0.53	0.44	0.31	21.804***
Asset index	6.96	4.95	3.64	52.167***

From Table 4.2, male heads had a higher financial asset index (15.43) than female heads (10.71) and female spouses (8.22). This was expected as the financial status of men is

[3]This study did not identify the specific proportion of jointly owned assets that is attributable to each owner. Therefore, equal proportion of these jointly owned assets was assumed.

always higher than women. For instance, in Ghana, female headed households are poorer than male headed households (GSS, 2014b). This observed distribution is similar to physical assets, human assets and political assets. Contrary, the social assets of female spouses (3.32) is higher than for female heads (1.65) and male heads (1.64). Female spouses in northern Ghana are often in close relationship with one another than observed among males. This is much demonstrated during cultural and religious ceremonies. Although the technological asset index is higher for male heads, the female spouses also recorded higher technological assets (0.39) than the female heads (0.37). This can be explained by knowledge diffusion theory, where people that are close to each other tends to learn from each other and adopts new technologies within a short period. Thus, unlike female heads, the female spouses might have access to the technologies that were accessed by their husbands (male heads).

4.4 Farmers' perceptions on the sources of gender inequality

The respondents were provided with a set of indicators that are identified in the literature as the main sources of gender inequality in the literature. The respondents were then asked to indicate the perception on the gender group that was favoured or otherwise under each indicator towards gender groups, and also, how these inequalities had evolved over the past five years. A three-point scales response was provided to the respondents as in the note of Table 4.3 and the mean responses estimated. From the scale, the higher the mean value towards three, the higher the inequality against females or the higher the inequality has reduced, vice versa. A perception index was also estimated. A mean index of 16 was expected if all respondents indicated that the difference in all inequality indicators is higher for males than females while a mean

index of 48 was expected if all the respondents indicated that the observed difference in all indicators is higher for females than males.

Generally from the results, the pooled mean estimates of all indicators is approximately two and the mean estimates of the change in inequalities is also approximately two. Thus, while the farmers respectively agreed that the difference in the inequality sources are balanced between males and females, they also agreed that these observed gender equalities have not changed over the past five years. Also, the perception index on inequality was higher for female heads (27.15) than female spouses (25.09) and male heads (23.96). This is similar to the perception on the changes in inequality over the past five years as female heads recorded a perception index of 31.90, male heads recorded a perception index of 30.44 while female spouses recorded 30.72. This means that the female heads perceived that gender inequalities favours males than females, and also have higher perception that the gender inequalities are gradually closing. The estimated mean values of both the perception on inequality and change in inequality among the sampled groups are significantly different at 1%.

Table 4.3: Farmers perception on the sources of gender inequality in the region

Indicator	Perception [a]				Change over past 5 years [b]			
	Male head	Female head	Female spouse	Test	Male head	Female head	Female spouse	Test
Participation in household decision making.	1.29	1.65	1.44	19.76***	1.83	1.84	1.89	1.21
Access to and control of household labour.	1.27	1.62	1.42	25.13***	1.82	1.95	1.81	0.86
Access and control of land.	1.25	1.52	1.27	34.60***	1.88	1.93	1.75	14.72***
Control of household financial resources	1.44	1.80	1.59	11.15***	1.92	2.10	1.89	2.46
Decision making	1.65	1.85	1.76		1.99	1.99	2.00	

on choice of economic activity				11.80***				3.11
Access to information	1.77	1.79	1.82	15.57***	1.97	2.31	1.98	67.60***
Access to production inputs. e.g. fertiliser	1.46	1.69	1.60	14.67***	1.93	1.85	1.95	6.92**
Leadership positions	1.30	1.44	1.35	8.75**	1.82	2.05	1.84	12.92***
Decision making on choice of crops to cultivate	1.72	1.90	1.79	12.10***	2.01	2.03	2.01	1.74
Decision making on the sale of crops and livestock	1.68	1.94	1.86	7.75**	1.95	2.02	2.10	2.44
Decision on credit access and training services	1.63	1.83	1.77	21.85***	1.95	2.05	2.10	4.83*
Leisure hours	1.46	1.30	1.45	104.8***	1.96	1.93	1.91	2.70
Diversification decision	1.58	1.78	1.65	5.87*	1.88	1.93	1.94	0.28
Control over income from livelihood activity	1.51	1.76	1.49	7.96**	1.88	1.97	1.91	43.98***
Decision on the type of assets to acquire	1.48	1.86	1.52	10.25***	1.82	1.94	1.85	16.36***
Management of family budget	1.51	1.71	1.52	7.86**	1.83	1.94	1.80	3.94
Domestic violence	1.44	1.41	1.34	3.05	1.90	2.06	1.92	3.51
Average	1.50	1.70	1.57	43.03***	1.90	1.99	1.92	14.13***
Perception index (average*16)	23.96	27.15	25.09	43.03***	30.44	31.90	30.72	14.13***

*NOTE 1: [a] is defined as 1=higher for males, 2=equal for males and females and 3=higher for females. NOTE 2:[b] is defined as 1=widened, 2=unchanged and 3=closed. NOTE: *,** and *** indicates Significant levels at 10%, 5% and 1%, respectively.*

Besides the general discussion, there are some interesting key findings. For instance, from Table 4.3, 'leadership position' recorded a mean value of approximately 1 for all gender groups. Thus, all gender groups perceived that males have higher leadership

positions at all levels than females. However, these were statistically different among the gender groups. The respondents argued that the upmost possibility is for females to deputy a substantive male leader. This shows that glass ceiling does not only exist in the formal labour markets, but also in the farm communities and local community leadership positions. Although there is a significant mean difference, the respondents perceived that the opportunity for males to occupy leadership positions by males over females remained unchanged.

While male heads and their spouses indicated that participation in decision making is higher for males than females (1.29 and 1.44, respectively), the female heads indicated that decision making is equal for both males and females (1.65~2). Generally, household decision making in northern Ghana is male dominated. Exceptionally, female heads are the major decision makers and does so in consultation with a male elder in the household. Household resources are hold in trust by male heads or a male elders of a household. Therefore, it is consistent that the estimated mean values for male heads and their spouses are approximately 1 for 'access to and control of household labour', 'access to and control of land' and 'control of household's financial resources'. Thus, the gender inequalities on these indicators favoured the males than females. The observed mean differences in the perceptions were statistically significant. For instance, in most part of Ghana, land ownership is a reserved right for males. Therefore, in farming communities, the males often identify more suitable arable lands for their farms and give marginal lands to their female household members for farming. Also, unlike a male heads who can demand farm assistance from household members with little or no resistance, the female spouses do not have such command rights over household members.

Related to these household or personal asset indicators, the male heads perceived that the decision on the type of assets to acquire is higher for men than women while the females perceived that decision making powers are equal for both males and females. The male heads argued that they can take sole decisions on the assets they want to buy, but the females can only seek approval from a male elder of the family. Contrary, the females argued that they can buy most of their own assets types without consultation or approval from another person. In all these resource indicators, the respondents perceived that, the observed mean inequalities have not changed for the past five years. Consistent with this study, Chandra et al. (2017) found that, women's decision making on land use and allocation, access to credit, access to extension services, and planning on how to cope with droughts in community gatherings and NGO programs is still low.

From Table 4.3, the mean estimate of all sampled respondents from the gender groups on 'decision making on the type of economic activity to engage' is approximately 2. This means that the final decision by both males and females on the choice of economic activity to undertake is made by the individuals irrespective of the gender group. This is confirmed by the approximate mean estimate of 2 on 'decision on choice of diversification strategy', and 'decision making on the types of crops to cultivate'. In most traditional homes of northern Ghana, male farmers mainly engage in the cultivation of relatively commercial crops such as maize while their spouse engage in the cultivation of minor and complementary crops such as vegetables. However, the mean values of 'decision making on the sale of crops and livestock' and 'control over income from livelihood activity' are approximately 2, thus, gender blind. Since gender inequalities are unobservable on these economic decisions, non-economic indicators must be considered in addressing gender inequalities.

The literature on gender studies (Aristei & Gallo, 2016; Okonya & Kroschel, 2014) also highlighted that females often do not receive information and access to credit as the male counterparts. From Table 4.3, male heads generally agreed that access to production inputs is higher for males than females while the females indicated an equal access opportunities to production inputs. The mean values on access to information, credit and training however, indicate that the respondents perceive that there is no difference in access opportunities to these inputs. The estimated mean values on change also indicate that the inequalities as perceived by the respondents have not changed over the past five years.

Another source of gender discrimination in Ghana is domestic violence against women (Adjah & Agbemafle, 2016; IDS, GSS, & Associates, 2016) and differences in leisure hours between males and females. From the result, both males and females perceived that domestic violence is against the females since the mean value estimates are approximately one. Thus, men violate women domestically than women violate men. According to a female spouse in Loho (one of the selected community), women are voiceless even when they are being violated by men. In her words, 'they [men] are the heads, so even if they are beating you [the female], you can't say anything, if not, he will throw your things [out of the house]'. While the respondents perceived a gender equality in 'management of family budget', they perceived that 'leisure hours' are higher for males than females. The latter result was expected since the reproductive duties and domestic chores of females which are often counted as no work, reduces their leisure hours. For instance, while females have to wake-up early each morning to prepare the children for school and prepare breakfast for the entire family before starting any economic activity, the males only take breakfast and go to their farms or even ask that the food be brought to the farms for them. Thus, females often spend

much of their time on household keeping in addition to working on their farms and other livelihood activities, hence, a lower leisure time. Chandra et al. (2017) also explained that together with women's constraint to working on their farms in the afternoons due to domestic works, most of them have menstrual periods that are accompanied with health complications, thereby, making them unproductive in these periods.

4.5 Patterns of climate variables

4.5.1 Observed rainfall and temperature distribution

The rainfall distribution of the three northern regions are shown in Figure 4.1. Data for Upper East region (UER) was available from 1976 while that of Northern region (NR) and Upper West region (UWR) starts from 1960 to 2011. Projections using five point moving averages were done for the period of 2012-2016.

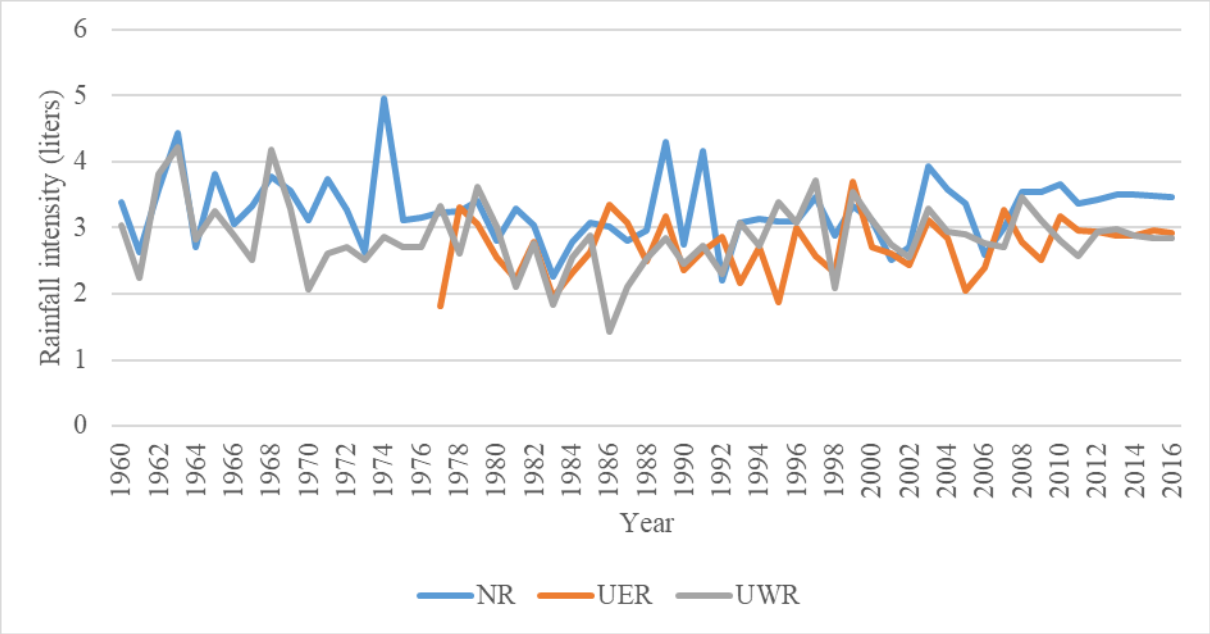


Figure 4.1: Rainfall distribution of the study regions
Source: GMA

This result shows that the rainfall level of NR is higher than for UER and UWR. The highest rainfall for NR was in 1974. The general observation is that the rainfall

distribution of the three northern regions shows several spikes and a slight downward trend. In the next section, the farmers' perception on the changes in rainfall distribution would be assessed.

Figure 4.2 also shows the minimum and maximum temperature for the three regions. Although this also show no sharp trend, it can be observed especially for maximum temperatures that the trend is slightly rising upwards. This is consistent with discussions in next section where the perceptions of the majority of the farmers that the temperature levels have increased over the years.

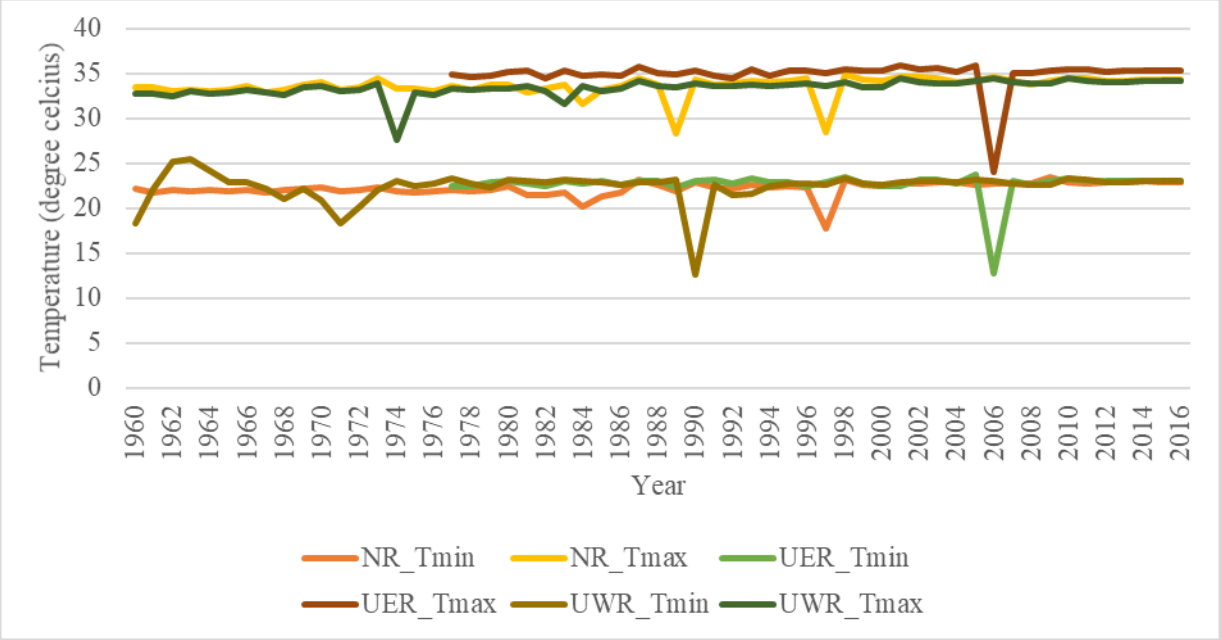


Figure 4.2: Minimum and maximum temperature patterns of the study regions
Source: GMA

4.5.2 Perceptions of farmers on climate change

Knowledge on climate change and variability is vital to enhance the adaptive capacities of farming households. Thus, individuals that have knowledge on climate change and variability are able to adopt appropriate adaptation strategies and diversify into high return activities that would minimize vulnerability and improve their wellbeing. From Table 4.4, the expected direction of a climatic variable (Baidu et al., 2017; Thornton et

al., 2014) of each variable is provided in parenthesis of first column and the percentage distribution of respondents who perceived these directions on each climate variable are shown in subsequent columns.

The result shows that, approximately 83%, 78% and 61% of the male heads revealed that the duration, intensity and timeliness of rainfall has decreased over the past ten years. Approximately, 78%, 77% and 74% of female heads and 71%, 81% and 66% of female spouses also perceived a decrease in the duration, intensity and timeliness of rainfall over the past ten years, respectively. Scientific predictions of rainfall patterns show an erratic rainfall pattern with a general decrease in Africa regions (WMO, 2018). Therefore, it can be concluded that the majority of the farmers in northern Ghana have fair knowledge on the patterns of rainfall. This is not surprising since the last decade have witnessed a more erratic rainfall patterns in the northern regions and the ability of farmers to time their productions have reduced. This corroborated the observed rainfall pattern in Figure 4.1.

Majority of the female spouses (89.94%), male heads (89.51%) and female heads (87.96%) perceived that temperatures have increased over the past ten years. With the increasing sunshine, it is expected that farmers would indicate an increasing temperature. While the majority of male heads (57.72%) and female heads (61.11%) perceived that the level of windstorms have increased, less than half (46.52%) of the female spouses perceived that wind or storm have increased over the past ten years. This is consistent with the observed trend for temperature in the past 56 years (Figure 4.2).

Knowledge on flood is low as less than half of all the respondents perceived that the level of floods is actually increasing. This is not surprising though as the frequency of floods with severe impacts on crop lands are only observed during a shorter period in

the farming season. Floods in northern Ghana, especially Upper East, that have devastating effect on majority of crop lands is usually associated with water spill over from Bagre Dam in Burkina Faso. In recent times, the spill over volume has been low. This could reflect the response of the respondents on flood. Unlike flood, over half of the respondents in all gender groups perceived that drought levels have increased. This is consistent with the high awareness on the reduction of the rainfall and increase in temperatures. Majority of respondents were unaware of the increasing impacts of climate change on human health and conflict occurrence.

Table 4.4: Farmer's perceptions on climate change

	Male head		**Female head**		**Female spouse**	
Climatic condition	Freq.	%	Freq.	%	Freq.	%
Rainfall duration (Decreased)	268	82.72	84	77.78	133	71.12
Rainfall intensity (Decreased)	253	78.09	83	76.85	151	80.75
Rainfall timeliness (Decreased)	198	61.11	80	74.07	123	65.78
Temperature (Increased)	290	89.51	95	87.96	168	89.84
Wind/Storm (Increased)	187	57.72	66	61.11	87	46.52
Flood (Increased)	107	33.02	41	37.96	78	41.71
Drought (Increased)	256	79.01	86	79.63	155	82.89
Climate induced sicknesses (Increased)	124	38.27	53	49.07	79	42.25
Climate induced community conflicts (Increased)	26	8.02	12	11.11	13	6.95

4.6 Assessing the livelihood diversification strategies adopted by farmers

4.6.1 Types of livelihood diversification

In this study, livelihood diversification occurs when a farmer engages in another economic activity in addition to maize production. For instance, a farmer who engaged in trading in addition to maize production is said to be a diversified farmer. Primarily,

the higher the number of activities engaged by a respondent, the higher the diversification. There are several methods of estimating diversification index. One of such methods is the Herfindah index. The Herfindah diversification index is determined be $\sum_{i=1}^{N} s_i^2$, where s_i is the market share or income from a diversification strategy and *N* is the number of livelihood diversification portfolios which is 5 in this study. The maximum expected diversification index is 1 (100%) for a complete diversification and a minimum of 0 for a complete specialization. The results are shown in Table 4.5.

Table 4.5: Livelihood diversification strategies engaged by the respondents

Sample	Strategy	Freq.	%	Mean years	Mean income (GHC)
Male heads	Crop diversification	288	88.89	14.04	1165.39
	Animal rearing	262	80.86	10.65	467.04
	Trading	88	27.16	2.55	251.60
	Agro-processing	92	28.40	2.68	236.69
	Professional or skilled employment	77	23.77	2.15	309.58
Female heads	Crop diversification	85	78.70	10.06	1000.65
	Animal rearing	61	56.48	11.39	261.68
	Trading	35	32.41	3.61	309.06
	Agro-processing	48	44.44	4.29	420.29
	Professional or skilled employment	30	27.78	2.13	294.28
Female spouse	Crop diversification	153	81.82	8.52	752.19
	Animal rearing	104	55.61	5.52	307.55
	Trading	56	45.99	6.43	523.98
	Agro-processing	54	28.88	2.44	244.92
	Professional or skilled employment	60	32.09	2.53	552.54
Descriptive statistics of diversification index					
Male heads	Min, 0; Max, 0.7450; Mean, 0.4616				
Female heads	Min, 0; Max, 0.7111; Mean, 0.4108				

Female spouse	Min, 0; Max, 0.76437; Mean, 0.4346

The result (Table 4.5) shows that the mean diversification for all gender groups are less than 0.5. Hence, it can be concluded that there is a low diversification among the farming households in northern regions of Ghana. The diversification score is slightly higher for male heads (46.16% diversification), followed by female spouses (43.46% diversification) and lowest for female heads (41.08% diversification). The maximum diversification index was recorded by female spouses. The low diversification in the study area could be due to the low availability of economic opportunities aside farming in the area. A similar study by Fabusoro et al. (2014) using Simpson diversity index revealed a mean diversification index of 0.42. Consistent with this study also, Dube & Guveya (2016) found that crop diversification index was higher for males than females.

The result (Table 4.5) shows that the majority of the respondents, both males and females, engaged in crop diversification. Thus, they cultivated maize and another one or more crops. Crop diversification is more pronounced among male heads (88.89%), followed by female spouses (81.82%) and lowest for female heads (78.7%). The other staple crops mostly cultivated by the respondents were groundnut, millet, cowpea and yam. The male heads engaged in crop diversification for an average year of 14 while the female heads and spouses engaged for an average of 10 and 9 years, respectively. Similarly, the annual income from crop diversification is higher for male heads (GH₵1,165.39), followed by female heads (GH₵1,000.65) and lowest for female spouses (GH₵752.19). The low annual income received by female spouses is explained by the fact that most spouses engaged in the cultivation of crops that are mainly consumed by the household and not for sale. The study of Adam & Zakaria (2015) revealed that although food crop production is high for both males and females in

northern Ghana, there is a significant difference favouring males in the cultivation of cash crops.

Diversification into animal farming is a practice in most rural farming communities. This is often described in the literature as crop-livestock integration (Thornton & Herrero, 2015; Ryschawy et al., 2013; Tarawali et al., 2011). Particularly in northern Ghana, farming households engage in rearing of poultry such as chicken and guinea fowls, and livestock such as cattle, goat, pig and sheep. While the females mostly engage in poultry rearing, the males engage in livestock rearing. From Table 4.5, 81%, 57% and 56% of male heads, female heads and female spouses engaged in animal rearing in addition to maize production, respectively. Generally, animal provides multi-purpose benefits to both the individuals and the society. Aside the consumption of animal products, livestock such as sheep serves as ceremonial animals while bullocks are used for ploughing and carting farm produce. Averagely, a female head engaged in animal rearing for slightly over 11 years while male heads and their spouses engaged in animal rearing for 10.65 and 5.52 years, respectively. Again, male heads recorded higher mean annual income from animal rearing than female spouses (GH₵307.55) and female heads (GH₵261.68). The estimated percentage of diversification (crop-animal integration) in this study is however higher than estimated by Owusu-Amankwah et al. (2017). The study of Soltani et al. (2012) also found that as high as 64% of households engage in combined forestry, animal and crop production.

Trading involves buying and selling. While some households trade agricultural products, others engage in trading non-agricultural (non-food) products. Some farmers buy agricultural products such as pepper and maize during peak seasons (when prices are low) and store them for sale during the lean season (when prices are high). Others engage in trading of agricultural products such as fish for the whole year. In terms of

non-food and other food commodities, traders buy their goods/products from cities such as Kumasi and Accra and sell same in either their local communities, nearby towns or local markets. These non-food products include footwear, cosmetics and clothes while other food commodities include soft drinks. From Table 4.5, 27.16% of male heads, 32.41% of female heads and 45.99% of the female spouses engaged in trading as a supplementary to maize production. Consistent with the level of engagement, the female spouses have a higher experience in trading (6.43 years) than female heads (3.61 years) and male heads (2.55 years). Similarly, female spouses earned higher annual income from trading than the female heads and male heads. This is not surprising though as trading in Ghana is mostly engaged by females.

Diversification into agro-processing is low as only 28.4% of the male heads, 44.4% of female heads and 28.88% of female spouses were engaged in agro-processing activities. The major agro-processing activities in the area were shea butter and groundnut processing. Female heads have more experience (4.29 years) in agro-processing activities than male heads (2.68 years) and female spouses (2.44 years). The observed average annual income levels also revealed that female spouses (GH₵523.98) and female heads (GH₵309.06) earns more income from agro-processing than male heads (GH₵251.60). Observably in northern Ghana, females are mostly engaged in agro-processing activities. Therefore, to improve the income levels of females and their standards of living, the promotion of agro-processing activities is necessary. This is consistent with the findings of Adam & Zakaria (2015). Recent government policies such as ‘one constituency, one factory’ are appropriate if it identify agro-processing activities and promote them.

Less than half of all gender groups engaged in professional (wage) and skilled (non-wage) jobs. The most common of these activities were teaching, nursing and artisanry

works such as tailoring, masonry and hairdressing. From the result (Table 4.5), more females than males engaged in these activities. Averagely, the number of years of engaging in such activities by both males and females is less than three years. Also, the average income from these activities is higher for female spouses (GH₵552.54) and lowest for female heads (GH₵294.28). From the survey, the major limitation of most of the artisans is the lack of capital to establish shops for their businesses. For instance, one of the respondent argued that although they can earn high incomes from artisan works, they do not operate from shops that would attract more customers and also allow them charge actual service price for their services.

4.6.2 Farmers' perception on the effects of livelihood diversification on livelihood outcomes

The respondents were asked to reveal their perceptions on the effects of diversification on a number of livelihood outcomes (indicators). This involved a four-point likert scale that were defined as improved (1), no effect (2), worsened (3) to uncertain (4). The mean values from the responses were estimated and the results presented in Table 4.6. Juxtaposing the mean estimates with the scale, the lower the mean estimate (approximately 1), the higher the perception that diversification leads to an improvement on the indicator, and vice versa. From the result, 'agricultural productivity' recorded the lowest mean estimate of 1.26 for male heads, 1.44 for female heads and 1.32 for female spouses; but this is insignificantly different between the gender groups. According to the respondents, income received from non-farm diversification activities are used to invest in crop production, and vice versa. Therefore, since capital is essentially required to drive production (at least, from the classical production function), it is expected that with increased capital from other livelihood activities, agricultural productivity would increase, *citerus parabus*.

Farmers' perception on the impacts of livelihood diversification on households' wellbeing is averagely one and statistically significant. Thus, the farmers perceived that livelihood diversification leads to an improvement in households' wellbeing. However, the mean value of consumption expenditure is approximately two. Thus, the respondents perceived no effect of diversification on consumption expenditure. The implication is that the positive impact of livelihood diversification goes beyond an improvement in household expenditure to an improvement in general wellbeing of the people. This is in line with the limitation of using monetary measures for measuring welfare. Owusu-Amankwah et al. (2017) argued that, the main reasons for livelihood diversification are to improve income and food security, reduce vulnerability and spread risks. However, Aziz et al. (2017) also estimated that, diversification into non-farm enterprises have a positive impact on consumption expenditure and food availability. Another indicator for measuring welfare is the household asset. From the result and contrary to apriori expectation, the mean perceptions on the effect of diversification on asset acquisition is approximately two. Also, there was no statistically significant difference in the mean values.

