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Climate Change Vulnerability and Perceived Resilience Among Smallholder Farmers in the Upper West Region of Ghana

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Abstract

Globally, observed climate change has become a major barrier to agricultural productivity. At the same time, present and projected climate impacts are disproportionately affecting smallholder farmers in sub-Saharan Africa (SSA) where smallholder agriculture constitutes the predominant source of livelihood. Due to the vast agricultural potential of SSA, climate change resilience has been central in several multi-level deliberations over the past few decades. However, existing policies aimed at improving the effects of climate change on food security have overwhelmingly focused on the climatic dimensions of vulnerability, resulting in a lack of knowledge of the role non-climatic factors also play in shaping smallholders' resilience. In fact, others have argued that smallholder farmers' lack of access to credit continues to militate against their climate resilience. Using data from a cross-sectional survey (n = 1,100) collected on household representatives across three districts in the Upper West Region of Ghana, this thesis examined the association between climate resilience and socio-economic aspects of smallholder farmers. Specifically, the study assessed the relationship between smallholder farmers' perceived climate change resilience and their credit access; and also examined the association between perceived climate change resilience and their intrahousehold decision-making arrangements. Findings from ordered logistic regression analysis suggest that households with access to credit from informal sources were more likely (OR = 1.73, $p \leq 0.05$) to report good resilience compared to those without access. Furthermore, households that received remittances (OR = 3.26, $p \leq 0.001$) were also more likely to report good resilience compared to their counterparts that did not receive remittances. Regarding resilience and decision-making, households that practiced joint decision-making were also more likely (OR=3.74, $p \leq 0.001$) to report good resilience compared to households where

only male heads made decisions. These findings reiterate that the multifaceted nature of climate vulnerability must be considered in the resilience-building process. The results also highlight the gaps and inefficiencies of current policies on strengthening the socioeconomic capability of smallholder farmers. It is recommended that policy makers should redesign policies that will combine the strengths of both formal and informal credit sources to better serve rural populations. Also, agricultural policies must take into account the traditional value systems of any targeted context to maximize the chances of realizing the intended effects.

Keywords: Smallholder agriculture, climate change, resilience, financial credit, intrahousehold decision-making arrangements, Upper West Region, Ghana.

Summary for Lay Audience

Climate plays an important role in sustaining the Earth's systems. Following notable differences observed in the composition of the atmosphere and changes in the climate partly due to human activities, some of Earth's systems have seen a decline in their performance. The agricultural sector is one of the key areas that has been negatively impacted across most regions of the world. In regions like sub-Saharan Africa (SSA) where small-scale farming is a major source of livelihood, poor agricultural productivity presents additional challenges for small-scale farmers who are already struggling with several issues such as land degradation, poor health, unequal land distribution, low levels of technological adoption, and rapid population growth. Agriculture also forms a strong economic base of most countries in SSA. Considering the importance of agriculture in the region, a lot of attention from national governments in the region and international organizations has been directed at building the climate resilience of farmers. Resilience essentially means ensuring that small-scale farmers are well-positioned with adequate resources to withstand the effects of climate change to sustain their livelihoods. In Ghana, the government overtime has implemented several policies targeted at improving the resilience of farmers. For instance, the government has made substantial investments in improving the availability of crucial agricultural inputs such as improved seeds and fertilizers, labor-saving technologies, and providing farmers with relevant agricultural information. Unfortunately, these efforts have not been enough to improve the resilience of the majority of farmers. Some scholars have attributed the poor resilience of small-scale farmers to the narrow focus of these policies, some of which have mostly centered on understanding atmospheric changes. The key argument here is that most of these policies often fail to consider other equally important factors that may shape farmers' resilience. One of such factors is the cultural and traditional practices of farming

communities. Other authors have also linked the poor resilience of these farmers to poverty, which is also reinforced by their inadequate access to financial assistance which limits their ability to acquire available farming inputs. Given these two highlighted factors, this thesis examined the relationship between smallholder farmers' perceived climate change resilience and their credit access; and also examined the association between perceived climate change resilience and the intrahousehold decision-making arrangements of small-scale farmers in the Upper West Region of Ghana.

Findings from this study suggest that farming households that had access to informal credit sources were more likely to be resilient to climate change than those that had no access to credit. The findings further reveal that households that made decisions jointly were more likely to be resilient than households where decisions were made solely by the male household head. The findings indeed provide evidence that increasing the financial capacity of farmers, as well as making related policies culturally sensitive can improve their resilience.

Co-Authorship Statement

This thesis is made up of two manuscripts that have been submitted for publication and are currently under peer review. While each manuscript has been co-authored with my supervisor Dr. Isaac Luginaah and other members of the Farmer Livelihoods and Agricultural Production (FLAP) Project, as a first author, the conceptualization and development of the manuscripts has been my responsibility with constructive feedback from my co-authors. The manuscripts include the following:

Chapter Four: Batung, E., Mohammed, K., Kansanga, M. M., Nyantakyi-Frimpong, H., & Luginaah, I., (2020). Credit access and perceived climate change resilience of smallholder farmers in semi-arid northern Ghana. Environment, Development and Sustainability (ID: ENVI-D-20-02449). (Under review)

Chapter Five: Batung, E., Mohammed, K., Kansanga, M. M., Nyantakyi-Frimpong, H., & Luginaah, I., (2020). Intra-household decision-making and perceived climate change resilience among smallholder farmers in semi-arid northern Ghana. SN Social Sciences (ID: SNSS-D-20-01321). (Under review)

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CHAPTER I

1. INTRODUCTION

This thesis examines climate change resilience strategies among smallholder farmers in the Upper West Region of Ghana. The thesis has two main objectives. First, the thesis seeks to explore the relationship between smallholder farmers' access to financial credit and their perceived climate change resilience. The second objective examines the relationship between intra-household decision-making arrangements and resilience outcomes. This introductory chapter situates the focal issues discussed in the thesis, together with the research questions and objectives. Further, it also presents the conceptual linkage between the two manuscripts and concludes with a structure of the rest of the thesis chapters.

1.1 Research Background

Globally, climate change is now barely a contentious issue considering there are now even motions put forward to relabel the phenomenon as a 'climate emergency' or 'climate crises' (Intergovernmental Panel on Climate Change [IPCC], 2019). Particularly worrisome is the fact that, in conjunction with the already negative effects seen around the world, both local and global climate change projections depict potentially worse outcomes in the coming years if no interventions are implemented (Yiridomoh et al., 2020). The urgency to control climate change impacts is therefore necessary for both short-term and long-term sustenance of the Earth's systems (Ernst et al., 2019). Accordingly, this urgency has relatively gained more attention and has reflected in discussions among key institutions such as the United Nations' (UN) previous Millennium Development Goals (MDGs) and Sustainable Development Goals (SDGs). Although the climate has a strong influence on diverse livelihoods, the agricultural sector is arguably the

most affected (Pandey, 2020). Reports from the IPCC confirm that the net climate change impact on agriculture has been consistently negative (IPCC, 2019).

Even though climate change impacts are widespread, this generalization often masks the inherent differential experiences around the world (Sims & Kienzle, 2017). A central feature of climate change is the uneven distribution of vulnerability. Vulnerability in the context of climate change refers to the 'degree to which a system is susceptible to, or unable to cope with adverse impacts' of climate change, including climate variability and extremes (IPCC, 2019). In the Global North for instance, advances in technology and socioeconomic statuses have helped minimize the vulnerability to climatic impacts. Some authors (e.g. Karl et al., 2009; Maracchi et al., 2005) have argued that some areas are more likely to benefit the most from the impact of climate change. Some projections suggest the possibility of an increased length of the growing season and the potential introduction of new crop species and varieties in the Northern hemisphere due to increasing temperatures and precipitation. On the other hand, in sub-Saharan Africa (SSA) and similar contexts in the Global South, the reverse is observed (Generoso, 2015; Owusu & Waylen, 2013). Despite having contributed the least to global emissions, SSA is one of the hardest-hit regions by negative climate change impacts. At the same time, it is perhaps the least well-positioned to tackle these impacts (Yiridomoh et al., 2020). Since a significant portion of the population in SSA are smallholder farmers—about 80%—who rely more directly on their natural environments for their subsistence, climate change also poses a livelihood threat in SSA (Antwi-Agyei et al., 2014; Vercillo et al., 2015).

Smallholder farmers are mostly rural farmers cultivating on less than 2.5 hectares of land in developing countries, and rely predominantly on family labor (Barnett, 2007). The fragile state of livelihoods is also compounded by the unique nature of climatic effects in the region. The effects of climate change in SSA include increasing rainfall unpredictability (amount, and changing onset and cessation dates), increasing temperatures, and increasing frequency of extreme weather events (floods and droughts), which cumulatively impinge on crop cultivation (Gariba & Amikuzuno, 2019). Climatic impacts are the primary cause of crop losses, and yield variations in the region (Jones & Tanner, 2017). The severity of climatic impacts in the region is further entrenched by the interactive role of multiple factors including environmental degradation, social

inequalities and poverty, and political instability (Food and Agricultural Organization [FAO], 2020). The strong linkages between smallholder livelihoods and the rapidly deteriorating environment induced by climatic changes have already manifested into manifold areas of concern including increased frequency of extreme climatic events, high prevalence of food insecurity with the highest burden of malnutrition, high poverty rates, and declining health (FAO, 2020). Coupling decreasing productivity of smallholder agriculture with an ever-increasing population in SSA, the reality of the 'Malthusian Dilemma' is inevitable (Fuglie, 2018).

In Ghana, agriculture is predominantly smallholder-based and remains a vital sector of the national economy, employing more than half of the working population in both formal and informal sectors (Raheem et al., 2021). The sector also provides food and export products, therefore contributing significantly to the country's Gross Domestic Product (GDP) (GSS, 2013). In the first quarter of the 2020 fiscal year alone, agriculture accounted for nearly half of the GDP (Raheem et al., 2021). Despite the crucial role of the sector, it has experienced a significant decline since the 1960s when the rainfall regime suffered notable changes (Owusu et al., 2008). This is consistent with the observation of Alemayehu and Bewket (2016) that rainfall is one of the most important determinants of crop productivity in the tropics. Because smallholder farming systems are also largely rainfed, corresponding climate vulnerability has also increased. Rising temperatures, as well as other concomitant aspects of rainfall variability including periodic floods and droughts, have also left an indelible mark on smallholder agriculture (Yiridomoh et al., 2021).

Climate vulnerability is also experienced differently in Ghana. Compared to other parts, the semi-arid north, which is composed of the Sudan savanna and Guinea savanna ecological zones, is characteristic of high exposure and low adaptive capacity. Unfortunately, these ecological zones host about half of the country's smallholder farmers (Yiridomoh et al., 2021). Increasing incidences of deforestation, soil erosion, and soil infertility resulting from protracted use have further entrenched climatic exposures in semi-arid Ghana. Unlike in the Southern areas of the country where there are substantial government investments in export-oriented agriculture, smallholder farming in the semi-arid areas has received less policy attention (Alobo Loison, 2015). Due to some of these characteristics listed above, the semi-arid northern Ghana is considered one of the climate change epicenters or vulnerability hotspots in West Africa (Yiran & Stringer, 2016). Considering the key economic and livelihood contributions of smallholder

agriculture, it is therefore necessary to strengthen the adaptive capacities of rural people especially, to help them cope with the unraveling impacts of climate change.

1.2 Problem statement

Despite the enormous challenges posed by climate change to Africa at large, the continent has not been idle and has instead been exercising its agency at multiple levels in climate change discussions. In Ghana and the broader SSA context, 'resilience thinking' has gained a foothold among scholars, policy makers, national governments, and most allies on the global stage since the 2000s to re-orient agriculture toward coping and adapting to climate change impacts (Cooper & Wheeler, 2015; Otsuki et al., 2018). Empirical studies suggest that by building the resilience of smallholder farmers, they can be less affected by adverse climate impacts, and also enhances their efficient use of meager resources (Gariba & Amikuzuno, 2019). In the smallholder farming context, resilience-building involves the intentional and incremental institution of actions, behaviors, and interventions to enhance their absorptive, adaptative and transformative capability to minimize vulnerability, maximize diversification of income sources, and ensuring the sustenance of existing livelihood systems (Asmamaw et al., 2019). There have also been efforts dedicated to understanding the components of resilience, especially its costs, large-scale application, and sustenance (Berkes & Ross, 2016). Consistent with the global development agenda of curbing and mitigating climate change, Yaro (2013) also argues that it is imperative for stakeholders to take a holistic approach of integrating resilience thinking into smallholder agricultural systems due to its potential contribution to global climate change mitigation efforts. Mitigation is concerned with curbing or halting the emission of greenhouse gases (GHGs) within acceptable limits to revert climate change impacts. Adaptation, on the other hand, refers to adjustments to the existing impact of climate change to sustain functionality, given the current levels of GHGs (Yaro, 2013).

Several agricultural policy initiatives, to which most governments in SSA including Ghana have subscribed, have been implemented to realize the benefits of resilience. For instance, the Comprehensive Africa Agriculture Development Program (CAADP) established by the African Union Assembly of Heads of State was implemented in 2003. Some of the primary objectives of CAADP were to steer the African continent toward food security, dietary diversity, and increasing incomes of most agricultural economies (Fanzo et al., 2020). The ongoing African Green Revolution agenda supported by the Alliance for a Green Revolution in Africa (AGRA) [1]; the New Alliance for Food Security and Nutrition in Africa (NAFSN)[2] and UN's recent SDGs underscore this new focus on promoting resilience and sustainably improving smallholder livelihoods through agricultural development (De Schutter, 2015). Cumulatively, these initiatives are aimed at improving farmer access to subsidized modernized farm inputs such as mechanized technologies, improved seed varieties, improved fertilizers, and new investments in key pillars of production including extending areas under sustainable land management strategies (Sanchez et al., 2009). Some success has been achieved in realizing some of the goals of these agricultural policy initiatives.

Ghana has enjoyed some benefits from such initiatives. For instance, indications from the FAO's Domestic Food Price Level Index[3] suggest that between the periods of 2000 to 2014, food security improved in Ghana when compared to statistics from previous years (Bahadur et al.,

[1] AGRA is a partnership between the Bill and Melinda Gates Foundation and the Rockefeller Foundation which was founded in 2006 with the objective of improving smallholder agricultural products and supporting local farm owners in SSA

[2] The New Alliance for Food Security and Nutrition in Africa (NAFSN) launched in May 2012 under the auspices of the G8, with the objective of creating conditions to support African countries to improve agricultural productivity and develop the agrifood sector through private agriculture investments.

[3] The FAO's Domestic Food Price Level Index measures the price of food in the country relative to the price of the generic consumption basket

2018). In 2011, Ghana also became the fastest growing economy in the World, following an impressive performance on the global market. Moreover, the agricultural sector in Ghana is growing very fast and becoming rapidly modernized following diverse governmental subsidy programs. Other technologically advanced approaches such as green housing, use of improved, modified, and smart agricultural input and equipment are also increasing (Raheem et al., 2021). Despite these laudable national feats, there has not been any strong evidence of a notable trickle-down effect at the local levels, particularly the rural agrarian areas. Moreover, some evidence also suggests that modern agricultural inputs and technologies largely benefit large-scale commercial agriculture, with only marginal gains among smallholder farmers (Stinner et al., 2012). Following the prolonged effects of poverty in the semi-arid area especially, access to and utility of these crucial agricultural inputs remained questionable due to their high capital and operational costs requirements (Gliessman, 2014). Studies have also demonstrated a bias in the targeting and distribution of these input programs whereby relatively wealthy smallholder farmers with high level networks tend to benefit the most from these schemes while neglecting the most vulnerable farmers (Gliessman, 2014). As a result of indigence, recurring policy bias amid other interacting factors, the intended goals of most agricultural interventions are yet to make significant improvement in building the resilience of smallholder farmers as the majority of farmers are still overwhelmed by climate change impacts (Abdul-Razak & Kruse, 2017).

In Ghana and elsewhere, climate change vulnerability, although primarily stimulated by the changing climate, is not merely an outcome of biophysical stressors (Adegbite & Machethe, 2020; Jost et al., 2016). According to Yiridomoh et al. (2021), in order to engage with climate change, there is first and foremost the need for a sociocultural context to situate the concept. Thus, sociocultural factors play a pivotal role in forming public perceptions of climate impacts

(Yiridomoh et al., 2021). A growing body of literature has also highlighted the need for addressing non-climatic factors such as sociocultural dynamics in the climate change resilience discourse. For instance, Leichenko and O'Brien (2008) argue that in many agrarian settings, climate change is only one of the several factors shaping farming systems and in some cases might not even be the primary cause of vulnerability. Similarly, Nyantakyi-Frimpong and Bezner-kerr (2015) also elaborate that, due to marked differences existing among social groups such as gender, age, culture, and governance, climatic impacts can precipitate very different livelihood experiences among vulnerable populations. This is because, in some contexts, access to and control of key agricultural production resources such as fertile land, climate information, and other relevant agricultural services such as financial credit are largely controlled by longstanding traditions and societal norms (Kasanga, 2002; Yaro, 2010). Empirical evidence from studies across the social and behavioral science domains demonstrates that people's interaction with climatic and environmental changes are reflective of how the broader societies they are embedded in determine, measure, and adapt to such changes (der Linden, 2017; Mengistu, 2011). To situate resilience and vulnerability in the sociocultural context, it is imperative to focus on a meaningful level of analysis. Yaro (2013) suggests that rather than a general approach, using the household as the unit of analysis in rural vulnerability studies provide a better metric of understanding differences within local socioecological systems.

Following the issues raised earlier, some authors argued that among other factors, longstanding poverty and contextual sociocultural dynamics are crucial facets of smallholder livelihoods contributing to climate change vulnerability. It is therefore important that in the analysis of climate change resilience, a lens of multicausality be employed to facilitate a comprehensive understanding of the constituents of climate vulnerability (Reid & Vogel, 2006).

Although there is growing literature on smallholder climate change resilience strategies (Derbile, 2013; Hirons et al., 2018), few exist on exploring the relationships between climate resilience and smallholder agricultural financialization. As well, there is a dearth of evidence on the sociocultural connotations of climate resilience at the household level as it relates to decision-making arrangements (Ali et al., 2019; Benjamin et al., 2015). This thesis therefore contributes to the literature on smallholder climate change resilience strategies in rural agrarian settings. Although semi-arid northern Ghana constitutes the primary focus of this thesis, the overarching argument speaks to broader efforts toward smallholder resilience in the broader SSA region, due to similar agricultural development factors.

1.3 Research questions

To explore the importance of these hurdles in building the resilience of smallholder farmers in semi-arid Northern Ghana, the main questions this thesis seeks to answer are:

1. How does climate change resilience differ between smallholder farming households without access to financial credit and those that do have access in semi-arid Northern Ghana?

2. What are the differences in climate change resilience outcomes of smallholder farming households as it relates to the differences in their household decision-making arrangements in semi-arid Northern Ghana?

1.4 Research objectives

To answer these research questions, this thesis is written as a collection of two manuscripts that cumulatively, address the following objectives:

1. To examine the association between financial credit access and perceived climate change resilience among smallholder farmers in semi-arid Northern Ghana;

2. To assess the association between intra-household decision-making arrangements and perceived resilience outcomes among smallholder farmers in semi-arid Northern Ghana.

1.5 Thesis outline

This thesis is composed of six chapters, including this introductory chapter which contextualizes the research problem and also presents the research questions and objectives. Chapter 2 presents a summary of the literature on smallholder climate change resilience; current policies and the sources of agricultural credit in the Ghanaian context. The research design and methods of data collection and analysis are discussed in Chapter 3. Chapters 4 and 5 present two independent manuscripts which are currently under review in peer journals for publication. Together these manuscripts examine climate change resilience among smallholder farmers. The first manuscript (Chapter 4) is submitted to Environment, Development and Sustainability Journal. The manuscript provides insights into the relationship between financial credit sources and climate change resilience among smallholder farmers. The second manuscript (Chapter 5) is also submitted to SN Social Sciences Journal. This manuscript examines the association between intrahousehold decision-making arrangements and climate change resilience. Drawing insights from socio-ecological resilience and the household bargaining theory, this manuscript also provides details on how intrahousehold interactions embedded within broader sociocultural fabric, can either promote cooperation or conflict in the actions of household members toward building desirable resilience outcomes. Chapter 6 summarizes the findings of the thesis. The study limitations and implications for future research then follow. The conclusion also highlights the literature and theoretical contributions of the research. Lastly, the references, appendices and my curriculum vitae are then presented.

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CHAPTER 2

2. LITERATURE REVIEW

2.1 Introduction

This chapter presents literature on the evolution of agriculture in Ghana since the colonial era and specifically, the policies that have shaped the current state of the agricultural sector. Climate change, as perhaps the most challenging hurdle of agricultural productivity, is also captured in detail from global to local levels. The overarching concept of resilience is also presented, along with its linkages with financial credit and sociocultural norms in smallholder contexts. A detailed understanding of resilience and its components that are likely to improve the resilience of households to climate change impacts is crucial in the face of rapid environmental changes.

2.2 Evolution of agriculture in Ghana

After overcoming a history of slave trade, political upheavals, and economic turbulences, the Republic of Ghana has become one of the most stable constitutional democracies in sub-Saharan Africa. Despite enormous attention on industrialization during the colonial and immediate post-colonial period, the economy of Ghana has remained notably agrarian. Although the performance of the sector has not been consistent, it has nonetheless out-performed other Sub-Saharan contexts in terms of growth, labor productivity, and farm incomes especially since the 1980s (Diao et al., 2019). Agricultural development in Ghana has primarily undergone four unique transformational series mainly driven by three main factors—policy, population growth, and rapid urbanization. In this section, I focus on the policy dimensions of agricultural transformation and their associated objectives which oscillated between sustaining domestic food security and promoting export-led agriculture (Kansanga et al., 2019).

For most of the pre-independence era, agricultural initiatives in Ghana then called the 'Gold Coast' were largely commercial with a narrow focus on the export of key cash crops such as cocoa, palm oil, tobacco, coffee, rubber, and bananas. On a local scale however, agriculture progressed differently in the northern and southern areas of the country (Diao et al., 2019). Compared to northern Ghana, the southern areas had more favorable agroclimatic characteristics owing to very fertile soils and a longer cultivation window due to the double maxima rainfall. Southern Ghana was therefore the hub of cash cropping and hence, the primary beneficiary of agricultural investments (Frimpong-Ansah, 1992; Lund, 2003). The desire of colonial rulers to minimize costs and maximize profits from produce exports also played a major role in the rapid agricultural development in southern Ghana due to better transport systems and the proximity of harbors. Notwithstanding the inferior agroclimatology of northern Ghana, agricultural underdevelopment of the area was also sustained by the political landscape at the time. Until 1952, Northern Ghana was not a colony of the colonial government which partly contributed to the neglect of the area (Kansanga et al., 2019b). However, as commercial agriculture in southern Ghana expanded with high labor requirements of plantations and export-related industries, northern Ghana became the labor market through north-south migration patterns which are still observed in contemporary times (Plange, 1979).

According to Akoto (1987), the first major agricultural impact in northern Ghana was through the Gonja Development Company (GDC), which later became a subsidiary of the newly formed Agricultural Development Corporation (ADC) in 1951. As part of a broader agricultural development plan from 1950 to 1960, the GDC aimed to diversify commercial crops and expand food crop production through increased mechanization and other large-scale capital-intensive techniques. For commercial crops in particular, the need for diversification was very crucial

because of prior disease outbreaks that wreaked havoc on cocoa plants, which was perhaps considered the most lucrative cash crop at the time (Lambert, 2019). Through the GDC, two main objectives were to be met. Firstly, an area of about 32000 acres of the Gonja District was to be used for a pilot project to test the feasibility of upscaling agricultural mechanization for crop cultivation. Another goal of the GDC project was to attract people from the densely populated neighboring areas to the sparsely populated Gonja District who could potentially serve as farm labor (Quansah, 1971). Despite these appealing objectives, they were unfortunately not achieved owing to a very slow pace of cultivation. For instance, at the peak of the project, only about a tenth of the original area was cultivated. As well, following very little yields of the project, there was also an exodus of the few families that resettled in the Gonja area (Dadson, 1971). By independence in 1957, the project came to halt following increasing financial and technical complexities. Around this same period under the government of Kwame Nkrumah, a new development plan from 1959 to 64 was formulated based on an entirely new economic development model—import substitution (Steel, 1972).

Immediately after independence, Ghana still relied on financial and technical aid from the Western world until about 1961 when the import substitution ideology became mainstream. Under import substitution thinking, the local economy was drastically steered in the direction of 'Nkrumahism'. A concept Due (1969) describes as approximating a communist philosophy for the socialization of agriculture and industry. The vision of Nkrumah's import substitution efforts was based on the principle that political independence without the compliments of sovereignty and self-sufficiency is still disguised colonialism (Lambert, 2019; Steel, 1972). In 1962, the Ghanaian government with some support from the Soviet Union began making substantial investments in large-scale plantations and industries with the objective of producing consumer goods that were

formerly imported under the 'Operation Feed Yourself' strategy (Lambert, 2019; Seini and Nyanteng 2003). As well, there was a slight shift from previous colonial establishments such as mining and the cocoa monoculture to diversify Ghana's economy (Akoto, 1987). To bolster these efforts, Arthur Lewis, who served briefly as an advisor to Nkrumah suggested significant investments be made toward research into novel crop varieties, mechanization, diseases and soils, expanding agricultural extension services, and dissemination of relevant information to farmers through all available mediums (Lambert, 2019). Some attention was also directed at smallholder agriculture during this period. Smallholders were to benefit from state-sponsored industrial infrastructure, marketing, and agricultural resources for the production of a new range of crops (Lambert, 2019). The ADC was also assigned a critical role under this plan to embark on a nationwide development of storage facilities (Akoto, 1987).

Despite the considerations of advancing smallholder agriculture in the 1959 to 64 development agenda, it was not until the implementation of the Seven Year Development Plan (SYDP) of 1963/4–69/70 that the potential of smallholder farming gained enormous attention as shown in this statement of Nkrumah: "The revolution taking place in Ghana is chiefly a revolution of the workers and the tillers of the land" (Lambert, 2019, pp. 37-38). Under this plan, the government acknowledged the potential contribution of smallholders in economic development. Yet, paradoxically, the smallholder sector was not allocated adequate funds per the government's budget. Data from the Ghana Planning Commission (GPC) (1964) indicate that only a quarter of the total planned expenditure on agriculture was available for state-run mechanized agriculture. After a prolonged spell of project failures from the ADC, the State Farm Corporation (SFC) was established in 1962 to replace the ADC following its liquidation (Akoto, 1987). The SFC along with the United Ghana Farmers' Corporation (UGFCC) and other state agencies were very

important actors in the implementation of this development (Steel, 1972). Direct public participation in agricultural production from smallholders was also heavily encouraged to facilitate the realization of the goals of the plan. Previous failures in northern Ghana in the case of the GDC did not deter subsequent policy attempts under the SYDP. Because of the aridity of northern Ghana, there was a focus on establishing irrigation facilities and technological dissemination among smallholder farmers (Kansanga et al., 2019b). The SYDP yielded some positive outcomes in the area. For example, in 1965, the Vea irrigation project was established in the then Upper Region to facilitate smallholder food production, along with key inputs such as labor-saving machinery (Seini and Nyanteng 2003). Consistent with the objectives of SYDP, similar initiatives were implemented to improve smallholder farming. These include the establishment of the Upper Region Agricultural Development Program in 1977 with some support from the Canadian International Development Agency (CIDA); the Tono Irrigation Scheme development in 1975, and the Ghana Seeds Company in 1979. Although it is beyond dispute that the SYPD underperformed in achieving the entirety of its objectives, agricultural productivity markers however, showed an upward trend until the late 1970s (Steel 1972).

The overthrow of the Nkrumah in 1966 marked the beginning of the end of the socialist foundations of Ghana's public policy. Within the same year for instance, the then ruling National Liberation Council completely remodeled the SFC, abandoned about 30 farms, and terminated the employment of about 10000 workers (Lambert, 2019). Thereafter, public policies were reshaped by global market systems (Akoto, 1987). This new policy approach also brought about significant changes in trade and pricing policies, as well as in the allocation of fiscal revenue and foreign exchange among others (Akoto, 1987). Attention on local industrial growth and the government's industrial and agricultural involvement also dwindled drastically. Following these

changes, Ghana experienced an economic decline in the late 1970s in part due to inefficiencies in manufacturing, a significant price drop of its most important export commodities—gold and cocoa—on the global market, and staggering national debt levels (Steel, 1972).

To navigate this economic dilemma, Ghana subscribed to the Structural Adjustment Programs (SAPs) initiated by the International Monetary Fund (IMF) and World Bank in 1983, with the hopes of rejuvenating its economy (Konadu-Agyemang, 2000). Primarily, the SAPs required financially constrained countries to abide by stipulated policies to reduce short to medium-term fiscal imbalances to facilitate long-term economic growth (Lall, 1995). These policies are typically centered around increased privatization, trade liberalization, increased foreign investment, and balancing government deficit (Bello, 2008). In Ghana, the SAPs called for reduced government interventionism, liberalization of the domestic economy, and austerity which cut subsidies on utilities, crucial agricultural inputs, and machinery (Hutchful, 1987). Significant efforts were also made to steer agriculture to suit the demands of the global market and away from the self-sufficiency notions of the Nkrumah era (Killick, 2010). Accordingly, the results of the SAPs quickly yielded some positive changes including reduced inflation, growing exports volume, and a high Gross Domestic Product (GDP) growth (Konadu-Agyemang, 2000). Effects of the SAPs extended to northern Ghana which saw increased technological use and efficiency in the rice industry (Kansanga, 2017). Notwithstanding these benefits, the SAPs also negatively impacted some people, especially those working in the public sector due to high job cuts. For some deprived smallholder contexts, removal of government subsidies on key agricultural input like seeds and fertilizer reconstituted a major threat to their livelihoods (Konadu-Agyemang 2000).

Consistent with the dictates of the SAPs, the Government of Ghana (GoG) withheld its active involvement in the agricultural sector until the early 2000s when the GoG reinitiated heavy investments toward agricultural mechanization (Diao et al., 2014). The prospects of mechanization quickly regained currency and thus, featuring prominently in Food and Agriculture Sector Development Policy (FASDEP) since 2002 (Ministry of Food and Agriculture [MoFA], 2007; Kansanga, 2017). The FASDEP was a framework to guide agricultural development and interventions with a particular focus on modernization and promotion of private sector involvement. However, following inefficiencies of initial attempts under FASDEP I, a more refined version—FASDEP II—was then implemented (MoFA, 2007). As part of the directives for achieving the objectives of FASDEP II, the GoG expanded its mechanization efforts by establishing the Agricultural Mechanization Services Enterprise Centres (AMSEC) program in 2007 through the Agricultural Engineering Services Directorate (AESD) of MoFA. With this initiative, the government provided imported tractors at affordable rates to select community-level service providers—both farmers and private entrepreneurs—who run the AMSECs on the rationale that, each service provider will be able to provide tractor services to smallholder farmers within their catchment area (Benin, 2015). In terms of spatial distribution, Ghana has a total of 89 AMSECs with about 44 of them located in northern Ghana (MoFA, 2016).

In 2010, some attention was also recentered on northern Ghana to increase food production through the Savannah Accelerated Development Authority (SADA) (Wiemers, 2015). The most recent of these agriculturally tailored policies however, is the Planting for Food and Jobs (PFJ) programme which aims to expand smallholders' access to vital inputs such as improved seeds and fertilizers through 50% subsidies; and improving the dissemination of agricultural information through e-agriculture (MoFA, 2019). Additionally, the PFJ initiative has also created

a strategic and flexible payment plan to accommodate the needs of a variety of farmers on the poverty spectrum. Unlike prior policies, interested farmers are only required to pay half the already subsidized cost before receiving benefits, while having a duration of two consecutive farming season to pay any outstanding balances (MoFA, 2019). The PFJ programme is expansive in design and targets all 216 districts in Ghana. Further, the program is also designed to minimize elite capture by institutionalizing a farm size limit of only 2 hectares per participating farmer. Cumulatively, these policies over time have yielded positive changes in the agricultural landscape of the country. Crop cultivation has significantly evolved, with the output of some key crops like maize showing a sustained growth. Maize is very essential as a flex crop with both export and local value (Kansanga, 2017). National-level data on crop production trends in Ghana from MoFA indicate a significant increase in the production of cereals including rice and groundnut from 2006 to 2015 (MoFA, 2016). In northern Ghana, Diao et al. (2019) also observed a substantial increases in farm production and cropped area.

2.3 Climate change impacts on agriculture

It is no doubt that the political and economic landscapes of any context play a massive role in agricultural development. However, the most prominent challenge of agriculture, especially in this 21st century, is the changing climate. Climate change can be loosely defined as the changes in the mean and/or the variability of the climate's properties for a long period, typically decades or longer (Intergovernmental Panel on Climate Change [IPCC], 2019). Although the climate has a long history of natural changes, recent debates such as the 'Anthropocene' have focused on the contributions of humankind in the changes experienced currently. Increases in global temperature averages, alongside high concentrations of atmospheric carbon dioxide and other Greenhouse gases notably from the industrial revolution, have been at the forefront of these debates

(Mikhaylov et al., 2020). The more worrying concern of climate change is that the phenomenon could cause irreversible damage to ecosystems and crucial livelihood resources if no meaningful measures are implemented (Fischer et al., 2002). Despite the wide-ranging systems that are impacted by climate change, the agricultural sector is perhaps the most vulnerable due to its huge dependence on climatic elements such as solar radiation, temperature, and atmospheric moisture among others.

Notwithstanding the generally negative outlook of climate change effects on agriculture, these effects are nonetheless still experienced differently across the globe. This is because regions fundamentally differ in their biophysical characteristics such as local climates, soil, degrees of vulnerability, available technology, economic and adaptive capacities, and the very nature of prevailing climatic effects (Rosenzweig & Liverman, 1992). For instance, the IPCC has projected with high confidence that climate change will have a net positive impact on the growth of crops in higher altitudes whereas a decline will be observed in lower-altitudes (IPCC, 2019). For developed countries such as Canada, Iceland, Finland, and Japan, increasing temperatures may rather be a driver for crop production by lengthening the frost-free season for cultivation.

In contrast, Rosenzweig and Liverman (1992) have highlighted that increasing temperatures in humid tropical regions, where most developing countries are located, may inhibit agricultural productivity due to the potential prevalence of weeds, pests, and crop diseases that thrive in such climates. The importance of temperature in the phenological development of plants through processes such as photosynthesis cannot also be understated. Changes in temperatures can negatively impact critical thresholds of some crops and thus, potentially changing growth patterns, or even killing them in extreme cases. As well, both surface and underground water resources will face severe changes in tropical regions owing to changes in rainfall regimes. There

is also evidence that even similar hydrological systems can react in various ways to similar types and intensities of climatic changes (van Roosmalen et al., 2007). Then again, there is a significant difference in climate vulnerability when a cursory comparison is done between the Global North and Global South. Compared to the Global North, a large proportion of the populations of most developing nations rely on agriculture to sustain their livelihoods amid other social problems—poverty, environmental degradation, unequal social norms, rising population, and poor health, which further reinforces their vulnerability.

In sub-Saharan Africa (SSA), the devastating impacts of climate change on agriculture are well documented (Dapilah & Nielsen, 2020; Dumenu & Obeng, 2016; Etwire, 2020; Luginaah et al., 2009; Owusu et al., 2019; Sultan & Gaetani, 2016). Overall, most studies have concluded that rainfall is increasing in unpredictability alongside rising temperatures (Zougmoré et al., 2018). The threats of drought are also on the rise, in especially lowlands areas of Central, Eastern, and Southern Africa subregions. West Africa in particular is known to exhibit a very unique rainfall variability that significantly impacts the regional hydrological cycle, surface water availability and food security, as seen in the famines that occurred in the 1970s and 1980s (Le Barbé et al., 2002). Further, there is evidence suggesting that more than 70% of households in coastal West Africa are vulnerable to floods with a weighted impact index ranging between 3.1 and 4.4 out of the maximum score of 5.0 (Zougmoré et al., 2018). Additionally, agricultural lands in these coastal areas may become disturbed by salt-water intrusion, and rising water tables due to rapid sea-level rise.

In Ghana, agriculture constitutes a high climate risk activity (World Bank, 2018). The agricultural sector in Ghana is already plagued by multiple climatic stressors including increasing temperatures, greater rainfall variability, extreme climatic events, and sea-level rise (Arndt et al.,

2015). For instance, Ghana has experienced an increase in mean annual temperature of 1°C per decade since 1960, and a decrease of mean monthly rainfall by about 2.4% within the same period (De Pinto et al., 2012). Though rainfall is the most important climatic parameter for crop growth in the tropics, rising temperatures will indirectly also reduce water availability for crops, which will exacerbate losses in agriculture production (Alemayehu & Bewket, 2016). To further complicate the harsh realities of climate change, mean temperatures are predicted to increase by 2.0 °C and 3.9 °C by 2050 and 2080, whilst rainfall will decline by 10.9% and 18.6% for the same duration. Empirical evidence has revealed a direct link between these climatic elements and agricultural productivity. For example, a 10% reduction in seasonal rainfall could decrease food production by about 4.4% (Zougmoré et al., 2018). Livestock rearing, which hitherto serves as a crucial means of livelihood diversification in Ghana and elsewhere will also be negatively impacted as projections of the IPCC indicate a shortening of fodder growing periods by an average of 20% by 2050. Shortening of the growing period will also translate to a 40% decline in cereal yields (IPCC, 2014).

Locally, the situation is even dire in the northern areas of the country (Abdul-razak & Kruse, 2017; Tambo, 2016). These areas have recorded multiple instances of crop failures due to high exposures and vulnerability to climate impacts like droughts, low technological innovation, low livelihood diversification, and low soil fertility. Wossen et al. (2014) indicate that one major factor contributing to the region's vulnerability is its high aridity levels. Antwi-Agyei et al. (2012) also suggest that the vulnerability of the region is further exacerbated because of low adaptive capacity. Adaptive capacity is linked to socio-economic development given that socio-economic capability plays a crucial role in channeling new forms of investments in smallholder agriculture (Rathi, 2019). Unfortunately, socio-economic development in this part of the country is also slow

(Laube, 2015). Like droughts, the much-needed rains have oftentimes led to floods that devastate crops, farmlands, livestock, and smallholder households. Unfortunately, cases of flooding have increased by a factor of about 6 to 12 times during the last two decades (Zougmoré et al., 2018), and climate projections have only suggested an even worse future with higher frequencies and intensities of flooding events (File & Derbile, 2020).

2.4 Climate change resilience in smallholder settings

The importance of the agricultural sector, especially for largely rural and agrarian contexts such as SSA, is enormous. As such, despite the sector's progress being persistently undermined by the interactive effects of a host of factors including climate change, attempts to sustainably re-orient the sector and the livelihoods of vulnerable groups such as smallholder farmers have gained traction on multiple levels among researchers, societal actors and policymakers over the past two-and-a-half-decades (Antwi-Agyei & Nyantakyi-Frimpong, 2021). Amid these ongoing deliberations, 'Resilience thinking' is perhaps one of the concepts that have been embraced by all stakeholders as having the potential to sustain the productivity of smallholder agriculture. Resilience has become a key term in the risk assessment of smallholder farmers and is used to denote the degree of vulnerability a system can withstand before reaching a breaking point. Other aspects of resilience thinking that have contributed to its appeal are the notions of its utility in dealing with uncertainty and complexities (Berbés-Blázquez et al., 2017). While no fixed definition exists in the climate change resilience literature, referring to Folke (2016) and Brown (2014), resilience can be described as having the capability to 'bounce back', function and develop after the experience of sudden adversities, particularly in this century of heightened global environmental changes. In smallholder contexts, resilience can be also conceptualized as the dynamic capacities of smallholder agriculture to reduce its vulnerability from a variety of

resourceful endowments in order to sustain its productivity (Lamichhane et al., 2020). Vulnerability, as it relates to agriculture, is also concerned with the probable loss and damage of an agricultural system associated with climatic changes, which also has a destabilizing effect on the livelihoods and wellbeing of any individual or social groups that depend on these systems (Kelly & Adger, 2000; Lavell, 2011). Agricultural vulnerability thus focuses on the physiological and phenological impacts of climate change on crops, as well as the socio-economic implications on farmers (Dong et al., 2015).

Smallholder resilience constitutes two prominent components—coping and adaptation—that I must elaborate on to situate the ongoing discussion (Antwi-Agyei & Nyantakyi-Frimpong, 2021). Coping here refers to interim strategies that farmers may implement to counter the adverse effects of climate change (Eriksen et al., 2005). Characteristically, coping strategies are rather oriented toward the immediate reduction of exposure to climatic effects, irrespective of their economic or environmental viability (Kates et al., 2012). According to Ellis (2000), the five predominant coping strategies that smallholder farmers are likely to implement, in an order of feasibility include livelihood diversification; resorting to reciprocal agreements such as seed and labor sharing; seasonal migration; reduction of movable assets including livestock; and sale of fixed assets such as lands. Although occurring rarely, permanent distress migration may also be undertaken in cases when all coping strategies have failed or are perceived as inadequate.

Adaptation, on the other hand, is usually seen as a more progressive form of coping. According to the IPCC (2019), adaptation involves the intentional shifts in both natural and human systems in response to experienced or expected climatic stimuli or their effects, to moderate harm or exploit beneficial opportunities. While the idea of 'intentional shifts' depicts numerous strategies, yet on the surface, adaptation can be broadly categorized as either incremental or

transformational (Kates et al., 2012). For instance, the augmentation of pre-existing behaviors that already minimize climatic exposure while maximizing benefits can be referred to as incremental adaptation (Antwi-Agyei & Nyantakyi-Frimpong, 2021; Feola, 2015). Incremental adaptation also conceptualizes climatic threats as unique and identifiable risks that can be adequately tackled from a strong institutional and technological standpoint. However, the additive nature of incremental adaptation has also attracted some critiques suggesting that the process may have the potential to extend the use of prior practices that are proving inefficient due to the non-static nature of environmental changes (Park et al., 2012). Contrary to the simplistic view of framing climatic threats as easily identifiable phenomena, growing literature on climate change as a 'super wicked problem' that defies any easy resolution also widens the debates surrounding this type of adaptation (Takacs, 2021). Increasing scrutiny of incremental adaptation have led to the emergence of 'transformational adaptation', which advocates for a shift away from building on existing adaptive practices. Proponents of transformational adaptation argue that effective adaptation can only be attained when the business-as-usual superficial treatment of climatic vulnerability is replaced by a thorough overhauling of underlying conditions that may be the causal or perpetuating factors of climatic threats (Eriksen et al., 2015; Tschakert et al., 2013).

As stated earlier, smallholder resilience building has gained prominence in the broader SSA region. In Ghana, different governments alongside non-governmental organizations have implemented several initiatives aimed at building the resilience of smallholder farmers. To that effect, some notable results have been produced at the national level. Fertilizer use for instance has grown rapidly in across Ghana. According to Diao et al. (2019), the share of rural agrarian households using fertilizer between 2006 and 2013 alone increased from 22.4 percent to about 33.4 percent (Diao et al., 2019). Similarly, these initiatives have increased famers' accessibility to

key inputs like herbicides, insecticides, and mechanized equipment; which has led to the expansion of cropped areas (Diao et al., 2019). In addition to policies, some evidence also suggests that smallholder farmers are increasingly integrating several forms of indigenous knowledge systems to tackle climatic issues like rainfall unpredictability to strengthen their resilience (De Pinto et al., 2012; Tachie-Obeng et al., 2013). Notwithstanding the gains from these collective efforts, climate change vulnerability is still a critical issue that is disproportionately distributed. Most smallholders in northern Ghana in particular, are still overwhelmed by climate change (Tambo, 2016). Beyond mere climatic exposure, the interaction of several factors has significantly contributed to this predicament. These include inadequate adaptation strategies, high poverty rates and unfavorable socio-cultural norms. Contrary to the suggestions of transformational adaptation, strategies of most smallholder farmers are predominantly composed of coping and incremental adaptation strategies (Antwi-Agyei & Nyantakyi-Frimpong, 2021) which are proving to be inefficient in the long-term given the changes and complexities of climate change (Tambo, 2016). Further, farmers in northern Ghana have had a relatively high restricted access to available agricultural inputs owing to poverty and limited smallholder access to financial credit. As an area with some of the poorest regions across the country, it is beyond doubt that despite some government subsidies, acquisition of these inputs is still difficult to navigate (Cramon-taubadel & Saldias 2014; Jiri et al. 2017). Evidence elsewhere suggests a positive association between the credit access, technical efficiency and resilience of smallholder farmers (Duy, 2012; Miller & Ladman, 1983). In addition to inefficient strategies and poverty, smallholder resilience cannot be separated from the socio-cultural environments in which they are immersed. This is because behaviours that are usually exhibited at smaller scales—farms and household levels, are drawn from traditional constructs and norms that are stipulated by the broader society. While there are benefits to this socio-

ecological relationship, adverse effects can also emanate especially when climatic threats mutate into new different effects that may require advanced adjustments.

2.5 Linkages between financial credit access and smallholder resilience

Access to financial credit is pivotal in rural development and smallholder agricultural productivity (Reyes et al., 2012). Agricultural productivity can play a significant role in reducing rural poverty, food insecurity and improving general well-being (Omonona et al., 2010). Financial credit also enables and sustains the flow of farm inputs and new investments which increases the agricultural productivity of smallholder farmers (Nouman et al., 2013; Ali et al., 2019). Some evidence in the rural development literature also indicates that improving the credit access of smallholders is an effective strategy for promoting the adoption of new forms of technologies due to the strong influence it has on risk-taking ability (Diagne et al., 2000; Simtowe & Zeller, 2006). Duy's (2012) study on agricultural credit and farm productivity in Vietnam demonstrates that smallholder credit access is key to improving crop yield. In the Ghanaian context, Dittoh (2006) observed that credit access is an important determinant in the uptake of farm-level sustainable practices among smallholder farmers, which can potentially strengthen their adaptation and resilience. These observations stem from the fact that smallholder farmers who lack access to credit are limited to traditional techniques and inputs which are increasingly proving ineffective because of their labor demanding nature, as well as rapid environmental changes. However, some authors also argue that traditional production systems in tandem with modern technologies can improve farmers' resilience (Kansanga et al., 2020). The findings of several scholars on the relationship between smallholder credit access and resilience in other contexts also align with these claims (Baffoe et al., 2014; Owusu, 2017).

2.6 Sources of financial credit for smallholder farmers in Ghana

For this study, financial credit refers to all loans available for potential borrowers for crop cultivation, including storage, processing, transport and marketing of agricultural produce where possible (Ozowa, 1995). Access to credit is therefore a farmer's ability to successfully borrow an amount of money, whether desired or not, for agricultural purposes. Conversely, a farmer is said to have no access to credit if the farmer cannot obtain any amount of money from either source (Hananu et al., 2015).

Except for personal savings, the main sources of financial credit in Ghana can be broadly categorized into two: formal and informal (Kuwornu et al., 2012). The former is controlled by registered financial institutions such as commercial banks—both local and foreign, microfinance organizations, credit unions, non-governmental organizations (NGOs), and more recently contract farming schemes. Regarding informal sources however, these are usually composed of non-institutionalized sources such as local moneylenders, friends and relatives, individual entrepreneurs/businessmen, and the 'susu' system from which these farmers repay their loans in the postharvest season, or any mutually agreed upon duration (Kuwornu et al., 2012; Owusu-Antwi & Antwi, 2010). The 'susu' system is a traditional savings system, where members deposit money regularly with a chosen keeper from which a member can obtain a loan and repay with low interest (Asiama & Osei, 2007).

Most rural and agrarian communities in Ghana are dominated by informal credit sources following longstanding neglect by the formal financial institutions. According to Osborne (2012), reasons for the prior neglect include limited infrastructure, poor deposit-base, and little profit potential. In recent times however, the renewed commitments towards improving smallholder agriculture have significantly increased the operations of formal financial institutions nationwide,

with the intention of ensuring financial inclusion of these rural populations (Evans et al., 2007). Notwithstanding this mandate of the formal credit sources, Ansong et al. (2015) argue that these efforts can best be described as superficial. Consistent with Ansong et al.'s (2015) claim, location data of formal credit sources have shown an unfavorable siting of these facilities. For instance, most formal credit sources are usually located in the urban centers of rural communities (Owusu, 2017), which still leaves the goal of improving rural access to financial institutions unattended. This bias spatial distribution alone raises concerns about the feasibility of the notions of achieving adequate financial inclusivity of rural populations.

2.7 Linkages between decision-making and smallholder resilience

Climate change is one of the pressing issues facing rural agrarian communities around the world. The possibility of worse implications for these communities in the coming decades necessitates that even more attention be directed on understanding and addressing the constituents of climatic vulnerability (Chaplin et al., 2019; IPCC, 2019). In Ghana and other contexts in SSA where adaptation— rather than mitigation—is a more viable option to tackling climate change impacts, attention has been disproportionately focused on enhancing access to crucial inputs and building the technological capacity of vulnerable populations. While these current approaches have yielded varying levels of effectiveness in minimizing the risks of climate threats, they have also led to the neglect of other equally important nuances of vulnerability, with one of these key areas being sociocultural systems (Reckien et al., 2018; Vinyeta et al., 2016). As succinctly argued by Blaikie et al. (2003), other than climatic stressors, resilience also has deep roots within the political ecology tradition which suggests that outcomes like climatic vulnerability or resilience are usually the by-products of the interaction of diverse social structures. The link between climatic resilience, vulnerability, and societal norms is further elaborated by Mark Pelling and his colleagues

that: "adaptation means prioritizing actions that have the reach to shift existing social systems (and their component structures, institutions and actor positions) onto alternative development pathways, even before the limits of existing adaptation choices are met." (Pelling et al. 2015, p.114). Consistent with Blaikie et al. (2003) and Pelling et al. (2015), empirical evidence suggests that resilience-building efforts in rural agrarian communities can be truncated by longstanding sociocultural norms (Nyantakyi-Frimpong & Bezner Kerr, 2017).

In northern Ghana where climatic vulnerability is highest, activities surrounding climate change adaptation and resilience-building are embedded in broader socio-cultural and power structures, which also control crucial livelihood dimensions such as resource access (Adzawla and Baumüller 2020; Clay and King 2019). A growing body of literature (Apusigah, 2009; Nyantakyi-Frimpong, 2017, 2020) also indicates that structural barriers emanating from these social dictates can restrict the potential of some community members to effectively build their resilience to climate change. Rural communities in much of northern Ghana have historically operated on patriarchal traditions which stipulate different livelihood roles for community members. Although these differences vary by social characteristics and several facets of intersectionality— age, kinship, disability, class, and religion, a prominent dimension is decision-making capabilities (Goodrich et al., 2019). Under patriarchal norms for instance, men control productive agricultural resources such as fertile lands, and also make decisions on the who, what, and how components of the cultivation season (Rademacher-Schulz & Mahama, 2012). From some of these social structures, climate vulnerability has outweighed any resilience-building endeavors for marginalized subgroups which are mostly women, youth and poor men in some cases (Jost et al., 2016; Nyantakyi-Frimpong, 2017; Rademacher-Schulz & Mahama, 2012). In relative terms, however, women are often the most affected populations owing to a lack of assets

in addition to their heavy loads of burden (Nyantakyi-Frimpong, 2021) at both the communal and household levels. A study by Rao et al. (2019) in northern Ghana revealed how women are usually given almost barren lands to cultivate, which presents a lot of uncertainty on their resilience potential. In a few instances where women are able to achieve a substantial harvest, they also face the threat of having their land taken over by men (Rao et al., 2019). In spite of this structural deprivation, women are also charged with tasks such as childcare and maintaining food and water security, which can further adversely impact their resilience potential. Unfortunately, most agricultural policies aimed at building the resilience of local communities have often failed to recognize the intersectional barriers posed by cultural structures which often leads to interventional inefficiencies (Arora-Jonsson, 2014).

On a smaller scale, most households in these contexts emulate broader sociocultural norms. This societal-household resemblance has led to the realization that the current status quo of weak resilience experienced in rural communities may also be attributable to the practice of traditional norms within the intrahousehold. One such intrahousehold dynamic that has faced some scrutiny is intrahousehold decision-making arrangements. This is because, decision-making structures shape familial interactions and dictates how problems are prioritized, how possible solutions are arrived at, as well as the feasibility of actions that can be implemented toward resilience building. As stated earlier, in most rural communities in Ghana, structural norms still support the patriarchal household models whereby male household heads make decisions about agriculture regarding what to plant, what methods to use in cultivation and how the proceeds from the farm are used (Eastin 2018; Tsige et al. 2020). These structural hierarchies mostly exclude women and the youth from partaking in household decision-making about agriculture and thus, undermining their capacity to contribute to household climate change adaptative

strategies (Schwerhoff & Konte 2020). This is despite evidence that climate change resilience of smallholder households can be enhanced if agricultural decision-making incorporates the perspectives of all stakeholders within the household (Carr & Thompson 2014; Gumucio et al. 2020). Some studies have highlighted the diverse and potentially mutually reinforcing knowledge base of men and women on how to address climate change and other environmental problems (Ravera et al. 2016). In most local communities across SSA and Ghana, women have developed a rich knowledge of the environment and changing climate from their culturally ascribed traditional conjugal roles, such as the sourcing of water and growing food crops for household consumption all year round (Apusigah 2009; Sachs 2018). Women in particular have rich knowledge about climate events including precipitation and drainage dynamics, which, when combined with men's knowledge and the vibrancy of youth, could improve agricultural decision-making and implementation at the household level, particularly with respect to determining the optimal location of farms and the types of crops to plant (Mitchell et al. 2007). Thus, in households where climate adaptation decisions are made by only the male family head, a significant portion of the valuable knowledge base of the household is not utilized. This can undermine the effectiveness of climate change adaptation decision-making and ultimately, the resilience of the household to climate shocks. At the same time, growing evidence suggests that contrary to the normative judgment of decisions made by the male household heads as representative of the household, there are often different and diverse interests by other members (Demetriades & Esplen, 2010). For instance, studies by Ambler et al., (2017), Seymour and Peterman (2018) reported both extreme instances of agreements and disagreements among household members regarding problem prioritization or the implementation of solutions which in agrarian settings, could have significant effects on household resilience outcomes.

In resource-constrained settings especially, some studies have demonstrated that joint household decision-making is significantly associated with better household resilience (Amugsi et al., 2016). For example, in India and Bangladesh, joint decision-making was found to be associated with smallholder climate resilience through improved farm productivity and crop yield (Bhagowalia et al., 2010). Joint decision-making within smallholder households is also associated with diverse benefits including knowledge and resource-pooling and rapid problem solving, which when considered collectively, can improve the climate change resilience of farming households (Agarwal 1997; Van Aelst & Holvoet 2018).

2.8 Types of household decision-making arrangements in Ghana

The household as a microcosm of society has rapidly become a key element in rural development research (Brown, 1996). The structure of interactions within the household is important in determining the welfare of its members. Approaches used to study intra-household interactions such as decision-making often follow a dichotomous pathway thus, decisions are either made jointly or solitarily (Acosta et al., 2020). This study follows similar reasoning in assessing the linkages between decision-making arrangements of smallholder households and their resilience outcomes. Involvement in the decision-making process is usually measured by identifying key persons making important decisions within the household. In semi-arid Ghana, decision-making arrangements within the household are presently composed of 3 main subtypes namely: male head only, female head only, and joint decision-making.

The oldest and predominant decision-making arrangement within the household is the male head only, due to the traditionally patriarchal orientation of the context (Nyantakyi-Frimpong & Bezner-Kerr, 2015). Within these households, although there is usually a clear division of labor based on gender and age, the male head is overall solely responsible for all crucial

decisions and holds the charge of ensuring the welfare of all members. He also evaluates the decisions of other members for approval and oversees the implementation of solutions to household problems (Apusigah, 2009). Another notable feature of this arrangement is the virtual non-existence of any resource pooling strategy by household members toward crucial expenditures or problem-solving.

In contemporary times however, owing to rapid social change brought about by increasing modernization and a gradual degeneration of traditional systems, decision-making at the household level has also morphed into different forms as a result of sheer necessity or by choice. The common forms of these non-traditional arrangements are the female head only decision-making and joint decision-making (Brown, 1996). Like the male head only, the female head only also bears the responsibility for dividing labor, approving, and overseeing the execution of other household members' decisions. However, some authors are of the opinion that this form of arrangement is inferior as females generally lack access to crucial productive resources especially in patriarchal contexts (Bukh, 1979; Kansanga et al., 2019). Regarding joint decision-making arrangement, a household is considered to be in this category when the notions of inclusivity, pooled resources and a common budget, shared interest and active consultation of all household members are reflected in the decision-making process.

2.9 Theoretical Underpinnings

Theoretically, this study draws insights from the concept of resilience, as well as developments in the intrahousehold bargaining approach. There have been sustained global efforts by researchers to understand the diverse effects of climate change, and the extent to which these effects are experienced in different contexts. Geographers and social scientists especially have

shown an unprecedented enthusiasm in investigating the factors that make populations more or less vulnerable to climatic impacts.

2.9.1 Theory of Resilience

Resilience, as derived from its Latin roots 'resilire', is a concept that fundamentally describes the ability to spring back from disturbances (Pizzo, 2015). In line with its Latin origins, resilience was initially used as a conceptual tool by physical scientists for describing the characteristics of a spring and the stability of materials and their resistance to external shocks. However, the concept became mainstream when its application was associated with the work of Crawford Stanley Holling in the field of ecology during the 1970s. The central point of attraction in Hollings's work was the distinction he made between ecological and engineering resilience. In the engineering domain, Holling described resilience as a system's ability to return to an equilibrium or steady-state after an external disturbance (Holling, 1973). Here, the key tenet in resilience assessment was the resistive ability to disturbance and the level speed it takes to achieve equilibrium. In other words, a system is more resilient if it takes less time to bounces back.

In the ecological construction of resilience however, resilience was described as the degree to which an ecosystem can absorb change, beyond which it will compromise its functionality (Holling, 1973). In this context, the focus of resilience is not a measure of time, but rather the magnitude of disturbance a system can withstand and not exceed its critical thresholds. Ecological resilience thus focuses on "the ability to persist and the ability to adapt" to changes (Adger, 2003, p.31). The main difference between these definitions is the fact that, contrary to the single steady state or equilibrium state assumed in engineering resilience, ecological resilience acknowledges the existence of multiple equilibria, and the potential of systems to alternate between them.

Following the appeal of the equilibristic view of phenomena, resilience became a discursive concept, with a very widespread utility in several scientific traditions. Accordingly, Moser (2008, p.5) describe the widespread use of resilience as "…derivative of the ecological theories from which resilience first emerged". Several definitions and modes of assessments have emerged in the process (Martinez & Häyrynen, 2021), leading some scholars to caution against associating the concept with potential ambiguities (Davoudi et al., 2012).

Social scientists took an interest in applying the concept in human-environment interactions following pioneering works in psychology and later in economics, sociology and human geography (Adger, 2000). Social scientists primarily sought to use the concept to explore relationships between attributes of social systems—individuals, communities, societies—and their capacity to recover from external shocks (Adger, 2000). As a result, 'social resilience' became a critical and useful lens for exploring and analyzing human and nature dynamics along with their complexities (Hanson & Heeks, 2020; Walker & Salt, 2012). Shocks in this context can be considered as external deviations from long-term trends that have significant effects on people's state of well-being, level of assets, livelihoods, safety, or their ability to withstand future shocks (Choularton et al., 2015). In this regard, Folke (2016) conceptualizes resilience as the capability of individuals, communities, societies or cultures to continually develop amid significant change occurring either incrementally, abruptly, or expectedly.

However, from the new millennium onwards, drastic societal changes around the world induced by the environment made it apparent that, analysis of resilience in the social setting cannot be isolated from their environments due to their symbiotic nature (Adger, 2000; Mehmood, 2016). As a result of mounting pressure for the interplay between society and environment to be recognized, the term 'socioecological resilience (SER)' emerged (Darnhofer,

2014; Folke et al., 2003). Unlike social resilience, SER acknowledged the complexity and non-linear dynamic of change in social systems. The view of humans as powerful agents of change, capable of shaping the environment through their cultural systems also became mainstream (Martinez & Häyrynen, 2021). Another idea that surfaced during this period was the evolutionary nature of SER (Davoudi et al., 2012) which disputed the prior notions of equilibrium with an argument that systems are prone to changes over time thus, these changes could take new forms that are different from earlier states of equilibrium (Berkes et al., 1998).

In socio-ecological terms, resilience is composed of three fundamental parts: buffer capability, adaptive capability, and transformative capability (Béné et al., 2012). The terminology—'capability'—used here is noteworthy as it describes not an intrinsic or innate property, but the ability to learn from previous adversities, utilize opportunities, mobilize resources and implement options (Darnhofer, 2014). In other words, capability is an earned quality through the implementation of some process. In the next sections below, I provide some detail on the three forms of capabilities (see Table 2.1).

Buffer capability here mirrors Holling's (1973) conceptualization of ecological resilience, where the idea of 'persistence' was a focal analytical component. It denotes the ability to withstand a disturbance without a structural or functional change (Darnhofer, 2014). Beyond this buffer capability, a system will change to an alternative state, different from its previously known structure and function (Speranza, 2013).

The second component, adaptive capability, is concerned with a system's ability to continually make adjustments in order to sustain its structure and function in the face of changing external drivers and internal processes (Folke et al., 2010). Adjustments here are also incremental

and thus, building on previous structures to achieve marginal positive results. However, doing so requires resourcefulness—efficient mobilization and use of resources; precise problem identification and prioritization; and learning from previous experiences (Darnhofer, 2014). Darnhofer et al. (2010) also emphasize that adaptive capability is not a one-time endeavor, but rather a process of continuous experimentation, tweaking and bricolage (Senyard et al., 2014).

Lastly, transformative capability is a transcendent form of adaptive capability that involves more radical changes. Changes here include entirely novel beginnings from which new livelihoods can evolve (Walker et al., 2004). Transformative capability therefore involves a complete structural and functional change which will also necessitate that a totally different set of factors be looked at in resilience assessments (Darnhofer, 2014). Examples of these transformational pathways as suggested by some authors (Coquil, 2014; Schoon et al., 2011) include changes in perception and meaning; resorting to new opportunities for innovation and reimagining interactions among actors. Some other unique attributes in the transformational process also involve factors of uncertainty and risk since there are no guarantees of success in these new ventures. It is along similar lines that scholars like Folke et al. (2003) posit the idea of a 'window of opportunity'—a situation where shocks can potentially give way to improvements in the performance of systems when adequate adjustments are made.

In socio-ecological settings such as smallholder farming communities, shocks occur when agricultural productivity deviates negatively from its longstanding cycles, which poses significant adverse livelihood implications. To sustain the functionality of these farming systems, resilience therefore needs to be built. However, this process also depends on the farmer's ability to effectively utilize these three capabilities, which can be achieved by assessing the degree of the shocks they are exposed to. This is because shocks come in diverse forms, intensities and scales,

which may require the application of different types of capabilities to maximize the use of available resources. Resources available to farmers are also equally variable. The differences in resource availability also suggest that, even in the face of a common shock, the resilience of farmers can vary significantly. It is no doubt that several studies have also assessed resilience through available resources, also known as capitals (Scoones, 1999).

Though not a strict grouping, the categorization of capitals or resources used in frameworks such as the 'sustainable livelihoods approach' is a widely accepted one that this study follows (Scoones, 1999). Broadly, these capitals are human, social, natural, physical, and financial (Quandt et al., 2017). Human capital constitutes the intrinsic and acquired asset an individual possesses including employable skills and good health. Social capital involves the relationships, networks and trustful interactions of an individual that can be relied upon in times of need (Adger, 2003b). Natural capital concerns the capability of accessing productive environmental services and resources such as land, water, and livestock. This is especially crucial in agrarian contexts where livelihoods are directly tied to natural resources (Sharafi et al., 2018). Physical capital on the other hand, extends to the availability of adequate infrastructure. Lastly, financial capital encapsulates all forms of financial resources including savings, income, remittances and credit sourcing facilities (Nasrnia & Ashktorab, 2021).

The focus of this study is on financial capital. Specifically, the study focuses on smallholder farmers' ability to access financial credit from available sources to invest toward agricultural productivity. Financial credit is chosen as the focus of this analysis because of the longstanding high poverty rates in the study context. Additionally, increasing the financial resources of farmers can directly lead to the acquisition of other resources relevant to the cultivating process which

include but are not limited to the acquisition of labor-saving technologies, improved seeds and fertilizers, and expanded access to storage facilities and markets (Rose, 2009).