Table 4.6: Perceived effects of livelihood diversification on livelihood outcomes

Indicator	Male heads	Female heads	Female spouse	Bartlett's test
Agricultural productivity	1.26	1.44	1.32	0.24
Availability of labour to agriculture	2.06	2.18	2.19	3.74
Household's food affordability	1.51	1.77	1.39	17.94***
Household's food nutrition	1.33	1.49	1.39	0.28
Household's wellbeing	1.36	1.46	1.33	15.85***
Household consumption expenditure	1.76	1.80	1.53	10.84***
Household's assets acquisition	1.51	1.69	1.57	1.04
Household per capita land holding	1.95	2.08	2.15	335.54***
Environmental and climate vulnerability	2.21	2.15	2.23	0.87

Social vulnerability	1.95	1.95	2.09	1.18
Economic vulnerability	1.91	1.86	1.79	1.16
Number of leisure hours	2.49	2.57	2.58	0.41

*SCALE: Improved (1); No effect (2); Worsened (3); Don't know (4); *** indicates significance at 1%*

The mean values (Table 4.6) of vulnerability indicators also suggest that the respondents perceived no effect of livelihood diversification on household's environmental, economic and social vulnerabilities. According to the respondents, the primary aim of engaging in livelihood diversification is to improve the income levels of their household and offset total agricultural losses due to climate and environmental shocks. Therefore, these households do not primarily see vulnerability as a prime reason for livelihood diversification. However, considering the fact that the respondents perceived an improvement in agricultural productivity and wellbeing, it can be concluded that these effects would translate into reducing the vulnerability of the households.

Expectedly, the respondents perceived that a diversification leads to loss of leisure hours. This is due to the need to share daily hours among various livelihood activities. Generally, the fact that the respondents perceived that livelihood diversification leads to improvement in total wellbeing, productivity, availability and affordability of food as well as nutrition means that livelihood diversification remained a prime policy strategy for improving the lives of rural folks. Importantly this study supports the conclusion of Gautam & Andersen (2016) that, there is the need for diversifying into high return strategies and not just diversification into any strategy.

4.6.3 Farmers' revealed challenges to livelihood diversification

A number of predetermined constraints to livelihood diversification were identified and provided to the respondents for assessment. From Table 4.7, the percentage distribution of respondents who confirmed specific constraints that limits or hinders their livelihood diversification opportunities were provided.

Table 4.7: Farmer's revealed challenges to livelihood diversification

	Male heads		Female heads		Female spouse	
Constraint	Freq.	%	Freq.	%	Freq.	%
Lack of information	149	45.99	50	46.3	103	55.08
Lack of labour	132	40.74	55	50.93	76	40.64
Lack of land	102	31.48	27	25.00	41	21.93
Lack of or poor access to market	96	29.63	47	43.52	79	42.25
Financial and credit limitations	275	84.88	87	80.56	156	83.42
Climate change and variability	152	46.91	48	44.44	107	57.22

From the result, the major constraint facing majority of respondents is financial and credit constraints. This was mentioned by about 85%, 83% and 81% of male heads, female spouses and female heads, respectively. The respondents noted that, they do not have enough money to expand their economic portfolios. They also argued that although there are limited credit opportunities in the region for farmers, the conditions for accessing credit from the few available institutions are too complicated and unfavourable. Financial constraint was expected to be a dominant factor affecting livelihood diversification considering the low resource levels of the farmers and the high poverty levels in the regions. On the flipside, the high risks associated with agricultural credit disincentives the credit institutions from providing credit to farmers and this also daunts the farmers from requesting credits. The lack of credit being reported by more males than females is due to the high incentive for credit by the

former than the latter. The study of Woldenhanna & Oskam (2001) also revealed that, the major entry barrier to diversification is lack of credit facilities. FAO (2011) noted that, despite the general low credit access by farmers, men are more often than women more likely to use credit and other financial services. On their part, lack of credit may limit farmers potential of diversifying into high return strategies (Gautam & Andersen, 2016).

Following financial limitations, climate change and variability was mentioned as the second major constraint limiting diversification among the male heads and the female spouses. The effect of climate change on livelihood diversification may be more noticeable in crop production than other livelihood strategies. A study by Asravor (2017) also revealed that changes in rainfall patterns leads to lower income and cropland diversification. FAO (2016) also estimated that weather shocks significantly influence both crop and labour diversification. From Table 4.7, the second major constraint reported by female heads is the lack of labour. This is conceivable due to the generally low family labour access by female heads. From labour literature, one of the major sources of gender discrimination is access to labour markets where women have low access to employment, high remuneration and low positions. For instance, Obasi & Kanu (2014) found that male farmers have more access to hired labour than female farmers and argued that females are disadvantage since household labour supply is irregular and the fact that males have more economic advantage to high labour. A similar finding was reported by Amu (2005).

The constraint with the third highest percentage among the three samples is lack of information on livelihood diversification. This was mentioned by more female spouses (55.08%) than female heads (46.30%) and male heads (45.99%). The respondents argued that, they have less information on how to engage in a particular livelihood

activity as well as the specific merits, challenges, threats and opportunities associated with each strategy. Therefore, they engage in diversification on their personal discretion. This lack of information could limit the realization of full benefits from livelihood diversification since specific actions and inactions of each strategy are less known by the households. The lack of information revealed by more female spouses may be due to their low access to social gatherings in the society. For instance, where community gatherings are conducted, it is household heads, particularly, male heads dominated.

Lack of land and poor access to market were seen as the less important constraints to livelihood diversification. Generally, nonfarm economic activities requires less land and so, this may not be a major constraint for farmers' engagement in these types of livelihood activities. While lack of land was mentioned as a constraint by many male heads than females, poor access to market was mentioned by many females than male heads. Crop diversification in Ghana is largely based on land extensification; therefore, the high crop diversification among male heads could explain their demand for more land, hence many of them than females mentioned land as a constraint. The low percentage of females revealing lack of land is contrary to previous reports (FAO, 2011) that women often have less access to land.

4.7 Summary and conclusions of chapter four

This chapter provided the descriptive statistics of the socioeconomic factors of the farmers and the qualitative analysis of farmers' perceptions on climate change, sources of gender inequality and livelihood diversification. This revealed that the majority of the farmers perceived changes in rainfall and temperature directions correctly than other climate shocks such as wind, climate induced disease and conflicts. The perceptions of

the farmers on rainfall and temperature supports the observed climatic data from the meteorological department. The farmers also perceived that gender inequalities exist and these inequalities favours males than females. However, it can be concluded from the perception index that the perceived gender gaps are gradually eroding. It can also be concluded that, except crop diversification and crop-animal diversification, the level of livelihood diversification of other strategies is low among the farmers. Generally, females have high advantage in agro-processing and trade diversification strategies than other diversification portfolios, hence, these should be promoted by local government.

CHAPTER FIVE

GENDER PERSPECTIVES OF THE DETERMINANTS OF LIVELIHOOD DIVERSIFICATION

5.1 Overview

5.1.1 Introduction and empirical model

Climate adaptation is crucial for maintaining and improving livelihoods. One of these localised climate responsive adaptation strategies is livelihood diversification. In this chapter, an analysis of the determinants of livelihood diversification within a gender perspective is provided. Admittedly, these strategies are not new strategies. However, its engagement in recent times is largely a climate risk aversion and responsive strategy. As discussed under section 3.5.2, livelihood diversification was analysed using a multivariate probit regression with five equations as crop diversification, animal rearing, trading, agro-processing and professional or skilled employments. These were estimated for the pooled sample and the gender groups; given four estimations.

This chapter address three missing information in diversification literature. Firstly, in addition to the socioeconomic variables commonly used in previous studies, this chapter included climate and asset variables. Secondly, it identified the effect of these factors on each specific livelihood strategy other than assuming livelihood diversification as a single alternative or mutually exclusive alternatives or through an index. Lastly, this study highlighted the gender perspectives of livelihood diversification other than the implicit assumption of previous studies that diversification decisions and its drivers are gender neutral. Empirically, the following model was estimated.

$$Livelihood\,diversification = \beta_0 + \beta_1 Gender + \beta_2 Age + \beta_3 Adults + \beta_4 Home\ keeping + \beta_5 Experience + \beta_6 Extension + \beta_7 Contract\ far\min g + \beta_8 Training + \beta_9 FBO + \beta_{10} Credit\ access + \beta_{11} Arable\ land + \beta_{12} Windstorm + \beta_{13} Flood + \beta_{14} Drought + \beta_{15} Forest\ fires + \beta_{16} C\lim ate\ \inf ormation + \beta_{17} CCV\ perception + \beta_{18} Financial\ asset + \beta_{19} Physical\ asset + \beta_{20} Social\ asset + \beta_{21} Human\ asset + \beta_{22} Techno\log ical\ asset + \beta_{23} Political\ asset + u \quad (5.1)$$

Table 5.1 Definition of the variables and their expected signs.

Variable	Definition	Apriori
Gender	Dummy: 1 if male, 0 if female	+
Age	Total number of years of a famer from birth	-
Adults	Number of household members with age 18 and above	+
Home keeping	Number of hours spent on domestic activities daily	-
Experience	Total number of years in farming	+
Extension	Dummy: 1 if a farmer had access and 0 if otherwise.	+
Contract farming	Dummy: 1 if a farmer engaged in contract farming and 0 if otherwise.	+
Training	Dummy: 1 if a farmer had agricultural related training and 0 if otherwise.	+
FBO	Dummy: 1 if a famer belonged to an FBO and 0 if not	+
Windstorm	Dummy: 1 if a farmer experienced windstorm that affects properties within the past 3 years and 0 if otherwise.	+
Flood	Dummy: 1 if a farmer experienced flooding within the past 3 years and 0 if otherwise.	+
Drought	Dummy: 1 if a farmer experienced drought within the past 3 years and 0 if not	+
Forest fires	Dummy: 1 if a farmer experienced forest fire within the past 3 years and 0 if not	+
Climate information	Dummy: 1 if a farmer had climate information and 0 if not	+
CCV Perception	Dummy: 1 if a farmer perceives an increase in temperature and decrease in rainfall simultaneously and 0 if not	+
Financial asset	Measured using access to credit. 1 if a famer had access to credit and 0 if otherwise.	+
Physical asset	PCA weighted sum of physical assets (tractor, car, mobile	+

	phone, TV, radio, bicycle, motorbike, sewing machine and electric cooker) of a farmer	
Social asset	PCA weighted sum of social assets (number of single sexed groups, number of combined sex groups and conflict) of a farmer	+
Human asset	PCA weighted sum of human assets (household labour force, number of days of causal labour provided in a month and education) of a farmer	+
Technological asset	PCA weighted sum of all technological assets (access to irrigation, improved seeds and subsidised fertiliser) of a farmer	+
Political asset	PCA weighted sum of all political assets (leadership position, family member involvement in national politics, membership of a political group) of a farmer	+

5.1.2 Model diagnosis

From the result, the estimated Wald chi squares in all four models were statistically significant, implying that the estimated models were well fitted. The joint correlation tests in all four models were also significantly different from zero (Table 5.2). The significance of the joint correlations implied that the hypothesis that the adoption decision of livelihood diversification strategies are independent (zero correlation between the error terms) was rejected; hence, the estimation of the multivariate model is appropriate. Also, most of the paired correlation test between livelihood strategies were statistically significant and positive or negative (Table 5.2). While the positive correlations means complementarity of livelihood strategies, the negative correlations means substitutability of strategies. Generally, majority of the paired correlations were negative, suggesting a high substitutability of the diversification strategies. This was expected as engaging in these strategies require resource investment, which may limit the farmers.

Table 5.2: Correlation matrix of error terms

X	**Sample category**	CD	CLD	CTD	CAD
CLD	Pooled	0.142(0.076)*			
	Male heads	0.035(0.139)			
	Female heads	0.235(0.194)			
	Female spouses	0.527(0.118)***			
CTD	Pooled	-0.200(0.075)***	-0.111(0.068)*		
	Male heads	-0.121(0.131)	-0.027(0.109)		
	Female heads	0.182(0.207)	0.079(0.174)		
	Female spouses	-0.54(0.116)***	-0.29(0.122)**		
CAD	Pooled	0.069(0.077)	-0.024(0.072)	-0.058(0.068)	
	Male heads	-0.006(0.116)	-0.157(0.08)**	-0.077(0.096)	
	Female heads	-0.009(0.245)	0.352(0.122)**	-0.382(0.227*)	
	Female spouses	0.363(0.137)***	0.092(0.143)	-0.124(0.135)	
CPD	Pooled	-0.003(0.081)	-0.019(0.071)	-0.19(0.0678)***	-0.23(0.069)***
	Male heads	-0.061(0.145)	-0.059(0.117)	-0.015(0.104)	-0.37(0.108)***
	Female heads	-0.66(0.150)***	-0.310(0.222)*	-0.331(0.259)	0.033(0.259)
	Female spouses	0.059(0.132)	0.219(0.133)*	-0.35(0.116)***	0.024(0.126)
Chi sq.	Pooled	33.744***			
	Male heads	24.278***			
	Female heads	18.034*			
	Female spouses	50.598***			

***, ** and * indicates significant levels at 1%, 5% and 10%, respectively

KEY: CD=On-farm (crop) diversification; CLD=Crop-Livestock diversification; CTD=Crop-Trade diversification; CAD=Crop-Agro-processing diversification; CPD=Crop-Prof/Skilled job diversification

5.2 Factors influencing crop diversification

Crop diversification involves the cultivation of more than one crop either on the same plot or on separate plots. In this study, crop diversification is defined as the cultivation of any other staple crop in addition to maize. In diversification literature, crop

diversification is identified as one of the strategies to improve household food security and welfare, amidst climate change. For instance, Neudert et al. (2015) provides that households become wealthy with higher crop diversity while Birthal et. (2015) argued that crop diversification into high-valued crops can enhance household's livelihood outcomes such as food security and welfare. On their part, agriculture diversification led to an improved children's nutrition (Chen & Salas, 2015). From the results in Table 5.3, the factors that significantly determine households' decision into crop diversification were gender, age, extension, contract farming, windstorm, flood, climate information, financial assets, physical assets, social assets, human assets and technological assets.

Gender had a positive effect on crop diversification in the pooled model and this means that male heads have higher probabilities of engaging in crop diversification than the females. This could be due to the vital role men play in providing food for the family. In most rural homes, men usually engage in the cultivation of multiple food crops to meet both the food diversity and cash needs of their families. Observations from the field survey revealed that women mostly cultivate a major staple crop and complement with vegetables (tomato, pepper, okro and local green leaves such as 'allefu' and 'bra') for home needs. The low availability of mechanised production tools and implement also means that more human power is necessary to sustain the cultivation of an additional staple crop or extra land for other crops, hence the males capacity to engage in crop diversification. This is consistent with the findings of Abay et al. (2009). FAO (2016) and Adam & Zakaria (2015) also estimated that male farmers have higher crop diversification probabilities than females. Contrary, Rehima et al. (2013) estimated a negative effect of gender on crop diversification and argued that female heads may be more concerned about providing food for the family than the males.

Table 5.3: Factors influencing crop diversification

Variable	Pooled		Male heads		Female heads		Female spouses	
	Coeff.	Std. Error	Coeff.	Std. Error	Coeff.	Std. Error	Coeff.	Std. Error
Gender	0.373[b]	0.162						
Age	-0.015[b]	0.007	-0.033[a]	0.012	-0.036	0.029	0.0001	0.017
Home keeping	0.049	0.053	-0.025	0.095	-0.020	0.144	0.104	0.105
Experience	0.008	0.007	0.016	0.010	0.019	0.019	0.013	0.016
Extension	-0.364[b]	0.156	-0.871[a]	0.249	-0.219	0.737	0.457	0.323
Contract farming	0.616[a]	0.212	0.923[b]	0.399	2.811[b]	1.363	0.360	0.337
Training	0.195	0.158	0.251	0.255	0.490	0.573	0.050	0.300
Adults	0.018	0.022	0.019	0.038	0.011	0.080	0.010	0.040
Windstorm	-0.133	0.165	0.217	0.271	-1.00[c]	0.541	-0.35[c]	0.356
Flood	-0.071	0.159	-0.639[b]	0.276	1.254[b]	0.629	0.403	0.320
Drought	0.099	0.154	0.141	0.242	0.729	0.485	-0.294	0.301
Climate info.	-0.268[c]	0.149	-0.131	0.245	0.413	0.452	-0.68[b]	0.281
Forest fires	0.012	0.059	0.071	0.099	0.002	0.157	0.021	0.126
CCV perception	0.087	0.158	0.255	0.260	0.196	0.473	-0.439	0.322
Financial asset	0.683[a]	0.183	0.647[b]	0.288	0.778	0.822	0.273	0.330
Physical assets	0.049	0.094	0.089	0.153	0.360	0.389	-0.24[b]	0.107
Social assets	0.031[b]	0.016	0.030	0.038	1.074[b]	0.454	0.020	0.022
Human assets	0.068[a]	0.023	0.049	0.037	0.156	0.101	0.066	0.042
Technology assets	0.284[c]	0.156	0.283	0.257	1.164[c]	0.706	0.537[c]	0.314
Political assets	0.097	0.154	0.291	0.232	-0.507	0.535	-0.592	0.383
Constant	0.801	0.384	1.915	0.626	0.202	1.236	1.047	0.797

NOTE: [a, b] and [c] indicate significant levels at 1%, 5% and 10%, respectively

Age had a significant effect on crop diversification among the male heads and also in the pooled model. The negative marginal effect means that the younger male heads or the younger farmers in general have higher probabilities of cultivating an additional staple crop than the older farmers. In adoption studies, younger farmers are described as early adopters due to their innovativeness and their desire to try new things. This is

significantly observed for males and not females. Also, the findings in this study is plausible since younger farmers are more energetic, and could effectively work on separate farms. Consistently, Shahbaz et al. (2017) and Asravor (2017) found a negative relationship between age and crop diversification and labour diversification, respectively. Jiao et al., (2017) argued that younger household heads are likely to engage in labour intensive diversification strategies than capital intensive strategies. Contrary, Asante et al. (2017) and Abay et al. (2009) found that the extent of crop diversification is higher for older farmers and argued that the older farmers are risk averse than the younger farmers.

Extension access had a negative significant effect on crop diversification among male heads and the pooled model. Thus, farmers, particularly male heads who had access to extension services had lesser probabilities of engaging in crop diversification. Although this is contrary to expectations, it is justifiable that extension services are often crop tailored. Extension services are provided to farmers cultivating a particular crop with no or minimal crop diversification promotion. In other words, the extension services received by the farmers encourage specialization in the cultivation of crops than diversification. In recent times, Non-governmental Organisations (NGOs) have engaged in the provision of extension services to farmers in northern Ghana, particularly, maize, soybean and rice farmers. Their objective in general is to enhance crop production amidst climate change but these do not also promote crop diversification. Generally, FAO (2011) indicated a low access to extension services by women. Although extension officers often encourage women to participate in extension programs, their participation is low relative to the males and this could explain the insignificance of extension on crop diversification by females. Consistent with this study, Mesfin et al. (2011) and Abay et al. (2009) found a negative effect of extension on crop

diversification. Mesfin et al. (2011) argued that, extension services aimed more at improving productivity and profitability which favour specialisation and neglects the role of crop diversification in risk reduction. The study of Asante et al. (2017) however estimated a positive effect of extension on both the decision and extent of crop diversification.

The effect of contract farming is positive in all models but significant for the pooled sample, male heads and female heads. This means that farmers, particularly, male and female heads who engaged in contract farming had higher probabilities of diversifying into many staple crops cultivation. Contract farming provides opportunity for farmers to receive both physical inputs such as improved seeds and technological assistance from their partners. Although contract providers usually engage farmers on specific crop such as maize, the benefits from these contractual agreements can be transferred by the farmers onto the cultivation of other crops. Similarly, the provisions of physical inputs have a positive income effect (increase in real incomes), hence farmers are able to invest these increases on other farms or crops.

From Table 4.7, this study revealed that one of the challenges to diversification by the farmers is climate change and variability. Therefore, climate variables were included in the model. The effects of floods on male farmer's decision and the pooled model were negative but positive for the female farmers. This was statistically significant for only male and female heads. These means that while male farmers who experienced flood within the past three years had less probability of engaging in crop diversification, female heads who experienced flood had higher probabilities of diversifying into other crops. Farmers who experienced floods may engage in specialization since the flood might have forced them to identify flood resistant maize varieties for the present and future cultivation, hence may not cultivate other crops for responding to flood changes.

Similarly, to avert future occurrence these farmers may abandon the lands on which there was flooding to uplands. These are not plausible for females as their access to land is limited and largely determined by the males. Hence, female farmers may be risk averse and would cultivate more staple crops on the same farm lands. FAO (2016) also estimated that rainfall shocks have a negative effect on crop diversification in Niger. Relatedly, Abay et al. (2009) found a positive relationship between average rainfall and crop diversification.

Contrary to expectations and the findings of Ngigi et al. (2017), farmers who received climate information had lesser probabilities of engaging in crop diversification. It was expected that climate information would encourage farmers to cultivate multiple crops other than only maize. However, the survey revealed that farmers that received climate information are able to identify the type of crop or maize variety to cultivate based on the information available to them. Therefore, they were engaged in crop specialization than crop diversification. According to the farmers, one of the major challenges to crop production is the lack of climate or weather information. Therefore, there is the need to make climate information more relevant to the farmers especially by providing the information timely and in a language that the farmers can fully understand.

Financial asset significantly influenced farmers' decision into crop diversification. Thus, male farmers and farmers as a whole, had higher probabilities of engaging in crop diversification through access to agricultural credit. The effect of credit on diversification can be explained through its effect on resource mobilization. As an inflow, cash credit improves the income levels of the resource-poor farmers, hence it improves the financial ability of cultivating more crops on the same land or separate farms. With the risk of losing maize and the inability to repay credits, farmers may engage in the cultivation of additional staple crops to spread farm risks and be able to

repay the credits on time. The credit risk averse nature of females could explain the insignificant effect of credit on crop diversification decision of the females. Consistently, Adam & Zakaria (2015) also estimated no significant effect of credit on crop diversification by females.

Physical assets had a negative significant effect on crop diversification decision of female spouses. For the other groups, the effect was positive but insignificant. The negative significant effect means that female spouses with higher physical assets had higher probabilities of engaging in crop specialization than crop diversification. The acquisition of physical assets is a major priority of female spouses. Therefore, it is clear that those female spouses with high physical assets would have high utility and thereby becoming risk neutral. Hence, may not have the desire to engage in crop diversification for the fear of losing maize yields. From Ngigi et al. (2017), the level of consumer durable (a form of physical) assets improved the decision of female spouses to adopt crop related climate smart technologies. Consistent with the pooled estimate, Shahbaz et al. (2017) also found that households with tractor (a physical asset) ownership have higher crop diversification intensity.

Social assets (group membership and peaceful coexistence) had a positive effect on both males and females as well as when gender blind is assumed. However, this effect was significant for only female heads and the pooled model. This means that, with increased group participation and peaceful coexistence among farmers particularly the female heads, they would engage in crop diversification. While groups serve as a source of labour by providing assistance to each other in a group (Ngigi et al., 2017), peaceful coexistence ensures that farmers have peace of mind to engage in their livelihood activities. This justified the important role of social assets in advancing diversification among households and the need to improve social assets among households and

communities. This is consistent with the findings of Dube & Guveya (2016). Relatedly, Ngigi et al. (2017) also estimated a significant effect of social capital of males on the adoption of crop related climate smart technologies.

There is a positive effect of human assets on crop diversification in all models but significant for only the pooled model. Thus, with higher human assets, famers have higher probabilities of engaging in crop diversification. A diversified farm implies that more activities and labour are required on the farm(s). Similarly, it is expected that with a healthy life, farmers become active enough to cultivate more crops or farms. The respondents argued that most of their farms are not in the same locality. For instance, some have maize farms closer to their homes while others such as rice farms are farther away from home. Therefore, since the farmers have to walk to these two farms, they argued that they must be healthy enough to manage these two farms. Also, education which is a major component of human assets improves the knowledge of farmers on crop diversification. It is not consistent therefore that Asravor (2017) and FAO (2016) also estimated a positive effect of education on labour and crop diversification.

Technological assets had a positive effect on all models and also significant for all models except for male heads. This implied that the probability of engaging in crop diversification increases with the level of technological assets. This is consistent with the researcher's expectation since technology provides numerous opportunities to the farmers. For instance, with access to subsidized inputs such as fertilizer and improved seed varieties, farmers can engage in the cultivation of many crops. This justified the calls for making technological opportunities available to farmers. Mesfin et al. (2011) also found that, farmers who owned machineries such as water pumps had higher probabilities of engaging in crop diversification. Contrary, Dube & Guveya (2016)

found that farmers who engaged in irrigation farming had lower crop diversification index.

5.3 Factors influencing mixed maize crop-animal diversification

This section examined the factors influencing maize farmers' decision to engage in animal rearing as a livelihood strategy; thus, simultaneous maize-animal farming. Mixed crop-animal production system is an environmentally and economically sustainable production method where farmers engage in the production of crops and animals on the same piece of land or different pieces of land (Liebig et al., 2017; Nhemachena et al., 2014; Lemaire et al., 2013; Ryschawy et al., 2013; Tarawali et al., 2011). The system provides mutual benefits to both crops and animals (Thornton & Herrero, 2015;Valbuena et al., 2012; Herrero et al., 2010), cost effective (Asante et al., 2017) and have less agricultural carbon footprints (Gil et al., 2016; Thornton & Herrero, 2015). Animals can easily be managed on farms in periods of climate shocks such as droughts (Chandra et al., 2017). Chandra et al. (2017) further argued that not only are livestock cheaper and less labourious, but also serves as an insurance for droughts or floods and as a source of relief in times of hardship or crop failure. In this study, a number of socioeconomic, climate and asset factors had significant influence on both male and female farmers' probability of engaging in crop-animal diversification. This is presented in Table 5.4 and discussed below.

From Table 5.4, gender had a positive significant effect on diversification into animal production. This implies that the male heads had higher probabilities of engaging in this diversification portfolio than the females. This again justified the need for the segregation of the estimation based on the gender groups.

In all four models, age had a negative effect on farmers' decision to engage in animal rearing. This is significant for all models except for male heads. This means that younger farmers, particularly, younger females had higher probabilities of engaging in mixed maize crop-animal farming system than the older farmers. Consistent with the findings of this study is the work of Jiao et al. (2017).

Table 5.4: Factors influencing crop-animal diversification

	Pooled		Male heads		Female heads		Female spouses	
Variable	Coeff.	Std. Error	Coeff.	Std. Error	Coeff.	Std. Error	Coeff.	Std. Error
Gender	0.520	0.136						
Age	-0.016	0.006	-0.004	0.010	-0.035 [c]	0.021	-0.049	0.014
Home keeping	-0.045	0.044	-0.024	0.081	-0.125	0.132	0.005	0.079
Experience	0.028	0.006	0.014	0.009	0.026 [c]	0.015	0.059	0.014
Extension	-0.235 [c]	0.134	-0.045	0.202	-0.322	0.411	-0.170	0.243
Contract farming	0.020	0.156	-0.064	0.245	1.606	0.643	-0.288	0.269
Training	0.079	0.132	0.407 [c]	0.208	-0.912	0.424	0.164	0.253
Adults	-0.004	0.019	0.042	0.033	-0.046	0.061	-0.058 [c]	0.032
Windstorm	-0.091	0.139	-0.291	0.215	-0.157	0.379	0.329	0.301
Flood	0.016	0.137	0.058	0.224	0.063	0.386	-0.450 [c]	0.249
Drought	0.537[a]	0.133	0.749 [a]	0.205	-0.361	0.403	0.423	0.247
Climate information	-0.154	0.126	0.029 [c]	0.203	-0.528	0.357	-0.244	0.230
Forest fires	-0.010	0.049	-0.006	0.081	0.154	0.134	-0.049	0.092
CCV perception	0.297[b]	0.133	0.336	0.209	0.566	0.368	0.186	0.240
Financial asset	0.279 [b]	0.141	0.107	0.211	0.468	0.454	0.242	0.267
Physical assets	-0.005	0.084	-0.160	0.133	-0.164	0.203	0.280	0.184
Social assets	0.017	0.012	0.034	0.027	0.109 [c]	0.068	0.001	0.019
Human assets	0.034 [c]	0.019	0.034	0.031	0.220 [b]	0.086	0.059 [c]	0.033
Technological assets	0.299 [b]	0.127	0.302	0.210	0.448	0.393	0.030	0.234

Political assets	0.065	0.135	0.175	0.192	0.187	0.410	0.114	0.295
Constant	0.036	0.324	-0.220	0.503	2.018	1.087	1.252	0.631

NOTE: [a, b] and [c] indicate significant levels at 1%, 5% and 10%, respectively

The experience level in crop production had positive effects on the decision making of households to engage in mixed crop-animal diversification. This is significant in all models except for male heads. This means that females farmers in particular who have being into crop farming for several years had higher probabilities of engaging in an integrated crop-animal diversification. With higher experience in crop production (the main occupation of the respondents), the farmers become conversant with the production process and are able to combine maize farming with other activities such as animal rearing.

Access to extension services had a negative significant effect on farmers' decision to diversify into animal farming. However, the effect is insignificant when gender groups were considered. The negative effect means that farmers who had access to extension services had lesser probabilities of integrating animals into crop farming systems than those who did not received extension services. With crop-tailored or crop-biased extension services that are provided to farmers in the country, it is consistent that the farmers who received extension service may not be willing to rear animals, instead, cultivate crops.

Training had a mixed effect on crop-animal diversification as this was positive and significant for male heads but negative and significant for female heads. Thus, male heads who had training in crop production had higher probabilities of engaging in mixed crop-animal farming, while the reverse is the case for the female heads. This indicates that training in crop production do not promote animal rearing for female

farmers or that the trainings make these farmers more conversant with crop production and are able to meet their household needs. Thus, the trainings received by the female heads makes them more efficient and effective in crop production.

The number of adults in a household had a negative effect on animal rearing decision in all samples except that of the male heads. However, this effect was significant for only female spouses. This means that female spouses with many household adults had lesser probabilities of engaging in mixed crop-animal farming system as a respond to climate change. In most agrarian households, adults provide readily available labour to each other, especially, the household heads. Therefore, farmers may use this labour opportunity for their crop farms other than in animal farms since the latter requires less labour.

Access to credit had a positive effect on mixed crop-animal farming and this is significant for female spouses and the pooled sample. For female heads, credit was dropped due to non-convergence in the model. One notable merit of credit is that it enhances access to other inputs. Farmers who have access to credit are able to buy the young animals (the stock) for rearing and buy supplementary feeds and vaccines where necessary. At the same time, able to obtain the needed inputs for crop production. On the flipside, credit constraint is a major concern to most farming households in the developing countries such as Ghana. Therefore, farmers who are able to break through this constraint are able to improve their livelihood activities such as crop-animal integration.

Farmers, particularly male heads and their spouses, who experienced droughts over the past three years had higher probabilities to engage in integrated crop-animal farming. The reverse is true for the female heads, although insignificant. One reason for which animal rearing is a preferred adaptation strategy is its low dependence on rainfall.

Therefore, it is conceivable that maize crop farmers who have experienced drought would engage in animal rearing since they can obtain water from other sources such as pipes, boreholes or streams for their animals. Contrary to drought, flood had a negative significant effect on crop-animal diversification for only female spouses. Although insignificant, the positive effect of flood on diversification by the pooled sample, male heads and female heads are consistent with the researcher's apriori expectation.

Generally, farmers who were able to observe or perceive correctly the trends in climatic variables such as rainfall and temperature had higher probabilities of rearing animals than those who perceived the trends in climate variables in the wrong direction. The implication thereof is that those who have the right predictions were able to take precautionary measures and adapted to climate change accordingly. This is particularly significant for the pooled model. This justified the need to improve the knowledge of farmers on climate change and variability and also enhance their understanding on the possible changes in the climatic conditions in the future.

In all samples, financial assets had positive effects on the decision to integrate animals into maize farming, but this is statistically significant for only the pooled model. Thus, farmers with high financial assets engaged in mixed crop-animal farming than those with lesser financial asset. Financial assets provided a source of income for farmers and this could have been a source of motivation towards the decision on animal rearing. Soltani et al. (2012) explained that access to financial capital encourages households to engage in lucrative activities such as animal rearing that require less labour and land. Similarly, Asante et al. (2017) estimated a positive significant effect of credit on the decision and extent of livestock diversification and also, a positive effect on the extent of crop-livestock integration.

The effect of social assets on integrated crop-animal farming is positive in all models but significant for only the female heads. In most farming communities, social asset is a major source of information, knowledge and labour. Therefore, with higher social assets, households can take the decision on rearing animals since they may get the social support for such activities. This is particularly significant among the female heads due to the high cohesion and social ties among these households.

Human assets also had positive effects on farmers' decision into integrated crop-animal farming. This is significant for all samples except the male heads. This implies that farmers, especially the female farmers, with high human assets had higher probabilities of engaging in animal rearing. From the literature, one important human asset is education. For instance, Jiao et al. (2017) and Soltani et al. (2012) found a positive effect of education on diversification into livestock production and Gil et al. (2016) estimated that, educated farmers had a higher probability of engaging in crop-livestock integration. Contrary, Winters et al. (2009) found that, there is a negative relationship between education and livestock rearing in Ghana.

The study also revealed that with increased technological assets, famers in general would have an increased probability of rearing animals in addition to crop production. This support the need for making technologies more available, accessible and easy to understand and use by farming households.

5.4 Factors influencing households' crop-trade diversification

Trading involves buying and selling. It is one of the common livelihood strategies especially in informal economies such as rural agrarian communities. From the literature, trading is generally classified under non-farm diversification portfolios. Table 5.5 present the results for the determinants of crop-trade diversification. In this section,

the factors that had significant effect on the decision of farmers to engage in trading and crop farming simultaneously as a response to climate change and variability are discussed.

Table 5.5: Factors influencing households' crop-trade diversification

	Pooled		Male heads		Female heads		Female spouses	
Variable	Coeff.	Std. Error	Coeff.	Std. Error	Coeff.	Std. Error	Coeff.	Std. Error
Gender	-0.453[a]	0.127						
Age	0.007	0.006	0.007	0.009	0.085[a]	0.026	-0.003	0.012
Home keeping	-0.112[a]	0.042	-0.112	0.074	-0.010	0.149	-0.187[b]	0.074
Experience	-0.009[c]	0.005	-0.002	0.008	-0.052[a]	0.018	-0.005	0.012
Extension	-0.337[a]	0.125	-0.103	0.176	-0.865[b]	0.417	-0.709[a]	0.239
Contract farming	-0.119	0.143	-0.016	0.208	-0.698	0.669	-0.203	0.258
Training	0.160	0.122	0.285[c]	0.177	-0.277	0.440	-0.076	0.243
Adults	0.014	0.017	-0.001	0.025	-0.275[a]	0.086	0.049	0.031
Windstorm	-0.039	0.129	-0.40[b]	0.197	1.366[a]	0.448	0.006	0.279
Flood	0.009	0.126	0.277	0.193	-0.316	0.386	-0.209	0.242
Drought	0.001	0.125	-0.019	0.183	0.067	0.408	0.124	0.243
Climate information	-0.001	0.117	-0.194	0.178	0.046	0.366	0.335	0.221
Forest fires	-0.065	0.045	0.023	0.066	-0.184	0.141	-0.207[b]	0.093

CCV		0.12				0.38		0.23
perception	0.053	8	0.085	0.197	-0.154	5	0.140	8
		0.12				0.44		0.26
Financial asset	0.233 [c]	7	-0.042	0.185	0.571	7	0.618 [b]	3
		0.07				0.36		0.17
Physical assets	0.032	9	0.240 [b]	0.123	-0.533	8	-0.211	5
		0.01				0.08		0.01
Social assets	-0.002	1	0.026	0.017	-0.147 [c]	2	-0.023	9
		0.01				0.11		0.03
Human assets	-0.006	8	-0.003	0.028	0.187	8	-0.005	1
Technological		0.11				0.41		0.22
assets	0.110	2	0.170	0.167	0.176	9	-0.112	7
		0.12				0.42		0.31
Political assets	-0.040	2	-0.104	0.164	-0.172	2	0.362	2
		0.30				1.21		0.58
Constant	-0.020	1	-0.912	0.440	-1.804	3	0.763	5

NOTE: [a, b] and [c] indicate significant levels at 1%, 5% and 10%, respectively

Expectedly, gender had a negative significant effect on trading decision by the farmers. Thus, females had higher probabilities of trading than males. Observation from Ghana's informal economy suggests that females often engage in trading activities than males. In a study on SSA, Rijkers & Soderbom (2013) also explained that there is an inverse relationship between gender and trading, hence females often have a higher probability for trading. Contrary to the result of this study, Mathenge & Tschirley (2015) found that male heads had higher probabilities of engaging in business and informal activities.

The result (Table 5.5) proved that, the higher the number of hours spent at home, the lesser the probability of engaging in trade activities. This is specifically significant for female spouses and the pooled model. The high domestic activities of female spouses such as the provision of water (which they have to walk very long distance especially in

the dry season), cooking and caring for children reduces their time and strength for trading. Most rural trade business are most effective in the morning and evenings where everyone is at home. Unfortunately, these are the hours for domestic activities by the female spouses.

The number of adults present in a female headed household decreases the probability of engaging in crop-trade diversification for the female heads. It was expected that, with higher household adults, the female heads would have much access to assistance for crop-trade diversification. However, the study revealed that trading assistance is provided by children and not the adults, hence the negative effect of adults on trading decision. Contrary to this finding, Asmah (2011) found that the number of household members in different adult categories had positive significant effects on non-farm diversification activities. Owusu et al. (2011) estimated that while household size generally leads to higher probability of non-farm employment, dependency ratio decreases the probability of engaging in such activities.

In general, experienced farmers had lesser probabilities of engaging in crop-trade diversification than the less experienced farmers. This is significant for the pooled model and the female heads. The study observed that, the experienced farmers have some understanding of climate change and are able to adopt crop production systems to minimise its impacts. Therefore, the probability of engaging in trading as a climate response strategy is lower for these experienced farmers.

Access to extension services have a negative effect on the decision to engage in crop-trade diversification by both males and females. This effect is significant for all samples except male heads. Since extension services are directed to improve agricultural productivity and make the farmers more efficient, it is relevant that the farmers who

received such services and become more efficient would be less willing to engage in a non-farm activity such as trading.

Windstorm had mixed effects on household's decision to engage in crop-trade diversification. While male heads whose homes were affected by windstorm for the past three years had lesser probabilities of engaging in crop-trade diversification, female heads who had similar windstorm impacts had higher probabilities of engaging in crop-trade diversification. Although positive for female spouse also, the coefficient estimate was insignificant. This demonstrates that although both males and females may be exposed to the same climate shock, adaptation decisions may differ between the gender groups. For females, their resistance and recovery from such climate shocks is low, hence, the positive effect of windstorm on trading decision is plausible. However, the mechanisms through which windstorm could reduce the probability of engaging in trading activities among the male heads needs further exploration.

The effect of forest fires on crop-trade diversification is significant and negative for female spouses. Thus, female spouses who experienced bushfires had lesser probabilities of engaging in trading. It was expected (as observed from male heads model) that since bushfires mostly affect farms than homes, households would adopt trading activities in order to assure a stable household income. However, the study survey revealed that farmers who were affected by bushfires had to put extra efforts in their farms to ensure that they are able to obtain enough output and income for the household. Nonetheless, this finding is no justification for promoting the occurrence of bushfires and should be considered with caution. Rather, it highlighted that climate shocks occurrences would increase climate adaptation.

Assets that had significant effect on crop-trade diversification includes financial assets, physical assets, social assets and human assets. Financial and human assets had positive

effects on female heads' decision to engage in crop-trade diversification; physical assets had positive effect on male heads' decision to engage in crop-trade diversification; and social assets had negative effect on female spouses' decision to engage in crop-trade diversification. The positive effects of financial, physical and human assets suggests that, the probability of engaging in trading increases with higher levels of these assets. This demonstrates the need to expand the asset levels of rural households in order to enhance their diversification into non-farm activities such as trading. Empirically, Jiao et al. (2017) also estimated that households with higher physical assets are more likely to engage in business activities. Owusu et al. (2011) also estimated a positive effect of financial asset on the decision to trade. Aziz et al. (2017) estimated a positive effect of access to formal credit on diversification into non-farm activities such as trading. On physical assets, Osarfo et al. (2016) estimated that the ownership of physical assets such as trucks and motorbikes improves farmer's probability of engaging in non-farm livelihood activities such as petty trading. The negative significant effect of social assets on trading decision among the female heads could be as a result of low effectiveness of female heads' participation in social networks. For instance, females are mostly unable to make contributions during mixed sex group meetings, especially, when their husbands are present in such social networks. This is contrary to the findings of Aziz et al. (2017). The positive effect of social asset on trading by male heads is consistent with the findings of Ngigi et al. (2017) who argued that there is a significant difference (favouring males) in farmer group participation although group members enjoy economies of scale.

5.5 Factors influencing farmers' crop - agro-processing diversification

This section presents the factors that influences farmers' decisions to engage in diversification into agro-processing activities. From Table 5.6, a number of these factors had significant effect on the farmers' decision. These includes home keeping hours, experience, adults, extension access, training, drought, forest fires, climate information, financial assets, physical assets, social assets, human assets, technological and political assets. Although negative, the effect of gender on diversification into agro-processing is insignificant. Generally, female farmers and entrepreneurs engages in agro-processing than the males as observed in Table 4.5 where more females than males engaged in agro-processing. The specific effects of the significant factors are discussed below.

The total number of hours spent on domestic activities had a positive significant effect on male headed households' and a negative effect on females' (significant for female spouses) decision into agro-processing. This finding proves that male heads who spent more time on domestic activities had higher probabilities of engaging in agro-processing while females that spends higher domestic hours had lesser probabilities of engaging in agro-processing. In most instances, men have much time to engage in off-farm activities than females since domestic works such as cooking are overly performed by women. Matshe & Young (2004) argued that, the low level of females' participation in off-farm work is due to their time commitments at home and the general bias in labour time allocation. Relatedly, Kassie et al. (2017) elucidated that females perform activities such as cooking and child bearing/caring which are not considered as income generating activities but limits available time for engaging in diversification activities outside the farm.

Table 5.6: Factors influencing farmers' crop- agro-processing diversification decision

	Pooled		Male heads		Female heads		Female spouses	
Variable	Coeff.	Std. Error	Coeff.	Std. Error	Coeff.	Std. Error	Coeff.	Std. Error
Gender	-0.153	0.132						
Age	0.006	0.006	-0.010	0.008	-0.021	0.024	0.014	0.014
Home keeping	0.037	0.043	0.120 [c]	0.071	-0.314 [c]	0.164	-0.131	0.084
Experience	-0.004	0.005	0.011	0.008	0.009	0.019	-0.034 [b]	0.014
Extension	0.360 [a]	0.126	0.264	0.178	1.076 [b]	0.440	0.383	0.243
Contract farming	-0.152	0.152	-0.056	0.218	0.559	0.581	-0.440	0.283
Training	0.117	0.124	-0.066	0.176	-0.143	0.433	0.400	0.249
Adults	0.023	0.017	0.042	0.026	-0.005	0.067	0.061 [c]	0.032
Windstorm	0.015	0.131	0.183	0.186	-0.394	0.419	-0.058	0.306
Flood	-0.179	0.131	-0.244	0.196	0.026	0.482	0.073	0.261
Drought	0.358 [a]	0.130	0.339 [c]	0.182	0.267	0.430	0.422	0.268
Climate information	-0.212 [c]	0.121	-0.436 [b]	0.182	-0.583	0.432	0.250	0.241
Forest fires	0.077 [c]	0.047	0.092	0.067	0.301 [c]	0.157	-0.044	0.104
CCV perception	-0.151	0.133	-0.162	0.195	-0.399	0.402	0.239	0.259
Financial asset	-0.473 [a]	0.136	-0.401 [b]	0.193	-1.913 [a]	0.522	-0.617 [b]	0.288
Physical assets	0.070	0.081	-0.058	0.120	1.413 [a]	0.395	-0.262	0.211
Social assets	0.024 [b]	0.011	0.037	0.017	0.490 [b]	0.251	0.003	0.020
Human assets	0.022	0.019	0.011	0.029	0.198 [b]	0.099	0.026	0.034
Technological assets	-0.202 [c]	0.119	-0.130	0.172	-0.669	0.431	0.049	0.245
Political assets	0.135	0.123	0.100	0.160	1.248 [b]	0.518	0.014	0.334
Constant	-1.088	0.309	-0.933	0.431	-0.093	1.216	-0.999	0.641

NOTE: [a, b] and [c] indicate significant levels at 1%, 5% and 10%, respectively

Household adults provide an essential labour that are readily available and at a minimum or zero cost. Therefore, households with many adults would have a positive urge to engage in off-farm activities. In Table 5.6, this was confirmed by the positive significant effect of adults on agro-processing diversification. This is consistent with the

work of Matshe & Young (2004) where households with many household adults had higher probabilities of participating in off-farm work and spend longer hours on these activities than those with fewer household adults. In a related study, Ali et al. (2017) found that farmers with larger household sizes had higher probabilities of engaging in off-farm activities such as agro-processing.

Experience had a negative effect on agro-processing diversification for the pooled model and the female spouses but negative effect for the male heads and female heads. However, this effect was significant for only the female spouses. Although naive, experienced female spouses become more conversant with farm works and are able to obtain higher gains from the farms. Therefore, it is possible that they may not be willing to engage in off-farm diversification. Consistently, Ullah et al. (2015) found that, experienced farmers are more likely to avoid diversification in response to climate risks. Contrary, Danso-Abbeam et al.(2017) estimated that farmers with higher experience in maize farming had higher probabilities of engaging in off-farm work.

Farmers, particularly, female heads who had access to extension services had higher probabilities of diversification into agro-processing. This was expected as extension services in recent times include agribusiness education such as agro-processing and marketing sensitisation. Therefore, considering the fact that agro-processing is a female favoured economic portfolio in northern Ghana, it is plausible that female heads who had access to extension service would engage in agro-processing. This justified the need to enhance the provision of extension services to rural households since this does not only influence agricultural productivity but also translate into off-farm diversification decisions such as agro-processing. Contrary and although not statistically significant, Kassie et al. (2017) found an inverse relationship between agriculture extension and off-farm work engagement.

The climate related factors that significantly influenced the decision to engage in agro-processing were drought, forest fires and access to climate information. For instance, farmers who experienced climate shocks, specifically drought and forest fires in the past three years had higher probabilities of engaging in agro-processing than those who experience none of these shocks. Because maize farming is more responsive to climatic conditions, farmers who experience climate shocks would become more cautious of future likely impacts and hence, diversify into other economic activities such as agro-processing that are less climate sensitive. In recent years, drought has become a major challenge to farming in northern Ghana, while floods are also affecting homes and properties. Therefore, farmers may engage in agro-processing activities as a way of spreading risks from total crop failure due to climate shocks and add value to farm products. This is consistent with the findings of Mathenge & Tschirley's (2015) who noted that rural households engage in off-farm work to offset the effects of weather shocks on farms. It is consistent therefore that household heads (both males and females) who had access to climate information had lesser probabilities of engaging in agro-processing. Thus, with access to climate information on climate shocks and information on the weather, farmers were better placed to make farming decisions and this reduces their probability of engaging in off-farm activities.

All assets had positive significant effect on diversification into agro-processing except financial and technological assets that were negative. This means that if household's assets are increased, the probability of engaging in agro-processing activities would also increase. This reiterates the important roles of assets in determining the livelihood portfolios of households. For instance, household heads with higher social assets had higher probabilities of engaging in agro-processing diversification due to the mutual

benefits from social networks and the fact that recent developmental agencies working with farmers prefers doing so through an already existing social group or network.

The negative significant effect of financial asset on agro-processing decision by the farmers can be due to the positive effect of credit on capital mobilization for farm activities and the ability to purchase farm inputs. Thus, farmers who obtained credit were able to obtain inputs and expand their farms, hence, enjoyed economies of scale of production. The negative effect of credit on agro-processing in this study is consistent with the findings of Kassie et al. (2017). The study of Beyene (2008) confirmed that financial assets such as the number of draft animals and human assets such as the health status of farmers have positive effects on off-farm diversification decisions. Similarly, the negative effect of technological assets on agro-processing diversification is due to the fact that with increased access to improved technologies, farmers would be willing to invest most of their resources into farming than diversifying into other activities such as agro-processing. For human assets, in addition to the positive role of education in understanding the economic merits of agro-processing, the availability of household's labour provides incentive for engaging in agro-processing activities. From Aziz et al. (2017), education which involves a measure of human assets had a nonlinear effect on diversification into non-farm activities. Generally, Matshe & Young (2004) found that, assets have a positive effect on the probability of engaging in off-farm work but a negative effect on the hours spent on these activities.

5.6 Determinants of maize farmers' diversification into professional and skilled employment

One of the major forms of livelihood diversification is professional employment and skilled jobs. In the case of professional jobs such as teaching and health works, farming

is considered as a secondary job while farming remained a primary occupation for most farmers into skilled jobs such as woodcarving, dressmaking or hairdressing. In this section, the factors that influenced the farmers' decisions to engage in professional or skilled jobs as a climate response strategy are discussed. From the results in Table 5.7, the factors that significantly influenced diversification into processional/skilled jobs were gender, age, home keeping hours, extension, contract farming, training, climate information, forest fires, climate perception, financial assets, physical assets and technological assets.

From Table 5.7, there was a negative significant relationship between professional/skilled employment and gender. This means that female household heads or spouses had higher probabilities of engaging in professional activities than the male heads. Although this is contrary to *a priori* expectations of the research, observations from rural settings of northern Ghana suggests that skilled employment is more common among the females than the males. The females engages in these activities as a source of cash income and engage in farming for food. It is also the case that these skilled and professional jobs are less climate sensitive. Therefore, with the high vulnerability of females to climate shocks and risks, it is plausible that their probability to engage in skilled and professional activities would be high. Contrary, Asfaw et al. (2017) however observed that females have less probabilities of engaging in non-farm works.

Table 5.7: Determinants of diversification into professional and skilled employment

Variable	Pooled		Male heads		Female heads		Female spouses	
	Coeff.	Std. Error	Coeff.	Std. Error	Coeff.	Std. Error	Coeff.	Std. Error
Gender	-0.303[b]	0.135						

Age	-0.009	0.006	-0.029 [a]	0.010	0.002	0.020	0.014	0.013
Home keeping	-0.037	0.043	-0.099	0.082	0.156 [c]	0.081	0.126 [c]	0.077
Experience	-0.006	0.006	0.004	0.009	-0.002	0.014	-0.025 [c]	0.013
Extension	0.089	0.134	0.038 [c]	0.209	-0.295	0.387	-0.104	0.244
Contract farming	-0.296[b]	0.154	-0.475 [c]	0.244	0.897 [c]	0.510	-0.189	0.267
Training	-0.517 [a]	0.135	-0.628 [a]	0.220	0.200	0.429	-0.437 [c]	0.250
Adults	0.011	0.018	0.015	0.028	-0.018	0.059	-0.001	0.030
Windstorm	-0.170	0.136	-0.321	0.219	-0.014	0.339	0.071	0.284
Flood	0.082	0.134	-0.010	0.221	-0.132	0.346	0.135	0.241
Drought	-0.031	0.130	0.187	0.202	0.316	0.415	-0.327	0.246
Climate information	0.282 [b]	0.124	0.620 [a]	0.204	0.314	0.383	-0.233	0.222
Forest fires	-0.129 [a]	0.048	-0.183 [b]	0.076	-0.110	0.133	-0.045	0.094
CCV perception	0.328 [b]	0.139	0.926 [a]	0.262	-0.062	0.354	-0.128	0.244
Financial asset	0.222 [c]	0.136	0.198	0.208	0.202	0.370	-0.009	0.274
Physical assets	0.185 [b]	0.083	0.222 [c]	0.130	0.337 [c]	0.198	0.256	0.179
Social assets	-0.009	0.012	-0.025	0.018	-0.094	0.137	0.008	0.019
Human assets	0.008	0.019	0.000	0.031	0.027	0.080	-0.018	0.033
Technological assets	0.107	0.119	0.230	0.189	-0.622	0.447	0.443 [c]	0.236
Political assets	-0.041	0.132	-0.270	0.194	0.059	0.386	-0.138	0.300
Constant	-0.134	0.324	-0.252	0.525	-1.048	1.052	-0.809	0.615

NOTE: [a, b] and [c] indicate significant levels at 1%, 5% and 10%, respectively

Age had a negative significant effect on diversification into professional/skilled employments among male heads and for the pooled model. This means that the relatively younger male heads or farmers in general had higher probabilities of engaging in skilled and professional activities than the older farmers. This is conceivable due to the fact that skilled and professional employment requires that a person is put under a specific training for a number of years. For instance, in most communities, a person is

qualified as a hairdresser after undergoing apprenticeship for two years or more. It is therefore the case that the younger farmers would have much time and passion towards such diversification. This is consistent with the findings of Mathenge & Tschirley (2015).

Expectedly, the higher the education of a household, the higher the probability of engaging in skilled or professional employments. Like most other parts of Ghana, persons with higher education would want to engage in white collar and skilled jobs. The respondents argued that professional jobs are secured job and reduces their economic vulnerability at old age. Similarly, because of regular or constant income from professional jobs and the fact that education is a prerequisite for professional jobs, educated farmers had higher definite probabilities of engaging in such economic portfolios. Ullah et al. (2015) also estimated a positive effect of education on diversification and argued that people become aware of the importance of diversification as a response to climate shocks. In a cross country analysis, Winters et al. (2009) found a positive effect of education on engaging in non-agricultural wage employments in Ghana. Consistently, Mathenge & Tschirley (2015) established that household heads with higher education have higher probabilities of engaging in salary employments.

The number of hours spent on domestic works had a negative effect on males but positive effect on females. However, the effect is significant for only the females. Although it was expected that domestic hours would reduce available time for economic engagement and diversification, it can be argued that skilled jobs (unlike professional jobs) are often performed at home, within the community and mostly at the time discretion of the individual. Therefore, females may be able to easily combine these skilled jobs with domestic activities than the males.

Experience in farming had a negative effect on the decision to engage in skilled and professional activities for all samples except for male heads. However, this effect was significant for only female spouses. Consistent with the farmers perception discussed under section 4.4, the decision making of female spouses are mostly influenced by their husbands. Therefore, with higher experience in farming, it is most possible that they would be advised by their husbands or voluntarily decide to concentrate on farming work than engaging in skilled and professional activities.

The effect of extension on the decision to engage in skilled and professional employment is positive and significant for male heads but negative and insignificant for the females. This implied that irrespective of access to extension service by females, their decision on engaging in skilled employment remained significantly unaffected. On the other hand, male heads who received extension services perhaps are able to use the lessons from extension officers in a way that improves their farm efficiencies and therefore free up time for skilled activities. Although not gender based analysis, Asfaw et al. (2017) estimated that farmers with access to extension services have a higher probability of engaging in skilled employments.