Table 2.1: Fundamental differences between the components of socio-ecologic resilience

Resilience		
Buffer capability	**Adaptive capability**	**Transformative capability**
▪ Withstand disturbances ▪ No change of state ▪ Conducive for small shocks	▪ Adjustments are required ▪ Change is incremental ▪ Knowledge and experience	▪ Changes lead to totally new systems ▪ Occurs post-shock ▪ Uncertainty is highest

2.9.2 Intrahousehold bargaining model

This study is also informed by the intrahousehold bargaining approach. From the earlier discussion on socio-ecological resilience, it is quite established that smallholder households when conceptualized as a system, can make the necessary adjustments and changes to withstand climate change impacts. These changes and adjustments however, not arbitrary, but rather stipulated by broader socio-cultural norms, political, economic and physical conditions of the context (e.g. Haider et al., 2019). As a result, implementing changes within smallholder households mostly constitute a rather complex interactional situation. Intrahousehold models offer a lens through which one can gain insights on how interactions within the household may or may not contribute to outcomes such as climate change resilience.

Attention to intrahousehold compositions have increased substantially especially in the fields of development studies and feminist political ecology, following the failures of interventions

that ignored the crucial asymmetries of relational dynamics within households (Agarwal, 1997; Becker & Becker, 2009). Relations within the household are largely social products that constantly evolve, rather than determined biologically (Agarwal, 1983). Intrahousehold models thus, outline the mechanics of power relations, and the factors that shape them. Intrahousehold relational theories can be generally group into two—the unitary and non-unitary models. The unitary approach assumes the household to be a single unit under the leadership of a single decision-maker who altruistically made decisions that were representative of all household members' perspectives, values and desires (Seebens, 2011). The application of this model was notable, especially among economists until the early 1980s, when it was critiqued by several authors (Manser & Brown, 1980; McElroy & Horney, 1981) as increasing evidence at the time suggested the existence of conflict among household members due to differences in their interests that partly influence their actions. Evidence of these new intrahousehold dynamics led to the emergence of non-unitary models, also known as the collective household models (Chiappori, 1988).

Collective models posit that household interactions are characteristic of elements of cooperation and conflict in key areas where labor and resource allocation decisions are made—consumption, production and investment (Agarwal, 1997). However, household members will cooperate inasmuch as cooperative arrangements will draw them closer to their individual desired outcomes when compared to a noncooperative stance (Agarwal, 1997). Yet, even under cooperative arrangements, aspects of conflict may still exist because of the possibility of multiple outcomes that serve individual members differently. In the face of usually conflicting interests, the prevailing outcome is dictated by the relative bargaining power of each household member.

Bargaining power, however, is not an intrinsic ability, but another socially constructed concept that depends on several factors including the person's fallback position—external options available to an individual in the event that household cooperation fails. According to De Backer et al. (2021), a fallback position may be assessed in terms of both waged and non-waged income, social networks, socio-cultural privileges. In rural contexts, Agarwal (1997) highlights relevant factors that influence each household member's bargaining power. These factors, which in many aspects are similar to the five categories of resources or capital discussed earlier include: arable land; access to income-earning opportunities; access to communal resources; access to social safety nets both within and without the local community; and lastly, the adherence to broader socio-cultural norms.

Using both resilience and intrahousehold bargaining theories, this study examines the factors that drive the decision-making process of households as it relates to resilience building. In so doing, the study is also cognizant of the use and distribution of resources and power as set forth by sociocultural norms. Taken together, these theoretical underpinnings of the study informed the research questions:

- How does climate change resilience differ between smallholder farming households without access to financial credit and those that do have access in semi-arid Northern Ghana?

- What are the differences in climate change resilience outcomes of smallholder farming households as it relates to the differences in their household decision-making arrangements in semi-arid Northern Ghana?

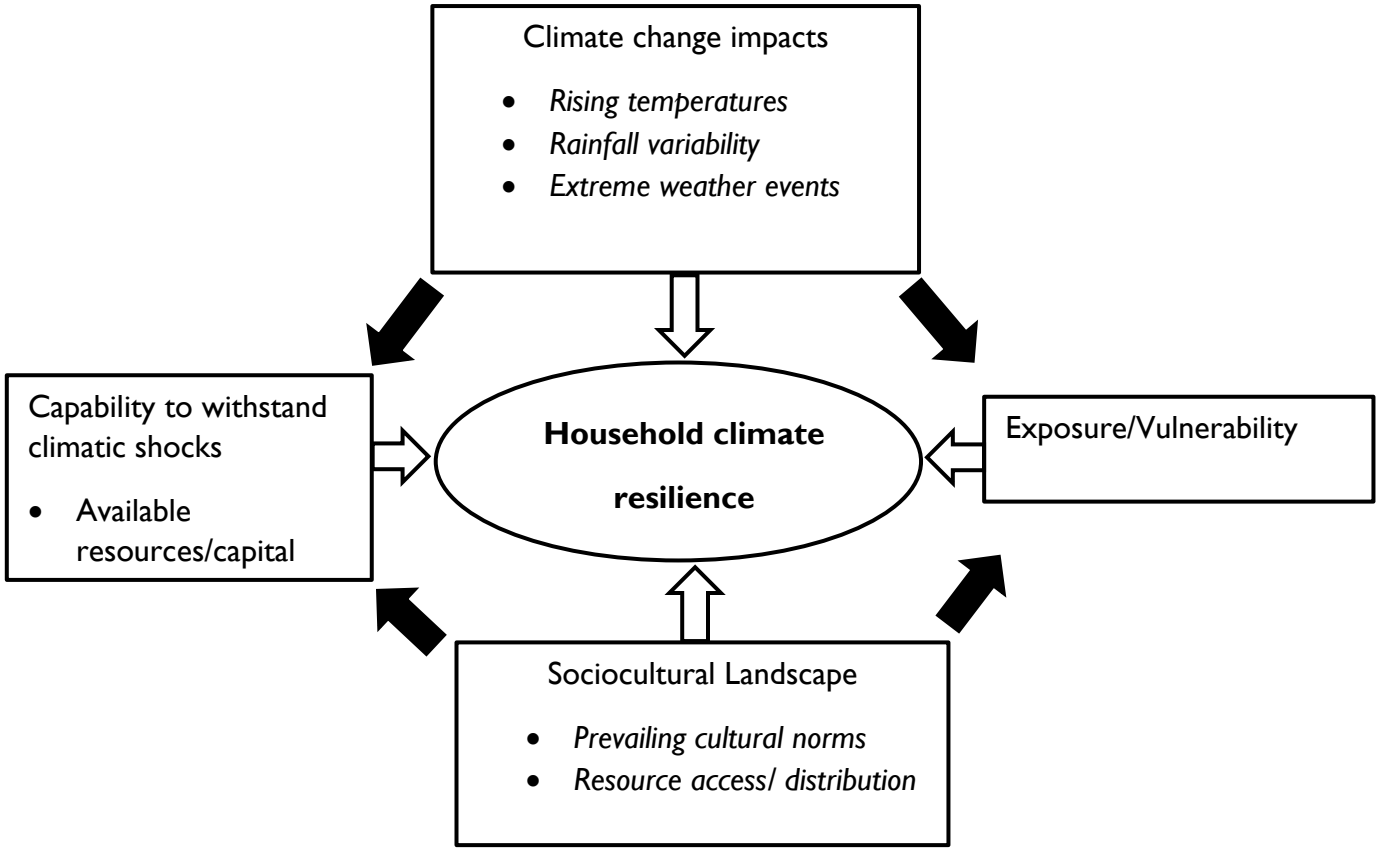

Figure 2.1: Theoretical framework

Adapted from Ericksen (2008).

2.10 Summary

In this chapter, I reviewed the literature on the political, climatic and sociocultural dimensions of agriculture in Ghana. Beginning from the pre-colonial era, I illustrate how the political landscape, both locally and globally, has shaped the agricultural sector to date. Climate change and its impacts, which is potentially the most devastating threat for agricultural productivity in the 21st century was also discussed. Despite being global in scope, and while the predictions of noble institutions such as the IPCC have indicated a net negative effect of climate change on agriculture, some evidence suggesting a differentiated experience on several regional levels was also presented. Most tropical regions, including SSA and Ghana, have been highlighted as some of the most vulnerable areas to climate change due to longstanding factors such as high levels of poverty and inequality, low education, low technology, and limited access to information. The impacts of climate change are only going to worsen soon, therefore these areas are in the most need of climate resilience. The chapter also reviewed the literature on resilience alongside its constituents. I also present literature on the relationship between resilience and contextual variables in the study area, which helps one appreciate the potential contributions of non-climatic variables to climate resilience. Finally, the chapter followed with a discussion of resilience and intrahousehold bargaining models, which provided a theoretical framework for the research questions and objectives in this study.

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CHAPTER 3

3. METHODS AND STUDY DESIGN

This chapter provides a detailed description of the study context, research methodology and related philosophical, ontological, and epistemological positions. The data collection and related ethical issues, sampling and analytical strategies are also presented here. Although the individual manuscripts making up this thesis contain similar sections on study design and methodology, they lacked depth due to limitations imposed by the style and requirements of journal articles.

3.1 Study context

The study was conducted in the Upper West Region (UWR) of Ghana. The UWR is a largely rural region located in the north-western part of the country on latitude 9.8° to 11.0° N and longitude 1.6° to 3.0° W (Ghana Statistical Service [GSS], 2014). The region is bordered to the north and west by Burkina Faso; to the south by the Savannah region, and to the east by the Upper East and North East regions. The spatial extent of the UWR is about 18,476 km^2. The most recent census estimated that the region is home to a population of 702,110, making it the least populated region (GSS, 2014). Administratively, the region is currently divided into eleven (11) districts with the regional capital being the Wa Municipality. While the Upper West region forms the broader focus of this thesis, my analyses take shape from data collected from three districts. The selected study sites—Wa West, Nadowli-Kaleo and Lawra districts, are longitudinally located on the western side of the region (see Fig. 3.1). The region is ethnically diverse with the Dagaaba, Sissala, Wala, Chakali and Lobi ethnic groups forming the major ones. Other smaller groups like the Hausa, Fulani, and Moshie are also rapidly increasing owing to resettlements from some neighboring countries (Ministry of Food and Agriculture [MoFA], 2021).

Ecologically, the UWR is in the guinea savannah zone which is characteristic of grasslands, shrubs and drought-resistant trees such as shea (Vitellaria paradoxa), baobab (Adanso-nia dipitata) and 'dawadawa' (Parkiabiglobosa). These trees are known to primarily serve domestic needs for women especially (Yiridomoh et al., 2020). In recent times, cashew and mango trees have become a major part of the landscape due to their economic importance. The guinea savannah is also characterized by a dry climate, increasing rainfall variability, and hotter temperatures. Rainfall in the region follows the migration of the Inter-Tropical Discontinuity (ITD)— the convergence zone of the dry Harmattan winds of the north and the wet Monsoon winds from the south (Aryee et al., 2019; Lyngsie et al., 2013). Unfortunately, this climatic phenomenon has proven to be unfavorable to most parts of the guinea savannah zone when it comes to rainfall distribution. Due to this climatic disparity, the guinea savannah zone is associated with a unimodal rainfall pattern which usually occurs between May and September and results in only a single planting season. In contrast, areas in lower-middle and southern Ghana rather experience a double rainfall season which further extends the planting season. The rainfall deficit experienced in the guinea savannah zone and most parts of northern Ghana constitute a uniquely different food insecurity experience (Asodina et al., 2020). For instance, a recent survey revealed that almost two-thirds of the population in the area are severely food insecure (Atuoye & Luginaah, 2017). In the UWR specifically, Glover-Amengor et al. (2016) found malnutrition rates in the region to be almost twice the national average. During the dry season which typically spans from October to April, out-migration is very common among smallholder farmers. Smallholders typically search for farming opportunities under diverse leasehold relationships, or other waged jobs southward of the country to sustain their livelihoods and households through remittances (Kuuire et al., 2013; Luginaah et al., 2009).

Notwithstanding the rapid expansion of other services sectors in the region, agriculture remains the key livelihood strategy despite the harsh climatic conditions (Nyantakyi-Frimpong, 2017). About 70% of the total land area is under agricultural use while 80% of the population engages in smallholder farming both directly and indirectly (GSS, 2014). Edaphically, soils in the region are composed of shallow sandy loams with medium to coarse quartz stones and iron pan boulders from the surface to deep, poorly drained alluvial clays in valleys areas (Coulibaly et al., 2020). The major crops produced include maize, finger millet, sorghum, beans, cowpea, groundnuts, and Bambara nuts. Rearing of livestock—chickens, goats, sheep, pigs, and cattle—have also been on the ascendency in recent years as a vital diversification or insurance strategy (GSS, 2014). Despite smallholder agriculture being the main economic driver, the sector is increasingly stressed and has precipitated in the rise of several adverse socioeconomic markers such as poverty, poor health, and prevalence of severe food insecurity among inhabitants (Luginaah et al., 2009; International Monetary Fund [IMF], 2012). Poverty rates are also among the highest in the region, with 9 in every 10 people living on less than a dollar a day (GSS, 2014).

In addition to an already inferior climatology, intensifying climatic changes have also been observed in the UWR region, making it the most sensitive to climate impacts (Dixon et al., 2014). The increasing frequency in the occurrence of droughts, heatwaves, floods, and wildfires has been cited as the manifestation of the rapidly changing climate (Dayour et al., 2014). Other scholars (Konadu-Agyemang, 2000; Songsore, 2011) however, also attribute the declining performance of the agricultural sector to poor governance resulting from skewed colonial and contemporary development agenda. Recent challenges facing the sector, have been exacerbated by an increasing trend of land expropriation and tenure insecurity across the region (Akologo & Guri, 2016). The Ghanaian government through eminent domain has granted land concessions to multinational

mining companies to engage lands that were previously farms and vegetated lands (Moomen et al., 2016). As a result, deforestation and environmental degradation is now rampant and hard to curtail. Whiles a significant portion of the inhabitants still rely heavily on ecosystem services through hunting and gathering, the viability of these strategies are also declining due to environmental degradation (Yaro, 2013). Further, environmental degradation also limits the viability of primitive subsistence livelihood strategies such as livestock rearing, through the continuous reduction of grazing fields and water pollution from mining especially.

Agricultural productivity in the UWR is also stifled by some sociocultural practices. In semi-arid northern Ghana, livelihood roles of men and women in the UWR are largely ingrained in traditional and sociocultural norms which sometimes militate against the changes necessary to support smallholder agriculture (Carr, 2008). Lands in particular, have been historically governed by customary laws and overseen by traditional rulers (Yaro, 2010) which give automatic access to males, whereas women have to rely on either their husbands or sons for user rights (Kansanga et al., 2018). This poses significant challenges for widows, single women, and female-headed households with a potential threat to agricultural production, food security and wellbeing.

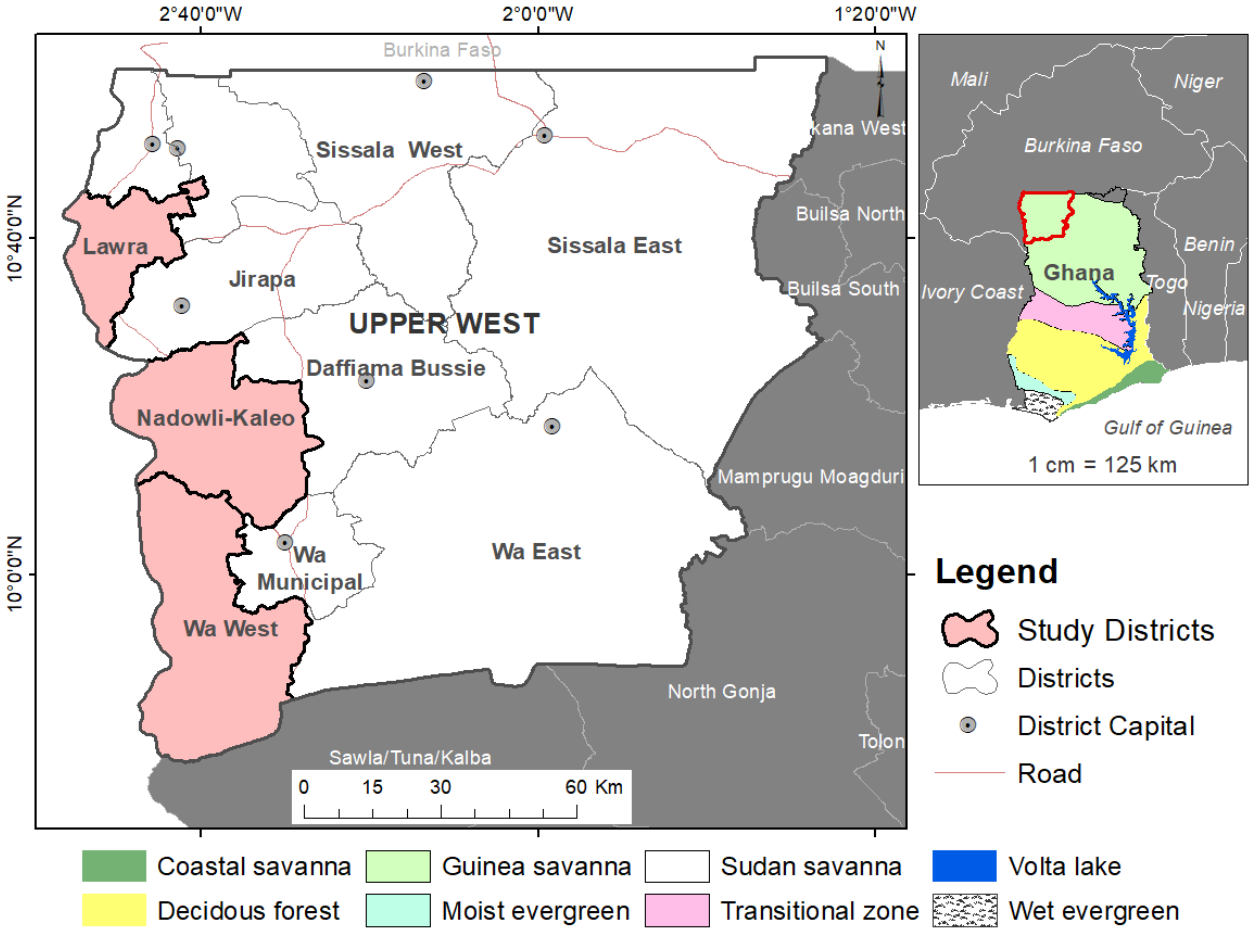

Figure 3.1: A map of the Upper West Region of Ghana

3.2 Epistemology and Ontology

Knowledge and the ways of discovering it are variable (Bahari, 2010). All knowledge can be situated in a particular scientific paradigm. A paradigm in the context of scientific research is a duration within which a set of beliefs are shared by knowledge seekers to guide their understanding of problems and the quest for solutions (Kuhn, 1970). Paradigms are distinctly differentiated by the ways three main pillars are defined—ontology, epistemology, and methodology (Guba & Lincoln, 1994). There is therefore a need to uncover the epistemological

and ontological undertones that underly any research to understand a researcher's choice of methodology and how it relates to findings.

Ontology is concerned with the 'study of being,' or 'what constitutes reality' (Crotty & Crotty, 1998). Reality however, depending on the stance of some schools of thought, is perceived as either 'objective' or 'subjective' due to the underlying processes of knowledge creation (Lincoln et al., 2011). Subjective reality entails the assumption that knowledge creation is non-static and differs from person to person (Guba & Lincoln, 1994). Subscribers of 'subjective reality' believe that reality is mediated through the sensory organs, emerges from consciousness, and evolves through continuous interactions with objects (Sandberg, 2005). Further, reality in this domain is not singular but individually created. Meaning that there are as many realities as there are a number of interactions. According to Frowe (2001), even the very means of interaction—which is language in most cases, actively shapes reality. On the other hand, 'objective reality' relates to the idea that reality has its own existence which is totally independent of the influence of any individual (Pring, 2004). In contrast to 'subjective reality', proponents of 'objective reality' hold onto the assumption that reality is devoid of the sensory or cognitive mediation (Weber, 2004). Although the influence of language is acknowledged here, it is only limited to a representation role, where sub-components like words only have a meaning by virtue of the objects they represent (Frowe, 2001).

Due to the stark contradiction of what constitutes reality on the ontological views of the world, two questions arise: first, 'how is it possible to accept one viewpoint and refute the other?' and secondly, 'what factors culminate in the stance of either school of thought?'. Notwithstanding the fact that all ontological assumptions are conjecture, which further complicates the quest to find answers to these questions highlighted above, the epistemology of each school of thought

can help find some answers. Epistemology is concerned with how knowledge can be created, acquired and communicated (Cohen et al., 2002). Thus, it captures the nature of the relationship between the inquirer, knower or researcher, and the knowable or subject (Guba & Lincoln, 1994). Epistemology can be conceptualized as a filter for indicating what should qualify as acceptable knowledge. Broadly, epistemology can be classified into two categories, that is 'interpretivism' and 'positivism'. Interpretivism is the form of epistemology that requires the acknowledgment of human behavior and the potency of agency in what holds as knowledge (Saunders et al., 2007). Knowledge here is created from intersubjective interaction. In the absence of an inquirer or researcher, knowledge basically does not exist (Smith, 1983). Knowledge is also created and shaped by an inextricable link between the researcher and subject in such a way that, every interaction matters in the final outcome of any knowledge. As Guba and Lincoln (1994) articulate, knowledge is value-laden and always contextualized in the form of multiple social and mental constructions dependent on perceived reality that individuals or groups hold.

Positivism however, is based on the idea of the existence of immutable natural laws among objects (Dieronitou, 2014). The objective view of positivists suggest that an inquirer or researcher can study objects without either projecting any influence, or being influenced (Sale et al., 2002). Due to the neutral position of the inquirer, absolute knowledge can be created by conducting research in a manner that is value-free through measurements, predictions, logical interpretation and conditional generalizations (Denzin, 1994; Sale et al., 2002). During the 20th Century, a modified version of positivism—'post-positivism'—emerged. Although post-positivism possessed markedly similar ontological and epistemological beliefs as positivism, it differed significantly in a few areas (Scotland, 2012). For instance, Heisenberg's uncertainty principle was a key factor that propelled the ideas of post-positivism (Crotty & Crotty, 1998). To contextualize

this principle, there were growing concerns that the belief in absolute knowledge in positivism was unachievable because more empirical data was required to understand the natural laws governing objects. However, getting such data is not always possible for any researcher. Heisenberg summarized this deficiency precisely with an example that, "it is impossible to know both the exact position and velocity of a subatomic particle at the same time" (Crotty & Crotty, 1998; p.29). Following this limitation, post-positivism embraced the idea that what passes as objective or absolute knowledge can still be influenced by an inquirers experiences and bias (Clark, 1998). Notwithstanding this caveat, post-positivism still claims that post-positivistic knowledge still supersedes knowledge from other paradigms in terms of certainty and objectivity. In this thesis, I adopt a post-positivist stance in the study of climate change resilience in rural agrarian contexts. Considering the assumptions of the post-positivist epistemology, I conceptualize smallholder climatic vulnerability and resilience to be the result of other factors such as history of environmental change, previous exposures, relative socioeconomic position, gender, education, age, wealth, health and even traditional beliefs amongst others.

All epistemological strands give rise to a methodological question: how should a researcher go about finding the knowledge? Or simply put, what methodology should a researcher adopt? Methodology is primarily concerned with answering why, what, where, when and how components that guides data collected and analyzed (Guba, 1990). Within any methodology are also 'methods', which are concerned with the specific techniques, tools and procedures employed in data collection and analysis (Crotty & Crotty, 1998). Both positivism and post-positivism share the epistemological belief that knowledge can be created quantitatively (Dieronitou, 2014). This methodological position can be drawn from the idea that facts can be separated from values. Hence true knowledge can also be conceptualized as the harmony

between observable data and the reality the data reflect (Guba & Lincoln, 1994). According to Creswell and Creswell (2017), quantitative knowledge development involves the use of cause and effect thinking, reduction to specific variables, hypotheses and questions, use of measurements and observations. Quantitative research also has a deductive characteristic in that, it usually tests an a priori hypothesis or theory from structured questionnaires with limited range of predetermined responses, randomization and statistical analysis (Dieronitou, 2014; Lee & Lee, 1999). Guba and Lincoln (1994) further highlight the crucial need for controlling confounding factors in the methodological process to prevent outcomes from being improperly influenced. There is also some attention on sample size in quantitative approaches due to its relationship with generalizability and proper use of statistical tools. In the design of this study, I adopt a quantitative approach because I conceptualize climate change impacts and other relevant markers as phenomena that can be represented in data that approximates reality. Further, this study, which focuses on exploring the association between climate change resilience, financial credit access and intra-household decision making arrangements also constitute the testing of some theories on socioeconomic resilience. My desire to make the findings of this research generalizable also informs this approach. Earlier works (e.g. de Oliveira et al., 2017; Tecson et al., 2019; Ung et al., 2016) on smallholder climate change resilience have used quantitative methods with generalizable results.

Table 3. 1: Multi-level distinction between qualitative and quantitative research methods

Orientation	Qualitative	Quantitative
♦ Principle orientation to the role in relation to research	• Inductive • Generation of theory	• Deductive • Theory testing
♦ Epistemology	• Interpretivist	• Positivist
♦ Ontology	• Subjectivism	• Objectivism

Source: Adopted from (Bryman, 2004)

3.3 Study design

In the post-positivist spirit that shapes this thesis, I used a quantitative approach in order to make generalizations about climatic vulnerability and explore associations between resilience and select household characteristics in semi-arid northern Ghana (Creswell & Creswell, 2017). The process in this thesis involves several linked stages. The first stage was the fieldwork for data collection, followed by data preparation and penultimately, data analysis. The last stage was composed of writing the individual manuscripts, manuscript integration and formatting to produce this thesis. This thesis can be described as a tree that has grown from seeds sown back in my undergraduate studies at the University of Ghana, which is located on the southern borders of Ghana. My interest in climate change first and foremost, took shape in my second year when I was exposed to a course titled "Weather and Climate". This course introduced me firstly, to the influence of climate on almost all livelihoods; and secondly, the implications that climate change holds for vulnerable populations in the SSA where adaptive capacity is low. Unlike some courses which I took which were often theoretical, I experienced some practical components of Weather and Climate during the occurrence of the north-easterly Sahara trade winds—also known locally as harmattan, which usually occurs from December to March. Notable characteristics of the harmattan are desert-like sandstorms, the prevalence of dust, extremely dry skin accompanied by cracked lips and generally very dry environments. Fortunately, my seldom visits to the Upper West Region (UWR) for Christmas celebrations with my extended family also coincided with this period. This travel further situated my experience of climatic impacts on smallholder farming after experiencing the firsthand imbalance of climate vulnerability. Throughout my short stay in the UWR, the only question that loomed in my mind was 'what can these locals do for themselves to better their livelihoods in this harsh environment? Provoked by desire to find satisfactory

answers to this lingering question upon returning from my Christmas break, this new experience rekindled my passion to study more about climate and smallholder resilience strategies. As a result, I also took relevant courses such as Climatology; Climate change of semi-arid lands; Climate and Society; Regional geography; Regional development and Rural resources development in the subsequent years of my studies. After my undergraduate studies, I began exploring an avenue to further this research possibility for post-graduate studies. Fortunately, one of my then potential supervisors—Dr. Isaac Luginaah—was leading a similar research project, which I am currently part of; and lays the foundation of this thesis. Reading the literature on smallholder climate change resilience, I realized that despite the massive attention climate change resilience has received in northern Ghana, little attention was paid to the underlying and indirect factors of climate change. Similarly, very little researchalso existed on the non-climatic connotations of smallholder vulnerability and resilience. These gaps within the literature informed the choice of study context and design.

3.4 Data collection

Data for this thesis is drawn from a larger project—Farmer Livelihood and Agricultural Production (FLAP)–which seeks to understand the drivers of food insecurity in smallholder farming communities in Ghana. Using a quantitative survey instrument, cross-sectional data were collected from three (3) districts in the UWR between July and August of 2019. Although the level of analysis was primarily at the household level, background data of respondents were also captured. The main thematic areas captured in the survey were crop production and consumption patterns, gender relations, socioeconomic characteristics, and perceptions about climate related events (see Table 3.2).

To ensure quality in the data collection process, 6 research assistants were recruited to assist the 3-member research team. The recruits were fluent in several local languages which played a tremendous role in navigating some linguistic barriers during the survey because the questionnaire was originally constructed in English. All research assistants were also natives of the UWR who also had some experiential knowledge on smallholder farming. Beyond the interpretative ability of the recruits, their in-depth understanding of the broader sociocultural dynamics as natives, advanced the survey process as they were able to develop rapport with a wide variety of people. This skill also proved very useful especially when sensitive questions such as household gender relations were being asked. Although most of the recruits participated in surveys in the past, the research team organized a 2-day training session for the recruits. This step was crucial because the data were collected digitally with the Qualtrics web-based survey tool, which was the first time most recruits transitioned from the tradition paper-based survey. The recruits were also trained on ethical issues as stipulated by the Non-Medical Research Ethics Board of the University of Western Ontario. Prior to the actual fieldwork, permission was sought from all relevant community stakeholders such as chiefs and elders. Stakeholders were also informed on the purpose of the survey. Similarly, respondents were also briefed on what the survey constituted, especially regarding the confidentiality of responses, and the final use of their data. Respondents were also made aware their participation absolutely voluntary, and that the survey was independent of any financial or political benefits. Following these disclosures, oral consent was required from each respondent before each session could proceed. For respondents that consented, the time for each survey ranged between 35 to about 45 minutes. The research team supervised data collection via online assessments of responses, as well as activities of recruits within the local communities. Mid way through the survey process, the agricultural cycle

of region at the time presented some noteworthy challenges. This portion of the survey's duration coincided with the planting season which necessitated a significant changing of the daily time schedules. Because most farmers worked on their farms between 9 am and 5 pm, most of the surveys had to be conducted outside this period.

Table 3. 2: Thematic areas captured in the survey

Thematic area	**Number of Questions (Sub-questions)**
Background information	10
Household demographics	10
Module A: Agricultural production and practices	45
Module B: Household food security	1(14)
Module C: Household expenditure	1(10)
Module D: Livestock	2(6)
Module E: Livelihood activities and other income	3
Module F: Access to credit	5
Module G: Household assets	1
Module H: Housing and amenities	6
Module I: Household gender relations	17
Module J: Adaptative capacity and resilience	5

Source: FLAP survey, Upper West Region of Ghana, 2019

3.5 Sampling approach

Respondents for this survey were sampled through a multi-stage approach. First, the overall analytical sample was computed using Yamane's (1967) formula for proportions at a 95% confidence level and assuming a maximum variability (P) of 50%. The equation is as follows:

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

where n = sample size; N = Total population of the Region, and (e) = desired margin of error. Based on the population figures at the time of the survey, the sample size was computed with N= 702110. Performing the computation at margin errors of 4% and 5% yielded sample sizes of 624 and 400 respectively, which was considered unsuitable for generalizability. At a 3% margin of error however (n = (702110/ 1 + 702110×0.03^2), a relatively robust sample size of 1,110 with a strong statistical power was estimated. However, we only surveyed 1100 households as granted by ethical guidelines.

A multi-stage sampling approach was subsequently employed in the distribution of the surveys to ensure an impartial representation of smallholder characteristics. A purposive non-probability sampling was first used to select three districts—Wa West, Nadowli-Kaleo and Lawra— in the region to administer the survey. These districts were selected to reflect microclimatic nuances experienced regionally (Dayour et al., 2014). For instance, due to the north-south location of these districts within the region, they possess differences in climatic elements—aridity— that exhibit a similar trend of variability (Totin et al., 2018). Additionally, these districts were also selected because of their different poverty rankings. To minimize bias in the survey, the share of total sample size for each district was calculated with respect to their

population sizes, which yielded the following sub-samples: Wa West (438), Nadowli-Kaleo (367), and Lawra (295).

Within each district, communities were randomly selected. From the point of entry into each selected community, every fifth household was systematically selected to administer the survey. This approach was employed to ensure randomness in the selection of respondents. For this study, a household is considered to be a singular infrastructure where a number of persons either related or unrelated live together, share the same cooking arrangements and acknowledges the existence of a household head. In each household, the survey was administered to the primary farmer rather than the household heads. The purpose of administering the surveys in this manner is because, contextually, some household heads are older folks who may not be actively involved in agriculture and thus, may not be able to respond adequately to the survey. In a few instances where the primary farmers were unavailable, other adult household members also engaged in farming activities were interviewed instead, with precedence given to the oldest (18 years or older) household member (O'Rourke & Blair, 1983). A major criticism associated with quantitative survey tools is the inability to capture abstract and subjective characteristics such as perceptions and feelings because of the close-ended nature of questions (Denscombe, 2010). Cognizant of this limitation, some aspects of the survey tool were structured to accommodate perceptual responses.