There is a negative relationship between contract farming and skilled or professional activities. This relationship is significant for all samples except for female spouses. This means that farmers who engaged in contract farming had lesser probabilities of engaging in professional and skilled employments than those who did not engaged in contract farming. This is due to the high commitment required under contract farming to improve productivity to meet contractual agreements. Also, contract service providers help farmers with inputs and guarantee them of a ready market that motivates their maize farming decisions other than engaging in skilled and professional activities.

Contrary to expectations, farmers who had any form of training in crop production had lesser probabilities of engaging in skilled or professional activities. It was expected that training on farm activities would lead to high desire towards farming and improves the possibilities of obtaining higher outputs to meet household's food and income needs. However, some of the respondents argued that most of the trainings are less effective but only provided incentive and broadened their knowledge on following due processes, which are also relevant for skilled activities.

Climate shocks and climate related variables had significant effects on maize farmers' diversification decision into skilled or professional jobs. These factors include forest fires, climate information and perception on climate change. For instance, there was a negative significant effect of forest fires on the decision of male heads or farmers in general to engage in skilled and professional employments. This is contrary to the *a priori* expectations of the research. Also, farmers, particularly male heads, who had information on climate change and have perceived changes in climatic conditions appropriately had higher probabilities of engaging in skilled and professional jobs. This means that with climate change, farmers are more likely to move away from farm activities to non-farm activities. Contrary, Mathenge & Tschirley (2015) found that households that are located in high rainfall regimes are less likely to engage in salary employments.

Among household asset variables, financial assets, physical asset and technological assets had positive significant effect on diversification into skilled and professional jobs. For instance, financial assets led to higher probabilities of engaging in skilled jobs by the farmers if gender blind is assumed. The learning of skill or professional activities requires money. Therefore, it is possible that access to agricultural credit relief household income to pay and learn skill and professional activities or that some parts of

the credit received are diverted to the learning of these jobs. In other words, the real income of the households increases with access to credit, thereby, promoting the learning of skilled or professional jobs. This is consistent to the findings of Asfaw et al. (2017) and Kassie et al. (2017). Also, physical assets had significant effect on diversification into skilled jobs by male heads, female heads and farmers in general while technological assets led to higher probabilities of diversification by female spouses.

5.7 Predicted probability distributions

Figure 5.1 shows the predicted joint probabilities of diversification by the respondents. This shows that the joint probability of the farmers engaging in none of the livelihood activities is higher (0.015) than the joint probability of engaging in all livelihood activities (0.006). This difference was highly observed among female heads than other gender groups while the female spouses had a higher probability of adopting all diversification portfolios. The implication is that there is minimal chance for a more diversified livelihood among the farmers. The low predicted probabilities of adopting all the livelihood strategies is consistent with the estimated negative correlation among majority of the livelihood pairings Table 5.2.

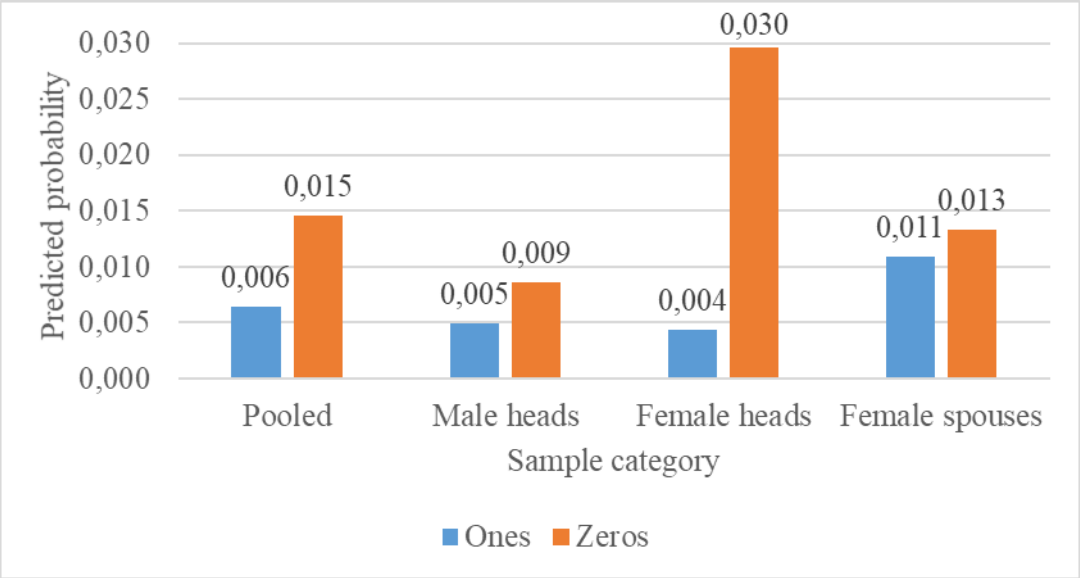


Figure 5.1: Predicted probability distributions
Source: Computed from multivariate regression results

5.8 Summary and conclusions of chapter five

This chapter examined the factors that influenced livelihood diversification among male heads, female spouses and female heads. It involved a multivariate probit model with five equations; crop diversification, animal rearing, trading, agro-processing and professional or skilled employment equations. The estimation of this model was justified by the model diagnosis results. The results highlighted that socioeconomic, climate factors, and household assets significant influenced the diversification decisions of the farmers. Depending on the gender group, the effects (either the level of significance or the sign of the marginal effect) of these factors differ. Based on the focus of the study, it is concluded that, climate shocks and access to climate information are essential in defining the livelihood diversification strategies of a household. It is also concluded that, neglecting gender difference in analysing the factors that influences livelihood diversification as done by previous studies is inappropriate since some factors which influence specific livelihood diversification for females do not have effect

on males, vice versa. Even in situations where these factors affect both males and females, the direction of the effects differs. There is the need to make climate information available to the farmers on regular basis. Perhaps, this could be done through mobile phones or radio in the native language of the farmers. Social policies and interventions that can reduce the domestic hours for females should also be promoted. Farmers, government and non-governmental agencies should promote effective social networks and extension service to the farmers since this promote their diversification decisions.

CHAPTER SIX

GENDER PERSPECTIVE OF THE EFFECTS OF LIVELIHOOD DIVERSIFICATION ON HOUSEHOLDS' VULNERABILITY TO CLIMATE CHANGE AND VARIABILITY

6.1 Overview

Climate change impacts are expected to be more severe in coming years if 'business as usual' actions are not realigned with deliberate mitigation and adaptation. This has made climate vulnerability assessment an important component of climate analysis. Justifiably, vulnerability assessment provides platform for assessing the disconnections among climate and other interaction variables. Unfortunately, the existing vulnerable groups are experiencing and would continue to experience the most severe climate impacts. One of such groups is the female population. This notwithstanding, Kakota et al. (2011) recounted that, one of the less focused areas of climate research is gender vulnerability assessment.

Within a gender perspective, this chapter examined both intra- and inter-household's vulnerability to climate change in northern Ghana and estimated the effect of livelihood diversification on vulnerability levels. This involved the use of LVI approach with equal weighting and unequal weighting through PCA. An ordered probit model was also estimated to identify the factors that influences household's vulnerability level. Due to the multidimensional nature of the indicators of LVI calculation, a number of steps were followed as discussed under Section 3.5.1. This steps include identification and normalisation of indicators, assigning weights to each indicator, and aggregation. The results are presented in the next sections.

6.2 Minor components of livelihood vulnerability

This section discussed the contributions of minor indicators under equal weighting and weighting through PCA. The mean statistics by gender of the normalised values of each specific indicator are provided in Appendix 1.

From Table 6.1, the factor contributing the largest proportion to the exposure of farmers is their perception on climate change and variability. This contribution was highest for female heads and lowest for female spouses. On adaptive capacity, resource and energy factors contributed the highest and this was highest for male heads and lowest for female heads. Health related factors contributed the highest to the sensitivity of households to climate change and variability. This is consistent with the findings of Alhassan et al. (2018).

Table 6.1: Mean statistics of minor components of LVI

		Equal weights			Unequal weights (PCA)		
Major component	**Minor component**	Male Heads	Female Spouse	Female Heads	Male Heads	Female Spouse	Female Heads
Adaptive capacity	Livelihood strategies	0.1748	0.1804	0.1515	0.2355	0.2604	0.1903
	Resource and Energy	0.5754	0.5745	0.5728	0.8499	0.8476	0.8276
	Social network	0.1295	0.1587	0.1540	0.2215	0.2713	0.2637
	Socio-demographic characteristics	0.1946	0.1932	0.2080	0.0678	0.0390	0.0159
Sensitivity	Wellbeing	0.2150	0.2115	0.2027	0.0437	-0.0064	0.1162
	Food	0.1960	0.2004	0.2205	0.0819	0.1023	-0.0209
	Health	0.2913	0.2856	0.3256	0.5402	0.5167	0.6123
	Water	0.1669	0.1931	0.1666	0.2835	0.3327	0.2706
Exposure	CCV perception	0.7321	0.7080	0.7556	1.4736	1.4419	1.5088
	Environmental shocks	0.2324	0.2536	0.2060	0.4615	0.4917	0.3929

Source: Computed from field data, 2017

Generally, except that the values under unequal weights are higher than equal weights, there are no differences in the proportion of contribution by the minor components

under the two weighting methods. Without further test and analysis, it can be argued that these factors provide fundamental policy alternatives on which factors to target in addressing climate and livelihood vulnerability. In subsequent sections (sections 6.3 and 6.4), these minor components were aggregated into their constituent major components based on the weighting method.

6.3 Major components and households LVI levels using equal weights

Table 6.2 provides the contribution of each major component to the livelihood vulnerability and the vulnerability levels using equal weights. Following this stage, the major components of LVI were calculated by finding the mean of the aggregates. The result (Table 6.2) shows that the exposure level of the respondents to climate change and variability is higher than their adaptive capacity and sensitivity. Overall, the adaptive capacity of the respondents was 0.2476 while their sensitivity and exposure were 0.2157 and 0.4246, respectively. In terms of gender distribution, climate sensitivity was highest for female heads and lowest for female spouses. Also, the exposure of the female heads is lower (0.4174) than that of male heads (0.4249) and female spouses (0.4284). The adaptive capacity for female spouses is highest (0.2542) followed by female heads (0.2486) and male heads (0.2435). Alhassan et al. (2018) also estimated that the adaptive capacity of females (0.475) is greater than that of males (0.433). In an empirical study, Abdul-Razak & Kruse (2017) found that, the adaptive capacity of smallholder farmers in Northern region of Ghana are low with a significant difference in the adaptive capacity score between males and females. This is largely due to the low economic resources (diversity in income sources, remittances and access to credit), technology and awareness of women (Abdul-Razak & Kruse, 2017). Similarly, Ahsan & Warner (2014) estimated that the adaptive capacity's contribution to social

vulnerability is lower than the contribution from sensitivity and exposure. Contrary to this study, Adu et al. (2017) and Pandey & Jha (2012) estimated that the adaptive capacity of their sample was highest, followed by exposure and sensitivity. Generally, while sensitivity and exposure to climate change and variability differ among gender groups, men often have more adaptation advantages over females (Kakota et al., 2011).

Table 6.2: Vulnerability indices using equal weighting

Category	Major components With Diversification			Without Diversification		With Diversification		Difference	
	Adaptive Capacity	Sensitivity	Exposure	LVI	LVI-IPCC	LVI	LVI-IPCC	LVI	LVI-IPCC
All	0.2476	0.2157	0.4246	0.2956	0.0404	0.2888	0.0382	0.0068	0.0022
Male Heads	0.2435	0.2084	0.4249	0.2923	0.0401	0.2846	0.0378	0.0077	0.0023
Female Spouse	0.2542	0.2209	0.4284	0.3012	0.0408	0.2945	0.0384	0.0067	0.0024
Female Heads	0.2486	0.2282	0.4174	0.2981	0.0404	0.2917	0.0385	0.0064	0.0019

Source: Computed from field data, 2017

The fourth stage in estimating vulnerability involves the computation of the LVI using equal weights. The objective is to estimate the gender differences in LVI and also estimate the effect of livelihood diversification on gender vulnerability. Therefore, the major components were estimated with and without livelihood diversification. Both LVI determination as proposed by Hahn et al. (2009) and the IPCC's method were used.

From Table 6.2 and with diversification, the vulnerability levels of the respondents shows the same trend under LVI and LVI-IPCC methods. However, the LVI-IPCC method provided lower vulnerability scores than the LVI. This low values under the LVI-IPCC method relative to the LVI method is consistent with the findings of Alhassan et al. (2018) and Etwire et al. (2013). Under LVI, climate vulnerability was highest for female spouses (0.2945), followed by female heads (0. 2917) and male heads

(0.2888). However, using the LVI-IPCC method, the vulnerability levels for female heads was highest, followed by female spouses and male heads. Thus, under both LVI and LVI-IPCC methods, the females are most vulnerable. This finding is consistent with other empirical studies. For instance, using the equal weighting approach, Alhassan et al. (2018) estimated that the LVI for males was 0.438 while that of females was 0.463. Similarly, the authors estimated that the LVI-IPCC was highest for females (0.005) than males (0.021).

Without diversification, the mean vulnerability of male heads was 0.2923 and 0.0401 using LVI and LVI-IPCC methods, respectively. That of the female heads was 0. 2981 and 0.0404 under LVI and LVI-IPCC methods, respectively, while female spouses had 0.3012 and 0.0408 under LVI and LVI-IPCC methods, respectively. A similar study by Etwire et al. (2013) revealed a lower LVI-IPCC score (-0.006) for the three northern regions of Ghana. Observable from Table 6.2, the estimated vulnerability distribution by gender are similar with and without diversification, except that the estimated vulnerability levels are higher without diversification. Expectedly, this is an indication that diversification led to a reduction in climate vulnerability. This is an important finding that justified the support for and the promotion of livelihood diversification among households to cope with climate change impacts. Consistent with the vulnerability scores estimated by this study, Adu et al. (2017) using equal weights compared the LVI of maize farmers in Wenchi and Techiman, Brong-Ahafo region of Ghana and found that, the LVI for Wenchi was 0.346 and 0.312 for Techiman. Similarly, the authors estimated that the LVI-IPCC for Wenchi and Techiman were -0.015 and 0.011, respectively. The climate vulnerability scores estimated in this study were lower than the 0.62 climate vulnerability index estimated by Cheb (2015).

Figure 6.1 shows the gendered vulnerability gaps in percentage terms. Given a gendered perspective without diversification, the vulnerability gap between male heads and female heads [4] is 0.0058 (2.95%) or 0.0003 (1.72%) under LVI and LVI-IPCC methods, respectively. Between male heads and their counterpart female spouses, the vulnerability gap was 0.0089 (1.95%) or 0.0003 (0.74%) under LVI and LVI-IPCC, respectively, while between the female heads and the female spouse, the gap was 0.00311 (1.03%) or 0.0004 (0.98%) using LVI and LVI-IPCC methods, respectively. With the introduction of diversification, the LVI and LVI-IPCC methods showed that the gendered climate vulnerability gaps had increased between males and females but decreased between female heads and female spouses. For instance, using LVI, the vulnerability between male heads and female heads has increased from 2.95% to 3.36% while between male heads and female spouses, this has increased from 1.95% to 2.43%.

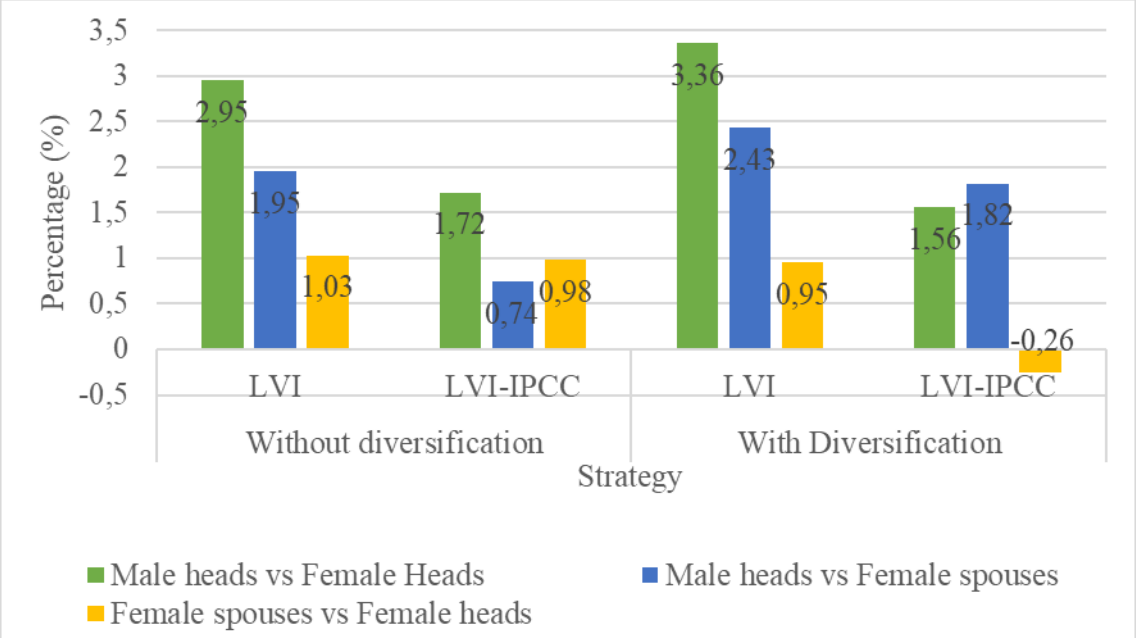


Figure 6.1: Gendered vulnerability gap among farmers
Source: Computed from vulnerability scores.

[4] This is calculated as: female's vulnerability level minus male's vulnerability level, all divided by female's vulnerability level multiplied by 100. Example: (0.2981-0.2952)/0.2981*100=1.95%.

The implications from the findings in Table 6.2 and Figure 6.1 is that, although livelihood diversification can lead to a general reduction in the climate vulnerability of both males and females, it may not necessary address gender vulnerability differences. With diversification, households distribute not only the available limited resources but also, spread risks emanating from social, economic and environmental sources. According to Kakota et al. (2011), one of the major reasons for high climate vulnerability by women is the social and cultural constraints that limits resource access and ownership by women. Since men have more climate advantage over women, Kakota et al. (2011) recommended for policies that would empower women's resource level and improve their resilience. From Djoudi et al. (2016), female headed households were particularly vulnerable to climate change due to low formal education, absence of reliable non-farm income and poor social networks. It can be therefore concluded that, more pragmatic or deliberate efforts such as relief programs, cultural reorientations and social discrimination against women should be address alongside empowering women economically.

6.4 Major components and households LVI levels using PCA weights

In the previous section, equal weighting of the individual factors as well as the minor components were assumed. However, following the second stage under section 6.2, weights from PCA were used in calculating the vulnerabilities scores of the households. Thus, the first components from PCA were retained and used as weights and the results used to constructs the major components of the LVI. Again, the vulnerability was estimated with and without livelihood strategies. Expectedly, the estimated sensitivity values for all categories of respondents were negative. On the other hand, exposure and adaptive capacity were positive; although the values of exposure were higher than the

values of the adaptive capacity. Thus, the major reason for the high climate vulnerabilities of the households in northern regions of Ghana was their high exposure to environmental and livelihood shocks. This is not surprising as the region is located in the upper part of the country where environmental shocks such as floods, droughts and diseases due to higher temperatures and rainfall patterns are high. Logically, exposure is largely a covariate factor which means that it may not vary much among households. Surprisingly, this result suggests that exposure to climate change was higher for males (0.3945) than female heads (0.3582) and female spouses (0.3359). On adaptive capacity, it was ironical that the adaptive capacity of female spouses (0.0818) was higher than the male heads (0.0701) and female heads (0.0580). Consistently, Panda (2016) found exposure to contribute a large share to households' vulnerability in India. Contrary, Etwire et al. (2013) and Cheb (2015) found that the adaptive capacity of households to climate change is higher than their exposure and sensitivity to climate change. Shah et al. (2013) also estimated that the sensitivity to climate change contributes largely to vulnerability than exposure and adaptive capacity. Abdul-Razak & Kruse (2017) however noted that the adaptive capacity of households in Northern region of Ghana is low and also revealed that males and females have moderate and low adaptive capacity, respectively.

Consistent with the results from section 6.3, Table 6.3 shows that, households' climate vulnerability was high without livelihood diversification than with diversification. This is due to the fact that diversification enhance the adaptive capacity of the respondents, hence, reducing their vulnerability. Averagely, the vulnerability of a respondent from this study without diversification was 0.516 or -0.0151 under LVI and LVI-IPCC methods, respectively. With diversification however, the average respondent was 0.48 or -0.0139 under LVI and LVI-IPCC methods, respectively. Panda (2016) estimated the

vulnerability of households in a State of India and found a vulnerability level of 0.1635. In all estimation methods, vulnerability was lower for males than females. For instance, under LVI with diversification, the vulnerability for male heads was 0.4591 while that of female heads and female spouses were 0.4838 and 0.4855, respectively. In a similar study, Shah et al. (2013) included livelihood strategies and found that the LVI of women is slightly higher (0.44) than that of men (0.42). The result also revealed that diversification led to a higher reduction in climate vulnerability levels of male heads (0.0395) than female heads (0.0364) and female spouses (0.0331).

Table 6.3: Vulnerability using principal component weights

Category	Major components With Diversification			Without Diversification		With Diversification		Difference	
	Adaptive Capacity	Exposure	Sensitivity	LVI	LVI-IPCC	LVI	LVI-IPCC	LVI	LVI-IPCC
All	0.0673	0.3578	-0.0478	0.5160	-0.0151	0.4800	-0.0078	0.0360	-0.0012
Male Heads	0.0701	0.3945	-0.0382	0.4987	-0.0105	0.4591	-0.0175	0.0395	0.0019
Female Spouse	0.0818	0.3359	-0.0519	0.5186	-0.0203	0.4855	-0.0030	0.0331	-0.0071
Female Heads	0.0580	0.3582	-0.0646	0.5202	-0.0137	0.4838	-0.0080	0.0364	-0.0057

Source: Computed from field data, 2017

Also, without diversification, the vulnerability gap between male and female heads is 0.0215 under LVI and -0.0032 under LVI-IPCC. However, this gap increased to 0.0246 under LVI and 0.0095 under LIV-IPCC when livelihood diversification is introduced. Similarly, the vulnerability between male heads and their spouses is 0.0199 under LIV and -0.0098 under LVI-IPCC but this increased to 0.0264 under LVI and 0.0145 under LVI-IPCC. The implication is that, diversification have a major impact in reducing males' vulnerability to climate change than females. Thus, gender climate vulnerability gap is worsened by livelihood diversification. This difference is more pronounced for

female spouses than female heads. It is important to recall that a similar observation was made under equal weights in Section 6.3. Generally, although diversification is an important strategy to reduce households' vulnerability to climate variability and change, the impacts are less on females than males. Therefore, if the objective of policy makers is solely to reduce gendered climate vulnerability gaps and not vulnerability levels, then diversification is not a preferred option. But since the objective of reducing climate vulnerability is a necessary condition to reducing gendered vulnerability gaps, livelihood diversification remain a viable and worthy strategy.

6.5 Hotelling's test of means

Due to the observed difference in the vulnerability levels between males and females as well as vulnerability indexes with and without diversification, it was necessary that a test is conducted to determine the significance difference or otherwise in the mean values. The Hotelling's test was applied since this approach allows testing for multivariate means (which is the case of this study) other than univariate means assumed under students' T test.

Table 6.4: Test of significant difference between gendered vulnerability scores

Pairing	Analytical method	Hotelling's statistics		
		T Value	F Value	Sig
Male heads	LVI vs LVI-Diverse	10.772	5.377	0.005
Vs	LVI-IPCC vs LVI-IPCC Diverse	8.036	4.012	0.019
Females	LVI-IPCC vs LVI-IPCC Diverse [pca]	11.666	5.824	0.003
Male heads	LVI vs LVI-Diverse	5.953	2.970	0.052
Vs	LVI-IPCC vs LVI-IPCC Diverse	6.430	3.207	0.041
Female heads	LVI-IPCC vs LVI-IPCC Diverse [pca]	12.652	6.311	0.002
Male heads	LVI vs LVI_Diverse	8.330	4.157	0.016
Vs	LVI-IPCC vs LVI-IPCC Diverse	4.738	2.365	0.095

Female spouses	LVI-IPCC vs LVI-IPCC Diverse [pca]	5.672	2.830	0.060
Female heads	LVI vs LVI Diverse	0.395	0.197	0.822
Vs	LVI-IPCC vs LVI-IPCC Diverse	0.566	0.282	0.755
Female spouses	LVI-IPCC vs LVI-IPCC Diverse [pca]	2.626	1.309	0.272

Note: [pca] indicates scores under PCA weighting

From the test result (Table 6.4), there was a significant difference in the mean values of vulnerability scores with and without diversification between the males and females (female heads, female spouse or both). This means that the observed higher impact of diversification on males' vulnerability than females was significantly different from zero. However, there is no significant difference in the mean vulnerability values with and without diversification between female heads and female spouse. This indicates that within the female groups, vulnerabilities do not differ significantly. The test results authenticate reports that females are more vulnerable to climate and this holds true for households in northern Ghana.

6.6 Factors influencing households' climate vulnerability levels

Beyond the identification of the vulnerability levels, there was the need to estimate the determinants of climate vulnerability using econometric model. Table 6.5 shows the estimated result of an ordered probit model. The dependent variable was vulnerability scores from the weighted and livelihood diversification exclusive and this was ordered into three categories (1=less vulnerable [0.00-0.33]; 2=moderately vulnerable [0.34-0.66]; and 3=severely vulnerable [0.67-1]). The selection of the scores from this approach was based on two reasons. Firstly, since livelihood diversification led to a reduction in vulnerability, the study sought to estimate the effect of each strategy on vulnerability of all sampled categories. Secondly, the unequal weighting method was

more realistic as variables do not practically affect vulnerability equally. Based on the ordered classification, Figure 6.2 showed that 15.7% of the total respondents were less vulnerable to climate change, 19.4% were moderately vulnerable while 64.9% were severely vulnerable. This shows that male headed households were more severely vulnerable than female headed households.