3.6 Description of study districts

The Wa West District is located in the south-western corner of the UWR (see Figure 3.1). It is bounded to the North by the Nadowli-Kaleo District, to the South by the Savannah region, to the East by Wa Municipal, and by the Republic of Burkina Faso to the West (GSS, 2014). With a

land area of 5899.3 km^2, it has a population density is about 13.7 per square kilometer. Similar to the ecological profile of the UWR, the Wa West district is also characterized by Guinea Savanna grassland, with some of the major trees on the landscape being dawadawa, shea, baobab, and neem trees. These trees provide essential ecosystem services for household provisioning, healing, and even employment in the case of shea (Yiridomoh et al., 2020). Average annual rainfall varies between 840 mm and 1400 mm. Rainfall is very erratic and very poorly distributed (MoFA, 2021). Temperatures in the district are usually high and range between 22.5°C to 45°C. Between December and January however, there is a notable decrease. The Black Volta River flows southwards through the district and plays a key role in shaping the district's soil profile. The main soil types are groundwater lateritic soil and Savanna orchrosols along the Black Volta (MoFA, 2021). The district has an undulating topography that supports agriculture. As such, about 91.6% of households engage in smallholder agriculture. Key produce cultivated here includes guinea corn, millet, maize, yam, groundnuts, soya beans, and cowpea. A very minute proportion of people also practice tree planting and fish farming. The district is the most deprived in the region, as it ranked as the impoverished district nationwide (GSS, 2014).The Nadowli-Kaleo District is situated on the western flank of the UWR, and bordered to the North by the Jirapa District, to the South by Wa Municipal and Wa West District, to the East and West by Daffiama-Bussie-Issa District, and the Republic of Burkina Faso respectively (MoFA, 2021) (see Figure 3.1). Compared to the other study districts, it is moderate in size with a land area of 2,594 km^2 and an estimated population density of about 25.8 persons per square kilometer. The district also lies in the guinea savannah ecological zone, with a similar vegetation profile as the Wa West region. Rainfall in the district usually peaks in August and records an annual average of about 1100mm. Although temperatures in the dry season can rise as high as 40°C, the annual average is about 32°C (MoFA,

2021). The Bakpong stream along with several seasonal streams flows into the Black Volta River (Dary & Grashuis, 2020). The soil profile of the district predominantly features laterite, sandy, and sandy loam which generally have low organic matter and nutrients. Soil fertility has also significantly declined owing to environmental degradation and excessive usage. That notwithstanding, smallholder is still the main economic activity and employs about 80.4% of the inhabitants. The main produce cultivated in this district includes maize, sorghum, guinea corn, millet, rice, cowpea, soybean, groundnuts, yam and Bambara beans. The rearing of cattle, sheep, goats, pigs, chickens, and guinea fowls has also been on an ascendency as a form of livelihood diversification and to supplement household food security.

The Lawra district is located in the north-western part of the UWR (see Figure 3.1). It shares borders to the North, South, East, and West the Nandom District, Jirapa District, Lambussie-Karni District, and the Republic of Burkina Faso (Shaibu et al., 2020). With a land area of 509 km^2, the district covers about 8 percent of the regional land area and has a population density of 107.8 per square kilometer (GSS, 2014). Ecologically, the district also lies in the broader Guinea Savannah zone with a tropical continental climate. In terms of rainfall and temperature measures, average annual rainfall ranges between 900mm to 1200mm, while annual mean temperatures also hover from 27°C and 36°C (GSS, 2014). The district's soil profile consists of mainly laterite soils. However, due to the presence of the Black Volta, strips of alluvial soils can be found along its flood plains. Some sandy loams are also present along some of its tributaries (Shaibu et al., 2018). Agriculture is the main livelihood strategy and employs about 78 percent of the economically active people. Crop production has focused on millet, groundnuts, soya bean and cowpea, and some livestock rearing (MoFA, 2021). The sources of water that inhabitants rely on include boreholes, pipe-borne water, protected wells and the Black Volta river (Shaibu et al.,

2020). Poverty rates are also high in the region but better than the Wa West District because it ranked as the 13th most impoverished district in Ghana (GSS, 2014).

Table 3. 3: Geographic location, land area, estimated population, and sampled population from the study districts in the Upper West Region

District	Location	Estimated land area (Km^2)	Population	Sampled population
Wa West	9° 49' 35" N 2° 40' 51" W	5899.3	81,348	438
Nadowli-Kaleo	10° 22' 26" N 2° 40' 26" W	2,594	66,975	367
Lawra	10° 38' 45" N 2° 52' 57" W	509	54,889	295

Source: GSS (2014)

3.7 Data analysis

After the data were collected using the Qualtrics software, I converted them into a Stata 15 acceptable format for cleaning and coding to remove data entry errors which can bias the results. All statistical modelling and analysis were also conducted with Stata 15. A detailed description of the analytical approaches for each manuscript is presented in chapters 4 and 5. However, to briefly present these details, the dependent variables in both manuscripts was 'perceived climate change resilience' which was constructed as a three ordered category variable (Mohammed et al., 2021). Therefore following standard analytical practice, I employed an ordered logistic regression to examine the relationships between the dependent and independent variables (Williams, 2006).

3.8 Robustness of findings

The generalizability of the findings in the study was a key focus in the study design. Hence, the robustness of findings was paramount in all stages—data collection, analysis, and writing. The survey tool was rigorously designed through multiple iterations of revisions by my thesis committee and other graduate students who are well-versed in the smallholder agricultural systems. This was meant to ensure that the survey was compendious to achieve the research objectives, as well as being contextually sensitive and valid. To obtain high-quality data during the data collection, research assistants with prior survey experience were recruited and trained to explain the connotations of all components of the survey, and to address any potential hurdles that may arise. The recruits were also briefed on all ethical concerns before the actual data collection started. During the data collection process, revisions were also made to the survey from feedback through daily digital assessments and field visits. Employing simple random sampling in the survey administration process was done to give statistical validity for the generalization of the findings. Internal validity testing such as satisfying the assumptions of analytical methods during analyses in both manuscripts also ensured the robustness and potential generalizability of findings in the study context.

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CHAPTER 4

4. CREDIT ACCESS AND PERCEIVED CLIMATE CHANGE RESILIENCE OF SMALLHOLDER FARMERS IN SEMI-ARID NORTHERN GHANA

Abstract

Climate change is a major driver of agricultural failure in the Global South. In semi-arid northern Ghana where rainfed agriculture is the dominant livelihood strategy, climate change is increasingly undermining rural livelihoods. Despite several policy efforts to improve climate adaptation in this context, smallholder farmers' lack of access to credit continues to militate against climate change adaptation. Using an ordered logistic regression model, this study analyzed data from a cross-sectional survey (n = 1,100) in the Upper West Region to examine the relationship between smallholder farmers' access to credit and their perceived climate change resilience. Findings show that households with access to credit from informal sources were more likely (OR = 1.73, $p \leq 0.05$) to report good resilience compared to those without access. Households that received remittances were more likely (OR = 3.26, $p \leq 0.001$) to report good resilience compared to non-receiving households. Further, households that did not rear any livestock were also more likely (OR = 2.00, $p \leq 0.001$) to report good resilience compared to those that reared livestock. On the contrary, households that had experienced climatic events in the past 12 months before the study were found less likely (OR = 0.29, $p \leq 0.01$) to report good resilience compared to households that did not experience any events. These findings highlight the potential contribution of informal credit sources to improving rural agricultural productivity and climate change

resilience. Informal credit sources may be capable of providing smallholder farmers with the needed access to more flexible financial credit options. The study provides policy recommendations on what might be useful to vulnerable groups, and others in similar contexts.

Keywords: Resilience; climate change; credit access; smallholder farmers; Ghana

4.1 Introduction

There is consensus that climate change is an important determinant of global agricultural productivity, and reports from the Intergovernmental Panel on Climate Change (IPCC) suggest the net climate change impacts on agriculture across the globe are negative (IPCC 2019). This poses a livelihood risk to the world's over 820 million food insecure smallholder farmers who depend on agriculture as the main source of livelihood (Food and Agriculture Organization [FAO], 2020). Smallholder farmers are mostly rural farmers usually cultivating on land less than 2.5 hectares in developing countries, with low technological input and reliance on family labor (Barnett 2007). Even though the brunt of climate change on smallholder farmers is global in scope, those in sub-Saharan Africa (SSA) are disproportionally affected by the effects of climate change. This vulnerability is because smallholder farming accounts for about 80% of total farms in this region. The effects of climate change in this region include increasing rainfall unpredictability, increasing temperatures, and increased frequency and intensity of floods and droughts (FAO, 2020).

With the increasing effects of climate change, agriculture has increasingly become a high climate risk activity in Ghana (World Bank 2018). Smallholder farmers in Ghana are particularly vulnerable to climate change due to their excessive reliance on rainfed agriculture, as well as the use of nutrient-deficient soils. Additionally, smallholder farmers have been victims of unfavorable

national policies since the colonial era when farming systems and agricultural service sector were cash crop oriented (Alobo-Loison 2015). The deprivation of northern Ghana also has roots in post-colonial policies especially the structural adjustment programs which removed government subsidies on public services including agriculture (Konadu-Agyemang 2000). With intensifying climate change, the semi-arid savannah zone is further exposed to effects such as floods and drought. Some scholars suggest that the vulnerability of the region is further exacerbated by the low adaptive capacity of the people given the lack of alternative livelihood opportunities (Abdul-Korah 2007). Due to the vital role of agriculture in Ghana, the sector has received considerable attention over the past few decades (Di Falco & Bulte 2013). Indeed, reports by the World Bank (2018) indicate that the agricultural sector holds the most potential of spurring socio-economic development that can benefit the rural poor. Consequently, building farmers' resilience is crucial for addressing many challenges faced by communities vulnerable to climate change. Etwire (2020) emphasize that building the climate change resilience of smallholder farmers in this context should be a non-negotiable venture.

The concept of resilience has emerged as an effective way of coping and adapting to climate change effects. Brown (2014) describes resilience as the ability to 'bounce back' after disasters. Building resilience to climate change impacts is therefore necessary for sustaining the livelihoods of smallholder farmers in semi-arid northern Ghana and also enhancing the use of meager resources available (Gariba & Amikuzuno 2019). In Ghana, governments have implemented several initiatives to strengthen the resilience of smallholder farmers. The most recent initiative called 'Planting for Food and Jobs Initiative' has focused on building climate change resilience and bolstering food security by further expanding smallholder access to vital inputs and extension services (MoFA, 2019). Another landmark government initiative is the Fertilizer Subsidy

Program (FSP) which was implemented in 2008 to provide farmers with subsidized fertilizer (Houssou 2017). In 2007, the government also implemented the Agricultural Mechanization Service Centers (AMSECs) to provide smallholder farmers with subsidized tractor-based mechanized plowing services (Benin 2015). Governments have also intensified agricultural extension services to advise smallholder farmers on adaptation strategies. The AMSECs initiative is particularly important given that the traditional methods of land preparation–use of manual implements and labor–is slow and thus, inhibit farmers from taking advantage of the early rains (Kansanga 2020). In addition to these government initiatives, smallholder farmers in semi-arid northern Ghana are also increasingly integrating generationally transferred strategies to better adapt their livelihoods to the effects of climate change. For instance, there is empirical evidence that despite increasing rainfall unpredictability, some farmers apply traditional knowledge in forecasting the onset of rains with reference to the flowering of the shea nut tree, migration of birds, and celestial movements such as the position of the 'constellation Pleiades' and intercropping strategies (Nyantakyi-Frimpong 2012).

Despite the implementation of various initiatives to improve smallholder farmers' climate change resilience in Ghana, the majority of farmers in Ghana, especially in the semi-arid areas, are still overwhelmed by climate change impacts (Abdul-razak & Kruse 2017). Some scholars have highlighted limited financial credit access as one of the key factors contributing to the longstanding vulnerability of smallholder farmers to climate change effects (Cramon-taubadel & Saldias 2014; Jiri et al. 2017). The key argument is that access to financial credit enables and sustains the flow of farm inputs and new forms of investments which increases agricultural productivity. Indeed, studies elsewhere have shown that improving smallholder farmers' access to financial credit can have a positive influence on their climate resilience (Duy 2012; Miller and Ladman 1983). For

instance, Reyes et al. (2012) working in Chile revealed that access to financial credit influences rural development and smallholder agricultural productivity. A study by Dong et al. (2010) in China revealed higher productivity and resilience among farmers with financial credit compared to those lacking credit. Similarly, in Vietnam, Duy (2012) demonstrate that access to credit improved farmers' resilience via increased yields. In Bolivia as well, Miller and Ladman (1983) highlighted the positive association of financial credit and wellbeing among smallholder farmers. Notwithstanding the positive relationship between financial credit and resilience espoused above, there is limited empirical evidence on the relationship between smallholder farmers' access to financial credit and climate change resilience in the semi-arid context in sub-Saharan Africa. Drawing data from a cross sectional survey, this study examines the relationship between credit access and climate change resilience in semi-arid northern Ghana. We hypothesize that smallholder farmers with access to credit will be more likely to report better climate change resilience than those who lack access.

This paper is structured in six parts. The next section outlines the theoretical underpinning of the study. This is followed by a description of the study area, data collection methods and the analytical approach. The results of the analyses are then presented and followed by the discussion and limitations of the study. In the last section, we conclude the study and make policy recommendations.

4.2 Materials and methods

4.2.1 Theoretical approach

This study is informed by the theory of resilience. There is no other time in history that has featured the concept of resilience more ubiquitously than the 21st century due to rapid development and unpredictable events ranging from terrorism and economics to intensifying climatic changes (Angeler, 2021). It is therefore unsurprising that 'resilience' was deemed the buzzword of the year 2020. Etymologically, resilience derives from the Latin word 'resilire', which means to 'bounce back' (Pizzo, 2015). Although the concept has a long history—dating back perhaps to the 1st century B.C, an important paradigm in its modern evolution can be traced back to Crawford Stanley Holling's work on systems ecology. Holling (1973) conceptualized resilience as a degree change a system can absorb or persist from interactions among biotic and abiotic processes, without collapsing and reorganizing into a different ecological state to maintain its functionality. The concept was also quickly reflected in the engineering domain where it was defined as a system's ability to return to its equilibrium after a disturbance (Gunderson, 2010). A common denominator between these definitions is a system's capability to avoid a downward trajectory following a disturbance. Nevertheless, the fundamental distinction between the two conceptualizations of resilience is the assumption of multiple possible return stable states in the case of ecological resilience, while engineering resilience assumed the existence of a single stable state.

Resilience is therefore a malleable concept and thus, has been extensively translated—redefined and applied—across several fields of study (Martinez & Häyrynen, 2021). Multiple meanings of the concept have since emerged, with each rooted in different scholastic traditions which led to several debates especially among critical scholars (Davoudi et al., 2012). From these

translations, the concept was introduced into the social sciences owing to earlier psychological works and later in sociology and human geography. In the social sense, Adger (2000, p. 347) defined resilience as "the ability of groups or communities to cope with external stresses and disturbances as a result of social, political, and environmental change". Social scientists primarily sought to use the concept to explore relationships between attributes of social systems—individuals, communities, society—and their capacity to recover from external stresses and shocks (Adger, 2000).

Despite social resilience gaining some currency, some proponents like Folke et al. (2003) argued that social systems are inextricably embedded in the natural environment which then called for a renewed conceptualization and redefinition of the concept in the social domain. Similarly, other authors also reiterated the symbiotic nature of the environment and the social world—human interaction, culture, politics and governance (Mehmood, 2016). Indeed, Martinez and Häyrynen (2021) argue that cultures, morals and ethics, wellbeing and world views of a social group can emanate from their immediate environment and vice versa.

It is from these ideologies that 'socioecological resilience (SER)' emerged in the late 1990s and has remained relevant hitherto. SER acknowledges the complexity of social systems and hence, assumes a non-linear change dynamic, and a continuous iterative process towards building a buffer capacity against external stresses and shocks (Folke, 2006). Due to this iterative component of SER, some scholars have also termed it 'evolutionary resilience' (Davoudi et al., 2012). Holling (2001) also maintains that external stresses and shocks can offer opportunities for change for positive outcomes from reorganization.

The new level of analysis that SER introduces is clearly summarized in the work of Béné et al. (2014) that, "resilience… is not simply about resistance to change and conservation of existing structures [engineering definition]' (Folke 2006: 7) or even about 'buffer capacity and persistence to change while maintaining the same function' (ecological definition), but is instead viewed as an emergent property that also includes two other dimensions: the adaptive capacity–the capacity to learn, combine experience and knowledge, adjust responses to changing external drivers and internal processes, and continue operating' (Berkes et al., 2003); and the transformative capacity–the 'capacity to create a fundamentally new system when ecological, economic, or social structures make the existing system untenable' (Walker et al. 2004: 5)" (pp. 8-9). SER therefore provides more relevant socioecological markers for resilience analyses and it is no doubt that its increasingly being used in analyzing relationships between communities and the environment (Wilkinson, 2012). An added dimension of SER—temporality—has been highlighted by Falk et al. (2019) as contemporary disturbances tend to exacerbate if left unattended. For example, following a disturbance of two independent systems by a similar external event, if one system recovers quickly than the other, it is very likely for the system to be perceived as more resilient.

In our analysis, we equate smallholder farming as a socioecological system, with farmers engaging in iterative processes (adaptation and/or transformation) towards building a buffer capacity (resilience) against external shocks like climatic events like droughts, floods, storms and erratic rainfall. However, despite the fact that a household through climatic events can reorganize, adapt or transform to minimizing vulnerability and maximize positive outcomes, the process is not simplistic (Beller et al., 2019). This is because vulnerability, which indicates a household's degree of susceptibility, is a function of available competencies including financial capital. In smallholder farming households, resilience is synonymous with the household's ability to engage

in seasonal agricultural cultivational which yields significant productive margins over a sustained period amid the prevailing climatic challenges. Access to financial credit in this context is very crucial in the cropping season as it is required throughout the cycle. This importance also suggests that access to financial credit, or lack thereof, is crucial in determining the success or failure of a cropping season. For example, compared to a household lacking financial capital, a household with sufficient financial capital can employ the services of tractors for timely land cultivation to benefit from early rains (Kansanga et al. 2020). Further, financial capital also enables the purchasing of vital farm resources like modified seeds and fertilizers to support the resistance and growth of crops. Djebou et al. (2017) have found a significantly positive relationship between fertilizer use and household resilience in Ghana and elsewhere. Food loss, partly due to lack of storage infrastructure, has also been a chronic issue undermining smallholder resilience and food security in this context (Nyo 2016). In this capacity, financial capital can also facilitate the effective storage and transport of crop produce to their desired destinations. Considering this conceptualized cycle of smallholder production season, we therefore argue that farming households with access to financial credit will be better positioned to adjust and reorganize their livelihood strategies to adapt to the complex changing climatic conditions (Mehmood, 2016).

4.2.2 Study area

This study was conducted in Ghana's Upper West Region (UWR). Geographically, the region lies in the north-western corner of Ghana between latitude 9.8˚ to 11˚North and longitude 1.6˚ to 3.0˚West. In terms of climate and ecologically of the UWR, it lies in the Guinea Savanna vegetation zone and is characteristic of a single rainy season for cropping, which typically spans from April to September. Outside of the rainy season is a long dry season when food is scarce

and expensive. The annual average rainfall of the region is approximately 115 cm (MoFA 2016). In recent times however, there has been a marked trend of rainfall unpredictability in the region (Owusu & Waylen 2013). The sporadic rainfall, high temperatures, and savannah conditions also cause the occurrence of extreme weather events such as erratic rains, droughts, storm surges and floods. After torrential rains, rapid run-offs are common thereby increasing soil infertility and have over the years inhibit agricultural activities in the region.

Agriculture nonetheless, remains the primary mainstay of the region, employing about 80% of the active population both directly and indirectly (Yidana et al., 2018). However, the general failure of agriculture has given rise to several livelihood diversification avenues in the area. Recently, animal rearing and vegetable farming, shea harvesting and charcoal production have been on the rise with women dominating the last two (Ghana Statistical Service [GSS] 2014; Yaro & Tsikata, 2013). For some people, southward migration to find engage in other livelihood ventures to support their households via remittances have also gained traction (Luginaah et al., 2009). Scholars (Atuoye et al., 2017; Van der Geest, 2011) are increasingly acknowledging the positive contributions remittances are making toward poverty reduction and livelihood sustenance of rural households. Some authors (e.g. Armah et al., 2011; Asodina et al., 2020) attribute the declining state of agriculture to the climatic dynamics of the region. This is because the UWR's unimodal rainfall pattern significantly differs from the bimodal pattern experienced in the South, which gives southern farmers an additional cropping season.

The hitherto reliance of the region on agriculture as its economic base has resulted in the reinforcement of a vicious poverty cycle among others (Atuoye & Luginaah 2017; GSS, 2014). For instance, despite a general decline in national poverty levels, significant increases have been observed in the semi-arid north, with the UWR having the highest rates. Indications from the GSS (2014) suggest that nine out of ten people being poor live on less than US $1.25 per day which is significantly less than the national average of US$ 1.90. Access to basic infrastructure to support economic activities is also highly restricted due to poor roads, inadequate storage facilities, and a lack of organized and competitive markets. Health and educational facilities are

also notably inadequate when compared to the middle and southern parts of the country (Dixon et al., 2014)

Governmental attempts to reposition agriculture as a functional sector have not reflected much in the UWR due to longstanding neglect of the semi-arid north. This neglect is evident in the locational discrimination of financial credit sources, where all the major banks and financial institutions are relatively concentrated in urban centers in the Southern parts of Ghana. Yaro (2013) and Songsore (2003) have traced this unfavorable political scene to the colonial era. Furthermore, with an even worse climatic projection for the semi-arid region, there will be a corresponding increased burden for smallholder farmers as new forms of investment in modern farm inputs are needed for effective adaptation. Considering all of the above-mentioned attributes of the region, this context provides an ideal opportunity to examine the associations between perceived climate change resilience and source of credit.

4.2.3 Data and Sampling

We draw data from a larger project–Farmer Livelihood and Agricultural Production Project (FLAP)–which seeks to understand the drivers of food insecurity in smallholder farming communities in Ghana. A cross-sectional quantitative survey was conducted between July and August 2019 in the Upper West Region of Ghana. A multi-stage approach was used in sampling smallholder farmers (n = 1100). Purposively sampling was first used to select three districts (Nadowli-Kaleo, Lawra, and Wa West) in the region. These districts were selected to ensure variation in their local ecologies (Totin et al., 2018). For example, aridity increases as one moves northward and hence, selecting these districts can maximize the variation in the experience of local scale climatic events. Within each district, communities were randomly sampled for the study. In every community, every fifth household was systematically selected starting at the entry

point of the community. In each household, the primary farmer (at least 18 years old) responded to the survey on behalf of the household. The survey covered the following themes: respondents and household demographics, socio-economic and agricultural production factors, household wealth and food security status, household gender relations and decision-making arrangements, climatic exposure, vulnerability and adaptive capacity. Ethical approval was granted by the Non-Medical Research Board of the University of Western Ontario, Canada. To ensure representativeness, the share of the total sample size of each district was based on their respective populations was calculated as follows: Lawra (295), Nadowli-Kaleo (367), and Wa West (438).

4.2.4 Measures

The dependent variable was 'perceived climate resilience'[4] was constructed from participants' responses to questions that sought to understand how their households' ability to recover, adapt and anticipate climatic events (i.e., drought, flood, erratic rainfall, storm surges) they had experienced in the last 12 months before the survey. Perceived resilience was constructed as a three-category variable where 0=poor resilience; 1=satisfactory resilience; 2 = good resilience to climate-related events. Our choice of a subjective measure follows Jones and Tanner's (2017) suggestion that from experiential knowledge and self-evaluation, households have a good understanding of their exposure, vulnerability and the efficiency of coping and adaptive strategies to disturbances. Another factor that motivated this choice is the lack of secondary data in rural contexts from which objective resilience measures are often computed (Jones & Tanner 2017).

[4] Survey question from which the dependent variable was constructed:
'How would you rate your ability to handle flood/drought/erratic rain related stress?'
This question was asked after respondents identified that they had adopted diverse coping strategies to climate related stresses they had experienced in the past 12 months prior to the survey

According to Jones and Tanner (2017), an advantage of a subjective approach is the ability to capture abstract connotations of a household's resilience. Due to these reasons, some authors (Oriangi et al., 2020) have subjectively measured resilience using this approach.

The focal independent variable in this study was 'access to financial credit'. Respondents were asked if they were able to access financial credit from a pre-set list of credit sources. For those that reported having access to credits, sources were then recategorized as formal and informal based on existing literature (Asiama & Osei, 2007; Kuwornu, 2012). Overall, the variable was composed of three categories from the survey responses which were as follows: 0=no access to credit; 1=access to formal sources of credit; 2= access to informal sources of credit.

Drawing insights from smallholder literature other relevant covariates were selected for analyses. The covariates include: age (18 to 25; 26 to 35; 36 to 45; 46 to 59; above 60), gender (male; female), education (informal; primary; secondary; tertiary), marital status (single; married; widowed/divorced), household size (1 to 4; 5 to 7; 8 to 11; above 12), decision-making arrangement (male household head only; joint household; female household head only), remittance receipt (No; Yes), experience of climatic events in the past 12 months (No; Yes); experience of drought in the past 12 months (No; Yes); experience of flood in the past 12 months (No; Yes); experience of storm surges in the past 12 months (No; Yes); experience of erratic rain in the past 12 months (No; Yes); farm size; main source of farm information (farmer experience; mass media; local community; external organizations); source of farm power (manual; animal; tractor); postharvest food loss and livestock rearing (yes; No). Although most households live below the poverty line, there are still economic variations among households thus, a wealth variable was constructed from a composite index of household assets such as TV, tractor, fridge,

mobile phones, and vehicles among others. Wealth was subsequently categorized as (richest; richer; middle; poorer; poorest).

4.2.5 Analytical approach

Using Stata/IC 15.0, we conducted a three-part analysis—univariate analyses, bivariate and multivariate ordered logistic regression models—to examine the relationship between credit access and climate change resilience. First, we used univariate analyses to understand the sample characteristics. Secondly, we used a bivariate ordered logistic model to explore the individual associations between each covariate and resilience. Finally, a nested multivariate ordered logistic model was used to control for the effect of individual, household, and agriculture-related variables. We chose an ordered logistic model because of the ranked categories of the dependent variable (poor, satisfactory, and good). Several studies (e.g. Tecson et al., 2019; Ung et al., 2016) have used this model in resilience analyses. An ordered logistic regression equation is as follows:

$$\log\left[\frac{P(Yij \leq 1)}{[1 - P(Yij \leq 1)]}\right] = \propto_0 + \sum_{k=1}^{p-1} \propto_{jk} X_{ijk} + V_{ij'} \; C = 1, \ldots . \; \Omega - 1$$

Where $P(Yij \leq 1)$ is the probability of a certain event occurring (household reporting good resilience), $[1 - P(Yij \leq 1)]$ is the probability of a certain event not occurring (a household not reporting good resilience), $\propto_{jk}$ is the coefficient term, X_{ijk} are the independent variables, $\propto_0$ and $\Omega - 1$ is the intercept term and Vij is the error term in the logistic model. A maximum likelihood estimation procedure was used to estimate the odds ratios of the model (Akaike, 1998). An odds ratio less than '1' indicates a lesser likelihood of reporting a good resilience. In contrast, an odds ratio greater than '1' indicates a higher likelihood of reporting good resilience (Kleinbaum and Klein 2010).

4.3 Results

4.3.1 Sample characteristics

Table 4.1 shows the findings from the univariate analysis. We found that while a majority of the primary farmers (47%) perceived their households as having a good resilience to climate change, 27% and 26% of them perceived their households' climate change resilience as satisfactory and poor respectively. In terms of a general experience of any climatic change event in the past 12 months, most of the primary farmers (57%) indicated their households experienced an event. Specifically, among those households that had experienced a climate change event, drought was the most prevalent (41%), followed by storm surges (37%), erratic rain (23%) and flood (14). While more than half of households lacked access to credit (54%), formal sources (36%) were the predominant credit source for those that had access and followed by informal sources (10%). Most of the primary farmers were aged 36 to 45 (35%), followed closely by 46 to 59 (31%), 26 to 35 (20%), 18 to 25 (8%), and by 60 and above (6%).

The majority (67%) of primary farmers were informally educated. As well, more than half of the primary farmers were male (52%), which is also reflected in the prevalence of male only household decision-makers (75%), relative to other household decision-making structures. The majority of the primary farmers were married (82%), whiles the remainder were either single (12%) or widowed/divorced (6%). Almost half of the households had about 5 to 7 members (45%). In terms of wealth, households were quite similarly distributed across the five wealth categories, with 20% of households in the lowest wealth category (poorest). While the majority of households reared livestock (63%), only a marginal proportion of the households were found to rely on remittances (4%). The mean farm size was 4.91 hectares. The majority of the primary farmers also referenced the local community (62%) as their main source of farm information,

followed by reliance on their personal experience (21%), external organizations (13%), and mass media (4%). More than two-thirds of households were able to employ the services of tractors for land preparation (77%). On average, households also lost 3% of their produce post-harvest. The sample characteristics are very consistent with the reports of the Ministry of Food and Agriculture, and the Ghana Statistical Service (GSS 2014; MoFA 2016).

Table 4.1: Sample characteristics of households

Variable	Percentages (%)
Resilience	
Poor	26
Satisfactory	27
Good	47
Credit source	
No credit	54
Informal sources	10
Formal sources	36
Age	
18-25	8
26-35	20
36-45	35
46-59	31
60+	6
Gender	
Male	52
Female	48
Education	
Informal	67
Primary	17
Secondary	12
Tertiary	4
Marital status	
Single	12
Married	82
Widowed/Divorced	6
Household size	
1-4	16
5-7	45
8-11	27
Above 12	12

Decision making arrangement	
Male household head only	75
Joint household members	16
Female household head only	9
Wealth	
Richest	19
Richer	17
Middle	22
Poorer	22
Poorest	20
Remittance	
No	96
Yes	4
Experience of climate change events in the past 12 months	
No	43
Yes	57
Experience of drought in the past 12 months	
No	59
Yes	41
Experience of flood in the past 12 months	
No	86
Yes	14
Experience of storm surge in the past 12 months	
No	63
Yes	37
Experience of erratic rain in the past 12 months	
No	77
Yes	23
Farm size†	4.91 (9.24)
Main source of farm information	
Farmer experience	21
Mass media	4
Local community	62
External organizations	13
Source of farm power	
Manual	20

Animal	3
Tractor	77
Postharvest food loss†	3.02 (8.07)
Livestock rearing	
Yes	63
No	27
Total sample	**1,100**

†Mean reported for continuous variables; Standard deviation in ()

4.3.2 Bivariate results

Table 2 shows the findings from the bivariate regression analysis. We found that compared to households with no access to credit, those with access to both informal (OR = 1.80, $p \leq 0.01$) and formal (OR = 2.13, $p \leq 0.001$) sources of credit were significantly more likely to report good resilience to climate change events. At the individual level, we also found that households with primary farmers within the age categories of 45 to 59 (OR = 0.46, $p \leq 0.001$), and 60 and above (OR = 0.44, $p \leq 0.01$) were significantly less likely to report good resilience to climate change events compared to their counterparts in the 18 to 25 age category. Further, households of farmers who had only primary school education were significantly less likely (OR = 0.39, $p \leq 0.001$) to report good resilience to climate change events, relative to those who were informally educated. Also, households of primary farmers who were either married (OR = 0.53, $p \leq 0.001$) or widowed/divorced (OR = 0.31, $p \leq 0.001$) were also significantly less likely to report good resilience when compared to their single counterparts.

At the household level, other factors were also significantly associated with perceived resilience to climate change events. For instance, compared to households with 1 to 4 members, those with 8 to11 members (OR = 1.87, $p \leq 0.001$) and at least 12 members (OR = 2.29, $p \leq$

0.001) were more likely to report good resilience to climate change events. Regarding wealth, it was households in the lower quintiles—poorer (OR = 2.02, $p \leq 0.001$) and poorest (OR = 6.70, $p \leq 0.001$), that were more likely to report good resilience compared to the richest households. In terms of the general experience of climate change events, we also found that households that were affected by an event in the past 12 months (OR = 0.39, $p \leq 0.001$) were significantly less likely to report good resilience than their counterparts that did not experience any event. However, when analyzing different climatic change events, there were notable differences. For instance, we found that households that experienced drought in the past 12 months (OR = 2.50, $p \leq 0.001$) were more likely to report good resilience compared to households that did not experience drought. Similarly, households that experienced floods in the past 12 months (OR = 7.97, $p \leq 0.001$) were more likely to report good resilience compared to households that did not experience floods. Also, households that experienced a storm surge in the past 12 months (OR = 2.04, $p \leq 0.001$) were also more likely to report good resilience compared to households that did not experience storm surges. In contrast, households that experienced erratic rain in the past 12 months (OR = 0.69, $p \leq 0.01$) were less likely to report good resilience than their counterparts that did not experience erratic rain.