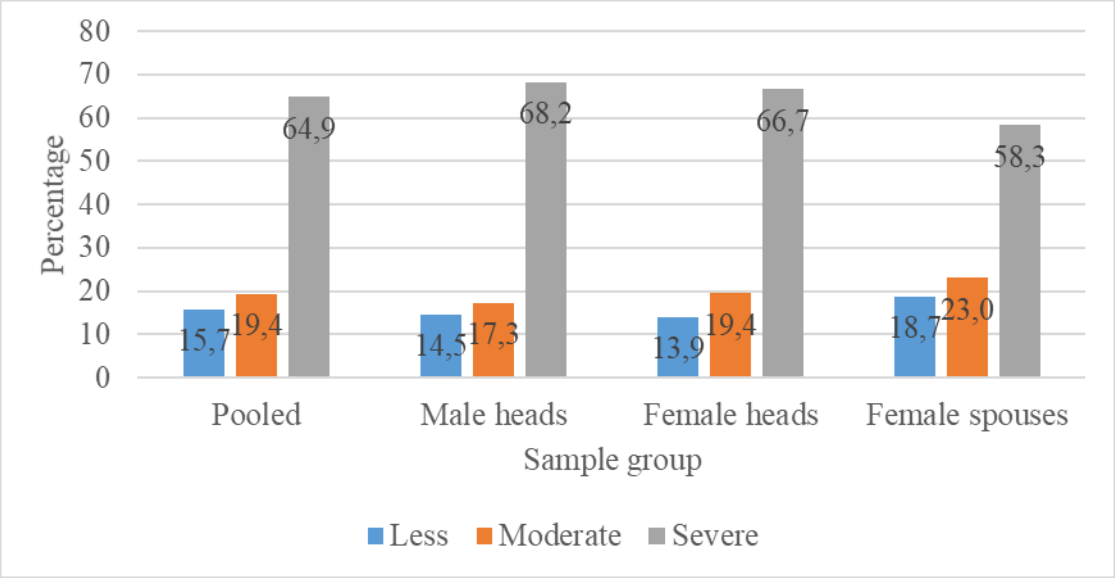


Figure 6.2: Distribution of vulnerability category by gender

Given the above information, a first step naïve ordered probit model was estimated using the pooled sample with only sex (male and female) as an independent variable. The estimated coefficient was 0.194 and a standard error of 0.094. Thus, sex was significantly different from zero and positive. This means that the male headed households have a higher probability of becoming less vulnerable. This was consistent with Zamasiya et al. (2017) and Shikuku et al. (2017) who found that, male headed households are more likely to adapt to climate change. Mehar et al. (2016) also indicated that males are more likely to make decision on the choice of coping strategies than females, thereby, reducing their vulnerability. A second step regression was estimated with gender (male heads as reference, female heads and female spouses) as an explanatory variable, and the result shows that both female heads and female spouses

were negative but significant for only female spouses. Within these backgrounds, the dataset in this study was categorised into gender groups and the estimation carried out on each sample. The chi square from all four models were statistically significant at 1%, suggesting that the models were well fitted. The threshold parameters (cut1 and cut2) shows the distribution of the categorisation and reflect the predicted cumulative probabilities at covariate values of zero. In the following sections, the significant variables from the models are discussed under four separate headings: assets factors; climate factors; livelihood diversification; and demographic and institutional factors.

6.6.1 Effect of household assets on household's vulnerability to climate change

Financial assets had a negative significant effect on the climate vulnerability of all gender groups. The implication is that farmers who had access to credit had higher probabilities of becoming less vulnerable to climate change. In other words, the probability of becoming severely vulnerable decreases with access to credit. Generally, credit improves the ability of households to invest into high adaptive and resilient activities and this have positive implications for reducing climate vulnerability. A similar argument was made by Mulwa et al. (2017) where they expounded that, credit restraint farmers' adaptation to climate change. Opiyo et al. (2014) also estimated that households who received credit were less vulnerable to climate change. From Tesso et al. (2012), households who received credit had higher probabilities of bouncing faster from climate shocks than those who did not receive credit. Nhemachena et al. (2014) found that credit improves households' decision into adapting to climate change through specific on-farm strategies. Contrary to this study, Notenbaert et al. (2013) estimated that households who received emergency loans or aid were more vulnerable and argued that credit reduces the money saving potential of the households. Unfortunately,

women’s access to agricultural capital and loans still remained low (Chandra et al., 2017).

Table 6.5a: Determinants of vulnerability to climate change-Pooled and Male heads

	Pooled					Males				
Variable	Coeff.	Std. Err.	Less Vul(1)	Mod. Vul(2)	Sev vul(3)	Coeff.	Std. Err.	Less Vul(1)	Mod. Vul(2)	Sev vul(3)
Female heads	0.087	0.155	-0.016	-0.014	0.030					
Female spouses	-0.177	0.133	0.037	0.028	-0.065					
Financial asset	-0.331[b]	0.129	0.066	0.053	-0.119	-0.325[c]	0.190	0.057	0.052	-0.109
Physical asset	-0.036	0.075	0.007	0.006	-0.013	-0.168	0.108	0.029	0.027	-0.056
Social asset	-0.042[a]	0.011	0.008	0.007	-0.015	-0.016	0.018	0.003	0.003	-0.005
Human asset	-0.041[b]	0.018	0.008	0.007	-0.015	-0.010	0.027	0.002	0.002	-0.003
Technological asset	0.003	0.117	-0.001	-0.0005	0.001	0.021	0.175	-0.004	-0.003	0.007
Political asset	-0.185	0.118	0.037	0.030	-0.067	-0.423[a]	0.155	0.074	0.068	-0.142
Windstorm	0.033	0.130	-0.007	-0.005	0.012	-0.046	0.182	0.008	0.007	-0.016
Flood	0.069	0.129	-0.014	-0.011	0.025	0.097	0.195	-0.017	-0.016	0.033
Drought	0.400[a]	0.121	-0.080	-0.065	0.144	0.548[a]	0.178	-0.096	-0.088	0.183
Climate info	0.339[a]	0.121	-0.067	-0.055	0.122	0.335[c]	0.177	-0.058	-0.054	0.112
On-farm	-0.310[b]	0.155	0.062	0.050	-0.112	-0.454[c]	0.252	0.079	-0.073	-0.152
Animal	-0.323[a]	0.124	0.064	-0.052	-0.116	-0.181	0.210	-0.032	-0.029	-0.061
Trading	-0.137	0.116	0.027	-0.022	-0.049	-0.002	0.171	0.0003	0.0003	-0.001
Agro-processing	-0.016	0.121	0.003	0.003	-0.006	0.077	0.171	0.013	0.012	-0.026
Prof/Skilled jobs	-0.295[b]	0.127	0.059	0.048	0.106	-0.651[a]	0.213	-0.114	-0.104	0.218
Remitters	-0.068[c]	0.037	0.014	0.011	-0.025	-0.058	0.056	0.010	0.009	-0.019
Contract farming	0.415[a]	0.149	-0.083	-0.067	0.150	0.206	0.214	-0.036	-0.033	0.069
Home-market	-0.067[a]	0.021	0.013	0.011	-0.024	-0.051[c]	0.032	0.009	0.008	-0.017
Production aim	0.330[b]	0.137	-0.066	-0.053	0.119	0.596[a]	0.210	-0.104	-0.096	0.200
Dependency	-0.046	0.055	0.009	0.007	-0.017	0.025	0.105	-0.004	-0.004	0.008
Male-female ratio	0.141[c]	0.079	-0.028	-0.023	0.051	0.286[b]	0.114	-0.050	-0.046	0.096
Extension access	-0.189	0.121	0.038	0.030	-0.068	0.096	0.172	-0.017	-0.015	0.032
Middle class	-0.416[a]	0.152	0.085	0.065	-0.151	-0.379[c]	0.231	0.065	0.060	-0.125

Rich class	-0.141	0.143	0.024	0.024	-0.048	-0.240	0.216	0.037	0.038	-0.076
Upper East	0.090	0.174	-0.018	-0.015	0.032	0.065	0.253	-0.010	-0.011	0.021
Upper West	-0.009	0.152	0.002	0.001	-0.003	-0.392 [c]	0.230	0.081	0.059	-0.140
Cut1	-0.720	0.285				-0.421	0.382			
Cut2	0.010	0.284				0.273	0.383			
LR Chi2	125.68 [a]					69.82 [a]				
Pseudo R-square	0.1142					0.1261				
N	619					324				

NOTE: [a, b] and [c] indicate significant levels at 1%, 5% and 10%, respectively

Table 6.5b: Determinants of vulnerability to climate change-Female heads and Female spouses

	Female heads					Female spouses				
Variable	Coeff.	Std. Err.	Less Vul(1)	Mod. Vul(2)	Sev vul(3)	Coeff.	Std. Err.	Less Vul(1)	Mod. Vul(2)	Sev vul(3)
Financial asset	-0.690 [c]	0.426	0.076	0.158	-0.234	-0.664 [b]	0.266	0.107	0.145	-0.252
Physical asset	0.172	0.242	-0.019	-0.039	0.058	-0.130	0.191	0.021	0.029	-0.050
Social asset	0.056	0.046	-0.006	-0.013	0.019	-0.072 [a]	0.021	0.012	0.016	-0.028
Human asset	-0.031	0.077	0.003	0.007	-0.011	-0.091 [b]	0.038	0.015	0.020	-0.035
Technological asset	-0.258	0.377	0.029	0.059	-0.087	0.430 [c]	0.228	-0.069	-0.094	0.163
Political asset	0.032	0.419	-0.004	-0.007	0.011	0.281	0.314	-0.045	-0.062	0.107
Windstorm	-0.053	0.402	0.006	0.012	-0.018	0.027	0.304	-0.004	-0.006	0.010
Flood	-0.199	0.373	0.022	0.046	-0.068	0.176	0.257	-0.028	-0.039	0.067
Drought	0.782 [c]	0.457	-0.087	-0.179	0.265	0.257	0.244	-0.041	-0.056	0.098
Climate info	0.401	0.369	-0.044	-0.092	0.136	-0.034	0.242	0.005	0.007	-0.013
On-farm	-0.422	0.213 [b]	0.047	0.096	-0.143	-0.374	0.324	0.060	0.082	-0.142
Animal	-0.241	0.372	0.027	0.055	-0.082	-0.662 [b]	0.229	0.107	-0.145	-0.252
Trading	-0.185	0.352	0.020	0.042	-0.063	-0.269	0.236	0.043	-0.059	0.102
Agro-processing	-0.316	0.389	0.035	0.072	-0.107	0.256	0.261	0.041	-0.056	-0.097

Prof/Skilled jobs	-0.020	0.354	0.002	0.005	-0.007	-0.445 [c]	0.239	0.072	0.097	-0.169
Remitters	-0.276 [c]	0.171	0.030	0.063	-0.093	-0.050	0.063	0.008	0.011	-0.019
Contract farming	1.405 [b]	0.676	-0.155	-0.321	0.476	0.938 [a]	0.291	-0.151	-0.205	0.356
Home-market	-0.244 [b]	0.101	0.027	0.056	-0.083	-0.095 [c]	0.053	0.015	0.021	-0.036
Production aim	0.549	0.486	-0.061	-0.125	0.186	0.073	0.286	-0.012	-0.016	0.028
Dependency	-0.351 [a]	0.122	0.039	0.080	-0.119	0.561 [a]	0.175	-0.090	-0.123	0.213
Male-female ratio	-0.218	0.198	0.024	0.050	-0.074	0.036	0.183	-0.006	-0.008	0.014
Extension access	-0.529	0.409	0.059	0.121	-0.179	-0.644 [b]	0.267	0.104	0.141	-0.245
Middle class	-0.963 [b]	0.473	0.096	0.204	-0.300	-0.598 [c]	0.312	0.103	0.124	-0.227
Rich class	-0.761	0.502	0.063	0.160	-0.223	-0.214	0.277	0.028	0.049	-0.076
Upper East	-0.350	0.544	0.051	0.078	-0.129	0.345	0.383	-0.057	-0.074	0.131
Upper West	0.608	0.468	-0.042	-0.124	0.166	0.374	0.296	-0.061	-0.081	0.142
Cut1	-2.778	0.850				-0.408	0.604			
Cut2	-1.747	0.824				0.627	0.602			
LR Chi2	53.40 [a]					101.25 [a]				
Pseudo R-square	0.2865					0.2802				
N	108					187				

NOTE: [a, b] and [c] indicate significant levels at 1%, 5% and 10%, respectively

There was a significant effect of social assets on the pooled households' and female spouses' (Table 6.5a and Table 6.5b) climate vulnerability levels. The estimated marginal effects suggest that a unit increase in social assets led to a 0.008 increase in the probability of all sampled respondents becoming less vulnerable, a 0.007 increase in probabilities of becoming moderately vulnerable and 0.015 decreases in probability of becoming severely vulnerable. This observed directions of the marginal effects from the pooled result is similar to that observed from female spouses' model (Table 6.5b). The implication is that social assets have the tendency of bringing household's climate vulnerability downwards. Social assets are safety nets. Therefore, households tend to interact with each other and share ideas on how to collectively reduce vulnerability to climate change and other environmental, economic or social shocks. Consistently, Tesso et al. (2012) found that social capital positively affects households' recovery period from climate shocks. Zamasiya et al. (2017) also estimated that social groups enhanced households' decision towards climate change adaptation. However, Paul et al. (2016) estimated that social capital had a negative relationship with private adaptation behaviour of households.

Generally, human assets described the labour resource, education and health status of a household. From the result (Table 6.5a and 6.5b), human assets had negative effects on the climate vulnerability of all gender groups but significant for only the pooled sample and the female spouses. These suggest that there is a general probability of reducing vulnerability through increased human assets. For the pooled sample, a unit increase in human assets increases the households' probability of becoming less vulnerable by 0.008 and decreases their probabilities of becoming severely vulnerable by 0.015, respectively. For the female spouses, there is relatively higher probability of becoming less vulnerable.

Technological assets had significant effect on the vulnerability of the female spouses (Table 6.5b). The coefficient estimate is positive, implying that, increased technological assets increase the vulnerability of female spouses. Although this was contrary to the research expectations, it can be argued that the low technological assets of female spouses in Section 4.3 could explain this finding. Thus, there is the probability that the negative effect of old and less improved technologies on vulnerability may crowd-out the potentials of new technologies in reducing their climate vulnerability.

Political assets had negative significant effects on the climate vulnerability of male heads. The effect was insignificant in the other three models or gender groups. The estimated marginal effects revealed a positive effect on less vulnerability and moderate vulnerability while a negative effect on severe vulnerability. Thus, a unit increase in political assets would increase the probability of becoming less vulnerable by 0.037 and moderately vulnerable by 0.03 while it would decrease the probability of becoming severely vulnerable by 0.067. In Ghana and as observed from Section 4.3, females are less involved in political activities. Although the level of participation and holding of national political positions by females is increasing, the fact still remained that, political positions even at the local and community levels are male dominated. This could explain the insignificance of political assets in the female and pooled samples. Consistent with this study, Mulwa et al. (2017) found that, farmers with village kinship ties had higher probabilities of adapting to climate change, hence reducing their vulnerabilities. Generally on assets, Shikuku et al. (2017) revealed that households with higher wealth or assets would have higher adaptive capacities which would improve their vulnerabilities. Paul et al. (2016) also stressed that, assets are crucial for building resilience and enhancing adaptation to various environmental stresses.

From a gender perspective, Kakota et al. (2011) estimated that men have more access to and control of all resources including political resources than women and this makes the women vulnerable to climate change than men.

6.6.2 Effect of climate related factors on households' climate vulnerability

This section presents and discussed the effects of the significant climate related factors on households' vulnerability. From the result (Table 6.5a and 6.5b), drought and climate information significantly influence the vulnerability levels of the households.

Drought had a positive effect on the vulnerability level of all samples but significant for the pooled, male heads and female heads. This means that as the frequency of drought occurrence increases, the probability of households becoming severely vulnerable to climate change also increases. For instance, using the pooled result, a unit increase in the frequency of drought led to 0.08 and 0.065 decreased in the probabilities of becoming less and moderately vulnerable but increase the probability of becoming severely vulnerable by 0.144. Expectedly, this means that drought worsens household's vulnerability to climate change. Consistent with this study, Zamasiya et al. (2017) found that farmers who experience drought had positive behavioural intentions towards adaptation to climate change in order to reduce their vulnerabilities since they become more cognitive and perceptive. A similar result was established by Mulwa et al. (2017). For Nhemachena et al. (2014), households located in areas with high mean annual temperatures had higher probabilities of adapting various climate coping strategies.

Access to climate information (defined as 1 if a farmer received no climate information and 0 if a farmer received any climate information) had positive significant influence on the vulnerability levels of the pooled and male head samples (Table 6.5a). From the pooled result, households who did not receive any climate information within the past one year had 0.067 and 0.055 units less of becoming less or moderately vulnerable to climate change, respectively and 0.122 increase in the probabilities of becoming severely vulnerable. This was also observed for the male heads. This indicates that providing climate information to the households is crucial to reducing climate vulnerabilities among farming communities. With climate information, households become aware of possible future events and therefore, plan their livelihood activities appropriately. As explained by Mulwa et al. (2017), access to climate information leads to higher probabilities of adapting to climate change. Consistently, Opiyo et al. (2014) estimated that, households with access to early warning information were less vulnerable to climate change. Relatedly, Zamasiya et al. (2017) found that, access to climate information positively influenced the behavioural intentions of farmers towards climate change adaptation, hence, recommended the provision of climate information to households to enhance their knowledge and climate decision making.

6.6.3 Effect of livelihood diversification on households' climate vulnerability

In northern Ghana, one of the major climate change adaptation strategy that is adopted to meet the food and income needs of farm families is livelihood diversification. Although this is the case for all other parts of the country, the high climate vulnerability of the north led to the promotion of this strategy by most developmental NGOs. Therefore, this section

highlight the effects of these strategies on households' vulnerability levels to climate change. From the result (Table 6.5a and 6.5b), crop diversification, animal rearing and professional or skilled employments had significant effects on the vulnerability levels of the sampled households. From previous studies, Kakota et al. (2011) explained that women are constraint with access to diversified livelihoods opportunities, leading to their low income and high vulnerability. Similarly, Abdul-razak & Kruse (2017) explained that the adaptive capacity of women is low due to low diversity of their income sources.

From the result, crop diversification had a significant effect on the vulnerability in the pooled sample, as well as on the male heads and female heads. From the pooled sample, households who engaged in crop diversification had 0.062 and 0.05 probabilities more and 0.112 probability less of becoming less, moderately and severely vulnerable to climate change, respectively. This was observed for the gender groups as well. The implication is that on-farm diversification leads to a reduction in household's climate vulnerability. This was expected since farmers rely largely on their farm produce for household's sustenance. Therefore, with increased on-farm diversification, the impact on total crop failure would reduce and climate vulnerability improved.

Animal rearing was significant in explaining the climate vulnerability for the models involving the pooled and female spouses. Unlike cropping, the impacts of climate shocks on animal rearing is less. For instance, during drought periods, farmers can provide hay and domestic water to their animals to sustain their growth. Therefore, it is plausible that animal rearing in addition to crop production would improve the vulnerability of the farmers. The marginal effect estimates suggested that animal rearing in addition to maize farming

increases household's probability of becoming less vulnerable and thus reduces the probability of becoming moderately or severely vulnerable to climate change.

Professional or skilled employment had significant effect on the vulnerability of the pooled, the male heads and female spouses. The estimated effects were negative, suggesting that there is the tendency of farmers' vulnerability to climate change reducing as a result of diversification into professional or skilled jobs. Generally, Tesso et al. (2012) found that livelihood diversification had a positive effect on bouncing duration from climate shocks and explained that livelihood diversification ensures that if one strategy is affected by climate induced shocks, households could survive on another livelihood alternative. Recognising that livelihood diversification can improve coping opportunities to climate change, Berman et al. (2014) recommended diversification into market based activities such as professional or skilled jobs other than sole dependence on customary (farming) activities. However, as noted by Berman et al. (2014), heterogeneity in sensitivity to climate change must be considered in designing and implementation of diversification policies.

6.6.4 Effect of socioeconomic factors on households' climate vulnerability

The effects of demographic, institutional and location factors on households' vulnerability to climate change are discussed in this section. The results (Table 6.5a and 6.5b) showed that several of these factors had statistically significant influence on the vulnerabilities of the sampled households.

The number of emigrants who send remittances to their households had a significant effect on the pooled and female head samples. But generally, remitters had negative effect on the

vulnerability of all sampled groups. This implied that the higher the number of remitters, the lesser the household's climate vulnerability. This is due to the positive effect of income in improving the resilience of households to climate change. In a related study, Petreski et al. (2016) found that households who received remittances were 20.1% less vulnerable to climate change than those who received no remittance. In a related study, Kangmennaang et al. (2017) found that not only does remittances reduces household's probability of becoming food insecure but also, leads to a general welfare improvement of the households. Musah-Surugu et al. (2017) explained that since climate change would require extra investments, remittances are used by the households to finance incremental costs and consumption.

Contract farming involves an agreement between producers and buyers. Therefore, beyond the provision of inputs (cash or kind) and technical supports to farmers, there is more guaranteed market and price for farmers under contract farming. Expectedly, these households or farmers should be less vulnerable under contract farming. From Table 6.5a and 6.5b, contract farming was significant in all models except for male heads. Contrary to expectation, the results were positive. Thus, farmers who engaged in contract farming had higher probabilities of becoming severely vulnerable to climate change. For instance, a farmer who engaged in contract farming had 0.083, 0.067 and 0.15 probabilities of becoming less, moderately and severely vulnerable to climate change, respectively. This could be explained by the fact that farmers who do not engage in contract farming store their produce and sell in the lean season where market prices are higher while those under contract were bound to sell at mostly at the discretion of the contract partners. The respondents also noted that, aside the provision of farm inputs, the contractors in the study

area do not provide technical support to the farmers. Therefore, farmers with low technical knowledge on the usage of these inputs may not realise the expected benefits from such technologies. However, Ng'ambi et al. (2015) found that farmers who had external support are more likely to become less vulnerable to climate change.

Market availability is important in crop production. In Ghana where most of the feeder roads are less motorable, the closer the market to the farmer's home, the better the merits accrued to the farmer. From the results, the distance from home to market was statistically significant in all models. The estimated coefficient was negative, indicating that market access reduces climate vulnerability of farming households. From the marginal effects, farmers that were located far from a market had probabilities of 0.013 units more, 0.011 units more and 0.024 units less of becoming less, moderately and severely vulnerable to climate change, respectively. Although these were unexpected results, the field survey revealed that the selected communities are far from most central markets where the markets are more competitive. Also, not only are the nearby markets being seasonal markets, but also, the respondents also indicated that there is high exploitation by market queens in these local markets, and this may offset the positive expected impact of closer markets on climate vulnerability. As explained by Tesso et al. (2012), market serves as a means of exchanging information with other farmers. Therefore, farmers become more informed through the market and this may reduce their vulnerability.

Production aim had significant effect on the vulnerability of farmers, specifically, on male heads. This implied that producing solely for subsistence purpose does not urge well for improving farmers' climate vulnerability. This justified the reason why subsistence farmers were unable to break vicious poverty cycle. For instance, farmers who engaged in crop

production solely for domestic consumption had 0.066 probabilities of becoming less vulnerable but 0.119 probabilities of becoming severely vulnerable. This justified the need for farmers to move production from subsistence levels to commercial levels.

Female-male ratio had a positive effect on household's vulnerability to climate change. This implied that households with more females than males had higher probabilities of becoming severely vulnerable. This is consistent with the generally held view and as established in Sections 6.3 and 6.4 of this study that women are more vulnerability to climate change. The effect of dependency ratio on household's vulnerability was mixed as it had negative effects on all models except female spouses. This was however significant for only the female samples. For female heads, the higher the dependency ratio, the higher the probability of becoming less vulnerable while for female spouses, the higher the dependency ratio, the lesser the probability of becoming less or moderately vulnerable to climate change. Consistently, Opiyo et al. (2014) argued that dependents do not contribute towards household's welfare; therefore, households with large dependents are more vulnerable to climate change and variability. In a related study, Ng'ambi et al. (2015) estimated that higher household size decrease the probability of a household to reduce its vulnerability from moderate vulnerability to a low vulnerability.

Consistent with the researcher's expectation, extension access had a negative effect on vulnerability. This was however significant for only female spouses. This implied that female spouses who had access to extension services had lesser probabilities of becoming severely vulnerable to climate change. Generally, extension officers are able to provide the needed information on climate and agronomic practices to the farmers to help them obtain higher yields. With increased yields, farmers are able to meet their food needs and also sell

some produce to meet cash needs, hence, improving their adaptive capacity and reducing their sensitivity to climate change.

Households were classified into rich, middle class or poor households depending on the district's poverty incidence as clearly outlined in the sampling design. From the result (Table 6.5), locating in a middle class district had a negative significant relationship with climate vulnerability. Thus, households located in middle class districts had lesser probabilities of becoming severely vulnerable than those located in poor districts. This is an important finding that justifies support for deprived or poor districts and addressing developmental inequalities in Ghana. Among the three northern regions of Ghana, the Northern region is fairly better in terms of development and climatic conditions. Therefore, this was used as reference group to Upper East and Upper West regions. The result shows that location in Upper East region had no statistically significant effect on households' vulnerability to climate change. However, there is a significant effect of locating in Upper West region on household's vulnerability for the male heads. Contrary to apriori expectations, the marginal effects shows that households located in the Upper West region had positive marginal effects of becoming less vulnerable to climate change than those located in Northern region. This also contradicted findings of Etwire et al. (2013) who found that households in Upper West region had higher LVI-IPCC index than those located in Northern and Upper East regions.

6.7 Chapter summary and conclusions

This chapter used equal weight and unequal weighting through PCA to estimate inter- and intra-households' (male headed households, female headed households and female spouses)

climate vulnerability. These were estimated using the LVI approach of Hahn et al. (2009) in analysing climate vulnerability. The LVI approach provided a comprehensive methodology for the data gathering and analysis as well as allowed to combine complex multidimensional variables in determining the households' vulnerability. Admittedly, the LVI methodology is very flexible to allow the introduction and omission of variables to observe vulnerability patterns. The findings under this chapter are policy relevant. The study concluded that although both LIV and LVI-IPCC methods provided similar patterns of gendered climate vulnerability, the vulnerability scores using LVI-IPCC method were lower than LVI.

Although, the majority of both male and females farmers under this study were severely vulnerable to climate change, it is concluded that, women were more vulnerable to climate change than men. On the impacts of livelihood diversification on climate vulnerability, it is concluded that the vulnerability levels of both males and females are higher without livelihood diversification than with diversification. Thus, household's vulnerability reduced by 7% with livelihood diversification. However, the impact is more noticeable for males (7.9%) than female heads (6.4%) and female spouses (7%). Conclusively, livelihood diversification have more impact on inter-households' vulnerability than intra-households' vulnerability. It is therefore argued that livelihood diversification is only a necessary condition for minimising vulnerability between males and females, but not a sufficient condition to addressing gender climate vulnerability gaps. More deliberate measures that addresses the structural gender inequalities in the society should be a central point in gender empowerment discussion. The provision of technological innovations to the farming households, especially women is crucial in achieving this objective. The study

recommended that in addition to the promotion of livelihood diversification, climate information should be made available to the farming households.

CHAPTER SEVEN

EFFECTS OF CLIMATE CHANGE AND LIVELIHOOD DIVERSIFICATION ON GENDERED MAIZE PRODUCTIVITY GAP IN NORTHERN GHANA

7.1 Overview

The role of gender in ensuring food security is a long-standing research priority among scholars, research institutions as well as many governments. Generally, there are conclusions to suggest that women play or could play a significant role in achieving a food secured world, the SDG2. For instance, FAO (2011) shows that women could help reduce global hunger by 12-17% if equal resources are made available to them as to men. Kilic et al. (2015) also pointed out that gender productivity gaps centred within 20-30% in SSA. This difference in gendered productivity gaps vary across countries and warrants country based or location specific research to understand gender productivity gaps and how to address same. Similarly, research has shown that climate change and variability would reduce yields of most staple crops including maize in SSA (Msowoya et al., 2016; Knox et al.,2012; Roudier et al., 2011; Schlenker & Lobell, 2010), for that matter Ghana (MacCarthy et al., 2013). Adaptation have become the best bet for farmers. One of such is livelihood diversification and this has been identified as one can help minimize the impacts of climate change and ensure a food secured society (Osarfo et al., 2016; Tsiboe et al., 2016). However, there is silence on the extent to which these arguments are placed in gender productivity framework. The focus of this chapter is to shed light on gender productivity differences, the effects of climate change and variability as well as adaptation through livelihood diversification on the gender productivity differences.

As discussed in Section 3.5.3, the analysis of the gender productivity inequality was analysed using the Oaxaca-Blinder decomposition model. Considering the fact that men are often

Table 7.1: Definition of variables in estimated productivity of farmers

Variable	Definition	Expected sign	VIF
Productive factors:			
Hired labour	Total number of hired labour used on farm	+	1.56
Family labour	Total number of family labour used on farm	+	1.29
Seed	Total kg of seed used per acre	+	1.98
Chemical	Total litres of weedicides and insecticides used	+	1.78
Fertiliser	Total kg of fertiliser used on farm	+	1.21
Farm size	Total number of hectares of land cultivated	+	1.47
Livelihood diversification:			
On-farm	Dummy: 1 if a farmer engages in crop diversification and 0 if otherwise.	+	3.04
Animal	Dummy: 1 if a farmer engages in maize cropping-animal rearing diversification and 0 if otherwise.	+	3.00
Trading	Dummy: 1 if a farmer engages in maize cropping-trading diversification and 0 if otherwise.	+	2.03
Agro processing	Dummy: 1 if a farmer engages in maize cropping-agro processing diversification and 0 if otherwise.	+	2.37
Prof/Skilled job	Dummy: 1 if a farmer engages in maize cropping-prof/skilled diversification and 0 if otherwise.	+	2.62
Climate factors:			
Climate perception	Dummy: 1 if a farmer perceives climate change wrongly and 0 if correctly.	+	1.15
Awareness of shock	Dummy: 1 if a farmer had no information on climate shock and 0 if a farmer had information.	+	1.24
Wind	The total number of times a farmer experienced windstorm within the past three years.	-	1.95
Forest fire	The total number of times a farmer experienced forest fires within the past three years.	-	1.35
Drought	The total number of times a farmer experienced drought within the past three years.	-	1.52
Flood	The total number of times a farmer experienced flood within the past three years.	-	1.82

LVI	The estimated vulnerability of a household.	-	1.79
Adaptation index	The weighted index of on-farm adaptation strategies adopted by a farmer.	+	1.58
Socioeconomic factors:			
Education	The total number of years of formal education by household head.	+	1.36
Household size	Total number of adult equivalents in a household sharing and pooling resources.	+	1.75
Credit access	Dummy: 1 if a farmer had access to credit in the production season and 0 if otherwise.	+	1.51
Production aim	Dummy: 1 if the primary aim of maize production is equally for domestic and sale and 0 if solely for domestic	+	1.60
Experience	Total number of years of maize production	+	1.78
Health status	Dummy: 1 if a farmer perceived to be healthy and 0 if otherwise.	+	1.30
Home keeping	The number hours spent on home activities each day.	-	1.35
Extension	The total number of times a farmer had access to extension services.	+	1.39
Age	The total number of years from birth up to the time of data collection.	-	1.79
Location:			
Home- farm	The total number of hours a farmer have to spend by foot to the farm.	-	1.25
Home-market	The total number of kilometers to the nearest market.	-	2.51
Home-Input shop	The total number of kilometers to the nearest input shop.	-	2.27
Upper West	Dummy: 1 if household head is located in Upper West and 0 if otherwise.	-	1.94
Upper East	Dummy: 1 if household head is located in Upper East and 0 if otherwise.	-	2.38
Middle class district	Dummy: 1 if household is located in a district classified under middle class and 0 if otherwise.	+	2.00
Rich class district	Dummy: 1 if household is located in a district classified under rich class and 0 if otherwise.	+	1.90
IMR	The predicted vector of IMRs of diversification strategies obtained from multivariate probit model	+/-	
Total VIF			1.96

advantage in terms of resources for production, the male category was used as a reference group for the analysis. The choice of the base group was based on the fact that, the reference group should be the group that is advantaged or favoured by discrimination. Two female groups, female heads and female spouses, were considered in the analysis separately. This means that the productivity gap between male heads and female heads was estimated separately, while the productivity gap between male heads and female spouses was also determined.

Empirically, equation 7.1 was estimated while the definition of variables are estimate variance inflation factor (VIF) are provided in Table 7.1. Overall, the VIF values suggests that the variables are not multicollinated.

$$\begin{aligned}\Pr oductivity = \delta_0 + \delta_1 \Pr oductive\ factors + \delta_2 Livelihood\ diversification + \delta_3 C\lim ate\ factors \\ + \delta_4 Socioeconomic\ factors + \delta_5 Location\ factors + \delta_6 IMR \end{aligned} \quad (7.1)$$

7.2 Maize productivity gap between males and females

Table 7.2 shows that G between males and females. On the average, male heads had a productivity of 670.648 kg/acre while female heads had a mean productivity of 276.111 kg/acre. Thus, the observed G between the male heads and the female heads was 394.537 kg/acre, implying that the male heads outperformed the female heads by 58.8%. In other words, the productivity for male heads is more than twice the productivity of female heads. For female spouses, the estimated average productivity is 370.484 kg/acre. This also showed that the observed G between male heads and the female spouses was 300.164 kg/acre; representing a G of 44.8%. After controlling for selectivity bias in the Oaxaca-Blinder model, the productivity gap between males and females have reduced. For G

between male heads and female heads, the estimated gender gap reduced to 329.96kg/acre, representing 49.2% of productivity gap. For G between male heads and female spouses, the estimated gap reduced to 235.60kg/acre, representing 35.1% of gap. These implies that the observed gaps, without controlling for selectivity bias in the model were overestimated by about 65kg/acre for male heads or underestimated by 65kg/acre for the female farmers. Thus, a 9.63% of the observed gaps were corrected by the selectivity biased correction model.

The estimated average productivities and G were significant at 1%. The study argued that the estimated gender productivity gaps were high considering the important role of women in providing food for the family. The estimated G were higher than the as provided by Kilic et al. (2015) that gender G in SSA is within 4-40%. Other empirical studies also found a relatively lower gender productivity gaps. For instance, Aguilar et al. (2015) estimated from farmers in Ethiopia that male farmers were 23.4% more productive than female farmers; Ali et al. (2016) found a male favoured gender G of 17.5% in Uganda; Campos et al. (2016) found that the G between male heads and female heads was 19.4% while that between male and female plot holders was 22%.

Table 7.2: Gendered maize productivity gaps

Gender	**Male heads vs Female heads**			**Male heads vs Female spouses**		
group	Coef.	Std. Err.	Z-Value	Coef.	Std. Err.	Z-Value
Male heads	670.648***	66.627	10.07	670.648***	66.615	10.07
Female	276.111***	16.854	16.38	370.484***	27.136	13.65
Observed gap	394.537***	68.726	5.74	300.164***	71.930	4.17
Adjusted gap	329.956***	94.987	3.47	235.603***	115.809	2.03

Source: Computed from field data, 2017

7.3 Aggregate decomposition of gender yield gap

In this section, G was decomposed using two-fold and three-fold methods and the results presented in Table 7.3. An initial naïve regression with only sex as explanatory variable was estimated and the result shows that there is no significant effect of gender on G. Therefore, differences in yield may not be due to the 'gender' of the farmer but due to differences in characteristics and returns from these characteristics. A similar observation was made by Campos et al. (2016).

Table 7.3: Aggregate decomposition of gender yield gap

	Male heads vs female heads				Male heads vs female spouses			
Decomposition	Coefficient	Std. Error	T-Value	% of G	Coefficient	Std. Error	T-Value	% of G
Three-fold decomposition								
Endowment	53.02*	32.75	1.67	13.44	18.94***	7.346	2.95	6.31
Coefficient	-21.80	131.85	-0.17	-5.53	-87.62	114.37	-0.77	-29.19
Interaction	363.32***	129.60	2.8	92.09	369.69***	114.24	3.24	123.16
Two-fold decomposition								
Explained	345.11***	86.67	3.98	87.47	294.39***	101.73	2.89	98.08
Unexplained	49.43	64.73	0.76	12.53	5.77	73.00	0.08	1.92

Source: Computed from field data, 2017

From the three-fold decomposition (Table 7.3), the major sources of G among the farmers was the interaction between the characteristics and coefficient (discrimination effect or factor returns); these were significant at 1%. This indicates that, the joint effect of the

differences in factor endowment and discrimination among gender groups is the major reason for the observed differences in productivity among the male and female farmers. For productivity among male heads and female heads, the endowment effect contributed 13.44% to G and this was significant at 10%. At 1% significant level, the endowment effect contributed 6.31% to G between male heads and their spouses. The implication is that when female heads or female spouses are given the same characteristics such as inputs, diversification opportunities, vulnerability to climate change and other socioeconomic characteristics such as education, the productivity of female heads and spouses could adjust upwards by 13.44% and 6.31%, respectively. Generally, there is the opportunity of resource transfer from male heads to their spouses, therefore, it is conceivable that the endowment effect on G for female spouses would be lower than female heads. Other studies have also observed a significant contribution of endowment effect to differences in productivity among gender groups. For instance, Ali et al. (2016) estimated a 12.9% net endowment effect to productivity gap between male and female plot managers while Aguilar et al. (2015) estimated that the endowment effect contributes 42.4% to the productivity gap between male and female plot managers. Also, Campos et al. (2016) estimated an endowment effect's contribution of 57.6% to gender productivity gap between male and female heads.

The coefficient term measures the change in productivity of women if the coefficient of men are applied to women's characteristics. From the result (Table 7.3), G between male heads and female heads could reduce by 5.53% if discrimination is eliminated while between male heads and their spouses, G could reduce by as high as 29.19% under the same strategy. Thus, if discrimination against women are eliminated, productivity gap can

be minimized between 5-29%. Nonetheless, the coefficient effect on G is statistically insignificant.

Aside the three-fold decomposition, a two-fold decomposition of G was performed to simply examine the explained and unexplained parts of G, ignoring their interactions. From Table 7.3, 87.47% of the differences in productivity between male and female heads (345.11 kg/acre) was explained by the resource difference between the two groups. The remaining 12.53% (49.43 kg/acre) were unexplained, thus, due to differences in unobservable characteristics between the two gender groups. For productivity comparison between male heads and their spouses, 98.08% (294.39 kg/acre) of the differences was explained by the resource difference between the two while the remaining 1.92% (5.77 kg/acre) was due to unobservable characteristics. Since the explained part is greater than the unexplained part, it implies that if men and women are given similar access to and levels of resources, differences in productivity would be minimized significantly.

7.4 Grouped decomposition of gendered yield gap

One of the objectives of this chapter is to estimate the contribution of the factor groupings (productive factors, climate factors, livelihood diversification, socioeconomic and location) to gender productivity gap. This is shown in Table 7.4. From the result, productive factors and livelihood diversification had significant effect on gender productivity gap through the endowment effects among male heads and female heads. The IMR was also significant at 1% in comparing productivity between male and female heads. For gendered productivity gap between male heads and female spouses, productive and socioeconomic factors had positive significant effects through the endowment effect component.

Table 7.4: Grouped decomposition of gendered productivity gap

Factor group	Male heads vs Female heads				Male heads vs Female spouses			
	Coeff.	Std. Error	T-Value	% of G	Coeff.	Std. Error	T-Value	% of G
Endowments								
Productive factors	67.330***	19.474	3.46	17.07	84.44**	32.41	2.61	28.13
Diversification	-32.710*	18.235	-1.79	-8.29	-15.23	25.86	-0.59	-5.07
Location	0.303	3.084	0.1	0.08	-4.35	5.65	-0.77	-1.45
CCV	-9.740	9.413	-1.03	-2.47	-1.72	11.12	-0.15	-0.57
Socioeconomic	0.469	22.118	0.02	0.12	-44.84*	26.75	-1.67	-14.94
Adaptation	-2.449	4.261	-0.57	-0.62	-0.63	2.24	-0.28	-0.21
IMR	29.815*	17.349	1.72	7.56	0.42	23.11	0.02	0.14
Coefficients								
Productive factors	181.821*	99.285	1.83	46.08	103.23	107.49	0.96	34.39
Diversification	483.735**	212.011	2.28	122.61	520.98**	233.16	2.23	173.57
Location	-42.777	125.894	-0.34	-10.84	-2.99	121.32	-0.02	-1.00
CCV	1047.40***	381.530	2.75	265.48	1048.93**	503.11	2.08	349.45
Socioeconomic	873.97**	387.490	2.26	221.52	899.46***	313.81	2.87	299.66
Adaptation	218.634*	116.591	1.88	55.42	302.22**	126.76	2.38	100.68
IMR	-262.57**	119.614	-2.2	-66.55	-278.19*	153.32	-1.81	-92.68
Constant	-2522.011	544.802	-4.63	-639.23	-2681.2	622.86	-4.3	-893.3
Interaction								
Productive factors	144.004***	47.041	3.06	36.50	47.68	39.35	1.21	15.89
Diversification	-4.162	69.714	-0.06	-1.06	107.01	82.44	1.3	35.65
Location	0.846	7.141	0.12	0.21	3.12	7.60	0.41	1.04
CCV	6.049	33.275	0.18	1.53	-24.84	46.10	-0.54	-8.28
Socioeconomic	84.541	91.936	0.92	21.43	209.71***	70.98	2.95	69.86
Adaptation	24.527	18.023	1.36	6.22	4.26	14.65	0.29	1.42
IMR	107.516	86.406	1.24	27.25	22.75	95.99	0.24	7.58

*****,** and * indicates significant levels at 1%, 5% and 10%, respectively.**

Source: Computed from field data, 2017.

The result (Table 7.4) shows that the productive factors contributed 17.07% to G between male heads and female heads. This implied that if male and female household heads are given the same level of productive resources irrespective of their gender, women's yield could increase by 17.07% points towards the yield level of men. For productivity between male heads and female spouses, providing same productive resources could increase the productivity of the spouses by 28.13%. In other words, the current existing productivity gaps between males and females is mainly due to the differences in access to or use of productive resources. The discrimination component also contributed a statistically significant proportion (46.08%) of G between male and female heads. Generally, it can be concluded from Table 7.4 that the differences in productive factors contributed the largest percentage of G than other factor groups.

Livelihood diversification had statistical significant effect on productivity difference between male and female heads through the endowment and coefficient components. It also had statistical significant effect on the coefficient component of the difference between male heads and their spouses. The signs showed that while endowment effect of diversification led to a reduction in gender productivity gap, the returns to diversification contributed to the high gender productivity gap. Thus, when male and female heads are given the same livelihood diversification opportunities, G would reduce significantly. In order words, had it not been the diversification, productivity difference between male and female heads would have been higher than observed. However, the returns from diversification opportunities was higher for males than females and this led to the worsened G. Specifically, livelihood diversification contributed very high percentage to G through

the coefficient component than the endowment component. While discrimination contributed -122.61% of G between male and female heads and -173.57% of G between male heads and female spouses, endowment contributed 8.3% and 5.1%. The implication is that while there is potential that providing equal diversification opportunities to both males and females would reduce the productivity gap between the two, the effects of the returns from diversification on agricultural productivity would be very high on male's productivity than female's productivity; offsetting the effect from equal diversification opportunities. This corroborate the findings in Table 4.5 where males have high diversification index and high income from diversification than females. The significance of IMR in this model also justified the need for correcting the endogeneity of the livelihood diversification strategies.

Table 7.4 also showed that climate factor endowment was negative and insignificant in both gender productivity comparisons while the male structural advantage (coefficient effect) is positive and significant in both gender productivity comparisons. Also, the female structural disadvantage (the interaction effect) is positive and insignificant for productivity difference between male and female heads but negative and insignificant for productivity comparison between male heads and female spouses. From the male structural advantage, climate change led to as high as 265.48% increase in the productivity gap between male and female heads and 349.45% of the productivity gap between male heads and female spouses. This means that climate change and variability related factors favoured the productivity of males than females. This means that in the midst of climate change, males were able to obtain higher yields than females. Therefore, climate change would perpetuate gender productivity differences in the region.

Climate adaptation was isolated from climate change factors because it is a negative function of G while climate factors are positive functions of G. The effect of climate adaptation to endowments effect was negative while the coefficient and interaction components are positive. Thus, climate adaptation led to a reduction in G. However, the effects of adaptation on G is only significant in the coefficient component. From Table 7.4, adaptation contributed 55.42% and 100.68% to the overall G between male and female heads, and between male heads and female spouses, respectively. This is an indication that the unobserved returns from on-farm adaptation to climate change and variability led to a higher productivity of males than females. Therefore, specific female adaptation strategies have to be identified and promoted.

The joint effect of the socioeconomic factors was significant in all components of the productivity gap between male heads and female spouses. However, this was significant in explaining the productivity difference between male and female heads through the coefficient component only. In both productivity gaps, the effect of socioeconomic factors was high through the coefficient component. For instance, while the socioeconomic factors contributed 221.52% to the pure discrimination between male and female heads, it contributed 299.66% to the pure discrimination between male heads and female spouses. The positive estimated values suggested that even if women and men are given the same socioeconomic characteristics, productivity gaps would still exist. Therefore, efforts should be directed in the ensuring that women obtain high returns associated with these socioeconomic factors. For instance, although the provision of credit to both males and females is necessary for improving productivity, it would be sufficient if there is proper education and monitoring to ensure that the credits obtained are effectively used, especially

among the females. Also, while education and extension services must be provided to the farmers, measures to ensure that knowledge learnt are effectively implemented on the farms especially by female farmers is crucial than the mere education or extension service.

7.5 Factors influencing maize production and productivity gap

Table 7.5 shows the detailed results of the Oaxaca Blinder model of the three gender groups as well as the contribution of individual factors to G between the gender groups. Using the adjusted R-squares, the models explained 50%, 42% and 38% of the variations in the productivity of male heads, female heads and female spouses, respectively. The factors that significantly influenced maize productivity of male heads included hired labour, seed, chemicals, farm size, on-farm diversification, professional/skilled jobs, location in rich class district, wind, household size, health status and production aim. Also, the factors that significantly explained the productivity difference among female heads were seed, farm size, on-farm diversification, shock awareness, flood, household size and production aim. Lastly, the factors that had significant influence on productivity among female spouses were seed, climate perception, flood, education and health status. These are shown with superscripts *a, b* and *c* in Table 7.5 and discussed in the subsequent sections.

7.5.1 Effect of productive factors on productivity and gender productivity gap

From the result, hired labour, seed, chemicals and farm size had significant effect on maize productivity of male heads. These were significant at 1% except farm size that was significant at 5%. For female heads, seed and farm size were significant at 1% and 5%, respectively (Table 7.5). Similarly, only seed had significant effect on the productivity of female spouses at 1% (Table 7.5).

In all models, hired labour had negative effect on the productivity of the farmers while family labour had a positive effects on productivity. However, hired labour is significant for only male heads. This implied that as more hired labour is used for maize farming, the productivity of the farmers would reduce. This can be explained by the general diminishing returns of labour in farm activities. The survey revealed that most of the farmers, especially the male farmers engaged in exchange of labour services on their farms. Mostly, the farmers organised into groups and work on one another's farm as a way of avoiding direct hiring of labour for farm activities which are often unavailable in the peak of production or too expensive to pay.

Seed had positive significant effect on the maize productivity of all gender groups at 1%. This implied that farmers who cultivated more seeds on an acre plot had more productivity than those who sowed less seeds. In other words, an increase in seed quantity planted would lead to an increase in output. This implies that the planting density of the farms has to be increased in order to realize higher productivity. Generally, seed is a fundamental unit for production. Therefore, the level of harvest justifiably depends on the level and quality of seed used on the farm. From the survey, it was realized that most of the farmers do not plant their maize in lines and do not plant with recommended spacing (75-80cmX40cm). To increase seed population on farm, both row planting and spacing appropriately has to be considered. The effect of seed on G between male and female heads was significantly positive and due to the endowment effects. Therefore, if female heads plant the same level and quality of seed as male heads, yield levels of the female heads could increase by 14.69%.

Table 7.5: Effects of variables on maize productivity and contribution to gendered productivity gap

	Male heads		Female heads		Contribution to G (%)			Female spouses		Contribution to G (%)		
Variable	Coeff.	Std. Error	Coeff.	Std. Error	Endowment	Coefficient	Interaction	Coeff.	Std. Err	Endowment	Coefficient	Interaction
Hired labour	-0.01[c]	0.008	-0.014	0.010	-0.25	-35.5[b]	-2.38	-0.014	0.010	-0.019	-0.267[c]	-0.055
Family labour	0.007	0.019	0.018	0.029	-1.14	-2.01	-0.45	0.043	0.029	0.020[b]	-0.184	-0.023
Seed	0.018[a]	0.004	0.044[a]	0.011	14.69[a]	24.92	10.57	0.052[a]	0.009	0.170	0.061	0.013
Chemical	0.062[a]	0.012	0.021	0.026	2.08	45.47[a]	22.10[a]	0.020	0.017	0.004	0.660[a]	0.251[b]
fertiliser	0.000	0.000	0.000	0.000	0.15	1.11	0.47	0.016	0.022	0.113	-0.108	-0.096
Farm size	0.050[b]	0.021	0.062[c]	0.037	1.53	12.11	6.19	-0.030	0.033	-0.007	0.182	0.070
On-farm	0.403[c]	0.214	-0.554[c]	0.333	-1.82	60.32	7.81	-0.03[c]	0.230	-0.003	1.549[c]	0.136
Animal	0.048	0.159	0.130	0.246	-0.40	22.40	9.67	-0.122	0.201	-0.020	0.254	0.113
Trading	-0.005	0.123	0.244	0.234	-0.49	-9.29	1.15	0.109	0.184	0.004	-0.050	0.019
Agro-processing	0.189	0.136	0.477	0.204	-5.27[a]	51.46[b]	-20.01[a]	0.140	0.204	-0.002	0.451[a]	-0.029[c]
Prof/Skilled jobs	-0.25[c]	0.149	-0.065	0.227	-0.30	-2.28	0.33	0.224	0.198	-0.030	-0.468	0.117
Climate perception	0.080	0.097	-0.015	0.136	0.09	-9.85[c]	-0.88	0.293[b]	0.134	-0.017	-0.084[c]	0.026
Prior awareness	0.007	0.100	-0.252[c]	0.141	0.00	11.59[c]	0.00	0.083	0.134	-0.001	-0.008[c]	0.000
Wind	0.090[c]	0.049	0.071	0.067	1.26	22.56	5.46	0.002	0.050	0.001	0.606[b]	-0.011
Forest fire	0.024	0.039	0.006	0.052	0.02	15.91	-1.94	0.043	0.045	0.000	0.102	0.002
Drought	0.028	0.030	-0.075	0.061	-1.35	-3.02	-0.61	-0.016	0.046	-0.001	-0.014	-0.0001
Flood	-0.077	0.051	-0.109[c]	0.062	-2.63[c]	7.72	3.58	-0.14[a]	0.052	0.011	0.249	-0.025
LVI	1.080	1.009	0.317	1.428	0.17	204.9[a]	-3.97	0.738	1.269	-0.004	1.762[b]	-0.050
Age	0.001	0.004	0.009	0.006	-1.12	135.58[c]	-4.81	-0.006	0.006	0.001	0.202[c]	-0.027
Education	-0.004	0.009	-0.012	0.017	-0.89	9.28	3.48	-0.02[b]	0.011	-0.057[c]	0.284[b]	0.084
Household size	0.043[a]	0.016	0.061[b]	0.025	1.47	22.75	2.20	-0.008	0.017	-0.009	0.358[b]	-0.023
Credit access	0.026	0.116	0.175	0.153	0.51	-17.79	-3.08	0.009	0.132	-0.002	-0.332	0.027
Maize experience	0.001	0.004	-0.006	0.006	-0.33	8.93	3.18	0.011	0.007	-0.006	-0.545[a]	0.049
Health status	0.368[a]	0.131	-0.124	0.161	-0.67	77.91[a]	18.01[b]	0.244[c]	0.140	0.108[c]	-0.076	-0.060
Extension times	-0.021	0.039	-0.034	0.055	0.17	-14.52	0.62	-0.036	0.040	-0.001	1.396[a]	0.055
Production aim	0.101	0.115	0.354[c]	0.176	-1.47	-26.7[b]	4.45	0.310[b]	0.125	0.006	-0.067	0.011

Home-Farm	0.003	0.031	-0.068	0.081	0.13	22.85[b]	-0.50	0.013	0.036	-0.004	0.198	-0.023
Home keeping	-0.006	0.039	-0.059	0.052	3.10	12.02	-4.41	-0.029	0.039	-0.182[b]	2.401[a]	0.608[a]
Home-Market	-0.013	0.026	0.049	0.030	-1.52	14.08	-2.72	0.041	0.030	-0.005	-0.440[c]	0.034
Home-Input shop	0.023	0.021	-0.014	0.024	0.73	-22.88	5.01	-0.001	0.028	-0.002	1.007	0.014
Upper West	0.103	0.144	-0.076	0.193	0.00	-3.17	0.00	0.088	0.140	-0.003	-0.037	0.005
Upper East	-0.172	0.135	-0.098	0.213	0.10	-7.83	0.27	0.008	0.189	0.00003	0.015	0.002
Middle class	0.144	0.126	-0.208	0.159	-0.04	-3.22	-0.03	-0.18[c]	0.134	-0.012	0.022	0.002
Rich class	0.320[a]	0.120	-0.101	0.172	0.01	3.37	-0.03	-0.064	0.135	0.000	-0.011	0.001
Adaptation	-0.083	0.067	-0.006	0.112	-0.62	55.42	6.22	-0.16[b]	0.077	0.001	-0.383	-0.035
IMR_Onfarm	-0.293	0.447	1.234[b]	0.609	-4.58	-36.52	13.56	0.269	0.470	-0.053	-1.253	0.385
IMR-Animal	-0.063	0.434	-0.192	0.549	0.00	-20.50	-0.03	-0.020	0.477	0.001	-0.148	0.003
IMR-Trading	1.068	0.412	-1.119[b]	0.546	3.91	36.03[b]	-18.99[c]	-0.021	0.447	0.022	0.327	-0.206
IMR-Agro-processing	-0.91[b]	0.428	-0.804[c]	0.453	6.80[a]	-59.5[b]	39.16[b]	-0.720	0.517	0.020	-0.318	0.130
IMR-Prof/skilled jobs	0.486	0.492	-0.169	0.541	1.42	13.89	-6.45	-0.056	0.522	0.011	0.464	-0.236
Constant	3.855	0.422	4.833	0.597	NA	-639.2	NA	5.109	0.504	NA	-8.933	NA
F-Value	8.72[a]		2.89[a]					3.78[a]				
R-square	0.559		0.6419					0.5183				
Adj. R -square	0.495		0.4195					0.3811				
N	324		108					187				

NOTE: [a, b] and [c] indicate significant levels at 1%, 5% and 10%, respectively

Source: Computed from field data, 2017

Contrary to this findings, Campos et al. (2016) and Palacios-López & López (2015) estimated a positive effect of hired labour on male and female farmers' productivity. In terms of contribution to G, hired labour significantly contributed to gendered productivity differences through the coefficient effect. Specifically, hired labour led to a reduction in productivity gap by 35.52% and 0.27% if men's coefficient are applied to the characteristics of female heads and female spouses, respectively. Ali et al. (2016) also estimated that hired labour contributes positively to G through the coefficient component.

Chemicals usage had a positive effect on the productivity effect of all gender groups but significant for only male heads. This implied that when more chemicals are used by the male farmers, their productivity levels would increase significantly. This is consistent with the findings of Campos et al. (2016) and Palacios-López & López (2015) who estimated a significant positive effect of pesticides usage on the productivity of male and females heads. Aguilar et al. (2015) also estimated a positive significant effect of chemicals (pesticides, herbicides or fungicides) on productivity of male and female plot managers. In recent years, there is an increasing use of weedicides and insecticides by the farmers in maize production. The use of herbicides ensures that farmers control weeds on their farms at the right time since it takes only few days to spray a large area of farm than manual weeding with hoe or cutlass. Farmers also reported that pest infestation is increasing. This was clearly evident in the 2017 production year where there was nearly an army worm epidemic on maize production in the northern and most other parts of Ghana. To obtain higher yield therefore, farmers resorted to the use of more insecticides on the farms. Significantly, chemicals contributed to productivity differences through the coefficient and interaction components.