Similarly, some agricultural factors were also significantly associated with perceived resilience to climate change events. For example, compared to households relying on the primary farmer's personal experience for farm information, households that depended on the local community for farming information were more likely (OR = 2.98, $p \leq 0.001$) to report good resilience. Conversely, households that relied on external organizations had a lesser likelihood (OR = 0.10, $p \leq 0.001$) of reporting good resilience. Also, households that prepared farmlands either animal power (OR = 0.22, $p \leq 0.001$) or employing tractor services (OR = 0.24, $p \leq 0.001$)

were less likely to report good resilience compared to households that manually prepared their lands. Additionally, postharvest food loss was associated (OR = 1.22, $p \leq 0.001$) with higher odds of reporting good resilience.

Table 4.2: Bivariate logistic regression results of predicting perceived resilience

Variable	Odds ratio (SE)	[95% Conf. Interval]
Credit source (Ref: No credit)		
Informal sources	1.80 (0.34) **	1.239—2.611
Formal sources	2.13 (0.26) ***	1.678—2.714
Age (Ref: 18-25)		
26-35	0.80 (0.19)	0.495—1.290
36-45	1.01(0.23)	0.643—1.591
46-59	0.46(0.11) ***	0.293—0.731
60+	0.44 (0.13) **	0.246—0.805
Gender (Ref: Male)		
Female	1.20 (0.14)	0.965—1.502
Education (Ref: Informal)		
Primary	0.39 (0.06) ***	0.284—0.523
Secondary	0.78(0.14)	0.550—1.111
Tertiary	0.69(0.19)	0.404—1.165
Marital status (Ref: Single)		
Married	0.53(0.10) ***	0.364—0.776
Widowed/Divorced	0.31(0.09) ***	0.174—0.548
Household size (Ref: 1-4)		
5-7	1.30 (0.21)	0.941—1.791
8-11	1.87 (0.34) ***	1.317—2.659
Above 12	2.29 (0.51) ***	1.482—3.539
Decision making (Ref: Male household head only)		
Joint household members	1.37 (0.23)	0.991—1.907
Female household head only	0.87 (0.17)	0.587—1.291
Wealth (Ref: Richest)		
Richer	1.07 (0.20)	0.743—1.545
Middle	1.06 (0.19)	0.752—1.506
Poorer	2.02 (0.36) ***	1.424—2.863
Poorest	6.70 (1.38) ***	4.473—10.036
Remittance (Ref: No)		
Yes	0.88 (0.24)	0.520—1.492

Experience of climatic events in the past 12 months (Ref: No)		
Yes	0.39 (0.04) ***	0.308—0.486
Experience of drought in the past 12 months (Ref: No)		
Yes	2.50 (0.29) ***	1.988—3.132
Experience of flood in the past 12 months (Ref: No)		
Yes	7.97 (1.77) ***	5.154—12.332
Experience of storm surge in the past 12 months (Ref: No)		
Yes	2.04 (0.24) ***	1.623—2.558
Experience of erratic rain in the past 12 months (Ref: No)		
Yes	0.69 (0.08) **	0.543—0.869
Farm size†	0.99 (0.01)	0.966—1.010
Main source of farm information (Ref: Farmer experience)		
Mass media	1.72 (0.60)	0.865—3.425
Local community	2.98 (0.45) ***	2.212—4.017
External organizations	0.10 (0.02) ***	0.058—0.161
Source of farm power (Ref: Manual)		
Animal	0.22 (0.08) ***	0.104—0.468
Tractor	0.24 (0.04) ***	0.173—0.337
Postharvest food loss†	1.22 (0.02) ***	1.176—1.275
Livestock rearing (Ref: Yes)		
No	1.06 (0.124)	0.844—1.334

Significance: *** p ≤ 0.001, ** p ≤ 0.01, * p ≤ 0.05 SE: Standard Error, †: Continuous variables

4.3.3 Multivariate results

Table 3 shows findings from multivariate analysis. After adjusting for individual-level factors in model 1, households with access to both informal (OR = 1.83, p ≤ 0.01) and formal (OR = 1.88, p ≤ 0.001) sources of credit were more likely to report good resilience, compared to their counterparts with no access. This association is reiterated in the post-estimation marginal effects plot in fig.2. After adjusting for household level factors, the odds as well as the strength of the association between informal credit and resilience attenuated, while that of formal credit became

insignificant. Only households with access to informal credit (OR = 1.59, $p \leq 0.05$) were more likely to report good resilience, compared to their counterparts with no access. In model 3, after adjusting for agricultural factors the results remained significant and similar to that of model 2 albeit there were notable odd increments. Similarly, only households with access to informal credit (OR = 1.73, $p \leq 0.05$) were more likely to report good resilience, compared to their counterparts with no access. The changes in the odds between model and model 2 were also captured in fig. 2 and fig.3. The graph highlights that among households that reported their climate change resilience as good, those that had access to informal sources of credit had that highest predicted probability of having good resilience relative to no credit and informal sources.

Table 4.3: Multivariate logistic regression results of predicting perceived resilience

	Model 1		Model 2		Model 3	
	Odds ratio (SE)	**CI**	**Odds ratio (SE)**	**CI**	**Odds ratio (SE)**	**CI**
Credit source (Ref: No credit)						
Informal sources	1.83 (0.36) **	1.248—2.694	1.59 (0.34) *	1.042—2.423	1.73 (0.44) *	1.053—2.851
Formal sources	1.88 (0.26) ***	1.441—2.466	1.23 (0.21)	0.883—1.726	1.15 (0.23)	0.783—1.695
Age (Ref: 18-25)						
26-35	0.91 (0.26)	0.521—1.579	0.83 (0.24)	0.467—1.463	0.61 (0.20)	0.316—1.161
36-45	0.98 (0.29)	0.550—1.757	0.90 (0.28)	0.494—1.645	0.71 (0.25)	0.361—1.407
46-59	0.45 (0.13) **	0.249—0.811	0.50 (0.15) *	0.271—0.919	0.51 (0.18)	0.253—1.017
60+	0.50 (0.18)	0.242—1.020	0.61 (0.23)	0.290—1.286	0.80 (0.34)	0.349—1.854
Gender (Ref: Male)						
Female	1.05 (0.135)	0.819—1.355	1.19 (0.17)	0.897—1.589	1.11 (0.18)	0.807—1.541
Education (Ref: Informal)						
Primary	0.331(0.06) ***	0.237—0.462	0.58 (0.11) **	0.403—0.830	0.70 (0.15)	0.462—1.058
Secondary	0.49 (0.10) ***	0.324—0.733	0.75 (0.17)	0.485—1.162	0.86 (0.21)	0.530—1.406
Tertiary	0.48 (0.14) *	0.272—0.850	0.78 (0.25)	0.414—1.465	0.73 (0.26)	0.367—1.451
Marital status (Ref: Single)						
Married	0.41 (0.10) ***	0.253—0.664	0.39 (0.10) ***	0.239—0.652	0.85 (0.25)	0.476—1.527
Widowed/Divorced	0.29 (0.10) ***	0.142—0.577	0.28 (0.11) **	0.126—0.622	0.55 (0.25)	0.223—1.350
Household size (Ref: 1-4)						
5-7			1.02 (0.19)	0.711—1.479	0.73 (0.16)	0.472—1.133
8-11			0.92 (0.20)	0.607—1.408	0.72 (0.18)	0.436—1.181
Above 12			0.97 (0.27)	0.566—1.671	0.64 (0.22)	0.334—1.246
Decision making (Ref: Male household head only)						
Joint household members			0.72 (0.15)	0.483—1.085	1.26 (0.30)	0.785—2.026
Female household head only			1.33 (0.35)	0.792—2.243	0.81 (0.25)	0.449—1.476
Wealth (Ref: Richest)						

Richer	1.10 (0.23)	0.733—1.654	1.13 (0.26)	0.718—1.795
Middle	1.14 (0.23)	0.772—1.690	1.56 (0.41)	0.938—2.610
Poorer	2.08 (0.44) ***	1.380—3.144	2.66 (0.78) ***	1.501—4.723
Poorest	5.34 (1.30) ***	3.309—8.607	5.35 (1.76) ***	2.805—10.196
Remittance (Ref: No)				
Yes	2.08 (0.64) *	1.140—3.787	3.26 (1.13) ***	1.653—6.429
Experience of climatic events in the past 12 months (Ref: No)				
Yes	0.29 (0.13) **	0.121—0.696	0.24 (0.13) **	0.081—0.688
Experience of drought (Ref: No)				
Yes	2.48 (1.32)	0.871—7.059	3.57 (2.30) *	1.008—12.636
Experience of flood (Ref: No)				
Yes	3.17 (0.87) ***	1.848—5.430	2.42 (0.70) **	1.373—4.284
Experience of storm surge (Ref: No)				
Yes	2.21 (0.98)	0.926—5.297	1.29 (0.64)	0.490—3.417
Experience of erratic rain (Ref: No)				
Yes	0.04 (0.02) ***	0.020—0.088	0.04 (0.02) ***	0.018—0.088
Farm size†			0.94 (0.04)	0.870—1.014
Main source of farm information (Ref: Farmer experience)				
Mass media			3.59 (1.43) ***	1.650—7.833
Local community			3.41 (0.76) ***	2.208—5.274
External organizations			0.16 (0.05) ***	0.087—0.298
Source of farm power (Ref: Manual)				
Animal			0.33 (0.19)	0.109—1.016
Tractor			0.42 (0.10) ***	0.264—0.667
Postharvest food loss†			1.22 (0.03) ***	1.160—1.286
Livestock rearing (Ref: Yes)				
No			2.00 (0.41) ***	1.340—2.996
Observations				1,100
LR chi2 (26)				819.06
Prob > chi2				0.0000

Pseudo R2	0.3554
Log-likelihood	-742.85217

Significance codes: *** p ≤ 0.001, ** p ≤ 0.01, '*' p ≤ 0.05 SE: Standard Error; †: Continuous variables

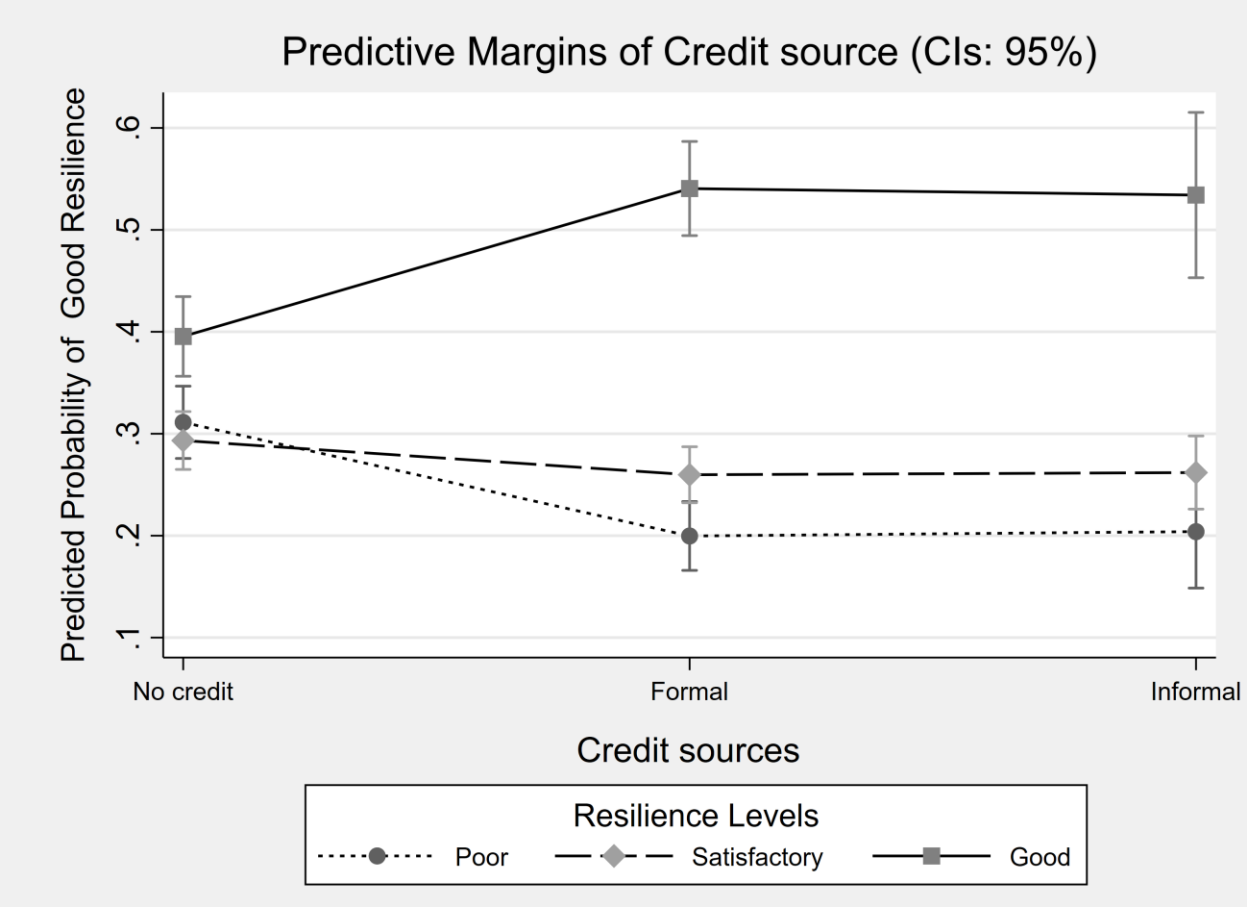

Figure 4.1: Predicted probabilities of perceived resilience and credit source (95% CIs) in model 1 after adjusted for the effect individual level factors

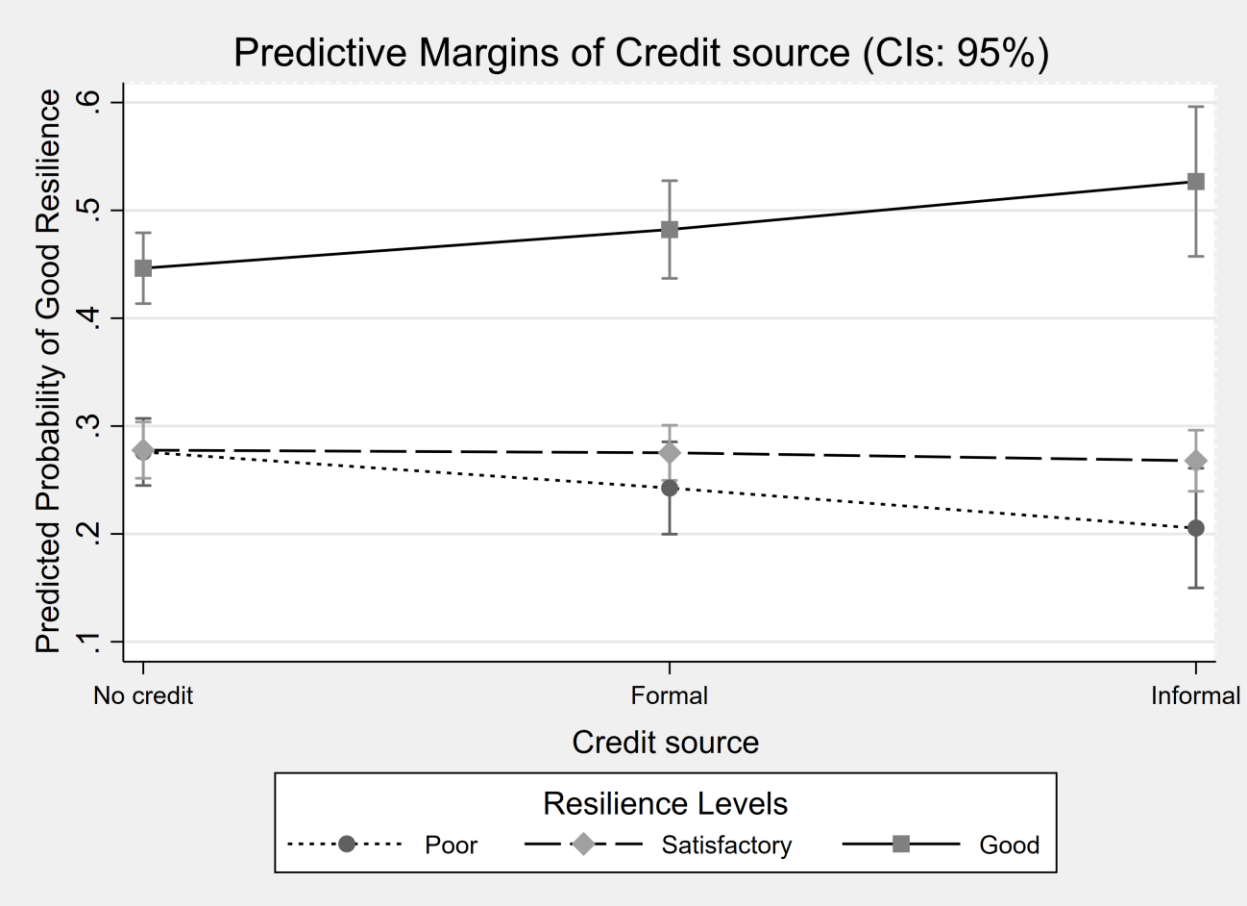

Figure 4.2: Predicted probabilities of perceived resilience and credit source (95% CIs) in model 2 after adjusted for the effect household level factors.

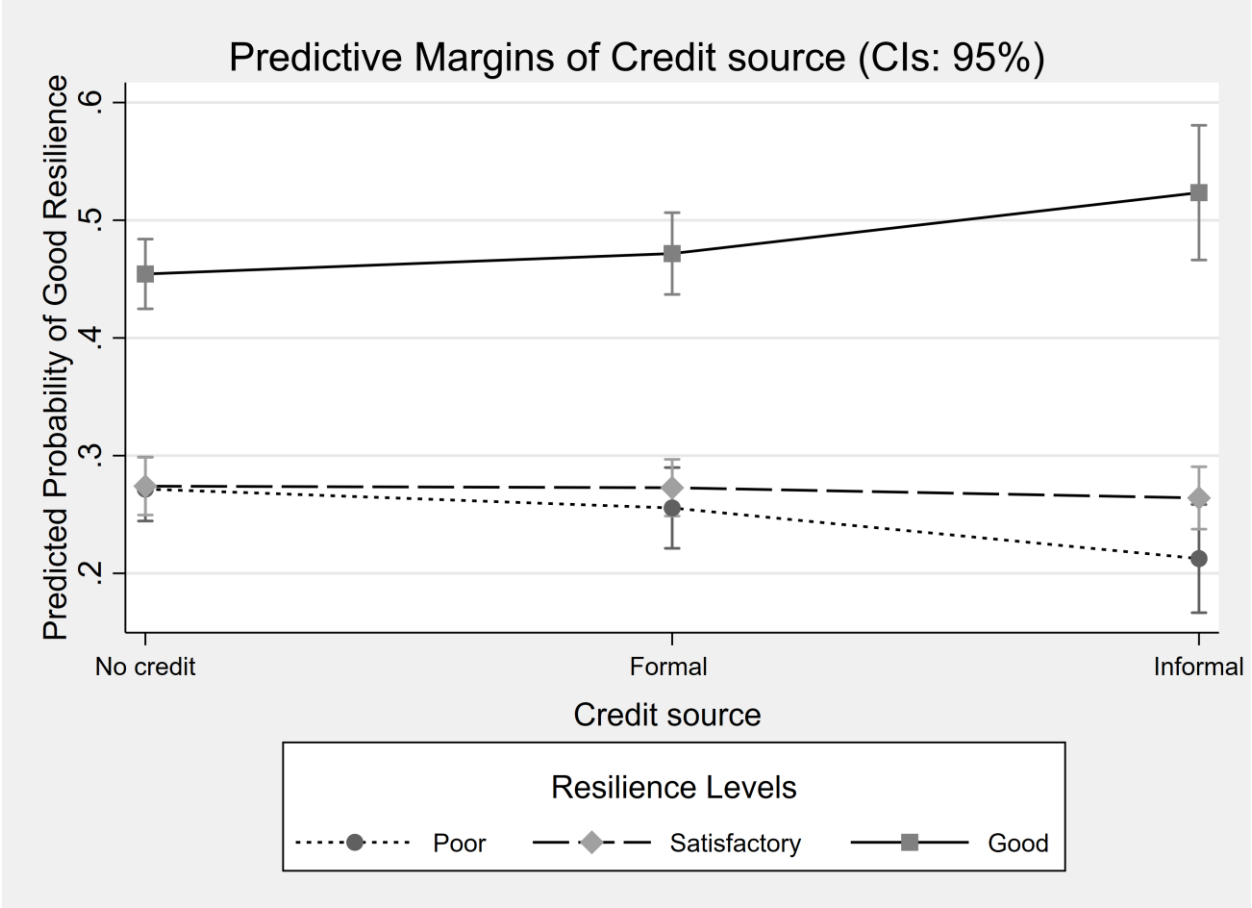

Figure 4.3: Predicted probabilities of perceived resilience and credit source (95% CIs) in model 3 after adjusted for the effect of agriculture-related factors.

In addition to source of credit, some covariates were also significant predictors of climate change resilience at the multivariate level. Overall, these associations were largely consistent with the bivariate analysis. For example, at the household level, we found that wealth-wise, households in the lower quintiles—poorer (OR = 2.66, $p \leq 0.001$) and poorest (OR = 5.35, $p \leq 0.001$), were more likely to report good resilience when compared to the richest households. The effect of wealth at the multivariate level was similar to the bivariate, although there was an increase and decrease in the odds for poorer and poorest quintiles respectively. Similarly, the experience of climatic events in the past 12 months was also significant. Households that experienced a climatic

event in the past 12 months (OR = 0.24, $p \leq 0.001$) remained less likely than their counterparts that did not experience any event, to report good resilience. This result was also similar at the bivariate level albeit with a reduction in the odds and strength of association. In the analyses of specific climate events, we found that households that experience drought were still more likely (OR = 3.57, $p \leq 0.05$) to report good resilience than those who did not experience drought.

Despite significant reductions in both the odds and significance at the multivariate level, households that experienced floods (OR = 2.24, $p \leq 0.05$) remained more likely to report good resilience compared to households that did not experience floods. Households that experienced erratic rain (OR = 0.04, $p \leq 0.001$) were still less likely to report good resilience than their counterparts that did not experience it. Although the effect of erratic rain was similar to results at the bivariate level, there was a notable odd reduction and an increase in the significance. Remittance, which was insignificant at the bivariate level became a significant predictor at the multivariate level. We also found that compared to households that did not receive remittances, those that received remittances (OR = 3.26, $p \leq 0.001$) were more likely to report good resilience to climate change events.

All agriculture-related factors but farm size, were significant predictors at the multivariate level. The results were largely consistent with the bivariate analysis. The study revealed that compared to households that relied on the experience of primary farmers as a source of farm information, those that relied on mass media (OR = 3.59, $p \leq 0.001$) and their local communities (OR = 3.41, $p \leq 0.001$) had significantly higher odds of reporting good resilience to climate change events. However, households that relied on external organizations had lower odds of reporting good resilience. Further, compared to households who prepare their farmlands manually, only those that used tractors for preparation were (OR = 0.42, $p \leq 0.001$) were less likely to report

good resilience. The effect of postharvest food loss (OR = 1.22, $p \leq 0.001$) remained unchanged from the bivariate analysis. Unlike the bivariate result, livestock rearing was significantly associated with resilience at the multivariate level as households that did not rear any livestock (OR = 2.00, $p \leq 0.001$) were surprisingly more likely to report a good resilience than their counterparts that reared livestock.

4.4 Discussion

This study examined the relationship between smallholder farmers' access to credit and perceived climate change resilience in Ghana. The study contributes to the growing body of literature on the role of credit access in climate change resilience. In line with the findings of other authors (Chandio et al., 2018; Khandker, 2005), our findings demonstrate that credit is an important factor for building smallholder resilience. This finding is not surprising considering the relatively higher poverty rates in this area. Beyond the general relationship between credit and resilience in this context, our findings further highlight some nuances associated with the sources of credit. For instance, households with access to informal credit were more likely to report good climate resilience.

There are several potential explanations for our findings. Improving credit access for smallholder farmers through formal sources has gained prominence among several stakeholders including national governments and international communities (World Bank, 2015). This new agricultural financialization paradigm has largely refocused credit provision mainly through private and formal financial institutions (Brune et al., 2016). Yet, studies in this context have highlighted the fact that the entry of private sector companies into the formal credit sector has created avenues for profit making. Within the agricultural financialization literature, some proponents (see Clapp and Isakson 2018; Krippner, 2011) have criticized this new relation with the argument

that, the current state of agricultural finance has reinforced existing lines of stratification by disproportionately affecting some subgroups within the broad categories of 'winners' and 'losers'. Despite the critiques, agricultural financialization through formal credit institutions is very widespread in SSA. In Ghana, this is evidenced by the MoFA's 'Food and Agriculture Sector Development Policy II' objective of promoting the integration of smallholder farmers into both local and international markets; and the government's establishment of institutions such as the Agricultural Development Bank to meet the banking needs of the agricultural sector (Abu & Haruna, 2017). However, increasing evidence suggests the intended results of agricultural investments through formal institutions are frequently unrealized (Kuwornu 2012; Saqib et al. 2018). Concerns of high-interest rates, skewed spatial distribution, credit rationing, and stringent repayment conditions which are mostly inconsistent with the local agricultural cycles constitute some central drawbacks in the efficiency of formal credit sources (Asante-Addo et al., 2017). With the study area's increasing rainfall irregularity, this situation can worsen for farmers who may be incapable of enduring the combined effects of crop failure and rigid repayment schedules. In some extreme cases, there is evidence of some farmers resorting to suicides following extreme crop failures (Adinkrah 2012).

Due to some of these negative characteristics of formal credit institutions, alongside the need to sustain and propel their agrarian livelihoods, there is evidence suggesting a significant transitioning of smallholders from formal to informal credit sources in recent times (Akudugu, 2016). For instance, Sekyi et al. (2019) revealed that farmers in rural Ghana with access to informal credit outperformed their counterparts without credit access in terms of yield. In earlier studies, the findings of Khandker (2005) and Mknelly and Dunford (1999) were consistent in rural Bangladesh and Ghana respectively. Most rural folks may be drawn to informal credits because

of the better experience they offer in key areas that formal credit is lacking—accessibility, dependability, flexibility and adaptability (Burkett 1988). Regarding accessibility for instance, informal sources are usually within close proximity since lenders or local groups are usually situated within communities which helps in quick access of funds. The 'timeliness' component of informal sources is very crucial for the poor because even the modest positive changes in purchasing power can have large consequences and spur significant output (Flory, 2018). Additionally, a close proximity also translates to low transactional costs which is a necessary requirement for an already deprived context such as the study area (Saqib et al., 2017). Additionally, informal credit sources have relatively flexible terms and conditions associated with loan acquisition. On the contrary, formal sources are often reluctant to lend to smallholder farmers due to a perception of them as 'risky customers' who may not be able to repay loans (Adegbite et al., 2017). In informal settings however, especially within local saving groups, members have a sense of shared vulnerability and are willing to help each other. In Senegal for example, Fadiga and Fadiga-Stewart (2004) report similar findings from their study on Collective Action and Informal Financial Institutions where they found that in rural areas where group saving systems were practiced, the members were able to navigate farming problems in a timely manner. Another vital characteristic of informal credit sources that may help explain our finding is also its relatively flexible collateral demands and methods of repayment (Nagarajan & Meyer, 2005). In some cases of informal transactions, cash given to borrowers are transformed into other payment forms such as food crops or future farm labor. For instance, Schindler (2010) found that in northern Ghana, smallholder farmers and traders had a symbiotic relationship where loans procured for farming were repaid with crop produce. Unlike the formal credit sources, this process is usually devoid of any substantial collateral demands, bureaucratic processes and long

wait periods (Schindler, 2010), and therefore plays a key role in sustaining the livelihood of smallholder households, and the community at large.

Our finding whereby relatively poorer households were more likely to report good resilience is similar to work in China by Zhai et al. (2018) who found a negative relationship between household income and adoption of climate change adaptation strategies. With increasing climate change effects on agriculture, richer farmers were likely focusing on non-agricultural ventures to the neglect of their farms. Nevertheless, poorer farmers, who may have little to non-existent livelihood alternatives, focus on better adapting their farming practices. Similarly, Collier and Dercon (2014) argue that poor farmers are more likely to resort to cultivating on smaller-sized farms on which they can concentrate their efforts in terms of farm management to improve crop production, which may then be indicative of their resilience to climatic impacts.

As established in the climate change adaptation and adaptation literature (Luginaah et al., 2009; Musah-Surugu et al., 2018), we found that households that received remittance were more likely to report a good resilience to climatic events. Remittance—both financial and in-kind (food)—has been highlighted to be a key driver of household wellbeing, in rural agrarian communities across SSA (Couharde & Generoso, 2015). Other scholars have reported a positive relationship between remittance and climate resilience of poorer households. Indeed, Betzold (2015) has even indicated that for decades, many households have primarily relied on remittances for survival during episodes of extreme environmental disturbances. Couharde and Generoso (2015) have made similar assertions that the survival of most agrarian communities in Mali during the great drought in the mid-1980s, was hinged on remittances. In Ghana, Musah-Surugu et al. (2018) categorize remittances as a complementary resource for financing climate change adaptation in deprived areas like the semi-arid north because of the significant contribution to

household provisioning. Their study revealed that monetary remittances were directed towards crucial household needs such as infrastructure, consumption, and in some instances, for anticipatory investments for climatic events. Indeed several studies by the new economics of labor migration (NELM) have reinforced the narrative that remittance is a key pathway to improve environmental risk management (Lucas & Stark, 1985).

We also found that households that experienced at least one climatic event within the last 12 months before the study were less likely to report good resilience. The Fifth Assessment Report of the IPCC has indicated an increase in the frequency and intensity of extreme climatic events globally (IPCC, 2019). Although the occurrence of these extreme weather events poses adverse effects on especially rural livelihoods, contextually, some events play critical roles than others. Rainfall is one of the key factors in sustaining the livelihoods of farmers in rural areas worldwide (Afifi et al., 2016). For instance, Alemayehu and Bewket (2016) argue that rainfall variability is the most important determinant of crop growth in the tropics. In poor contexts like the study area, the significance of rainfall cannot be understated. Because agriculture is largely rainfed, rainfall unpredictability constitutes a direct livelihood threat and increases the vulnerability of households to farm-related unemployment and food security (Arndt et al., 2015). In the study of Rademacher-Schulz et al. (2014) in Northern Ghana, they reveale that the dominant complaint of smallholders was rainfall variability which resulted in crop yield decline, livestock mortality and increasing food prices. Other studies have also attributed the increased pattern of out-migration of smallholder farmers in the region to rainfall variability (Afifi et al., 2016; Luginaah et al., 2009; Rademacher-Schulz et al., 2014).

In sync with the diversification literature on rural communities like the UWR, one will have the presumption that livestock rearing will aid in livelihood diversification and thus resilience

building (Mohammed et al., 2021). However, we found the contrary. Households that did not rear livestock were more likely to be resilient compared to those that reared livestock. The finding aligns with the argument of Antwi-Agyei et al. (2014) that given a particular context, some livelihood diversification strategies in climate change adaptation can be considered a 'two-edged sword'. Although farmers are generally faced with some degree of agricultural failure, this often comes as an increased burden for households with livestock as finding feed for livestock is often a difficult endeavor (Rademacher-Schulz et al., 2014). Feeding livestock adequately will require the redirection of crucial household resources—whether crop produce or income to buy feed—which can further increase the vulnerability of households to climatic events.