Farm size had a positive effect on the productivity of male heads and female heads but a negative effect on the productivity of female spouses. This means that while the productivity of the male and female heads would increase with increased farm size, the productivity of the female spouses would decrease if farm size is increased. However, this was significant for only the male heads and female heads. Traditionally, farming is known as men's job and from the survey also, while male heads cultivated 1.62 hectares of land, female farmers cultivated 1.07 hectares of land. As recounted by Chandra et al. (2017), women often cultivate less farms as a response to their societal disadvantage. This finding supports that farming household heads, particularly, the male headed households have to invest more lands into maize production since the returns from such extensification strategies is positive. Contrary to this study, Campos et al. (2016) found that plot size had a negative significant effect on the productivity of both males and females. Nonetheless, Campos et al. (2016) also argued that females are less productive when they have large plot sizes. From the result, farm size had no significant on G. Contrary, Ali et al. (2016) found that farm size contributed significantly to the explained component of gender productivity gap. Similarly, Palacios-López & López (2015) estimated that the marginal productivity of land is 27 percent higher for male managed plots than female managed plots.

7.5.2 Effects of climate change on maize productivity and gendered productivity gap

From the result, the climate factors that significantly influenced maize productivity includes climate perception, windstorm and flood and prior awareness of climate shocks. Although not significant in explaining productivity levels among farmers, LVI significantly influenced G through the coefficient component.

Climate perception had positive effect on the productivity of male heads and female spouses but a negative effect on the productivity of the female heads. However, this was significant for only female spouses. The positive effect means that the productivity of female spouses who perceived climate change wrongly was higher than those who perceived climate change correctly. This was contrary to the research expectations and to the findings of Ehiakpor et al. (2016). The result also showed that climate perception contributed significantly to G through the coefficient component. This effect was negative suggesting a reduction in productivity gap if females correctly perceived climate changes.

Climate awareness had a negative effect on the productivity of female heads but a positive effect on male heads and female spouses. This was however significant for only the female heads. This implied that female heads who were aware of climate shocks prior to their occurrence had higher productivities than those who were unaware of the climate shocks. With higher awareness of climate shocks, farmers are able to adopt strategies appropriately to offset the impacts of the shocks. This justified the need to provide up-to-date information on the possible climate shocks prior to their occurrences. As explained by Kakota et al. (2011), increasing temperatures are associated with heat stress, health problems and high domestic water demand, thereby, affecting the quality of human labour for farm and other livelihood activities. Therefore, awareness can help farmers adjust their labour accordingly. The result also revealed that climate shocks awareness had a significant contribution to G through the coefficient components.

Windstorm had a positive effect on the productivity of all farmers but significant for only male heads. This suggested that male heads who experienced wind storm in the past three years had higher productivities than those who experience no windstorm. This was

unexpected since wind storms may destroy farms, leading to lower productivity. However, the survey revealed that there is lesser effect of windstorm on crop farms but severe on domestic/housing properties. This could also explain the silence of researchers on the effects of windstorm on crop production in the area. The effect of wind on G however showed that the unobservable effects of windstorms led to a significant productivity difference between male heads and female spouses.

Expectedly, flood had negative significant effect on the productivity of all farmers. Thus, floods led to a reduction in the productivity of both male and female farmers. Generally, water requirement for maize is moderate and maize does not tolerate excessive water. During flood periods, most of the crops are either washed away or lodged. Thereby, reducing the farm output levels. The result also suggested that flooding had a negative significant effect on gender productivity differences between male and female heads through the endowment effect.

The effect of on-farm adaptation was negative in explaining maize productivity and significant for female spouses. This implied that female spouses that adopted more climate effective strategies had lower productivity than those who adopted less of the strategies. Climate adaptation is an effective localised option for farmers to ensure that they obtain higher yields amidst the changing climate. However, the findings of this study suggest that the adoption of many on-farm adaptation strategies may not necessarily translate into higher productivity. The adoption of more strategies influences the labour requirement which the female spouses generally are limited with. Perhaps, specific and few strategies must be identified and adopted by the farmers. However, adaptation had no significant effect on G in the region.

7.5.3 Effects of livelihood diversification on productivity and gender productivity gap

Another major objective of this study is to examine the effects of livelihood diversification on maize production. In this section, the specific effects of each livelihood strategy on maize production and gender productivity gap are discussed. From the result however, only on-farm diversification and professional or skilled jobs had a significant effect on the productivity of male and female heads. For female spouses, none of the livelihood diversification strategies had significant effect on their productivity. Although agro-processing is insignificant in influencing maize productivity, it significantly influenced the productivity gap between males and females.

On-farm diversification had a positive effect on the productivity of male heads but a negative effect on the productivity of female heads. This means that male heads who engaged in on-farm activities had higher productivity than those who did not engage in on-farm diversification, and this is opposite for female heads. The difference in the estimated signs could be due to the differences in crops cultivated with maize by males and females. Male farmers due to the high resource available to them are able to harness the gains from on-farm diversification, hence the estimated positive effect. The result also showed that on-farm diversification had no significant effect on the productivity gap between male heads and females heads but significantly contribute 1.55% to the productivity gap between male heads and female spouses through the coefficient component. Makate et al. (2016) also estimated that crop diversification is a viable climate smart strategy to improve crop productivity.

The effect of professional and skilled jobs on productivity was negative and negative in explaining the productivity of male farmers. This is conceivable considering that professional activities and skilled jobs require more time and this may limit the farmers' abilities to be on the farms even when critical farm activities have to be performed. However, it was expected that incomes from these professional and skill jobs would be reinvested into the farms to enhance productivity. This appears to be missing significantly among the farmers. Instead, these incomes are used for direct home consumption.

7.5.4 Effects of socioeconomic factors on productivity and gendered productivity gap

Socioeconomic factors are important in understanding the productivity of the maize farmers. A number of such factors are examined in this study. From the result, the socioeconomic factors that significantly influenced productivity of the farmers were education, household size, health status and maize production aim. Although not significant in explaining productivity of the farmers, age, experience and extension access had significant effects on G through the coefficient component.

Contrary to expectations, education had a negative effect on the productivity of all farmers and this was significantly different from zero for the female spouses. Although not significant, education led to a higher productivity of the male heads. One would expect that female spouses with higher formal education would follow proper agronomic practices, thereby, obtaining higher yields. However, considering the generally low education among the farmers or the low involvement of educated people in crop farming, it is possible that the effect of education on crop production may be shadowed. The estimated negative coefficient of education is contrary to the result of Aguilar et al. (2015) where education

had positive significant effect on the productivity of female plot managers. From the result also, education significantly influenced G between male heads and female spouses through the endowment (0.057%) and coefficient (0.284%) components. Consistently, Kilic et al. (2014) estimated that, education contributed 8% to endowment effect and 6% to overall gender productivity gap among their selected farmers. Similarly, Slavchevska (2015) found that the male structural advantage (coefficients component) of the 10^{th} percentile was significantly increased through education.

The health status of farmers have implications on their productivities through effective performance of farm activities, time and capital allocation to farming. Expectedly, male heads and female spouses who self-reported to be healthy were more productive than those who self-reported to be slightly ill or ill. The health status had significant effect on the difference in productivities between males and females. Between male and female heads, health status affected G through the coefficient and interaction effects while between male heads and their spouses, health status significantly affected G through the coefficient component.

Smallholder farm activities are generally described as subsistence agriculture since the prime goal is to provide food for the family. However, farmers sometimes sell their excess produce in order to buy other non-food household commodities. From the result, farmers whose production aim is either solely for sale or partly for sale had higher productivities than those farmers who produced solely for direct household's consumption. This justified the need to encourage farmers to take farming as a business other than for pure subsistence. The result also revealed that production aim significantly affects the gendered productivity gaps through coefficient effect component.

7.5.5 Effects of location on maize productivity and gender productivity gap

The location variables included in the model were Upper West, Upper East, Middle class district, Upper class district, distance from home to market and distance from home to the nearest input shop. From the result, none of the location variables had significant effect on the productivity of the female spouses. Male heads located in a rich class districts had higher productivities than those located in poor districts. This is consistent with the *a priori* expectation of the research since the standard of living in wealthy districts may be high and famers may be able to invest much capital into farming. For female heads, the distance from home to market had positive significant effect on their productivities. This implied that female heads that were located far from a market had higher productivities than those located closer to a market. This is contrary to *a priori* expectation since the existence of market should provide an incentive to the farmers to improve their farm production. Except distance from home to market, all other location variables had no significant effect on G. This is consistent with Slavchevska (2015) who found that, plot distance to market had a significant contribution to gender productivity gap.

7.6 Summary and conclusions of chapter

This chapter examined the gender productivity gaps between male and female heads as well as the productivity gaps between male heads and their spouses. Secondly, the chapter provided evidence on the effect of climate change, livelihood diversification, productive inputs, adaptation and socioeconomic factors on maize productivity and G. From the objective, a selectivity biased corrected gender decomposition model (OB model) was

analysed, and the result showed the presence of this endogeneity. The study found that there is a substantial gender maize productivity gaps among farmers. This gap was higher for female heads than for female spouses. Endowment difference in resources contributed the largest proportion of G. Therefore, gender productivity gap can be significantly minimised by providing equal resources to both male and female farmers. Both climate change and livelihood diversification had significant impact on maize production and G. From the endowment component, productive factors such as labour contributed the highest percentage to G, followed by livelihood diversification, and climate change and variability. It can also be concluded from the pure discrimination component that climate change, socioeconomic and livelihood diversification contributed the highest percentage to G. To reduce G, farmers, particularly female farmers, should be provided with livelihood diversification opportunities and climate information. To begin with, a conducive market and production environment for non-farm activities such as agro-processing and shea butter extraction should be established by the government and other development agencies. The Secretariat in charge of government's flagship 'one district one factory' program should consider improving the existing non-farm industries such as agro-processing units in northern Ghana. In addition to providing equal livelihood diversification opportunities to male and female farmers, more direct support in education on livelihood opportunities should be given to the women to increase their returns from diversification. NGOs and extension officers should intensify campaign on climate adaptation while women should be encouraged to fully participate in adaptation programs. Farmers, particularly female head farmers, are encouraged to adopt improved seed varieties, planting in lines and recommended planting spacing.

CHAPTER EIGHT

GENDER PERSPECTIVES OF THE EFFECTS OF CLIMATE CHANGE AND LIVELIHOOD DIVERSIFICATION ON HOUSEHOLDS' WELFARE IN NORTHERN GHANA

8.1 Overview

Globally, addressing poverty levels and inequalities remained one of the top priority and has been accorded the first place in the SDGs. In Ghana also, poverty and inequality reduction remained a crucial objective of both past and present governments. This has led to the introduction of some social intervention programs such as Livelihood Empowerment Against Poverty (LEAP). Although the country as a whole is faring well in poverty reduction over the past decades, poverty levels in the northern regions still remained higher than other parts of the country. One of the sources of inequality in the country is gender welfare difference. With the worsening climatic conditions and its varying impacts, addressing poverty and inequality is becoming a more difficult objective. Therefore, since climate change effects are non-gender blind, it is important to estimate the effect of climate change on gender welfare differences in the region. Also, climate change adaptation literature suggested that livelihood diversification is a potential strategy to improve households' welfare amidst climate change. However, the literature failed to examine the effect of livelihood diversification on gender welfare gap among households. In this chapter, the thesis seeks to address these underlining gaps in the literature and provide policy recommendations on how to improve welfare and reduce gender welfare gaps. Welfare in this chapter is defined as the per capita consumption expenditure of households in US dollar currency ($). The conversion rate used was the November, 2017 (since the data collection ended in November) exchange rate of 1$ to GH₵4.62. The peculiarity of

this chapter is that it is one of the studies that used a gender decomposition model to examine the welfare inequality and the impact of climate adaptation through livelihood diversification on gendered welfare inequality in the northern region of Ghana. From the Oaxaca Blinder model discussed in chapter three (Section 3.5.3), the following empirical model was estimated to examine the determinants of welfare and gender welfare gaps (G) among farming households of the three northern regions of Ghana.

$$\begin{aligned} Welfare = {} & \delta_0 + \delta_1 Heads'education + \delta_2 Household's education + \delta_3 Household\,size \\ & + \delta_4 Dependency + \delta_5 Credit\,access + \delta_6 Land\,ownership + \delta_7 Upper\,East \\ & + \delta_8 Upper\,West + \delta_9 Flood + \delta_{10} Drought + \delta_{11} Windstorm + \delta_{12} Forest\ fire \\ & + \delta_{13} C\lim ate\ perception + \delta_{14} C\lim ate\inf ormation + \delta_{15} LVI + \delta_{16} On-farm \\ & + \delta_{17} Animal + \delta_{18} Trading + \delta_{19} Agro\ proces\sin g + \delta_{20}\Pr of/Skilled\ job + \delta_{21} IMR \end{aligned}$$

Table 8.1: Definition of variables

Variable	Definition or measurement	A priori sign	VIF
Education	The total number of years of formal education by household head.	+	1.16
Household's education	Total number of household members who completed JHS.	+	1.43
Household size	Total number of adult equivalents in a household sharing and pooling resources.	-	1.49
Dependency	The ratio of the total number of household members under 16 to total number of household older than 15.	-	1.13
Credit access	Dummy: 1 if household head had access to credit in the production season and 0 if otherwise.	+	1.31
Land ownership	Dummy: 1 if household head own land and 0 if otherwise.	+	1.29
Upper East	Dummy: 1 if household head is located in Upper East and 0 if otherwise.	+	1.62

Upper West	Dummy: 1 if household head is located in Upper West and 0 if otherwise.	-	1.54
Flood times	The total number of times a household experienced flood within the past three years.	-	1.56
Drought times	The total number of times a household experienced drought within the past three years.	-	1.32
Windstorm experience	The total number of times a household experienced windstorm within the past three years.	-	1.16
Forest times	The total number of times a household experienced forest fires within the past three years.	-	1.21
Climate perception	Dummy: 1 if household head perceives climate change wrongly and 0 if correctly.	-	1.71
Climate information	Dummy: 1 if household head had no access to climate information and 0 if otherwise.	-	1.46
LVI	The estimated vulnerability of a household without diversification.	-	1.66
On-farm	Dummy: 1 if household head engages in crop diversification and 0 if otherwise.	+	2.93
Animal	Dummy: 1 if household head engages in maize cropping-animal rearing diversification and 0 if otherwise.	+	2.84
Trading	Dummy: 1 if household head engages in maize cropping-trading diversification and 0 if otherwise.	+	1.89
Agro processing	Dummy: 1 if household head engages in maize cropping-agro processing diversification and 0 if otherwise.	+	2.27
Prof/Skilled job	Dummy: 1 if household head engages in maize cropping-prof/skilled diversification and 0 if otherwise.	+	2.34
IMRs	The predicted vector of IMRs of diversification strategies obtained from multivariate probit model (chapter 5)	-/+	
TOTAL VIF			1.94

8.2. Gendered welfare gap

Table 8.2 shows the mean welfare levels of male and female headed households and the difference between the two gendered households. From the data and without a gender-based analysis, the average welfare of the sampled farming households was $389.30 (equivalent of GH₵1,798.56). However, from Table 8.2, the average male headed household spends $400.76 (equivalent of GH₵1,855.51) per annum while the average female headed household had an average welfare of 354.91$ (equivalent of GH₵1,639.67) per annum. These average mean values were statistically significant at 1%, suggesting that they significantly represent the welfare levels of all the selected male and female household heads in the regions, respectively. The estimated mean welfare values were higher than the lower poverty line (GH₵792.05) and upper poverty line (GH₵1,314.00) of Ghana but lower than the observed average consumption expenditure of the country (GH₵2,926.86) (GSS, 2014).

From the average welfare values, the estimated gender welfare gap was $45.85 (equivalent of GH₵211.84) per annum. The welfare gap was also significant at 10%, indicating that there was a statistically significant difference in the welfare levels between male headed and female headed households. Thus, male headed households spend $45.85 (GH₵211.84) every year more than female headed households. This implies that to address gender welfare inequality, 11.4% (45.85/400.76*100) of the welfare of male headed households have to be redistributed between both male and female headed households. However, after controlling for selectivity bias due to the endogeneity of livelihood diversification, the gender welfare gap increased to $79.80 (GH₵368.69). This suggests that under the current

diversification differences between male heads and female heads, the observed gender welfare gap was underestimated and without controlling for this endogeneity, policy makers would be misled in addressing gendered welfare inequalities. Using assets as a measure of welfare in Ghana, Osei-Assibey (2015) found that the gender distribution of welfare was biased in favour of males, with males having a total of 69.8% of total wealth while females had a share of 30.2% of total wealth. Although Ghana is making progress in reducing headcount poverty, poverty inequalities continuous to widen (Cooke et al., 2016; Osei-Assibey, 2015).

Table 8.2: Gender welfare gap

Gender	Coefficient	Std. Err	Z-Value	P-Value
Male heads	400.76***	15.984	25.07	0.000
Female heads	354.91***	18.115	19.59	0.000
Observed G	45.85*	24.159	1.90	0.058
Adjusted G	79.80**	33.214	2.40	0.016

*****, ** and * indicates significant at 1%, 5% and 10%, respectively**

Source: Computed from field data, 2017

8.3 Aggregate decomposition of gendered welfare gap

The aggregate decomposition (stage two of the OB model) involved the separation of gender welfare gaps into endowment and discrimination components. This was provided in Table 8.3. The decomposition was done using two approaches; three-way and two-way decompositions. From the three-way decomposition, the differences in characteristics of male headed and female headed households was found to be the main contributor to G.

Thus, the endowment effect contributed 104.9% to the observed differences in welfare between male and female headed households while the discrimination component contributed 17.09% to G. The interaction between the two lead to a reduction of G by 21.99%. The implication is that both the differences in endowment and actual discrimination led to an increase in the welfare difference between male and female headed households. However, when these two sources of inequality interact, it led to a reduction in the gendered welfare differences. However, only the endowment effect had a statistically significant effect on G.

From the two-way decomposition also, the explained component that measures the contribution of differences in observable characteristics contributed positively (95.03%) to welfare gap between male and female heads. Also, the unexplained component that measures the contribution by unobservable characteristics (a measure of discrimination) had a positive insignificant effect on G; contributing 4.97% to G. The results implied that in order to address welfare or poverty inequalities in northern regions of Ghana, more efforts should be directed in improving the resource difference between male and female headed households. These resources include the socioeconomic endowment such as education and credit access, livelihood diversification as well as improve the resilience of female headed households to climate change and variability. In the subsequent sections, the contribution of the resource groups and the individual characteristics was provided. The further decompositions in the following sections are based on the two-way decomposition approach since the interaction actually leads to a reduction in G.

Table 8.3: Aggregate decomposition of gender welfare gap

Source of G	Coef.	Std. Err	Z-Value	P-Value	% of G
Three-way decomposition					
Endowments	83.713***	32.031	2.61	0.009	104.90
Coefficients	13.638	42.041	0.32	0.746	17.09
Interaction	-17.548	34.979	-0.50	0.616	-21.99
Two-way decomposition					
Explained	75.842***	20.850	3.64	0.000	95.03
Unexplained	3.962	30.382	0.13	0.896	4.97

***** indicates significance at 1%**

Source: Computed from field data, 2017

8.4 Grouped decomposition of gender welfare gap

Table 8.4 shows the grouped variables decomposition of the gender welfare gap estimated in Table 8.2. The factors were grouped into socioeconomic, location, climate change/variability, and livelihood diversification factors. From the result (Table 8.4), socioeconomic and climate factors had significant influence on the explained component of gender welfare gap while climate factors and livelihood diversification significantly contributed to the unexplained component of gender welfare gap.

Table 8.4: Grouped decomposition of gender welfare gap

Source of G	Coef.	Std. Err	Z-Value	P-Value	G (%)
Explained component					
Socioeconomic	27.37**	10.57	2.59	0.010	59.70
Location	1.32	5.28	0.25	0.802	2.89
CCV	29.63***	10.16	2.92	0.004	64.62
Diversification	17.52	12.40	1.41	0.158	38.21
IMR	15.30	11.22	1.36	0.173	33.38
Total	91.14***	20.46	4.45	0.000	198.78
Unexplained component					
Socioeconomic	53.45	66.34	0.81	0.420	116.58
Location	8.18	24.52	0.33	0.739	17.83
CCV	-88.61*	50.82	-1.74	0.081	-193.26
Diversification	102.50**	52.34	1.96	0.050	223.55
IMR	-49.25**	23.96	-2.06	0.040	-107.42
Constant	-71.55	101.42	-0.71	0.480	-156.06
Total	-45.29**	20.70	-2.19	0.029	-98.78

*****, ** and * indicates significant at 1%, 5% and 10%, respectively**

Source: Computed from field data, 2017

Socioeconomic factors had a positive effect on gender welfare gap through both explained and unexplained components. This means that the differences in education of the head and household members, access to credit, land ownership and difference in household size and dependency contributes positively to the observed differences in welfare among households and at the same time, the returns from these characteristics also leads to a worsening gender welfare gap. Thus, the returns associated with these characteristics favour the male heads more than the female heads. However, the effect of socioeconomic factors on gender welfare gap is significant only through the observed differences in socioeconomic

characteristics. Specifically, socioeconomic factors contributed 59.70% and 116.58% to the observed and unobservable portions of G, respectively. These are reasonably high and call for improving the socioeconomic base of the female heads. Also, efforts that would ensure that women realize higher returns from an improvement in their socioeconomic status are needed to address gender welfare inequalities.

Livelihood diversification had positive effect on explained and unexplained components of the observed welfare difference. However, the effect was significant only through the unexplained component. This means that the unobservable returns from livelihood diversification led to an increase in welfare differences between males and females by as high as 223.55%. Thus, male heads have higher returns from livelihood diversification than female heads. The inclusion of the IMR was to correct endogeneity of livelihood diversification. The result was significant at the unexplained component, consistent with the estimates of livelihood diversification's contribution to G. This justified that the estimated result is unbiased. Empirically, Gautam & Andersen (2016) estimated that while diversification strategies such as trading and salaried jobs leads to an improvement in welfare, wage labour and handicraft or tool making leads to a reduction in welfare. Therefore, the authors concluded that diversification does not per ser lead to higher welfare, but the ability of the households to attract high return activities into their livelihood portfolio is what brings about the improvement in welfare. This justified the significance of livelihood diversification on the unexplained component but not the explained component in this study. Similarly, Dzanku (2015) concluded that livelihood diversification in Ghana is transient and this have a significant welfare cost on the households.

From Table 8.4, climate change and variability had positive significant effect on welfare gap through the explained component and a negative significant effect through the unexplained component. Thus, gender differences in resilience to drought, flood, forest fires and windstorm, access to climate information and climate perception led to an increase in gender welfare gap by 64.62%, while the unobservable returns from these factors contribute to a reduction in gender welfare gap by 193.26%. Since addressing unobservable climate factors is a mirage, there is the need to improve the climate characteristics of women. Generally, Osei-Assibey (2015) hinted that climate change pose a threat to poverty reduction in northern Ghana. Also, Asravor (2017) estimated that higher climate variability is associated with lower per capita consumption in Ghana.

8.5 Detailed decomposition of welfare gap and factors influencing households' welfare

Table 8.5 shows the effect of each factor on the welfare of male and female household heads. In these models, a log-linear model using the natural logs of welfare values were assumed in estimating the welfare determinants. This is discussed under the various factor groups in the following sections.

Table 8.5: Determinants of welfare and detailed decomposition of G

	Male heads			Female heads			Contribution to G (%)	
Variable	Coef.	Std. Err	Z-Value	Coef.	Std. Err	Z-Value	Explained (%)	Unexplained (%)
Education	0.009*	0.005	1.74	0.008	0.010	0.84	6.30	-10.56
Household education	-0.056***	0.017	-3.23	-0.035	0.023	-1.50	-1.30	-86.07*
Household size	0.051***	0.009	5.42	0.035*	0.018	1.94	33.88*	250.08**
Dependency	0.027	0.036	0.74	-0.025	0.030	-0.83	-0.64	-12.20
Credit access	-0.010	0.068	-0.14	-0.078	0.112	-0.69	1.81	2.61
Land ownership	-0.003	0.060	-0.05	0.293***	0.094	3.12	19.64*	-27.31
Upper East	-0.137*	0.072	-1.89	-0.287***	0.095	-3.02	2.89	22.21
Upper West	-0.079	0.081	-0.97	-0.055	0.114	-0.48	0.00	-4.38
Flood times	0.017	0.029	0.58	-0.039	0.044	-0.89	11.67	55.10**
Drought times	0.061***	0.019	3.24	0.126***	0.038	3.35	25.09*	-78.88**
Windstorm experience	-0.111*	0.059	-1.87	-0.004	0.087	-0.04	12.42*	-93.97
Forest times	-0.024	0.023	-1.02	-0.033	0.033	-0.99	4.07	14.43
Climate perception	0.102	0.084	1.22	-0.211**	0.102	-2.06	-0.39	-44.45
Climate information	-0.236***	0.063	-3.72	-0.224**	0.099	-2.25	12.94	10.10
LVI	-0.050	0.063	-0.80	-0.141*	0.082	-1.73	-1.20	-55.57*
On-farm	0.055	0.137	0.40	-0.035	0.228	-0.15	7.88	87.28
Animal	0.361***	0.100	3.62	0.345**	0.168	2.05	58.66***	-98.59
Trading	0.093	0.077	1.21	-0.227	0.147	-1.54	1.31	86.76*
Agro processing	0.187**	0.087	2.14	0.099	0.141	0.71	-32.67**	18.36
Prof/Skilled job	0.023	0.091	0.25	-0.444***	0.153	-2.90	3.02	129.71***
IMR_on farm	0.245	0.289	0.85	0.135	0.430	0.31	-1.86	10.77
IMR_Animal	-0.804***	0.275	-2.92	-0.643*	0.374	-1.72	-0.08	15.20
IMR_Trading	0.052	0.265	0.20	0.271	0.362	0.75	-7.80	-36.29
IMR_Agro processing	-0.365	0.275	-1.33	-0.284	0.299	-0.95	51.79**	-15.67
IMR_Prof/Skilled	-0.222	0.311	-0.72	0.998***	0.372	2.69	-8.68	-81.41**
Constant	5.317	0.168	31.70	5.524	0.225	24.54		-156.03

Table 8.5 Continue

Statistics	Male heads	Female heads
N	324	108
F	7.62	3.34
R Squared	38.99%	50.44%
Adj. R-Squared	33.87%	35.33%

*****,** and * indicates significant at 1%, 5% and 10%, respectively**

Source: Computed from field data, 2017

8.5.1 Effects of socioeconomic factors on households' welfare and G

Empirically, one of the observed field of research is the estimation of the effects of socioeconomic factors on household's welfare. This is justifiable considering the role of these factors in shaping household's resource mobilization, production and consumption decisions. From Table 8.6, the socioeconomic factors that significantly influenced the welfare of male headed households were education of the household head, number of household members with JHS level education or more and household size. Also, significant for the female headed households were household size and land ownership.

For both males and females, education had positive effect on household's welfare while household members' education had negative effect on the welfare except that these were statistically significant for only male heads. The positive effect means that higher levels of education leads to improved welfare. In most occupations, particularly formal occupations, educational level of a person is a significant measure of qualification for higher position and higher remunerations. However, in the informal sector such as farming, higher education improves efficiency of the farmers leading to higher yields and also search for information on higher produce prices since they are able to understand market dynamics better. Estimates from GSS (2014) showed that households headed by uneducated heads contributed 72.4% of Ghana's poverty incidence while

those headed by educated heads contributed less than 1% of Ghana's total poverty incidence. The estimated negative effect of household's education is unexpected. However, the survey revealed that most of the highly educated household members always assume some level of independence which reduces resource contribution to the entire household. While household head's education had positive and insignificant contribution G, the household members' education contributes negatively to G and significant through the unexplained component. Thus, the returns from household members' education leads to a reduction in differences in welfare. This justified the need for improving the education level of household members and not only the household heads. Consistent with this study, Dzanku (2015) estimated that having educational level above basic level had a positive effect on both consumption expenditure and composite welfare index. Similarly, studies such as Tambo & Wünscher (2017), Donkoh et al. (2014), Rolleston (2011) and Tamvada (2010) estimated a rising welfare benefit from education.