Households that reported getting their farm information from their local communities and the local media were more likely to report good resilience. Local communities of smallholder farmers are ideal spaces that foster social networking and interaction among members, and also therefore tend to be spaces where farmers can acquire knowledge about novel innovations and adaptive strategies (Kansanga et al., 2020). Mass media also plays a critical role in providing information to smallholders on climate change and adaptation processes of rural communities. In fact there is evidence that mass media creates awareness and knowledge of climate change in a cheap and accessible way, and influences attitudes toward environmentally friendly livelihoods (e.g. Junsheng et al., 2019; Hassan et al., 2010). Further, mass media has contextually relevant characteristics such as offering services in different languages which makes it an important tool in bridging language barriers. Despite the importance of external organizations and extension services in the dissemination of agricultural information, the study found a negative association with good resilience. In this context, even though extension services have been historically long-standing, they have been under-resourced and dysfunctional at best (Anang et al., 2020). Additionally, this finding

may be because external organizations usually offer services via irregular field visits and hence, may not be available to provide timely information when it is most needed.

The study also highlighted that households that used manual tools for farmland preparation were associated with higher odds of reporting good climate change resilience in comparison to households using tractors. Agricultural mechanization has gained traction among policymakers and smallholder farmers in an attempt to replicate the benefits of the green revolution (Fonteh, 2010). However, there is also evidence suggesting that mechanization may have some deleterious effect on the food security of smallholder households (Kansanga et al. 2020). For instance, Kansanga et al.'s (2020) study in northern Ghana revealed that tractor use aggravates environmental degradation and deteriorates vital livelihood resources like shea trees, which women rely upon to support household food provisioning. Kansanga et al. (2020) further highlight that tractorization may have also 'shrinked the food basket' by partly re-orienting agriculture toward a monoculture to fulfill the demands of the market. Invariably, this compromises household food and nutritional security. Additionally, Swennen (1990) also argues that farmlands that are cultivated with minimal disturbance to soil attend to maintain both their ecological and nutrient integrity. Although tractorization has re-invented the farming process for the most part, in some contexts it reverses some of its intended benefits.

4.5 Study Limitations

Despite the significance of the findings of this study, there may be underlying limitations. The study was restricted to semi-arid northern Ghana hence, limits the extent of generalizability. Additionally, because resilience was self-reported, there is a possibility of different responses to the same climatic events. Further, there is the potential for recall bias especially that resilience was assessed for the past 12 months prior to the survey. That notwithstanding, this study

contributes to the literature on smallholder farmers' climate change resilience . It highlights the important role informal credit sources play in building resilience to climate change.

4.6 Conclusions

The study indicates that informal credit sources have the potential to improve smallholder farmer resilience. At the same time, both local and global climate change projections indicate a worsening scenario that correlates with the increasing vulnerability of the rural poor who are already in the most need of risk management and resilience building. Therefore, informal credit presents another pathway toward resilience-building if its potential can be harnessed. This study calls for a renewed focus on the informal finance sector to ensure an expansive and efficient delivery of financial credit for smallholders. Through the digitization of informal credit sources, they can be linked to established formal sources suck as banks to bridge the spatial disparity as exemplified in rural India (Nagarajan & Meyer, 2005). Also, stakeholders must re-tailor banking practices to the needs of farmers including lower interest rates, reasonable repayment schedules, and collateral agreements should be implemented.

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CHAPTER 5

5. INTRA-HOUSEHOLD DECISION-MAKING AND PERCEIVED CLIMATE CHANGE RESILIENCE AMONG SMALLHOLDER FARMERS IN SEMI-ARID NORTHERN GHANA

Abstract

Climate change vulnerability remains a major challenge for smallholder farmers. There is consensus that the climate resilience of smallholder farming households could be enhanced if agricultural decision-making incorporates the perspectives of all household members. Yet in smallholder farming communities such as northern Ghana, deep-seated socio-cultural and intra-household structures continue to influence joint decision-making. Although smallholder climate resilience has received enormous research attention, the role of household decision-making arrangements on climate resilience remains underexplored. Using cross-sectional data (n = 1100) from the Upper West Region of Ghana (UWR), we examined the relationship between smallholder household decision-making arrangements and their perceived resilience to climate change impacts. Findings from regression analysis indicate that households practicing joint decision-making were more likely (OR=3.74, p≤0.001) to report good resilience compared to households with only male head decision-makers. Moderately food insecure (OR=3.45, p≤0.001) households were also more likely to report good resilience. In contrast, households with primary farmers aged between 46 to 59 (OR=0.36, p≤0.05) and formally educated (OR=0.47, p≤0.01) were less likely to report good resilience. In a context with age-long sociocultural beliefs and

practices, our findings highlight the importance of joint decision-making in climate change resilience initiatives, and the need for practical programs that are aimed at encouraging intra-household decision-making toward climate change resilience.

Keywords: Climate change resilience; household decision-making; smallholder farmers; UWR

5.1 Introduction

Climate change is a major driver of food insecurity in the Global South, particularly for smallholder farmers in semi-arid rural settings. Given that smallholder farming is predominantly rainfed, rural farming households are particularly exposed to the growing effects of climate change. At the same time, underlying poverty undermines the capacity of already poor smallholder farming households to anticipate, cope with, and recover from climatic events such as droughts and floods (Hallegatte et al 2018). This puts smallholder farming households—especially those in semi-arid contexts—in the greatest need of climate change adaptative strategies, in order to build their resilience (Adenle et al., 2017; Harvey et al., 2014). Climate change adaptation is the shifts in natural and human systems in response to experienced or expected climatic stimuli or their effects, to moderate harm or exploit beneficial opportunities (Intergovernmental Panel on Climate Change [IPCC] 2019). In spite of global initiatives aimed at improving climate change adaptation and resilience, a key issue militating against this agenda in smallholder farming households is the lack of participation of other household members, especially women, in climate change adaptation decision-making, due to pervasive gender inequalities (Ampaire et al. 2020; Schwerhoff and Konte 2020).

Generally, activities surrounding climate change adaptation are embedded in broader socio-economic, cultural and political structures, including gender norms, collective decision-

making and resource access arrangements (Adzawla and Baumüller 2020; Carr and Thompson 2014; Clay and King 2019). In fact, there is widespread consensus that the climate change resilience of smallholder farming households can be enhanced if agricultural decision-making incorporates the perspectives of all stakeholders within the household (Carr and Thompson 2014; Gumucio et al. 2020). Nonetheless, in most smallholder farming communities in northern Ghana, longstanding structural norms support the patriarchal household models whereby male household heads make decisions about agriculture regarding what to plant, what methods to use in cultivation and how the proceeds from the farm are used (Ahmed et al., 2016; Tsige et al., 2020). These structural hierarchies mostly exclude women and the youth from partaking in household decision-making about agriculture and thus, undermining their capacity to contribute to household climate change adaptative strategies (Schwerhoff and Konte 2020). This is despite growing evidence that women and men have diverse and potentially mutually reinforcing knowledge base on how to address climate change and other environmental problems (Djoudi and Brockhaus 2011; Ravera et al. 2016).

In most local communities across SSA and Ghana, women have a rich knowledge of the environment and changing climate through their culturally ascribed traditional conjugal roles, such as the sourcing of water and growing seasonal food crops for household consumption (Apusigah, 2009; Sachs, 2018). Women therefore have rich knowledge about climate events including precipitation and drainage dynamics, which, when combined with men's knowledge, could improve agricultural decision-making at the household level particularly with respect to determining optimal location of farms and the types of crops to plan. Thus, in households where climate adaptation decisions are made by only the male family head, a significant portion of the valuable knowledge base of the household is left untapped. This can undermine the effectiveness

of climate change adaptation decision-making and ultimately, the resilience of the household to climate shocks. Additionally, these unitary decisions do not comprehensively reflect the interest and needs of all stakeholders, especially women, who play crucial roles in household sustenance (Carr and Thompson 2014).

Despite the presence of culturally defined gender roles, both societal and household relations have also evolved which has produced new social structures that coexist with traditional ones. For instance, the calls for women's empowerment and transformative gender relations to kick start a new development paradigm constitute some of the key periods of recent societal change (Cornwall, 2016). These notions of providing equal opportunities for men and women have featured heavily in contemporary policies and have been deemed crucial for achieving global food security and other development goals set by leading experts such as the World Bank and the Food and Agricultural Organization. Focal areas of this agenda include maternal and child health, household nutrition, poverty alleviation, education, and improving investments in human capital. Positive benefits of women's empowerment in these areas have already been well documented (Zereyesus, 2017). As a result, several interventions have targeted women as their main beneficiaries (Tsiboe et al., 2018). Other related policies have also created a platform for women to form associations for discussing pressing issues. In agrarian settings, women also tend to dominate some activities such as shea production to generate additional income. Research in northern Ghana also shows that leisure and autonomy for food crop production have notably increased slightly for women (Tsiboe et al., 2018). The increasing number of female-headed households in the study area also bears testament to these social changes.

Amid the growing need for studies to examine the impact of joint agricultural decision-making toward climate change resilience, this study contributes to the literature by examining

the association between household decision-making arrangements and climate change resilience among smallholder farmers in northern Ghana. We hypothesize that households practicing joint decision-making—involving the husband, wife and other adults in the household—are more likely to perceive their resilience as good when compared to households with other arrangements. This analysis casts light on the climate change resilience outcomes of households under diverse agricultural decision-making arrangements.

5.2 Materials and methods

5.2.1 Theoretical approach

This study is informed by theoretical developments in socio-ecological resilience and Agarwal's (1997) intrahousehold bargaining approach. Following the devastating effects of the 2011 famine in the Horn of Africa, the concept of resilience re-emerged among researchers studying socio-ecological systems (Béné et al. 2012). This resilience turn not only sparked enormous conversations on the root causes of environmental issues but also highlighted several conceptual debates (Cutter, 2016). Earlier deployment of the term largely viewed it as an element of persistence and the ability of individuals and groups to anticipate, cope with and recover from shocks (Holling, 1973). This conceptualization focuses on the biophysical structure of a system, and research from this perspective prioritizes the identification of objective measures of the constituents that are causally related to resilience, often focusing analysis on broader geographical scales (Darnhofer et al., 2016). This ecological/apolitical framing of resilience has been argued to obscure the role socio-economic and political systems such as household gender relations play in shaping the resilience outcomes of individuals and groups in any given context (Folke, 2006; Weichselgartner and Kelman 2015). Similarly, Watts (2015) also argues that, although the concept of resiliency has a seemingly attached promise of delivering all sorts of benefits, reaping

them is very dependent on the availability of relevant themes of analysis—power, agency, resource access and control—which are, unfortunately usually ignored. Duit et al. (2010) comprehensively summarize the inadequacy of ecological resilience by stating that:

> Resilience is a cumbersome concept for social science… It is difficult to avoid clashes with cornerstone concepts such as power, democracy and the right to self-determination when attempting to apply the concept of resilience to politics and governance. The reason for this is quite straightforward… societies and ecosystems are… fundamentally different. (p. 365)

Recognizing the constraining roles of the ecological conceptualization, a socio-ecological dimension of resilience emerged with an emphasis on the roles of social structures, agency and power relations, and how they shape the manner in which social actors decide on ways to address environmental shocks and the approaches they prioritize in addressing them (Cinner & Barnes 2019; Folke et al. 2016). A key argument underpinning this re-emergence was that neglecting political influence and the power of agency was a dangerous endeavor as social systems across the globe are far from equal, considering their differing economic and political capabilities (MacKinnon and Derickson 2013). Along this transformational perspective of resilience, some scholars (Carr 2019; Darnhofer et al. 2016) have further called for a more relational theorization that move away from viewing resilience as a fixed asset, to reflect how it is constantly shaped by changing social dynamics and relations among social actors. Hence, the need for interrogating the climate change resilience of smallholder farmers from a relational perspective (Carr, 2019). Smallholder farmer resilience from a relational perspective therefore depends on how the relations characterizing actors in the farming household are constituted both historically and contemporarily; and how these relations facilitate or constrain varying agricultural responses and outcomes amid prevailing ecological conditions (Darnhofer et al., 2016).

Drawing on this relational perspective, we characterize resilience as an outcome of the constantly evolving relations between social actors within the farming household in the context of ecological constraints (drought, floods, pests, rainfall variability). Thus, the resilience of smallholders in semi-arid Northern Ghana can be conceptualized as a result of the relations between members in the household as shaped by underlying structures and ecological forces such as climate change, and the dynamism of these relations over time. In line with the observation of Davoudi et al. (2013), the resilience of smallholder farming households depends largely on the transformation of the socio-ecological structures—including changes in household decision-making arrangements—that characterize them.

Agarwal (1994) also conceptualizes intra-household interaction "as simultaneously containing elements of cooperation and conflict subject to constraints set by underlying structures such as gender norms" (p.51). Agarwal however notes that cooperation is not automatic nor egalitarian, but instead, household decisions depend largely on the relative bargaining power of the differently positioned household members (Agarwal 1997). This description contrasts the notion of the household as a unitary model where only a particular altruistic family member makes decisions solely on behalf of the household. Household decision-making about agriculture may therefore reflect cooperation where all household members participate and contribute to decision-making about agriculture or a unitary approach where a designated household member makes decisions for the household. Drawing from both conceptualizations, different approaches are possible in each context: sole decision-making by the male or female household head or other designated members on one hand, and joint decision-making by all adult household members on the hand. It is important to mention that the household may also move between these two main forms over time. From the theoretical

perspective that household decision-making is inherently transformational and characterized by unfolding relations between actors over time, we are able to explore how different household arrangements that have evolved in the context of smallholder farming, may shape the resilience of households to climate change while paying attention to other underlying socio-economic and ecological variables as well.

5.2.2 Study area

The Upper West Region (UWR) is located in the North-western corner of Ghana. It has a total of 11 administrative districts (Ghana Statistical Service [GSS] 2014). The region lies in the Guinea savannah belt and thus, associated with a uni-modal rainy season which only allows farmers to cultivate once a year (Asodina et al., 2020). This contrasts the bi-modal rainfall regime in the Southern part of the country where smallholder farmers can cultivate twice annually. This difference in rainfall patterns is very important for food production and food security and resilience in northern Ghana (Aryee et al., 2019). In the lean season, some farmers from northern Ghana migrate to the Southern areas to take advantage of the second farming season by working on shared cropping arrangements, or as wage laborers in order to remit food and money to their families (Luginaah et al., 2009). Average monthly temperature ranges from between 25°C to 40 °C, with higher temperatures experienced during March (GSS 2014). Unfavorable climatic conditions and protracted use of nutrient-deficient soils is hindering agricultural productivity of the region, although it is the livelihood and economic mainstay (Bellon et al. 2020). Smallholder agriculture employs between 80 percent of the population (Luginaah 2008). The region produces food crops such as millet, maize, yams and groundnuts. Additionally, some households are also actively engaged in rearing livestock, including cattle and ruminants (Ministry of Food and

Agriculture [MoFA] 2020). Shea production is also a major alternative livelihood activity for women (Kent, 2018) although increasing degradation is impeding its prospects (Kansanga et al., 2020). Other livelihood activities that employ a small percentage of the population include tourism, trading, transport services, weaving and handcrafts (Atuoye et al., 2019).

The UWR is also the least ranked in terms of several socio-economic indicators (Cooke et al. 2016). A vast majority (83.7 percent) of the population resides in rural areas, leaving only the small proportion of urban dwellers mainly concentrated in the regional capital which also serves as a financial hub. In fact, the UWR has had the highest levels of inequality nationwide since the 1990s (Cooke et al. 2016). Empirical studies also reveal the prevalence of food insecurity and poor health affecting both children and adults alike (Luginaah et al. 2009; Atuoye & Luginaah 2017). Poverty and illiteracy rates in UWR are also among the highest in the country (GSS, 2013). The vulnerability and poor socio-economic status of the UWR emanate largely from the cumulative effect of harsh climatic conditions of the changing climate, and also the reflections of incomprehensive colonial policy patterns in post-independence periods (Songsore 2011). Additionally, the implementation of the Structural Adjustment Programs in the 1980s also contributed to the neglect of vulnerable smallholders in northern (Songsore, 1983; Konadu-Agyemang 2000).

Although females constitute the majority (51.4 percent) of the population in this region, males still make up the majority of household heads (GSS, 2013). Customarily, household decision-making in the UWR is done by the male family head who per custom is the custodian of the family (Ahiale et al. 2020). Land ownership in this context is also the reserve of males, who not only determine the approaches of cultivation, but also the amount of family resources to invest into farming (Yaro 2010). However, given that these structural norms and the relations

they engender are not static but constantly negotiated and subject to change, household decision-making arrangements about agriculture and land use are gradually evolving with evidence of collective decision-making and women's increased participation in recent times (Michalscheck et al., 2020). This context provides an ideal opportunity to examine the associations between resilience and decision-making arrangements.

5.2.3 Data and Sampling

A cross-sectional survey was conducted between July and August 2019 in the UWR, with the assistance of six research assistants knowledgeable in research and fluent in the local dialects of the target districts. The survey covered the following themes: respondents and household demographics, socio-economic and agricultural-related dynamics. Ethical approval was granted by the Non-Medical Research Board of the University of Western Ontario.

The survey employed a multi-stage sampling approach. While a purposive sampling method was used in selecting the target districts, all communities were randomly selected for the survey. Beginning from the entry point of every community, every fifth house was then systematically selected for the survey. In each household, the primary farmer who was at least 18 years old responded to the survey on behalf of the household (O'Rourke and Blair 1983). We highlight that primary farmers were chosen as active lead farmers within households. Although it was possible to administer the survey to household heads, in this context, a household head may also be the oldest person in the house. Hence, household heads are typically the elderly who are agriculturally inactive and may not have first-hand information on household farming dynamics. To ensure a representative sample size was attained for each district, a sample size proportionate to the respective district population size was computed for each district. A total of 1100 smallholder farmers were successfully surveyed for the study.

5.2.4 Measures

The dependent variable for this analysis was 'perceived climate change resilience'[5]. The variable was derived from respondents' answers concerning climatic events they experienced within the last 12 months prior to the survey. During the survey, respondents were asked how they will rate their households' ability to handle flood, drought, and other climate-related stresses occurring in their environment. A three-category variable was subsequently constructed from their responses and coded as 0 if respondents perceived their household to be poorly resilience, 1 if they approximate their resilience as satisfactory, and 2 if respondents perceived their households had a good resilience to climatic events (0=poor; 1= satisfactory; 2=good). We followed other studies (see Jones & Tanner, 2017; Mohammed et al., 2021) to measure resilience from this subjective approach following the lack of comprehensive data for objective measures in this rural setting. From a benefit standpoint however, measuring resilience subjectively allows the study to capture the more abstract connotations of climate exposure and vulnerability which is crucial in climate risk assessments (Ludi et al., 2017).

The focal independent variable in this analysis was 'household decision-making arrangement'. The variable was derived from respondents' answers to the question on how they will describe the dominant decision-making arrangement within their households. Responses were coded as; (0 = male household head only; 1 = joint decision-making involving all household members; 2 = female household head only. Decision-making for the purpose of this study included

[5]Survey question from which the dependent variable was constructed:
'How would you rate your ability to handle flood/drought/erratic rain related stress?'
This question was asked after respondents identified that they had adopted diverse coping strategies to climate related stresses they had experienced in the past 12 months prior to the survey

decisions on agricultural practices and other relevant activities such as large household purchases, responsibility for education and health care costs and utilization of farm produce and proceeds.

Covariates constituting three unique blocks—individual, household and farm level factors—were sequentially adjusted in the analysis. Individual level factors include age (0 = 18 to 25; 1 = 26 to 35; 2 = 36 to 45; 3 = 46 to 59; 4 = above 60), gender (0 = male; 1 = female), education (0 = informal; 1 = primary; 2 = secondary; 3 = tertiary) and marital status (0 = single; 1 = married; 2 = widowed/divorced) of primary farmers. Household-level factors include credit access (0 = no credit, 1 = formal sources, 2 =informal sources), remittance receipt (0 = no; 1 = yes), household size (0 = 1 to 4; 1 = 5 to 7; 2 = 8 to 11; 3 = above 12), wealth (0 = richest;1 = richer; 2 = middle; 3 = poorer; 4 = poorest) and food security status (0 = food secure; 1= mildly food insecure; 2 = moderately food secure; 3 = severely food insecure). Farm level factors were farm size (continuous), farm power (0 = tractor; 1 = animal; 2 = manual), main source of farm information (0 = farmer experience; 1 = mass media; 2 = local community; 3 = external community), food storage (0 = sacks; 1 = granaries; 2 = open storage), postharvest food loss, cause of food loss (0 = other animals; 1 = pests/insects; 2 = rats/mice.; 3 = mold/spillage) and food treatment during storage (0 = chemicals; 1 = traditional methods).

5.2.5 Analytical approach

The association between climate resilience and intrahousehold decision-making arrangement was examined. Considering the fact that the dependent variable had three categories which were also ordered, we employed an ordinal logistic regression model to examine the relationship. Ordinal logistic regression is a statistical technique with a high utility in describing associations and testing hypothesis between dependent variable with more than two categories, and either a categorical

or continuous independent variables (Peng et al., 2002). All analyses were conducted in Stata 15.0. The equation for ordinal logistic regression is:

$$\log\left[\frac{P(Yij \leq 1)}{[1-P(Yij \leq 1)]}\right] = \propto_0 + \sum_{k=1}^{p-1} \propto_{jk} X_{ijk} + V_{ij'} C = 1, \ldots. \Omega - 1$$

Where $P(Yij \leq 1)$ is the probability of a certain event occurring (household reporting good resilience), $[1-P(Yij \leq 1)]$ is the probability of a certain event not occurring (a household not reporting good resilience), $\propto_{jk}$ is the coefficient term, X_{ijk} are the independent variables, $\propto_0$ and $\Omega - 1$ is the intercept term and Vij is the error term in the logistic model. Further, the maximum likelihood estimation procedure was used to estimate the odds ratios of the model (Akaike, 1998). An odds ratio less than '1' indicates a lower odd of reporting a good resilience. In contrast, an odds ratio greater than '1' represented a higher odds of reporting good resilience (Kleinbaum and Klein 2010).

Three levels of analysis were employed for this study. First, descriptive analysis was conducted to understand the sample characteristics. To explain the individual associations between the dependent variable and each independent variable, a bivariate ordinal logistic regression was then conducted. Lastly, three nested multivariate models were sequentially fitted to the data to understand the association between decision-making and climate resilience.

5.3 Results

5.3.1 Sample characteristics

Table 5.1 presents the descriptive statistics. Nearly half of the respondents (47 percent) perceived their household climate resilience as good. Most respondents were aged between 36 and 45 years (35 percent), married (82 percent), and were informally educated (67 percent). Most households on average had about 5 to 7 members. Overall, there were more men (52 percent) than women in the sample which reflected in the fact that the majority (75 percent) of households had males

as household heads. 54 percent of households lacked access to any credit sources. For those with access however, the majority (36 percent) relied on formal sources for financial credit. Additionally, only a very small proportion (4 percent) of the households received remittances as a diversification strategy. As well, more than half (75 percent) of the respondents reported that their households were food insecure. There was almost a non-existent wealth disparity between the households under study. Most households cultivated on about 4.91 hectares of farming land. Over two-thirds of households (77 percent) employed tractor services for land preparation. The majority of households (62 percent) also relied on local community support systems for their farming information. With regards to food storage practices, most households used sacks (86 percent) to store food while the remaining used granaries (7 percent) and open storages (7 percent). Furthermore, respondents also identified pests and insect attacks (69 percent) as the main cause of postharvest food loss, which was about 3 percent of farm produce on average. The majority of the respondents (55 percent) also utilized chemical treatments in the storages to preserve stored food.

Table 5.1: Sample characteristics of households surveyed in the Upper West Region

Variable	Percentages (%)
Resilience	
Poor	26
Satisfactory	27
Good	47
Decision-making	
Male household head only	75
Joint decision-making	16
Female household head only	9
Age	
18-25	8
26-35	20
36-45	35
46-59	31
60+	6
Gender	
Male	52
Female	48
Education	
Informal	67
Primary	17
Secondary	12
Tertiary	4
Marital status	
Single	12
Married	82
Widowed/Divorced	6
Credit source	
No credit	54
Informal sources	10
Formal sources	36
Remittance receipt	
No	96
Yes	4
Household size	
1-4	16
5-7	45

8-11	27
Above 12	12
Wealth	
Richest	19
Richer	17
Middle	22
Poorer	22
Poorest	20
Food security	
Food secure	25
Mildly food insecure	22
Moderately food insecure	30
Severely food insecure	23
Farm size†	4.91 (9.24)
Farm power	
Tractor	77
Animal	3
Manual	20
Main source of farm information	
Farmer experience	21
Mass media	4
Local community	62
External organizations	13
Food storage	
Sacks	86
Granaries	7
Open Storage	7
Proportion of postharvest food loss†	3.02 (8.07)
Cause of food loss	
Other animals	3
Pests/insects	69
Rats/mice	17
Mold/spillage	11
Treatment of storage	
Chemicals	55
Traditional	45
Total sample	**1,100**

†Mean reported for continuous variables; Standard deviation in ()

5.3.2 Bivariate results

Table 5.2 shows the results of the bivariate ordered logistic regression model. Households practicing joint decision-making were more likely (OR = 1.37, $p \leq 0.05$) to report good climate resilience than those with only male household heads. Compared to households with the primary farmers in the age ranges of 18 and 25 years, households with the primary farmers aged between 46 to 59 (OR = 0.46, $p \leq 0.001$), and at least 60 years (OR = 0.44, $p \leq 0.01$), were less likely to report good climate resilience. Households with the primary farmers having only primary education (OR = 0.38, $p \leq 0.001$) were also less likely to report good climate resilience when compared to households with informally educated primary farmers. Similarly, households of married (OR = 0.53, $p \leq 0.001$) and widowed/divorced (OR = 0.31, $p \leq 0.001$) primary farmers were also significantly less likely to report good climate resilience when compared to their single counterparts.

Several household factors were found to be significantly associated with climate change resilience. For instance, relative to households that lacked access to financial credits, those who had access to either formal (OR = 2.13, $p \leq 0.001$) and informal credit sources (OR = 1.80, $p \leq 0.01$) had a higher likelihood of reporting good climate resilience. Compared to households with 1 to 4 members, those with sizes between 8 to 11 members (OR = 1.87, $p \leq 0.001$) and above 12 members (OR = 2.29, $p \leq 0.001$) had a higher likelihood of reporting climate good resilience. In terms of wealth, surprisingly, it was only households within the poorer (OR = 2.02, $p \leq 0.001$) and poorest (OR = 6.70, $p \leq 0.001$) wealth categories that were more likely to report good resilience when compared to the richest households. Similarly, we also found that food insecure households—mildly food insecure (OR = 4.37, $p \leq 0.001$), moderately food insecure (OR = 6.37,

$p \leq 0.001$), and severely food insecure (OR = 13.39, $p \leq 0.001$)—were significantly more likely to report good climate resilience than their food secure counterparts.

We also found that some farm-level factors were also significant predictors of climate resilience. For example, compared to households that prepared farmlands with manual tools, those that employed tractor services (OR = 0.22, $p \leq 0.001$), as well as those using animal power (OR = 0.24, $p \leq 0.001$) were less likely to report good climate resilience. Further, when compared to households where their primary farmers relied on personal experiences for farm information, households of primary farmers that received farm related information through the local community were more likely (OR = 2.98, $p \leq 0.001$) to report good climate resilience. In contrast, households that depended on external organizations for farm information had a lesser likelihood (OR = 0.09, $p \leq 0.001$) of reporting good climate resilience. Additionally, households that stored food in open storages were significantly more likely (OR = 6.79, $p \leq 0.001$) to report good climate resilience when compared to households that used sacks for food storage. Postharvest food loss was also found to be positively correlated (OR = 1.23, $p \leq 0.001$) with good climate resilience. In terms of the specific causes of postharvest foodless, only households that lost food to mold/spillage (OR = 10.86, $p \leq 0.001$) were significantly more likely to report good climate resilience, when compared to losing food through other animals.

Table 5.2: Bivariate logistic regression results of predicting perceived resilience

Covariates	Odds ratio (SE)	[95% Conf. Interval]
Decision-making (ref: Male household head only)		
Joint decision-making	1.37 (0.23) *	1. 709—1.991
Female household head only	0.87 (0.17)	0.587—1.291
Age (ref: 18-25)		
26-35	0.80 (0.19)	0.495—1.290
36-45	1.01 (0.23)	0.643—1.591
46-59	0.46 (0.10) ***	0.293—0.731
60+	0.44 (0.13) **	0.246—0.805
Gender (ref: Male)		
Female	1.20 (0.12)	0.965—1.502
Education (ref: No formal)		
Primary	0.38 (0.06) ***	0.284—0.523
Secondary	0.78 (0.14)	0.550—1.111
Tertiary	0.69 (0.18)	0.404—1.165
Marital status (ref: Single)		
Married	0.53 (0.10) ***	0.364—0.776
Widowed/Divorced	0.31 (0.09) ***	0.174—0.548
Credit source (ref: No credit)		
Informal sources	1.80 (0.34) **	1.239—2.611
Formal sources	2.13 (0.26) ***	1.678—2.714
Remittance receipt (ref: No)		
Yes	0.88 (0.24)	0.520—1.492
Household size (ref: 1-4)		
5-7	1.30 (0.21)	0.941—1.791
8-11	1.87 (0.33) ***	1.317—2.659
Above 12	2.29 (0.50) ***	1.482—3.539
Wealth (ref: Richest)		
Richer	1.07 (0.20)	0.743—1.545
Middle	1.06 (0.19)	0.752—1.506
Poorer	2.02 (0.36) ***	1.424—2.863
Poorest	6.70 (1.38) ***	4.473—10.036
Food security (ref: Food secure)		
Mildly food insecure	4.37 (0.79) ***	3.063—6.225
Moderately food insecure	6.36 (1.04) ***	4.616—8.763
Severely food insecure	13.39 (2.57) ***	9.193—19.508
Farm size†	0.98 (0.01)	0.966—1.010

Farm power (ref: Manual)		
Animal	0.22 (0.08) ***	0.104—0.468
Tractor	0.24 (0.04) ***	0.173—0.337
Main source of farm information (ref: Farmer experience)		
Mass media	1.72 (0.60)	0.865—3.425
Local community	2.98 (0.45) ***	2.212—4.017
External organizations	0.09 (0.02) ***	0.058—0.161
Food storage (ref: Sacks)		
Granaries	1.29 (0.30)	0.817—2.040
Open storage	6.79 (2.09) ***	3.714—12.433
Postharvest food loss†	1.22 (0.02) ***	1.176—1.275
Cause of food loss (ref: Other animals)		
Pests/insects	1.75 (0.57)	0.927—3.323
Rats/mice/	0.01 (0.35)	0.520—1.980
Mold/spillage	10.86 (4.48) ***	4.836—24.374
Treatment of storage (ref: chemicals)		
Traditional	1.21 (0.14)	0.965—1.512

Significance codes: *** p ≤ 0.001, ** p ≤ 0.01, * p ≤ 0.05 SE: Standard Error; †: Continuous variables

5.3.3 Multivariate results

Table 5.3 shows the results of the nested multivariate regression models. After controlling for the effect of individual factors in the first model, there was no significant relationship between climate resilience, joint decision-making as well as female head decision-making. However, after adjusting for household factors in the second model, the association between households practicing joint decision-making and female-headed households became significant. Households that practiced joint decision-making were significantly more likely (OR = 2.08, p ≤ 0.001) to report good climate resilience relative to male-headed households. Similarly, female-headed households were also more likely (OR = 1.73, p ≤ 0.05) to report good climate change resilience, albeit with lesser odds. In the third model where we controlled for the effect of farm-level factors, the association between good climate change resilience and households that practiced joint

decision-making remained significant, with a notable increase of odds. Households practicing joint decision-making were about three times more likely (OR = 3.04, $p \leq 0.001$) to report good climate resilience when compared to male-headed households. In contrast, the previous association between resilience and female-headed households lost its significance.

In the final model, some individual, household, and farm-level factors were also significant predictors of good climate resilience. Overall, these associations mirror the results presented in the bivariate analysis. Age-wise, the study found that when compared to households with primary farmers in the 18 to 25 years range, only those aged between 45 to 59 were less likely (OR = 0.44, $p \leq 0.05$) to report good climate resilience. Consistent with the bivariate results, it was only households with primary farmers who had attained only primary school education that were less likely (OR = 0.53, $p \leq 0.01$) to report good resilience when compared to households of informally educated primary farmers.

At the household level, all variables except for household size remained significantly associated with resilience. Similar to the bivariate results, households that had access to either formal (OR = 1.75, $p \leq 0.05$) and informal sources (OR = 1.62, $p \leq 0.05$) of credit had a higher likelihood of reporting good climate resilience relative to households that lacked access. Remittance however, which was insignificant in the bivariate analysis, became significant at the multivariate level. Households the received remittances were about three times more likely (OR = 3.03, $p \leq 0.01$) to report good resilience when compared to their non-receiving counterparts. Household wealth also remained significant although with some notable changes. For example, unlike at the bivariate level, it was only the poorest households (OR = 2.83, $p \leq 0.001$) that were more likely to report good resilience when compared to the richest households. Despite some attenuations in the association between food security and resilience at the multivariate level, it

was very similar to the bivariate results. Food insecure households— mildly food insecure (OR = 1.85, $p \leq 0.01$), moderately food insecure (OR = 2.09, $p \leq 0.01$), and severely food insecure (OR = 4.37, $p \leq 0.001$)— had a higher likelihood of reporting good resilience when compared to their food secure counterparts.

Regarding farm-related factors at the multivariate level, the study found that households employing the use of tractor services for land preparation remained less likely (OR = 0.40, $p \leq 0.001$) to report good climate resilience compared to those using manual tools. Further, households where the primary farmers depended on the local community (OR = 3.33, $p \leq 0.001$) and external organizations (OR = 0.18, $p \leq 0.001$) also remained consistent with the bivariate results. Mass media, which was insignificant at the bivariate level also became significant in the final model. Households of primary farmers that received farm information via mass media were found more likely (OR = 3.09, $p \leq 0.01$) to report good resilience. Although the significance of open storages also remained robust (OR = 3.18, $p \leq 0.01$) at the multivariate level, it was about half of what was observed at the bivariate level. Similarly, the influence of postharvest food loss (OR = 1.18, $p \leq 0.001$) also remained consistent, although with a slight odd reduction. The result of the post-estimation margins analysis in figures 5.1 and 5.2 also reiterates the reported associations between joint household decision-making and good climate resilience. The graphs highlight that households operating under joint decision-making arrangements have the highest predicted probabilities of reporting a good climate change resilience in the second and third models.

Table 5.3: Multivariate logistic regression results of predicting perceived resilience

	Model 1		Model 2		Model 3	
Covariates	Odd ratios (SE)	[95% CI]	Odd ratios (SE)	[95% CI]	Odd ratios (SE)	[95% CI]
Decision-making (ref: Male household head only)						
Joint decision-making	1.36 (0.23)	0.973—1.908	2.08 (0.40) ***	1.424—3.046	3.04 (0.69) ***	1.949—4.738
Female household head only	1.31 (0.32)	0.811—2.144	1.73 (0.46) *	1.030—2.911	0.84 (0.25)	0.467—1.511
Age (ref: 18-25)						
26-35	0.94 (0.26)	0.545—1.637	0.95 (0.28)	0.530—1.702	0.74 (0.25)	0.378—1.451
36-45	1.04 (0.31)	0.585—1.854	0.91 (0.26)	0.490—1.681	0.77 (0.28)	0.382—1.578
46-59	0.45 (0.13) **	0.250—0.806	0.44 (0.14) **	0.233—0.815	0.44 (0.16) *	0.213—0.904
60+	0.48 (0.18) *	0.237—0.985	0.58 (0.23) *	0.269—1.248	0.62 (0.28)	0.256—1.502
Gender (ref: Male)						
Female	1.27 (0.15) *	1.005—1.617	0.93 (0.13)	0.705—1.218	1.01 (0.16)	0.736—1.394
Education (ref: No formal)						
Primary	0.30 (0.05) ***	0.217—0.418	0.49 (0.09) ***	0.342—0.715	0.53 (0.12) **	0.343—0.829
Secondary	0.49 (0.10) ***	0.331—0.741	0.65 (0.15)	0.413—1.014	0.72 (0.19)	0.432—1.191
Tertiary	0.53 (0.15) *	0.300—0.933	1.23 (0.40)	0.652—2.325	1.02 (0.38)	0.487—2.134
Marital status (ref: Single)						
Married	0.44 (0.11) ***	0.270—0.706	0.40 (0.10) ***	0.242—0.656	1.11 (0.34)	0.606—2.025
Widowed/Divorced	0.24 (0.09) ***	0.111—0.511	0.27 (0.11) **	0.120—0.600	0.54 (0.25)	0.218—1.379
Credit source (ref: No credit)						
Informal sources			1.50 (0.32)	0.990—2.286	1.75 (0.45) *	1.057—2.898
Formal sources			1.11 (0.17)	0.819—1.513	1.62 (0.33) *	1.090—2.408
Remittance receipt (ref: No)						
Yes			2.15 (0.68) *	1.158—4.006	3.03 (1.08) **	1.512—6.076
Household size (ref: 1-4)						
5-7			1.00 (0.19)	0.694—1.456	0.76 (0.18)	0.479—1.199
8-11			1.10 (0.23)	0.723—1.670	0.89 (0.23)	0.532—1.476
Above 12			1.20 (0.32)	0.709—2.043	0.84 (0.28)	0.435—1.626
Wealth (ref: Richest)						
Richer			1.08 (0.22)	0.727—1.628	0.92 (0.22)	0.576—1.469
Middle			1.29 (0.26)	0.870—1.903	0.90 (0.21)	0.564—1.430
Poorer			1.87 (0.38) **	1.248—2.795	1.39 (0.34)	0.860—2.263
Poorest			4.94 (1.18) ***	3.094—7.901	2.83 (1.81) ***	1.613—4.956

Food security (ref: Food secure)				
Mildly food insecure	4.75 (0.94) ***	3.227—6.988	1.85 (0.43) **	1.178—2.916
Moderately food insecure	5.50 (0.06) ***	3.770—8.020	2.09 (0.54) **	1.256—3.479
Severely food insecure	9.43 (2.06) ***	6.140—14.478	4.37 (1.16) ***	2.599—7.339
Farm size			0.97 (0.04)	0.901—1.042
Farm power (ref: Manual)				
Animal			0.76 (0.41)	0.264—2.216
Tractor			0.40 (0.10) ***	0.247—0.651
Main source of farm information (ref: Farmer experience)				
Mass media			3.09 (1.26) **	1.391—6.855
Local community			3.33 (0.74) ***	2.148—5.162
External organizations			0.18 (0.06) ***	0.095—0.345
Food storage (ref: Sacks)				
Granaries			1.02 (0.33)	0.541—1.932
Open storage			3.18 (1.28) **	1.442—7.012
Postharvest food loss			1.18 (0.03) ***	1.119—1.247
Cause of food loss (ref: Other animals)				
Pests/insects			0.99 (0.41)	0.432—2.254
Rats/mice/			0.48 (0.22)	0.195—1.175
Mold/spillage			2.70 (1.43)	0.955—7.633
Treatment of storage (ref: chemicals)				
Traditional			1.23 (0.22)	0.859—1.760
Total sample				1100
LR chi2 (38)				711.52
Prob > chi2				0.0000
Pseudo R2				0.3297
Log likelihood				-723.36849

Significance codes: *** p ≤ 0.001, ** p ≤ 0.01, '*' p ≤ 0.05 SE: Standard Error

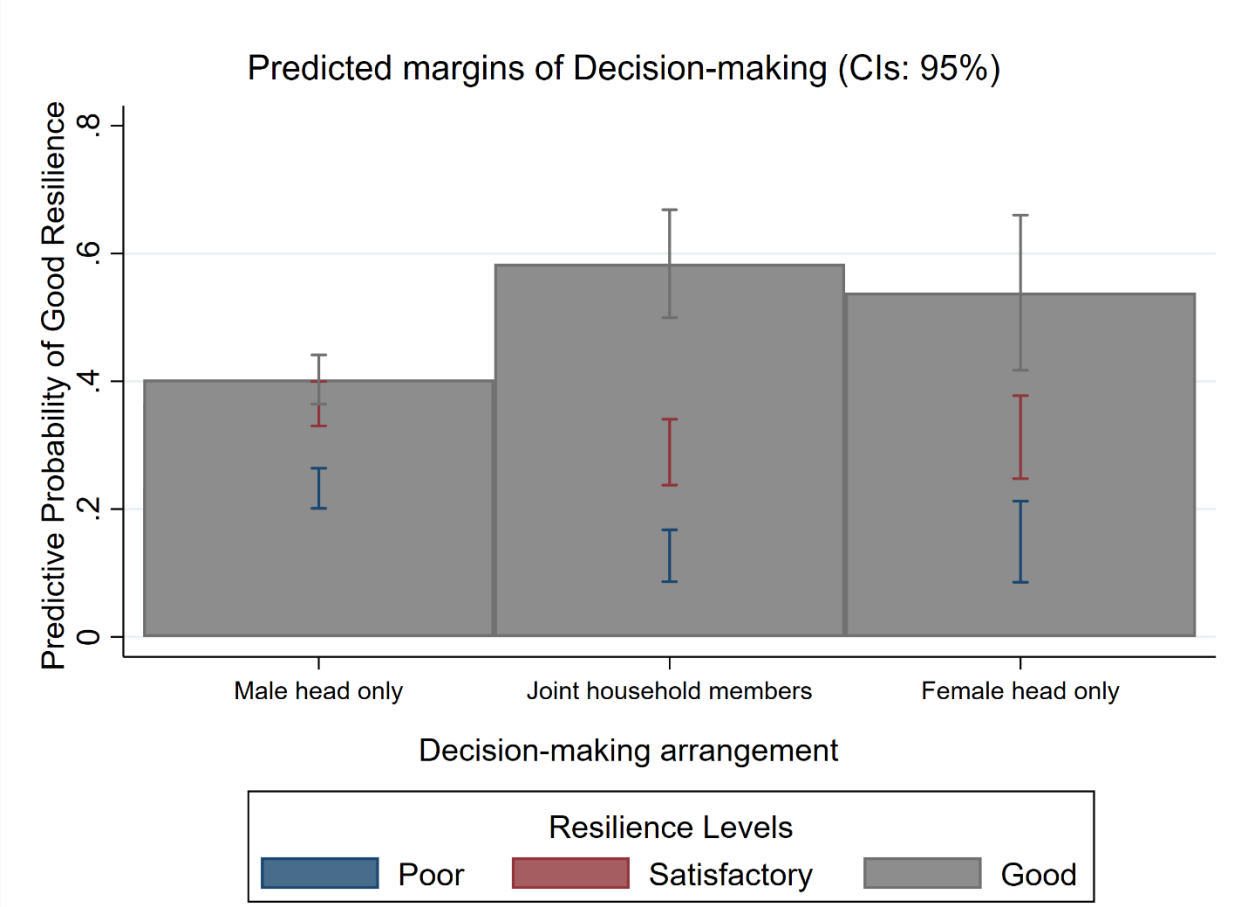

Figure 5.A: Predicted probabilities of good resilience by household decision-making arrangement, after adjusting for the effect of household level factors

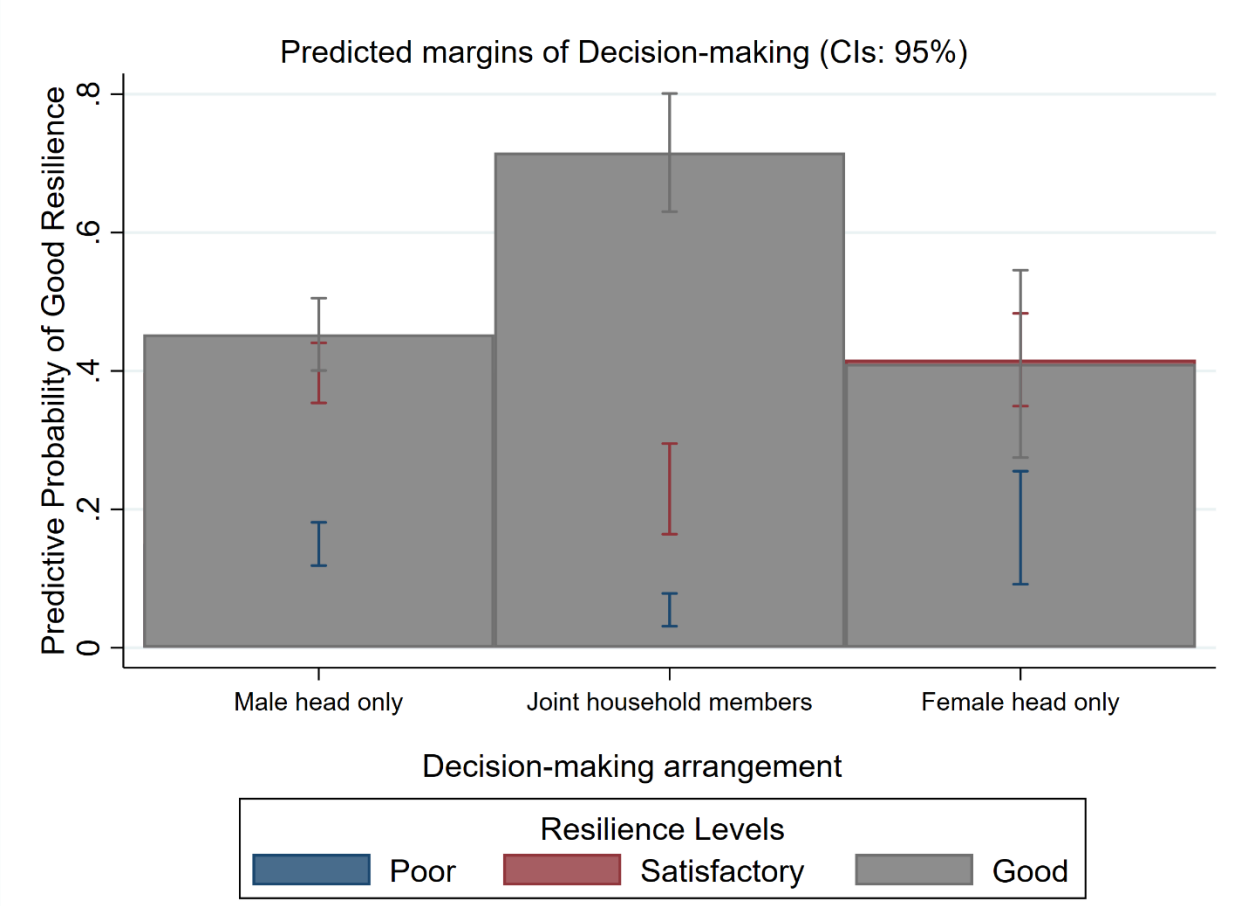

Figure 5.B: Predicted probabilities of good resilience by household decision-making arrangement, after adjusting for the effect of farm level factors

5.4 Discussion

This study examined the association between household decision-making arrangements and the perceived climate change resilience of smallholder farming households in semi-arid northern Ghana. We found that households practicing joint decision-making were more likely to report good climate resilience compared to those conforming with the traditional norm of having only male head decision-makers. Similar findings have been reported in other empirical studies (e.g. Gummerson and Schneider 2013; Kewisch 2015; Van Aelst and Holvoet 2018) on smallholder climate change resilience. Climate change resilience is socially constructed given the fact that it is ingrained in broader socio-cultural and political structures, including gender norms (Adzawla and Baumüller 2020). Climate change resilience can therefore be conceived as an outcome of the constantly evolving relations between social actors in the face of ecological challenges such as climate change (Davoudi et al. 2013). In smallholder farming contexts, the ability to cope with and recover from climate shocks is shaped by prevailing socio-cultural structures including household decision-making systems and how these structures influence the relations between household members. In northern Ghana, male household heads are the culturally ascribed decision-makers (Apusigah, 2009). Male household heads decide what to plant, how to plant it, what family resources to commit to farming, and how the proceeds from the farm are to be used (Yaro 2010). This power disparity also negatively position women such that in the absence of a male head, they face a lot of challenges in accessing vital resources such as fertile lands and labor services (Kansanga et al., 2020). Further, this culturally constructed decision-making arrangement offers little opportunity for especially women, and the youth to participate in household decision-making despite the potential for joint decision-making to improve household resilience. Meanwhile, the adverse outcomes resulting from unilateral decisions by the male family head

usually extend to the entire household, with women and children being disproportionately affected (McElroy and Horney 1981). Unilateral decision-making systems also have the potential to engender reluctance and non-co-operation from other household members to implement decisions that are made by family heads (Anderson et al., 2017).

Increasing evidence highlight that joint decision-making within households improves climate change resilience, especially in the adoption of climate-smart agricultural practices (Shiva 2016; Twyman et al. 2017). Joint decision-making within smallholder households yields diverse benefits including knowledge and resource-pooling and rapid problem solving, which can collectively improve their climate resilience (Agarwal 1997; Van Aelst & Holvoet 2018). For instance, under joint decision-making arrangements, household members are more willing to share their perspectives on the expected or perceived trend of climate change, as well as their preferred adaptive practices. From this potentially vast pool of knowledge, well-weighted adaptation decisions can be made, prioritized, and supportively implemented (Graef et al. 2015; Guloba 2014). Indeed, there is evidence of enhanced adoption of climate-smart farming strategies under joint household decision-making systems. For instance, Van Aelst and Holvoet (2018) found increased uptake of adaptive practices such as cover cropping and drought-resistant crop cultivation in smallholder households practicing joint decision-making. Gummerson and Schneider (2013) also found that in households practicing joint decision-making in rural South Africa, expenditures were directed towards vital household needs such as food.

Joint decision-making also facilitates rapid problem solving which can significantly improve household resilience. In traditional household settings where decisions are typically made by only the male head, problem-solving can be relatively slow (Apusigah, 2009). This is especially common in cases where on-farm problems may require substantial financial investments. Invariably, there

is evidence that when household problems are collectively approached, and other household members involved, there is ownership of the decisions and increased willingness to ensure their implementation (Kewisch, 2015). In northern Ghana where climate variability is persistent, farming operations such as land preparation must be done more precisely to maximize the benefits of rainfall to avoid crop failure. Thus, joint decision-making on agricultural issues may consequently increase commitment from all household members towards the implementation of these increasingly uncertain decisions, which can help households execute farming operations promptly, especially given the labor-intensive nature of most farm operations (Abagale et al. 2020).

We also found that the age and education of the primary farmers were significant predictors of good climate resilience. Households with primary farmers aged between 46 to 59, as well as households with primary farmers who had attained only primary school education were found less likely to report good resilience compared to households with younger and informally educated primary farmers. In relation to age, our findings could be because, considering the high proclivity of crop failures witnessed in previous seasons, poor transportation and unsupportive markets structures, older farmers in this resource-poor context may become risk-averse and thus, feel reluctant to invest substantially in the management of their farms in terms of buying modern inputs or hiring farm labor. Furthermore, though old farmers may be experienced in crop production, their biophysical ability to meet the manual labor demands of cultivation may be faltering. In effect, these farmers may therefore have to limit their production altogether. With regards to education, a reason for this association may be because smallholder farmers with no education are engaged in agriculture all their lives and would have more experience in dealing with climate-related challenges compared to those who have been in school for some years

before engaging in farming (Tetteh, 2019). Additionally, our findings also add to the increasing emphasis made by several researchers (Guthiga and Newsham 2011; Gyampoh et al. 2009) on the potentially important contributions of traditional knowledge systems in climate change adaptation and environmental sustainability policies.

The use of tractor services for land preparation was also associated with a lesser likelihood of a household reporting good climate resilience. This is in line with other studies that highlight the eco-unfriendly effects of agricultural mechanization on the natural environment in some contexts. Kansanga et al.'s (2020) study in northern Ghana for example, found that tractor use aggravates environmental degradation and deteriorates vital livelihood resources like shea trees, which women rely upon to support household food provisioning. Even though tractors possess some climate-sensitive advantages such as increased farm expansion capabilities and cultivation speeds amid increasing rainfall variability, their agronomic disadvantages are also very crucial (Kansanga et al., 2020). For instance, farmlands that are cultivated with minimal disturbance to soil are more likely to maintain their nutrient integrity (Swennen, 1990).

Because farm information is essential in the entire crop production cycle, it is therefore inextricably linked to household climate change resilience (Di Falco et al., 2012). Households relying on mass media for farm information were found more likely to report good resilience compared to those using their personal experience. Mass media is particularly important in poor rural settings because it is cheap, readily accessible, and capable of reaching a larger audience. Mass media also has the added advantage of being context-specific, thereby bridging language barriers (Escalada et al., 1999; Hassan et al., 2010). Further, households relying on the local community for farm information were also more likely to report a good resilience. This is in line with the finding of Denkyirah et al. (2017) that local communities enhance farmer-to-farmer

learning among farmers. Denkyirah et al. (2017) also report an increased adoption of effective adaptation practices and the creation of robust local market chains among these farmers. In contrast, households relying on external organizations were found less likely to report good resilience. This could also be explained by the fact that, although external organizations (e.g. extension services) may always diffuse the valuable agricultural information, they are not the most preferred option for farmers (Denkyirah et al., 2017). This finding may be because external organizations usually offer services via irregular field visits and hence, may not be available to provide timely information when it is most needed. Additionally, they may be unable to provide all crucial information such as planting dates and crop varieties in a single visit. The absence of such technical knowledge often leaves farmers to cultivate with their own experience, which is sometimes inadequate (Zougmoré et al., 2016).

Households using open storage for food storage were also more likely to report a good resilience. The use of open storage in the study context is a traditionally learned process used by most farmers because of their focus on grains, tubers, and leguminous cultivation. Additionally, these are also crops that can be effectively preserved via this method. Plausibly, this result could be due to the ease, cost-effectiveness and minimal food losses observed to be associated with this storage type (Manandhar et al., 2018).

The poorest and food insecure households, as well as those that experienced post-harvest food loss were also more likely to report a good climate resilience. This is consistent with previous studies (see Sarkar and Fletcher 2014; Seery and Quinton 2016) that argue in favor of the additive role of previous adversities in the resilience-building process. Crane et al. (2019) also provide evidence of how previous stresses can be used to improve well-being. In smallholder farming settings, households that have been previously beset with livelihood threats may be

forced to adopt adaptive frameworks and adjust livelihood practices and investments in the hope of achieving long-term sustenance and resilience (Oken et al., 2015). Further, considering the precariousness of agricultural-related climatic elements, and the need to invest substantially to improve farm yields, wealthier farmers may resort to off-farm enterprises, or even subjecting farmlands to other perceived lucrative uses such as commercial leasing (Zhai et al., 2018).

5.5 Study Limitations

Notwithstanding the relevance of the findings of this study, there are some noteworthy limitations. First, the findings from this study are based on a cross-sectional design which only limits our results to associations. To elucidate our findings, a longitudinal study will be required to reveal the causal dynamics in the study area. Secondly, despite the household focus of this study, the survey was answered only by household representatives. As a result, some responses may not be representative of the entire household which also limits the generalizability of our findings. Also, because the dependent variable was based on respondents' perception, there is the potential of both over-reporting and under-reporting of climatic experiences.

5.6 Conclusion

In spite of these limitations, our findings indicate that joint decision-making within smallholder households is vital to building climate resilience. We emphasize the need to promote co-operation within smallholder households. Further, there is also the need for agricultural policymakers, through gender equity programs, to reiterate the importance for households to leverage the rich experiences of women and other household members to augment their climate change resilience. Further, we also call for the critical appraisal of the traditional agricultural production pathways which can complement the use of modern production systems in deprived contexts such as the UWR. The governmental agenda on agricultural development should be

integrated with rural development plans and also support the establishment of smallholder farmer unions across local communities to facilitate the diffusion of agricultural information.

5.7 References

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CHAPTER 6

6. SUMMARY AND CONCLUSION

This concluding chapter gives a summary of the findings of this thesis and highlights the theoretical and methodological contributions of the research to the smallholder climate resilience discourse. The chapter also makes important policy suggestions for relevant stakeholders in Ghana and the broader SSA region. To conclude, the chapter also outlines the study limitations and provides some suggestions for future research.

6.1 Introduction

This research aimed to investigate climate resilience strategies among smallholder farmers in the Upper West Region (UWR) of Ghana. Whiles climate change constitutes a significant threat to global agricultural productivity, several indications highlight the agricultural sector of sub-Saharan African (SSA) as one of the disproportionately affected sectors (Palazzo et al., 2017). As a region with enormous agricultural potential, climate change has received tremendous attention, with the resilience to climate impacts agenda being a primary objective for sustainable development in the region (Yiridomoh et al., 2020).

Using a quantitative approach, this research examined the relationship between smallholder financial credit access, intra-household decision-making arrangements and the perceived climate resilience of smallholder farmers in the UWR of Ghana. The primary objectives of this research were as follows:

1. To examine the association between financial credit access and perceived climate change resilience among smallholder farmers in semi-arid Northern Ghana.

2. To assess the association between intra-household decision-making arrangements and perceived resilience outcomes among smallholder farmers in semi-arid Northern Ghana.

6.2 Summary of Findings

6.2.1 Objective One:

To examine the association between financial credit access and perceived climate change resilience

To address this objective, a nested ordinal logistic regression model was used to estimate the association between perceived climate resilience and credit access (see chapter 4). The findings reveal that overall, households that had access to credit were more likely to report good climate resilience when compared to households with no access. This finding concurs with other studies that report that access to credit, especially in deprived contexts such as the UWR, is a crucial driver for smallholder climate resilience through its positive influence on boosting agricultural productivity (Chandio et al., 2018; Girabi & Mwakaje, 2013). However, paying attention to the specific sources of credit also highlighted some nuances associated with resilience. Among households with access to credit, it was only households that sourced credit from informal avenues that were more likely to report good resilience. Formal sources of credit rather had an insignificant effect on climate resilience. Although this result was surprising, particularly because of the frantic efforts in recent times made by the government of Ghana and other international institutions to expand credit access to smallholder farmers, other authors (Khandker, 2005; Sekyi et al., 2019) have reported similar results. In the phraseology of Jennifer Clapp, this is a classical situation where bigger is not always better (Clapp, 2017).

Probable reasons for these results are briefly presented here. Smallholder contexts are generally dominated by informal credit sources following prolonged neglect by formal credit institutions (Akudugu, 2016). Evidence from the agricultural financialization literature suggests that informal credit sources, despite their relatively lower-income generation potential, have proved very advantageous for rural smallholder farmers (Girabi & Mwakaje, 2013; Sekyi et al., 2019). For example, Burkett (988) highlights four (4) main categories (accessibility, dependability, flexibility and adaptability) that explain why informal credit sources may have outperformed their formal counterparts in terms of improving smallholder livelihoods. In terms of accessibility, closer proximity of informal sources translates into low transactional costs and also offers a timely funds acquisition process over time. Together, the notions of dependability, flexibility and adaptability concern the relaxed, and often mutually beneficial requirements that surround the loan acquisition from informal sources. For instance, terms and conditions are usually tailored to the capabilities of the borrowers (Nagarajan & Meyer, 2005; Schindler, 2010). Also, the concept of 'risky customers' which is well-known informal institutions is not as pervasive in informal credit domains, especially in group savings settings where members share a sense of shared vulnerability and are willing to help (Adegbite et al., 2017). The preceding helps explain our findings whereby those with access to informal credit sources are reporting better resilience than those who accessed credit from formal sources.

Other variables that were also found to be significant predictors of climate resilience include household wealth; remittance receipts; sources of farm information; sources of farm power, postharvest food loss; livestock rearing and experience of climatic events in the past 12 months prior to the study. Specifically, these climate events are draughts, floods and erratic rain.

6.2.2 Objective Two:

To assess the association between intra-household decision-making arrangements and perceived resilience among smallholder farmers.

This objective examined the relationship between the climate resilience of smallholder households and intrahousehold decision-making in the context of broader sociocultural norms (see chapter 5). The findings reveal how underlying dynamics between climatic impacts and sociocultural factors may facilitate or otherwise impede resilience building. The results indicate that households practicing joint decision-making were nearly three times more likely to report good climate resilience when compared to households where only the male head made decisions. The influence of decision-making arrangements on female-headed households though, was insignificant. Since resilience in smallholder settings is a function of relations between social actors (Davoudi et al., 2013), these findings may result from the fact that joint decision-making arrangements maximize cooperation while minimizing the potential of conflicts when compared to households where only the male head made decisions. For instance, joint decision-making arrangement is empowering, and has been identified as a way of transforming power-relations (Hillenbrand et al., 2015) between household members which has a strong potential for improving collective resilience and wellbeing (Ambler et al., 2017; Anderson et al., 2017). Additional benefits that may precipitate from joint decision-making include knowledge and resource-pooling and timely problem solving, which have significant implications for household resilience (Yamba et al., 2019). Invariably, transforming power-relations in a patriarchal context such as the UWR may result in restructuring previous traditionally ascribed gender roles and agricultural labor distribution within the household (Nyantakyi-Frimpong, 2017; Rademacher-Schulz & Mahama, 2012). For example, in an era of increasing mechanization, evidence of uneven labor distribution

still exists in some households owing to the adherence of sociocultural norms (Kansanga et al., 2019). Consequently, the findings point to the need for agricultural policies to be formulated based on a thorough understanding of contextual structures that influence behaviours and interpersonal interactions at both household and community levels.

6.3 How the findings of manuscripts are integrated

Overall, the two manuscripts examined climate change resilience strategies among smallholder farmers in the UWR of Ghana. The first manuscript, Chapter 4, investigates the association between climate resilience, access to credit as well as specific sources of credit. It demonstrates that informal sources of credit are significant predictors of smallholder climate resilience due to the flexibility they provide.

The second manuscript, Chapter 5, also assesses the effect of intrahousehold decision-making arrangements on climate change resilience. It advocates for the need for relevant stakeholders to acknowledge the complexity of smallholder climate resilience, especially when relations and livelihoods activities in these contexts are bounded by sociocultural structures.

Together, the two manuscripts provide insights on the multifaceted nature of smallholder climate vulnerability and resilience in the region and reiterates the need for scholarship and policy efforts to be evenly distributed on exploring both climatic and non-climatic dimensions of this societal threat.

6.4 Contributions of the Study

6.4.1 Theoretical contributions

Climate change especially in the 21st century has destabilized global agricultural productivity. In the SSA where more than 80% of the population engage in smallholder agriculture, climate change

is also a significant livelihood threat (Mohammed et al., 2021; Nyantakyi-Frimpong, 2021). Building the resilience of smallholder farmers is therefore necessary for securing their livelihoods. The first key theoretical contribution of this study lies in its demonstration that, in addition to the assessments of climatic variables, analyses surrounding climate resilience need to acknowledge the role of non-climatic factors including local socioeconomic, sociocultural, and political structures. Consistent with other studies (Acosta et al., 2020; Anderson et al., 2017; File & Derbile, 2020), the study highlights the key roles smallholder credit access and their intrahousehold decision-making arrangements play in shaping their resilience outcomes.

Although empirical studies on the influence of financial credit on crucial agricultural activities of smallholder farmers—adoption of new and improved seeds and fertilizer, technical efficiency, and crop yield—in the UWR are widespread, research on credit access and climate resilience is non-existent. To my knowledge, this study is the first to directly examine the role of credit access in smallholder climate resilience. Moreover, the study went on to highlight the dynamic relations between resilience outcomes and the sources of credit in the study context. This aspect of the analysis helps uncover some of the multiscale differences of credit provisioning schemes that are often masked by national-level trends in the agricultural financialization literature in Ghana (Brune et al., 2016). I therefore argue that despite policy efforts of both government and international donors like the Bill and Melinda Gates Foundation to spur agricultural development by expanding smallholder credit accessibility, the use of formal institutions as the primary conduits of these investments need critical reimagination and adjustments to ensure the people most in need reap the most benefits (Abu & Haruna, 2017; Nagarajan & Meyer, 2005).

Focusing on the sociocultural landscapes of smallholder farmers in manuscript two, I found that joint household decision-making arrangements enhance smallholder climate resilience. This supports prior explanations that in households with this arrangement, responsibilities and labor duties are likely shared equitably to minimize the emergence of winner and losers (Agarwal, 1997; Ambler et al., 2017; Hillenbrand et al., 2015). Problems identified within households with joint decision-making arrangements are usually more likely to be acknowledged by all members thereby reinforcing their joint efforts to find solutions that are inclusive and mutually beneficial. As a result, collective action is often maximized at the implementation stages of identified solutions which can help catalyze the achievement of better and sustainable outcomes. The findings of this study may be generalizable to other communities in northern Ghana and the broader SSA region where socioeconomic, sociocultural, and environmental characteristics are similar.