For both male and female heads, household size had positive effects on households' welfare. Thus, an increase in the number of people (adult equivalent) in a household leads to an increase in the welfare of the households. Unlike total household size used in previous studies, the adult equivalent computation of household size in this study means that the higher the number, the higher the number of adults who may be engaged economically or contribute positively to resource mobilisation. Therefore, the resource pooling of the households improves with higher adults in the household. This is also justifiable considering that the major source of labour for farming households is the household members. From the result also, household size contributed positively and significantly to gender welfare gap through both explained and unexplained components. Thus, the observed difference in household size and the associated returns

from household size led to a widened gender welfare gap. Perhaps, male headed households were able to effectively manage their household members to contribute higher levels to household's welfare than managed by female headed households. Giesbert & Schindler (2012) also estimated a positive significant effect of household size on asset growth in Mozambique. Contrary, Rolleston (2011) used Ghana Living Standard Survey panel data and found that adult equivalent household size had a negative effect on household's welfare. Also, Tamvada (2010) found a convex relationship between household size and welfare while Tambo & Wünscher (2017) found a negative effect of household size on welfare.

Land ownership had a positive significant effect on the welfare of female headed households. This was expected since land ownership or access is an important resource in farming communities. Land access and ownership by women is low and this is a source of gender discrimination in the area (recall from section 4.4). Therefore, it was expected that female heads who had ownership of lands would be able to improve the welfare of their household members. Consistently also, the observed differences in land ownership significantly contributed 19.64% of the total gender welfare gap. Empirically, Donkoh et al. (2014) also estimated a positive effect of land ownership on welfare. But contrary to this study, Bhaumik et al. (2013) found that ownership of land does not necessary improve women's welfare, instead, ensuring tenure security, access to complementary inputs and market are crucial to accrue the benefits of land ownership by women.

8.5.1 Effects of location factors on households' welfare and G

Only regional dummies were included in the model as location variables. Although the relationship between both Upper East or Upper West regions and welfare were negative, the coefficient estimate is only significant for Upper East region. This means that households located in Upper East region had lower welfare than those located in Northern region. Consistently, the study of Adzawla et al. (2016) found that the average welfare of households in Northern region are higher than those in Upper East and Upper West regions. This is however contrary to the 2012/13 national estimates which shows that among the three northern regions, Upper East region had higher average welfare (GH₵1,861.14) and poverty level (44.4%) than the Northern region's average welfare of GH₵1,763.60 and poverty level of 50.4%, and Upper West region's average welfare of GH₵1,390.67 and poverty level of 70.7% (GSS, 2014a). Location variables in Table 8.6 had no significant contribution to G, and this is consistent with the result in Table 8.5. Empirically, Dzanku (2015) used selected districts from the Eastern region (south of Ghana) and Upper East region (north of Ghana) and found that there is welfare discrimination against rural households in Upper East region. Therefore, the author argued that, there is the need for more emphasis on location specific poverty reduction policies.

8.5.1 Effect of climate change and variability factors on households' welfare and G

A number of climate variables including climate shocks and climate awareness variables were included in the model. From the result, the climate variables that had significant effect on household's welfare included drought, windstorm, climate perception, access to climate information and LVI. Although flood had no significant effect on the welfare of both males and females, it significantly contributed 55.10% to

gender welfare gap through the unexplained component. Thus, the unobservable characteristics of floods are male favoured, demonstrating higher impact of floods on female headed households.

Drought had a positive significant effect on the welfare of both male and female headed households. This means that household who experienced frequent or annual droughts had higher welfare than those who experienced no drought over the past three years. Although this was contrary to the researcher's expectations, it can be explained that households that experienced frequent droughts might have spent more, especially on non-food commodities in order to maintain the living conditions of their households. It is quite expected that if welfare is measured using non-monetary measures such as asset index, drought would have had a negative effect on household's welfare. While the observed difference in drought experience significantly contributed positively (25.09%) to G, the unobservable effects of drought significantly contributed negatively (-78.88) to G. Contrary to this finding, Tambo & Wünscher (2017) estimated that, households that experienced drought within five years had lower outcomes such as income, consumption expenditure and food consumption expenditure. Donadelli et al. (2017) explained that the speed of adjustment in adaptation to temperature shocks is crucial for reducing welfare costs. On their part, Giesbert & Schindler (2012) found that, although drought had negative effect on asset growth, the interaction of drought and nonfarm wage had a positive effect on asset growth in Mozambique.

Expectedly, windstorm had a negative effect on the welfare of both male and female headed households but significant for only the latter. This means that female headed households that experienced frequent windstorms over the past three years had lower welfare than those that who experienced few or no windstorm. The destructions of windstorm leads to a reduction in available income and other resources for households'

consumption. The result also showed that windstorm contributed to a reduction in G through both explained (-12.42%) and unexplained (-93.97%) components but the reduction is significant only in the explained component. This is consistent with the findings of Arouri et al. (2015).

Climate perception had a positive effect on male headed household's welfare while a negative effect on female headed household's welfare. The negative effect means that households who perceived changes in the directions of rainfall and temperature appropriately had higher welfare than those who perceived the changes in the direction wrongly (not consistent with scientific predictions). This is conceivable as household heads that predict climate change correctly might have adapted appropriately to maintain or improve the welfare levels of the household members. Climate perception however had no significant contribution to G among the households. Consistently, climate information had a negative significant effect on the welfare of the households. This means that household heads who had access to climate information had higher welfare than household heads who had no access to climate information. Like perception, access to climate information also had no significant effect on G, although the effects were positive.

Although LVI was constructed from different indicators including some climate variables, a correlation between these variables and LVI suggest no significance correlation. Therefore, LVI was used as an independent variable. From the result, LVI had a negative significant effect on the welfare of female headed households. This means that the higher the LVI, the lower the welfare. This can be explained by the fact that the severely vulnerable households do not have enough resources to improve their consumption expenditure. This also indicate that there is an inverse relationship between LVI and welfare, therefore, if LVI is not strategically addressed, it can lead to

total welfare loss. However, LVI contributes to a reduction in gender welfare gap, and this is significant through the unobservable component. Hallegatte et al. (2018) explained that there is a reciprocal effects of poverty and climate vulnerability; thus, while poverty is a cause of high climate vulnerability, climate vulnerability is also a cause of poverty.

8.5.1 Effects of livelihood diversification factors on households' welfare and G

In this section, the result from Table 8.5 on the effect of livelihood diversification on household's welfare and the specific effect of each diversification strategy on gender welfare gap is provided. From the result (Table 8.5), animal, agro processing and profession/skilled employment had significant effects on household's welfare. Although trading had no significant effect on the welfare of the male and female headed households, it contributed significantly (86.76%) to the gender welfare gap of the households. While some of the IMR were significant, others are not. However, the inclusion of the IMR lead to consistent estimates.

Animal rearing in addition to crop production had positive significant effects on the welfare of both male and female headed households. This means that households who engaged in crop-animal diversification strategy had higher welfare than their counterparts who did not engaged in it. This is because, animal rearing provides a cheap source of available protein to the family and the use of livestock such as bullocks and donkeys for agricultural power and carting produce from farms to the home or market. Animal rearing is one of the recommended strategy among agrarian communities to adapt to climate change. Consistently, Tambo & Wünscher (2017) estimated that livestock holding leads to an improvement in household's income. In terms of gender welfare gap, crop-animal diversification significantly contributed 58.66% to G.

From the result, agro-processing had positive effects on the welfare of both male and female headed households, however, this is significant for only the male headed households. This means that engaging in agro-processing tends to increase the welfare of such households. This justified the need to improve agro-processing in the country which would also lead to reduction in post-harvest loses. Relatedly, the study of Giesbert & Schindler (2012) revealed that nonfarm employment is important to offset the effects of droughts on asset wealth. Contrary, Tamvada (2010) estimated that engaging in self-employment leads to a reduction in household's welfare.

The engagement in professional and skilled employments increase welfare for male headed households but decrease welfare for female headed households. This is due to the high hours spent on domestic works which were considered non-economic activity. However, in terms of contribution to G, observed differences in engaging in professional and skilled employment led to an increase in the welfare differences, although insignificant. Nonetheless, the unobserved characteristics of profession and skilled employment had positive and significant effect on G. This is consistent with the findings of Gautam & Andersen (2016) who estimated that households who diversified into salaried jobs had higher welfare. Rolleston (2011) and Tamvada (2010) expounded that engaging in professional employment or salary employment leads to an improvement in household's welfare.

8.6 Summary and conclusions of chapter eight

This chapter examined the gendered welfare gap and welfare inequality in northern regions of Ghana. The section also examined the sources of gendered welfare gap, the effect of climate change/variability and diversification on gendered welfare gaps and the

determinants of welfare among farming households. A selectivity corrected Oaxaca Blinder model was estimated using household per capita consumption expenditure as a measure of household's welfare. This chapter found that there is a significant welfare gap of 11.4% between male heads and female heads. This study conclude that climate change does not only lead to welfare reduction but also leads to increase in gender welfare gap. While the effect of livelihood diversification on household's welfare is established, it is concluded that the unobservable returns from livelihood diversification are male favoured, thereby, leading to a worsening gender welfare gap. A number of socioeconomic, climate, location and livelihood diversification factors significantly explained the variations in welfare among households and welfare differences among the households. It is also concluded from the findings that although livelihood diversification is a necessary condition, policies that would ensure that females also have higher returns from such strategies are sufficient to address gender welfare gaps. For instance, training and education of females on livelihood diversification portfolios is crucial to improve their abilities to obtain higher returns from such ventures.

CHAPTER NINE

GENERAL SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

9.1 Overview

This chapter provides a summary of the major issues addressed in this Doctoral thesis that sought to analyse gender inequalities and the effects of climate adaptation through livelihood diversification on the identified inequalities. The study addressed four specific objectives that largely centered on diversification analysis, climate vulnerability analysis, productivity analysis and welfare analysis; all within gender framework. This chapter also made final and general conclusions from the empirical results and consolidated the conclusions made at the end of the various chapters. Recommendations were made from the conclusions for both policy makers and researchers.

9.2 Summary

9.2.1 Summary on study methodology and farmers perceptions

The study was conducted in northern Ghana. The three northern regions of Ghana were studied to its socioeconomic characteristics and climatic conditions. A total of 619 maize farmers from 432 households were selected through a multistage sampling procedure and the data analysed through quantitative techniques; LVI, PCA, ordered probit, multivariate probit and Oaxaca Blinder decomposition model.

The summary of the result on farmers perceptions on a wide range of factors are as follows. Farmers in general had relatively higher perceptions on gender inequality in their societies and homes. All gender groups, especially, female heads expressed the opinion that gender inequality is biased against women. The perception index estimated

by the study also showed that the famers perceived that gender inequality is declining over the years. The observed rainfall patterns of the three regions showed several spikes with a slightly downward trend. Both minimum and maximum temperatures also showed slight upward trends. These are corroborated by the perceptions of over of the majority of the respondents that rainfall intensity, duration and timeliness are decreasing while temperatures are increasing.

9.2.2 Livelihood diversification among gender groups

Five livelihood diversification portfolios were identified and examined by this study. These were on-farm diversification, crop-animal diversification, crop-trading diversification, crop-agro-processing diversification and crop-professional/skilled job diversification. From a Herfindah diversification index, it was estimated that the diversification level was lower than 50% for all gender groups; 0.4616 for male heads, 0.4346 for female spouses and 0.4108 for female heads. The most common diversification strategies were on-farm and crop-animal diversification. In order of priority, the major constraints to livelihood diversification were financial constraints, climate change and variability and lack of information/education on livelihood diversification portfolios. From a multivariate probit model, the hypothesis that the livelihood diversification strategies are independent was rejected. The result also shows that the following factors had significant effect on the respective diversification strategy:

- On-farm diversification: gender, age, extension service, contract farming, windstorm, floods, climate information, financial assets, social assets, human assets and technological assets.

- Crop-animal diversification: gender, age, experience, extension service, training, adults, floods, droughts, climate information, climate perception, financial assets, physical assets, social assets, human assets and technological assets.
- Crop-trading diversification: gender, number of hours spent on domestic works, experience, extension, training, adults, windstorm, forest fires, financial assets, physical assets and social assets.
- Crop-agro-processing diversification: home keeping hours, experience, extension, adults, droughts, climate information, forest fires, financial assets, physical assets, social assets, human assets, technological assets and political assets.
- Crop-professional and skilled job diversification: age, home keeping, experience, extension service, contract farming, training, climate information, forest fires, climate perception, financial assets, physical assets and technological assets.

9.2.3 Gendered climate vulnerability and effects of livelihood diversification

Equal weights and unequal weights from PCA were used to analyse households' LVI and LVI-IPCC. From the result, farmers perception on climate change and variability contributed the highest proportion of household's exposure to climate change, resource and energy factors contributed the highest to adaptive capacity and health factors contributed the highest to sensitivity.

From the equal weighting method, the adaptive capacity was highest for female spouses and lowest for male heads. The sensitivity to climate change was highest for female heads and lowest for female spouses, while the exposure was highest for male heads and lowest for female heads. From LVI, the vulnerability was highest for female spouses

and lowest for male heads. Also, LVI-IPCC revealed that the vulnerability levels for female heads was highest, followed by female spouses and male heads. Livelihood diversification led to a reduction in LVI by 0.077 for male heads, 0.0067 for female spouses and 0.0064 for female heads. Under LVI-IPCC, livelihood diversification led to a reduction in climate vulnerability by 0.0023 for male heads, 0.0024 for female spouses and 0.0019 for female heads. Although livelihood diversification led to a decline in vulnerability levels, it led to an increase in gender climate vulnerability gap between the males and females. For instance, using LVI, the vulnerability between male heads and female heads has increased to 2.43% while between male heads and female spouses has increased to 3.36%.

From the weighting through PCA, the exposure to climate change was highest for males and lowest for female spouses. The adaptive capacity was highest for female spouses and lowest for female heads. The sensitivity was highest for male heads and lowest for female heads. The vulnerability levels for both female heads and female spouses were higher than for male heads. Livelihood diversification led to a reduction in climate vulnerability by 0.0395 for male heads, 0.0331 for female spouses and 0.0364 for female heads. Also, from LVI, livelihood diversification led to an increase in climate vulnerability gap between male heads and female heads from 4.31% to 5.38%, and from 3.99% to 5.75% between male heads and female spouses. However, the farmers perceived that livelihood diversification had no significant effect on social, economic and environmental vulnerability of the household.

From an order probit model, the factors that significantly influenced the vulnerability of male heads were political assets, droughts, climate information, on-farm diversification, crop-professional/skilled diversification, distance from home to market, aim of maize production, male-female ratio and locating in middle class districts and Upper West

region. For female heads, financial assets, droughts, number of emigrants providing remittances, contract farming, distance from home to market, dependency ratio and locating in middle class district. Significant in explaining vulnerability variations among female spouses were financial assets, social assets, human assets, technological assets, crop-animal diversification, crop-professional/skilled job diversification, contract farming, distance from home to market, dependency ratio, extension access and locating in middleclass district.

9.2.4 Gender productivity gap and the effects of climate change and livelihood diversification

A selectivity corrected Oaxaca Blinder decomposition model was estimated to analyse gender productivity inequality. The result showed significant observed productivity gaps of 394.537 kg/acre (58.8%) between male heads and the female heads and 300.164 kg/acre (44.8%) between male heads and female spouses. These gaps reduced by correcting for selectivity bias. From a three-way decomposition, the interaction between endowment and coefficient contributed the highest percentage to gender productivity gap; 92.09% of productivity gap between male heads and female heads and 123.16% of the productivity gap between male heads and female spouses. A two-way decomposition revealed a significant contribution by the explained component to gender productivity gaps. Productive factors had significant effect on gender productivity gap through the endowments among male heads and female heads. Livelihood diversification and climate change/variability significantly contributed to an increase in gender productivity gap through the coefficient component. The contributions of livelihood diversification were corrected by the significance of IMR. The specific livelihood diversification strategies that had significant effects on gender productivity gap were on-farm diversification and crop-agro-processing diversification. From the

farmers' perception also, livelihood diversification positively leads to an improvement in agricultural productivity. A detailed decomposition revealed that hired labour, seed, chemicals, farm size, on-farm diversification, crop-agro-processing diversification, crop-professional/skilled job diversification, location in rich class district, climate perception, windstorm, household size, health status and production aim significantly influence the productivity of males. The productivity of female heads was significantly influenced by seed, farm size, on-farm diversification, prior awareness on climate shock, flood, household size and production. For female spouses, productivity was significantly influenced by seed, climate perception, flood, education, health status, production aim and adaptation index.

9.2.4 Gendered welfare gap and the effects of climate change and livelihood diversification

A selectivity corrected Oaxaca Blinder decomposition model was estimated in a four step. In the first step, a welfare gap was estimated. This revealed a significant welfare gap of $45.85 (equivalent of GH₵211.84) per annum (11.4%). The observed welfare gap increased to $79.80 (GH₵368.69) per annum. The major contributor to the observed gender welfare gap is the endowment effect, contributing as high 158.07% to the gender welfare gap. Similarly, a two-way decomposition also revealed that the explained component contributed significantly, 198.78% to the observed gender welfare gap between male and female heads. In both three-way and two-way decompositions, the discrimination components showed a negative effect on welfare gap. On the grouped factors, livelihood diversification had positive insignificant effect on the explained but a positive significant effect on the unexplained components of gender welfare gap. Also, climate change/variability had positive significant effect on welfare gap through the explained component and a negative significant effect through the unexplained

component. Consistently from the farmers' perspectives, livelihood diversification positively leads to an improvement in wellbeing. A number of specific factors influenced the welfare level of the households. For instance, education of household head, number of household members with education not lower than JHS, household size, drought, windstorm, climate information, crop-animal diversification and locating in Upper East region significantly influenced the welfare of female headed households. On the other hand, household size, land ownership, locating in Upper East region, droughts, climate perception, LVI, crop-animal diversification and crop-professional/skilled job diversification had statistically significant effect on the welfare level of female headed households. Gender welfare gap is significantly influenced by households' education, household size, drought, windstorm, LVI, crop-animal diversification, crop-agro-processing diversification and crop-professional/skilled job diversification.

9.3 Conclusions, contribution to knowledge and policy implications

In the midst of climate change and the need for sustainable development, climate-gender analysis has become a central position for many policy makers, including researchers. This study examined gender inequalities among farming households and the effect of climate adaptation through livelihood diversification on addressing gender inequalities. This study was the first study that analysed the role of climate adaptation on gender inequality. Unlike previous gender studies that only compared between male and female household heads or farm managers, this study integrated household heads and fame managers to arrive at a comprehensive conclusion on gender inequality among farming households. Similarly, this study have expanded the research frontier on the analysis of the impact of climate change and climate adaptation through livelihood

diversification on household's welfare and farm productivity. Strategic conclusions were made at various chapter endings. However, it can generally be concluded that livelihood diversification is highest for male heads and lowest for female heads and also, the factors that significantly influenced each diversification strategy are not universal among gender groups. It is concluded that, female household heads were most vulnerable to climate change, followed by female spouse and male heads. The impact of livelihood diversification on climate vulnerability was more noticeable at inter-household than intra-household. The study concluded on climate vulnerability that although diversification would improve vulnerability among all gender groups, it would not address gender vulnerability gap. Hence, climate adaptation through livelihood diversification is necessary but insufficient condition for addressing gender climate vulnerability differences.

On gender productivity analysis, it is concluded that there was significant productivity gaps of 58.8% and 44.8% between male and female heads, and between male heads and female spouses, respectively. Evidently, the main source of gender productivity differences was due to resource endowment among male and female farmers. Overall, livelihood diversification significantly affected gender productivity through endowment and coefficient effect components. It is also concluded that climate variables significantly affects gender productivity gap through only coefficient effects. The research also concluded that there is a significant difference in gender welfare gap and calls for action. Livelihood diversification and climate change affected the gender welfare gap.

The researcher therefore concluded that while livelihood diversification had positive implications for improving climate vulnerabilities, productivity and welfare, it cannot be relied on solely for addressing gender inequalities. Therefore, calls for women

empowerment with the purpose that if women are empowered economically, then the gender inequalities were be address have to make such calls more inclusive with addressing the fundamental issues such as social discriminations that limits the potentials of women.

9.4 Recommendations

Based on the findings and the conclusions of this research, the following recommendations were made.

9.4.1 Policy recommendations

1. There is the need to not only intensify extension services to the farmers but also, the services should incorporate livelihood diversification education especially to women. This would ensure that they obtain high returns from livelihood diversification. There must be a stepped-up effort to providing financial assistance to farming households to enhance their diversification decisions and management. Social networks especially among female heads should be strengthened and be used as a source of climate information and livelihood diversification promotion and education among the farmers.
2. Livelihood diversification, especially, on-farm diversification and crop-skilled job diversification are vital strategies to reduce climate vulnerabilities among male and female farmers. However, beyond the provision of these economic empowerment opportunities, the Ministry of Gender, Children and Social protection through collaboration with local NGOs must provide education and training to women in order to improve their knowledge on livelihood diversification and climate change. The secretariat on government's one district

one factor program should consider promoting skilled jobs and agro-processing among the farmers, particularly, the female farmers in order to strengthened their resilience to climate change.

3. Providing equal livelihood diversification and climate information to both males and females is necessary to reduce gender productivity gaps. However, there is the need to promote measures that would increase the returns associated with livelihood diversification and climate information by women. For instance, female farmers are encouraged to engage in maize production as a business other than for subsistence purposes. In addition to providing improved seeds (early maturing and drought tolerant varieties) to the farmers, there must be an education to ensure that the appropriate planting space and planting density are adhered to in order to improve both productivity and address gender productivity gaps.

4. The effect of socioeconomic factors is significant in explaining the gender welfare gap among male and female headed households. Therefore, the vicious cycle of unequal socioeconomic characteristics such as education among gender groups should be broken. While female children should be given more education opportunities to address this challenge in the long-run, female adults should be provided with non-formal education in order to make them compete favourably with men in all endeavours in the short-run. Crop-animal and crop-agro-processing diversification are important in improving the welfare levels of both males and female headed households and also address gender welfare gap among households. There is also the need to address the impacts of drought through the provision of irrigation and drought resistant varieties to farming

households. Again, animal rearing and agro-processing that are less affected by drought should be promoted.

5. Generally, the well touted ‘women empowerment’ is a good call. However, equal economic empowerment of men and women is not sufficient to addressing gender inequalities in the farming communities. Female farmers must be specifically and deliberately targeted for special purpose programs.

9.4.2 Recommendations for further study

Further study should consider applying the methodology of this study to a panel data to make recommendations that would address gender inequalities in a sustainable manner other than the snapshot (short term) approach of this study.

Also, there is the need for further study into the other sources of gender inequality such as cultural and political differences, and how addressing these could impact gender inequality or complement the impacts from livelihood diversification. Thus, a further study should analyse the integration of major sources (economic, social, and political among others) of gender inequality and how inequality would respond if these integration are holistically considered.

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APPENDICES

Appendix 1: Measurement of the indicators used in calculating LVI and their normalised means

Major group	Mino group	Indicators	Mean		
			Male heads	**Female heads**	**Female spouses**
Adaptive capacity	Socioeconomic	The ratio of males to females in a household	0.15	0.14	0.14
		The total dependency ratio of a household	0.08	0.10	0.10
		The number of years of formal education of the household head	0.25	0.18	0.19
		Number of household members with education not less than Junior high school.	0.22	0.21	0.20
		Number of hours spent for domestic activities	0.25	0.40	0.34
	Livelihood strategies	Herfindal diversification index	0.46	0.41	0.43
		Number of household members (15-35yrs) without economic activity	0.08	0.06	0.13
		Number of household members (36-65yrs) without economic activity	0.10	0.08	0.10
		Number of household members engaged solely in agriculture	0.13	0.11	0.15
		Number of emigrants who remits	0.04	0.05	0.04
	Resource and energy	Total agricultural land area of household(acres)	0.13	0.10	0.09
		Electricity is the primary lightning source. (1)Yes (0)No	0.74	0.77	0.75
		Solid cooking fuel is the primary cooking source. (1)Yes (0)No	0.95	0.90	0.93
	Social networks	Have you participated in any capacity building in the past three years? (1)Yes (0)No	0.28	0.42	0.42
		Number of single sex (male only or female only) groups a farmer belonged.	0.01	0.02	0.02
		Number of both sex (males and females) groups a farmer belonged.	0.02	0.02	0.04
Sensitivity	Well being	In which category would you place your household? (1) Poor (2)Middle (3)Rich	0.28	0.19	0.31
		Do you owe anybody? (1)Yes (0)No	0.34	0.40	0.28
		Is there any conflict in the past one year between your community/household and another over any natural resource? (1)Yes (0)No	0.05	0.02	0.05
	Food	How many months in a year do you have food deficit?	0.17	0.16	0.18
		What is the source of your household's food?	0.26	0.46	0.29
		Number of household members depending solely on agriculture for food	0.18	0.16	0.21

	Health	Number of children under five reported ill of malnutrition in the past six months	0.13	0.09	0.12
		Are you insured under national health insurance scheme? (1)Yes (0)No	0.74	0.86	0.73
		How many household members are reported ill in the past one month?	0.07	0.07	0.07
		What is the distance to the nearest health center (miles)?	0.04	0.05	0.06
	Water	What is the distance to the source of your drinking water (minutes by foot)	0.14	0.17	0.18
		Did any of your household member had conflict with other households over water? 1) Yes 0) No	0.10	0.14	0.13
		How many months in a year do you have water shortage for household usage?	0.21	0.19	0.27
Exposure	Environmental shocks	Number of times of flood in the past 3 year	0.14	0.10	0.16
		Number of times of drought in the past 3 year	0.19	0.16	0.19
		Number of times of forest (bush)fire in the 3 one year	0.23	0.26	0.22
		Number of times of severe windstorms that destroyed properties in the past 3 year	0.20	0.16	0.20
		Have you received any warning on any environmental shock? 0) Yes 1) No	0.30	0.22	0.33
		Level of pests infestation on crops (0) Increasing (1) Decreasing	0.14	0.09	0.16
		What is the level of external fertiliser requirement to improve soil fertility on your farm? (1)None (2)low (3)medium (4)high	0.32	0.38	0.43
		Were you aware of any climate shock prior to its occurrence? 0) Yes 1) No	0.31	0.28	0.34
	Climate perception	Duration (days/yr) of rainfall (0) Increased) (1) Decreased	0.17	0.22	0.29
		Intensity of rainfall (Volume) (0) Increased) (1) Decreased	0.22	0.23	0.19
		Timeliness of rains (0) Increased) (1) Decreased	0.39	0.26	0.34
		Temperature (0) Increased) (1) Decreased	0.10	0.22	0.10
		Windstorm (0) Increased) (1) Decreased	0.42	0.39	0.53

Appendix 2: List of publications

Adzawla W. and Kane A. (2019). Effects of climate shocks and climate adaptation through livelihood diversification on gendered welfare gaps in northern Ghana. I*nternational Journal of Environment and Climate Change*, 9(2): 104-119. https://doi.org/10.9734/ijecc/2019/v9i230100

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