This thesis also extends the utility of socioecological resilience and intrahousehold bargaining models as it relates to constantly evolving outcomes such as climate resilience (Davoudi et al., 2013). This thesis also contributes to the broader debates surrounding environmental determinism and possibilism (Fekadu, 2014; Thirumoorthy & Arulsamy, 2021) by suggesting that humans are powerful agents of change that have the ability to shape aspects of their environment to sustain their livelihoods through their capability to learn from past adversities, innovation and efficient resource mobilization and utilization (Darnhofer, 2014). Resources in this context, are the range of tools that can be acquired, traded or negotiated for, through unfolding relations between actors over time. However, the operational boundaries of resource acquisition and utility vary across settings and defy any one-size-fits-all approach. As a result, intrahousehold bargaining models help bring some contextual clarity by using the

household, which is a microcosm of the broader sociocultural landscape, as a lens to explain the potential outcomes of interactions between actors based on socially accepted ways of assessing what qualifies as valuable and desirable, methods of labor division, consumption and production pathways, and resource allocation (Agarwal, 1997).

6.4.2 Methodological contributions

This study also makes some methodological contributions. Using the concept of intrahousehold decision-making arrangements, this study was able to demonstrate the differences in the resilience outcomes of smallholder households as it relates to the nature of interactions among household members. To my knowledge, this is the first study to have used a collective approach in analysing interactions and power relations within the household, to examine climate change resilience in the study context. Further, the subjective measurement of climate resilience in this study is not widespread in the UWR. Despite some of its drawbacks, I argue that assessing resilience subjectively is useful in capturing the abstract and experiential aspects of how households relate with climatic events (Oriangi et al., 2020). Together, the approaches I employed in this study add new methodologies in climate resilience assessments especially for rural agrarian contexts.

6.5 Policy Implications

The findings from this study concur with the suggestions of previous studies that the current state of climate vulnerability in SSA is a product of the complex interactions between several factors. As a result, resilience approaches must consider multiple pathways including building strong institutions and renewing investments in the environmental, socioeconomic, and infrastructural needs of the vulnerable groups (Kumasi et al., 2019). The research highlights some policy recommendations for smallholder climate resilience in Ghana and elsewhere.

First of all, regarding the socioeconomic needs of smallholder farmers, results from the study suggest that, contrary to the current status quo where major forms of agricultural investments are channeled through formal credit institutions, informal credit sources rather have the most potential to boost agricultural development (Khandker, 2005; Sekyi et al., 2019). Formal credit sources are undoubtedly superior to their informal counterparts in some aspects of the credit dissemination process, with regulations and periodic evaluations being some important areas. That notwithstanding, formal credit sources are often unable to achieve the primary goals of these investment schemes, which is providing adequate funds for smallholder farmers. As discussed earlier in Chapters 2 and 4, some reasons for their shortcomings include their rural absence, profit inclination, high collateral and interest rates, and most importantly, general inconsistency with smallholder farming cycles (Asante-Addo et al., 2017; Schindler, 2010). However, to achieve any significant results, inequality in accessibility must be minimized to facilitate smallholder participation (Ansah et al., 2020). Informal sources on the other hand, are tailored to the needs and capabilities of smallholders. Because of the different characteristics of both credit sources, rural populations will be better served if stakeholders focus on redesigning policies that will combine the strengths of both formal and informal credit sources. As highlighted in the conclusion of Chapter 4, enhancing digitalization (Nagarajan & Meyer, 2005) efforts for both credit sources is one of the time-tested pathways that can facilitate smallholder financial inclusion.

Further, due to the increasing unpredictable impacts of climate change on local agricultural systems, the establishment of agricultural insurance schemes against extreme weather effects such as droughts and floods will serve as an efficient disaster preparedness and safety net systems for sustaining smallholder livelihoods. Earlier work by Ankrah et al. (2021) indicates that under

the right circumstances, smallholders farmers may be willing to enroll in such insurance schemes should they become available.

Also, the results on resilience and intrahousehold decision-making arrangements suggest that current policies targeted at climate resilience may have failed to contextualize smallholder activities within important aspects such as their sociocultural landscapes. This study suggests that agricultural policies should be cognizant of traditional value systems, as is often the case that some contemporary agricultural practices have strong linkages with cultural prescriptions and traditional knowledge systems. Thus, policies that do not align may likely be rejected. Climate change impacts do not occur in vacuums, and although catering for the myriad of cultures across any space may be a daunting task, some effort toward cultural sensitivity may be invaluable due to its significant influence on the socio-ecological decision-making of smallholders (Adzawla & Baumüller, 2021).

Lastly, considering the multifaceted nature of climate resilience, there is also a need for innovative policies with the potential of spurring simultaneous developments in diverse areas. Climate-smart agriculture (CSA) is one of such approaches that has emerged in the SSA development agenda with a promising capability of building synergies between agricultural productivity, climate change adaptation and mitigation (Zougmoré et al., 2018). Some components of CSA that have been underscored as feasible in even unfavorable environments such as the semi-arid areas of West Africa include agroforestry; conservation agriculture with a focus on soil and water; and crop diversification (Rhodes et al., 2014; Zougmoré et al., 2018). Indeed, CSA presents a new pathway for boosting agricultural productivity and also constitutes a novel toolbox for smallholder resilience building. Adoption of CSA in the Ghanaian context will

also be crucial in achieving the goals of the United Nations' sustainable development agenda and the Paris Agreement it has subscribed to.

6.6 Limitations of the study

Notwithstanding the significant contributions of this study, some limitations are worth highlighting. First, data for this study was cross-sectional which limits the interpretation and generalizability of the findings. For instance, even though relationships between climate resilience, socio-economic and socio-cultural elements are more complex and dynamic in the real world, they were only limited to associations in this study. Similarly, practices such as intrahousehold decision-making are very context-specific and in practice may vary in other contexts. The contextual variability of this variable therefore presents a challenge to the generalizability of findings from this study.

Secondly, perceived climate resilience was self-reported. Notwithstanding its advantages in the literature (Jones & Tanner, 2015; Oriangi et al., 2020), there is a potential for inaccurate responses due to inadequate recall bias considering that fact that the study sought responses that dated back to the last 12 months prior to the survey (Maxwell et al., 2015). Also, reported resilience may not be congruent with the perceptions of all household members since the surveys were only administered to household representatives.

Also, data on some relevant variables are non-existent. I resorted to using their proxies for the analysis. For instance, due to the importance but yet limited data on household wealth, household asset ownership was used a proxy to determine wealth levels through principal component analysis (Filmer & Pritchett, 1999; Mohammed et al., 2021).

Lastly, the immediate cultural environment of people impacts their behavioral and psychological orientation (Schwartz et al., 2014). While the conceptualization of the study area as characteristic of a homogenous cultural landscape helped to situate this research, there are also several microcultural practices at the district and communal levels, that could possibly shed more light on crucial smallholder livelihood dynamics such as agricultural production methods and religious beliefs, that can influence climate vulnerability and resilience (Nyantakyi-Frimpong, 2020).

6.7 Directions for future research

While this study has shed some light on some dimensions of smallholder climate resilience, it also signaled the need for future research in some key areas. First, given that the findings in this study are limited to associations, future research can employ longitudinal data analyses to make causal connections between these variables.

Secondly, despite my efforts to capture some sentiments of smallholder livelihoods in the construction of the resilience variable, future research can utilize qualitative or ethnographic methodologies to gain more insights on smallholder resilience. These methodologies will give a firsthand knowledge of the lived experiences of individuals regarding credit access, household decision-making and how these factors relate to their perceived resilience to climatic events.

As earlier stated in the limitations section of this Chapter, the generalizability of the findings is limited owing to the nature of the study design. Although most of the findings may hold true for northern Ghana, the same cannot be said for smallholder farmers in the middle and southern areas of Ghana. Future research could involve studies in these areas so that a comparative analysis can be conducted across the different agroecological zones. For instance,

using a rural-urban lens, smallholder climate resilience can be examined for farmers in the northern and southern parts of Ghana. As well, beyond the variables analyzed in this study, future studies can explore the potential effects other smallholder livelihood aspects may have on their climate change resilience.

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APPENDICES

Appendix A: Research Ethics Approval

Western Research

Date: 2 July 2019

To: Dr. Isaac Luginaah

Project ID: 114075

Study Title: Using participatory scenario planning to understand community seed systems resilience to climate change in Ghana and Malawi Region

Short Title: Climate change and seed security in Ghana and Malawi

Application Type: NMREB Initial Application

Review Type: Delegated

Full Board Reporting Date: August 2 2019

Date Approval Issued: 02/Jul/2019

REB Approval Expiry Date: 02/Jul/2020

Dear Dr. Isaac Luginaah

The Western University Non-Medical Research Ethics Board (NMREB) has reviewed and approved the WREM application form for the above mentioned study, as of the date noted above. NMREB approval for this study remains valid until the expiry date noted above, conditional to timely submission and acceptance of NMREB Continuing Ethics Review.

This research study is to be conducted by the investigator noted above. All other required institutional approvals must also be obtained prior to the conduct of the study.

Documents Approved:

Document Name	Document Type	Document Date	Document Version
FLAP Survey Ghana June 13, 2019	Online Survey	13/Jun/2019	2
FLAP Survey Malawi June 13 2019	Online Survey	13/Jun/2019	1
Focus Group Letter of Information and Consent Ghana June 25 2019	Verbal Consent/Assent	25/Jun/2019	2
Focus Group Letter of Information and Consent Malawi June 25 2019	Verbal Consent/Assent	25/Jun/2019	1
Ghana Participatory Scenario Planning Activities May 24 2019	Focus Group(s) Guide	24/May/2019	1
Letter of Invitation Farmers Ghana June 25 2019	Recruitment Materials	25/Jun/2019	2
Letter of Invitation Farmers Malawi June 25 2019	Recruitment Materials	25/Jun/2019	2
Malawi Participatory Scenario Planning Activities June 25 2019	Focus Group(s) Guide	25/Jun/2019	1
PSP Participants Characteristics Data Collection Sheet Ghana Malawi June 25 2019	Other Data Collection Instruments	25/Jun/2019	1
RA_Confidentiality Agreement Ghana and Malawi - June 25 2019	Verbal Consent/Assent	25/Jun/2019	2
Recruitment Letter of Invitation Focus Groups Ghana June 25 2019	Recruitment Materials	25/Jun/2019	2
Recruitment Letter of Invitation Focus Groups Malawi June 25 2019	Recruitment Materials	25/Jun/2019	2
Verbal Letter of Information and concent Farmers Ghana June 25, 2019	Verbal Consent/Assent	25/Jun/2019	2
Verbal Letter of Information and consent Farmers Malawi June 25 2019-1	Verbal Consent/Assent	25/Jun/2019	1
Written Letter of Information and concent Farmers Ghana June 25, 2019	Written Consent/Assent	25/Jun/2019	1

Written Letter of Information and consent Farmers Malawi June 25 2019	Written Consent/Assent	25/Jun/2019	1	

No deviations from, or changes to the protocol should be initiated without prior written approval from the NMREB, except when necessary to eliminate immediate hazard(s) to study participants or when the change(s) involves only administrative or logistical aspects of the trial.

The Western University NMREB operates in compliance with the Tri-Council Policy Statement Ethical Conduct for Research Involving Humans (TCPS2), the Ontario Personal Health Information Protection Act (PHIPA, 2004), and the applicable laws and regulations of Ontario. Members of the NMREB who are named as Investigators in research studies do not participate in discussions related to, nor vote on such studies when they are presented to the REB. The NMREB is registered with the U.S. Department of Health & Human Services under the IRB registration number IRB 00000941.

Please do not hesitate to contact us if you have any questions.

Sincerely,

Kelly Patterson, Research Ethics Officer on behalf of Dr. Randal Graham, NMREB Chair

Note: This correspondence includes an electronic signature (validation and approval via an online system that is compliant with all regulations).

Appendix B: Farmer Livelihood and Agricultural Production (FLAP) Survey

INTRODUCTION

Informed Consent. ENUMERATOR, PLEASE READ THE FOLLOWING TO THE RESPONDENT

My name is _____. I am working for the Department of Geography at the Western University in Canada and University of Denver and Cornel University in the United States of America. We would like to understand more about your family and farming practices. I would like to ask you if I might interview you, and I'd like to explain more about what will be involved. Please feel free to ask any questions at any time. The results from this study will be used to inform future initiatives aimed at improving farmers' food security and agrobiodiversity.

If you agree to participate in this part of this study, we want to learn from your knowledge and how you are farming. We will be spending about an hour asking you questions about your cropping practices, your diet and other information that affects your family's food security. There is no right or wrong answer to our questions. If you feel uncomfortable at any moment or would prefer that I not participate/observe certain activities, you can refuse my presence at any time.

There is no direct benefit to you for participating in this part of research; however, it will help you to get to know us and become familiar with our study and provide an opportunity for you to express any concerns that you have regarding your life as a farmer. Additionally, the knowledge gained in this study will benefit your community indirectly. We will share what we learn from your farming practices with local, national and international institutions such that it can be used to inform initiatives for improving food security for smallholder farmers. You will not incur any costs by participating in part of the study other than about an hour spent discussing things with us. You will not receive any payment for this time.

Your participation in this study is completely voluntary and you may refuse to participate or leave the study at any time. Your name will only be recorded to document that you have agreed to participate in this research. It will not be put in any of the project documents to be prepared from this research. Only the research team will have access to the data provided and records will be kept safely in a locked cabinet to which only the research team will have a key, to ensure no one apart from the study investigators can have access to them. The survey will take about an hour.

Do you agree to continue with the survey? ☐ **YES** ☐ **NO**

You are encouraged to ask me questions at any time during or after this study, Thank you for all your help and cooperation with this study.

1.1 Name of Enumerator: _____

1.2 Date of assessment: _____

1.3 Village name _____

BACKGROUND INFORMATION

Respondent Information

1.1 . Respondent number:

1.2 . Age: _____ (years)

1.3 Gender (Sex): ☐ Male (1) ☐ Female (0)

1.4 Relationship: ☐ Household head (1) ☐ Spouse (2) ☐ Son/daughter (3) ☐ Other living in HH (4)

1.5 Education ☐ No formal (1) ☐ Primary school (2) ☐ Secondary (3) ☐ Tertiary (4)

1.6 Marital status ☐ Single (1) ☐ Married (2) ☐ Divorced (3) ☐ Widowed (4).

1.7 . If married, what is your marital structure ☐ Monogamous ☐ Polygamous

1.8 . Religion ☐ Christian (1) ☐ Muslim (2) ☐ African Traditional ☐ Other (4)……...

1.9 . Ethnicity ☐ Dagao (1) ☐ Sisaala (2)

Household Demographics

1.10 Which of the following best describes the structure of your household?

a	Female centered (No husband/male partner in household, may include relatives, children and friends)	
b	Male centered (No wife/female partner in household, may include relatives, children and friends)	
c	Nuclear (Husband/male partner and wife/female partner with or without children)	
d	Extended (Husband/male partner and wife/female partner with or without children and relatives	
e	Child centered (Child-centered)	
f	Other	

1.11 Gender of household Head (HH).

☐ Male (1) ☐ Female (0)

1.12. Residential status of the household (HH). To be revised or omitted if there is no distinct category

☐ Resident (1) ☐ Returnee (2) ☐ Refugee (3)

1.13 For how long have you continually lived in this area?_____(years)

1.14 Household size: How many people live in this household? Specify the number under each age group below

Age group→	< 5 years	5-17 years	18-35 years	36-60 years	>60 years

1.15. How many household members are involved in Agricultural activities?

Module A: AGRICULTURAL PRODUCTION AND PRACTICES

The next questions ask about the land your household uses for agriculture. I mean all the land that your household used for agriculture in all the agricultural seasons in which your household planted crops during the **[season].**

Crop Production/ Seed System Profile

A.1 What crops did you plant last season? (Retain/add/remove crop(s) based on most likely one to be found in the target areas. Modify the codes as well)

	Sorghum = 1	Maize=2	Rice=3	
	Finger Millet = 4	millet =5 (pearl)	Wheat=6	Teff = 7
Oilseed				
Pulses	Groundnut=8	Sesame=9		
	Beans=11	Cowpea=12	Sunflower =10	
			Green grams	
	French beans = 14		=13	Dolicos = 17
RTB	Cassava=18	Sweet potato=19	Potato=20	
	Cocoyam = 21	Yams = 22	Banana =23	
Vegetables	Local	exotic		

A2. Should be asked only if the household indicated that they planted vegetable:

A.2a for what Main purpose do you cultivate vegetables?

Domestic (1) Commercial (0)

A.2b. If commercial, who decides on how the money is used?

Men (1) Women (2) Both (3)

A.3 Name the three most important crops you cultivate

1)

2)

3)

A.4 Did you change the main crop you used to produce in the last few years?

A.5 Main reason for change of area if yes (see codes below): For statistical analysis, var can be grouped into structural: logistics, environmental …

1 = Lack of land;

2 = Access to more land; 3 = Lack of labor force

4 = Access to more labor force; 5=Lack of seed

6=Better access to seeds

7=Free seed

8=Increase in seed prices

9=Decrease in seed prices

10=Decrease of produce price

11=Guaranteed selling price produce

12=Secure market

13=Increased need at household level

14 = Lack of tools and equipment

15= Replanting of seed

Crop production parameters				
		a	b	**B1b: Units codes** 1 = hectares 2 = acres -8 = Not applicable
A6	What is the total amount of land your household owns?	Quantity ||||.|||	Units ||	
A7	During the **[season]** , how much land did your household use for agriculture (including land that is owned, rented/leased in, and borrowed, i.e., used without payment)?	Quantity ||||.|||	Units ||	

A8.	Was the land your household used for agriculture during the **[season]** more, less, or about the same as the amount of land your household used for agriculture during the **[previous season]**? **(If "More", go to question B3) (If "Less", go to question B4)** **(If "About the same", go to question B5)**	||	1 = More 2 = About the same 3 = Less

A9.	What were the two most important reasons you used more land? **(Go to question B5)**	a	b

A10.	What were the two most important reasons you used less land?	a	b

B3a /b: Codes for planting more land	**B4a /b: Codes for planting less land**
1 = Wanted to increase production because of increased need (e.g., for increased household consumption increased expenses/income, etc.)	1 = Reduced production because of reduced need (i.e., smaller household, lower expenses/income, etc.)
2 = Wanted to increase production to meet new demand (for existing or new crops)	2 = Reduced production because you lost markets
3 = Had more own capital (not borrowed) to invest in agriculture (hire labor, rent/buy land, buy inputs, buy/rent equipment or draught power, etc)	3 = Had less own capital (not borrowed) to invest in agriculture (hire labor, rent/buy land, buy inputs, etc)
4 = Able to access more credit (c ash or in-kind) to invest in agriculture (hire labor, rent/buy land, buy inputs, buy/rent equipment or draught power, etc)	4 = Had access to less credit (cash or in-kind) to invest in agriculture (hire labor, rent/buy land, buy inputs, etc.)
5 = Had access to more land that you didn't have to pay for	5 = Did not have access to as much land that you didn't have to pay for
6 = Had access to more labor you didn't have to pay for	6 = Less household labor available (due to illness, smaller household, etc.)
7 = Had access to more draught power you did	7 = La ck of access to as much draught power that you did not have to pay for
	8 = Could not afford as many inputs because of higher prices or lower subsidies

	not have to pay for	9=	Lower prices for crops discouraged you from
8 =	Could afford more inputs because they		planting as much

were less expensive or more subsidized 9 = Higher prices for crops encouraged you to plant more 10 = More of the land you use for agriculture was useable (less damage from floods/weeds, etc.) 11 = Began using land left fallow in previous year 12 = Other -8 = Not applicable/ no other reason	10 = Land became unusable (Flood/drought/Invasive weeds, etc.) 11 = Wanted to leave land fallow 12 = Other -8 = Not applicable/no other reason

A11. With which source of draught power did you cultivate the most land during the past 12 months?	| |	1 = Tractor 2 = Donkeys/Horses 3 = Cattle (cows & bulls) 4 = Other -8 = Not applicable/none

A12. I'd like to know how you divide agricultural work among household members and whether men and women have different responsibilities. Do the men or the women of the household do most of_____**[name of task from rows]** or is the work shared about equally among men and women?

		Crops kept for household consumption	Crops sold for c ash income
		a	b
1	Ploughing		
2	Hoeing		
3	Planting		
4	Weeding		
5	Applying fertilizer/pesticides		
6	Irrigation		
7	Harvesting		
8	Shelling/threshing maize/beans/ groundnuts/rice		
9	Post-harvest cleaning and sorting		
10	Marketing decisions (selling, transport to market, negotiating, etc.)		

B6a/b: Codes for source oflabor:
1 = Female household members
2 = Male household members
3 = Shared among male and female household members 4 = Hired labor 6 = Other
-8 = Not applicable

The following questions ask about the crops your household planted or harvested during the **[season]**.

A13.	Season	Which crops did you plant or harvest?	Did you intercrop this crop with another crop?	How much area did you plant to this crop?	**Record area units**	How much____did you harvest?			Of the seed you used to plant this crop, how much had you retained from your own production?	If you had had to buy this seed, what would it have cost?	How much improved/certified seed did you buy to plant this crop?	How much indigenous seed did you buy to plant this crop?	**(Do not ask if j & k are both "0")** Considering cash and in-kind payments, what was the total amount you spent on indigenous and improved seed to plant this crop?
	Enter names of (or codes for) the seasons relevant to the country	See codes below	1 = Yes, 0 = No			Quantity **0 = None**	**Weight units**	**Weight of "other" in kg**	0 = None -7 = Don't know Quantity (kg)	-7 = Don't know Local currency	0 = None -7 = Don't know Quantity (kg)	0 = None -7 = Don't know Quantity (kg)	Local currency
		a	b	c	d	e	f	g	h	i	j	k	l
	[first season] - if only one season, name it here and ask specifically about planting in this season.												
0													
1													
2													
3													
4													
	[second season] - if more than one season, name them in separate sections and ask specifically about planting in each season.												
5													
6													
7													
8													
9													

A14	For crops that are intercropped with other crops, record common expenses in the row corresponding to the first crop and do not record common expenses in the row corresponding to the second crop.		What was the cost of pesticides, herbicides, and spraying services you bought for this crop?	How much did you spend on non-labor expenses incurred to plant, tend, and harvest this crop (for example, e.g., leasing land or irrigating,)? **(Enter "0" if none)**	Did you hire any labor for this crop that you p aid based on the amount of time they worked? **(If "No" or 'don't know", go to next row/ crop)**	How many days of labor did you hire for preparing land, weeding, and harvesting for this crop? **(If "0", go to column r)**	Considering c ash, and the value of in-kind payment, what was the total amount you paid for this labor?	How many days of labor did you hire for other tasks for which you paid by the time spent for this crop? **(If "0", go to next crop)**	Considering cash, and the value of in-kind payment, how much did you pay for this labor?
			0 = None, -7 = Don't know	0 = None	1 = Yes 0 = No -7 = Don't know	Days of labor	Lo c al currency	Days of la bor	Lo c al currency
			m	n	o	p	q	r	s
		[first season] - if only one season, name it here and ask specifically about planting in this season.							
0									
1									
2									
3									
4									
		[second season] - if more than one season, name them in separate sections and ask specifically about planting in each season.							
5									
6									
7									
8									
9									

Season codes	Crop codes	area unit codes	weight units codes	
Develop c odes for each of the seasons using "1" for the main season, etc.	Insert codes for all staple and cash crops relevant to the country from the list of crop c odes in the Data Collection Manual.	1 = hectares 2 = acres 8 = Not applicable	1 = grammes kilogrammes 3 = 100 kg bags = 90 kg bags	5 = 50 kg bags 6 = metric tonnes 2 = 7 = quintals 8 = Other 4

A15. During the **[season]**, did you pay any labor based on the task (for example, ploughing or transporting crops from the field to your house)? **(If "No" or "Don't know", go to question A17)** **(If "Yes", go to B9)**	|__|	1 = Yes 0 = No -7 = Don't know

A`16. Considering c ash and the value of in-kind payment, how much did you p ay for all these tasks?

Local currency
|||||||||

A17.		Quantity (bags)	Weight units See c odes below	Weight of " other" units (kg)	Considering both cash and in-kind payments, what was the total amount you p aid for this fertilizer? Local currency
		a	b	c	d
	How much chemical and natural fertilizer did you buy for all the crops you planted last season?	| | | | |	| |	| | | | |	| | | | | | | |

: weight units codes

2 =	kilogrammes	5 =	50 kg bags
3 =	100 kg bags	6 =	metric tonnes
4 =	90 kg bags	7 =	quintals
		8 =	Other

The following questions ask about your sales of crops during the **[season]**.

A18	Season	Which crops did you harvest or sell during [season]? **(Include all crops listed in question B7a plus any other crops the respondent sold)**	How much of the quantity that you harvested have you sold, bartered, or used to repay loans?			What is the main reason you did not sell any of this crop?	Considering c ash, the value of in-kind goods, and the value of what you bartered or used to repay loans, what was the total amount you received for what you sold?	Which member of the household ma de the decision about how (timing, buyer, price, etc.) to sell this crop?	What was the total value of all costs (both c ash and in- kind) you incurred to sell this crop (e.g., transportation, storage, cleaning, drying, market fees, commissions, taxes, etc.)	Did you have any difficulty selling this crop?	What were the two most significant problems you had selling this crop?	
	Enter names of (or codes for) the seasons relevant to the country	Use codes from B7	Quantity **(If "0", go to e, Otherwise, complete c and d and then go to f)**	**Weight units**	**Weight of "other" in kg**	**(Go to next row/ crop or question)** See codes below	Lo c al currency	See codes below		**(If "No", go to next row or next question)** 1 = Yes, 0 = No	See codes below	
	a a	a	b	c	d	e	f	g	h	i	j	k
	[first season] - if only one season, name it here and ask specifically about planting in this season.											
0												
1												
2												
3												
4												
	[second season] - if more than one season, name them in separate sections and ask specifically about planting in each season.											
5												
6												
7												
8												
9												

A19: Season codes	**B11c: weight units codes**	**B11e: Reasons for not selling**
Develop c odes for each of the seasons using " 1" for the main season, etc.	2 = kilograms 3 = 100 kg bags 4 = 90 kg bags 5 = 50 kg bags	1 = No surplus to sell 2 = Had surplus but did not need/want to sell 3 = Wanted to sell but price not attractive 4 = Had surplus, but no-one to sell crops to/no affordable access to markets

	6 =	metric tonnes	5 =	Tried to sell but crop rejected due to poor quality
	7 =	quintals	7=	Have surplus to sell but waiting to sell it later
	8 =	Other	6 =	Other

A19g: Decision maker codes 1 = Household head 2 = Spouse of household head 3 = Joint decision of household head and spouse 4 = Other	**A19j/k: Problems selling crop** 1 = High cost of transport to market 2 = Low prices in acaccessible markets 3 = High market fees/taxes 4 = Poor transportation infrastructure 5 = Trade restrictions (for example, restrictions on cross-border trade or restrictions on traders buying particular ccommodities) 6 = Not able to meet quality requirements of buyers 7 = Unpredictable prices 8 = Lack of price information 9 = Difficult/unable to find buyer 10 = Farmers' organization not effective at selling your commodities 11 = Late or slow payment from buyers 12 = Other -8 = Not applicable (no other problem)

The following questions ask about how your household used the [staples] commodities you harvested during the **[season]**.

A20.	Crop **(list all [staples] commodities harvested from question A13a)**	Considering all the ___ **[name of crop]** that you harvested during the **[seasons]**, about what proportion did you… **(Use proportional piling if necessary) (Ensure that columns b through f sum to 100)**					What was the main cause of loss during storage?	How did you store the portion of this crop that you consumed in your household? **(Indicate up to two types of storage)**		How did you store the portion of this crop you sold (immediately or later on)? **(Indicate up to two types of storage)**		How did you usually dry this commodity?
		Sell, barter, use to repay loans, or give away?	Retain for sale later on	Lose to spoilage or pests during storage or use for other than its intended use because of spoilage?	Retain for consumption in your household?	Retain specifically for seed or animal feed?						
		Percent	Percent	Percent	Percent	Percent	See codes below	See codes below	See codes below	See codes below	See codes below	See codes below
	a	b	c	d	e	f	g	h	i	j	k	l
1												

2												

3												
4												
5												

A21.	Did you dry this commodity adequately to reduce spoilage during storage?	Did you store the commodity in a structure that kept out rats, mice, and moisture?	Did you treat the commodity with chemicals during storage to control insect pests?	**Continue only for crops reported sold in column b**	Considering all the ___ **[name of crop]** that you sold during the [seasons], about what proportion did you … **(Use proportional piling if necessary) (Ensure that columns p through r sum to 100)**			Of the portion of the __ **[name of crop]** that you sold, about what proportion did you … **(Ensure that columns s and t sum to 100)**		**(Ask only if s > "0")** What was the main reason you sold some of this crop within four weeks of harvest?	Was there a market for a better quality than what you sold (i.e., lower moisture, less foreign matter, fewer small/ broken grains)? **(If "No", go to next row)**	What was the main reason you did not improve the quality for this buyer/ market?
					Sell to or through a farmers' organization?	Sell yourself at your farm gate?	Sell yourself somewhere re re other than at your farm gate?	Sell within four weeks of harvest?	Store and sell at a later date?			
	1 = Yes 0 = No	1 = Yes 0 = No	1 = Yes 0 = No		Percent	Percent	Percent	Percent	Percent	See codes below	1 = Yes 0 = No	See codes below
	m	n	o		p	q	r	s	t	u	v	w
1	|__|	|__|	|__|									
2	|__|	|__|	|__|									
3	|__|	|__|	|__|									
4	|__|	|__|	|__|									
5	|__|	|__|	|__|									

A21a: Crop codes	**A21g: Storage loss codes**	**A21h/ i / j / k: Storage options**	**A21l: Drying methods**

	1 = Mould /spoilage 2 = Pests/insects 3 = Rats/mice/etc. 4 = Other animals 5 = Other -7 = Don't know **Reasons for selling at harvest**	1 = In traditional granaries 2 = Indoors – in basket/bags 3 = Indoors – open storage 4 = Outside – open storage 5 = In certified warehouses for which you received a receipt specifying the quality and quantity deposited 6 = In other warehouses/stores 7 = Metallic home silos (Latin America) 8 = Other -8 = Not applicable / did not store **Reason for not improving quality**	1 = On the ground 2 = On tarpaulins or iron sheets 3 = On concrete / grain yards 4 = Mechanic al dryer 5 = Crib 6 = Hanging 7 = In the field (standing or stacked) 8 = Other -8 = Not applicable/did not dry
	1 = Needed immediate c ash 2 = Could not store 3 = Offered a good price 4 = Other	1 = Normal practice meets buyer specifications 2 = No increase in price to justify cost 3 = Increase in price not enough to justify cost 4 = Farmers' organization provided this service 5 = Do not have ability to dry, clean, or sort to buyer specifications 6 = Other	

A22.		During the past 12 months, where did you get information about prices of staple commodities? **(Mark all that apply and prompt if necessary)**	**(Ask only if B13a = 1)** Did this information help you in your selling decisions?
		1 = Source of information 0 = Not a source of information -8 = Not applicable	1 = Yes 0 = No
		a	b
1	Radio/TV	|__|	||
2	Direct contact with traders	|__|	||
3	Farmers' organizations	|__|	||
4	Newspapers	|__|	||
5	Extension workers	|__|	||
6	SMS system/mobile phone	|__|	||
7	Neighbors/friends/relatives	|__|	||
8	Information boards at local agricultural offices	|__|	||
9	Personal knowledge of the market	|__|	||
10	Information from food reserve agency (country-specific name)	|__|	||
11	NGOs	|__|	||
12	International development organizations	|__|	||

A23. Did you cultivate any cash crops last season?

☐ No (1) ☐ Yes (2)

A23a. Did you grow crops in a backyard garden this past dry season?	Yes	1
	No	2
A23b. If yes, what was the size of the garden?	Area cultivated:	
A24. What crops did you grow in the garden? *Enumerator: Probe for all possible crops…*) Green leafy vegs, tomatoes, onions, potatoes, carrots, pumpkins, beans, maize, sweet peas, sweet potatoes, yams, sugar cane, cassava…	Crops:	
A25. What methods do you use to water the garden crops?	Diesel pump	1
		2
	Hand watering	3
	Gravity canals	4
	Deep planting/ residual moisture	5
	Other	97
A26. Did you grow any cash crops last season?	Yes	No

A27a. Did you receive a fertilizer coupon?	
A27b. If yes what quantity (specify in bags)?	
A28a. Did you apply any herbicide to your fields last season?	
A28b. If yes, what quantity?	

A29. Which of the following did you do to improve soil fertility

Strategy	Yes	No
Planted legumes		
Buried crop residue		
Agroforestry		
Mulching		
Prepared box ridges		
Planted vertiva grass		
Applied compost manure		
Crop rotation		
Other (specify)		
Applied chemical pesticides/herbicides/ fertilizers		
Other (specify)		

A30. Did you do any of the following to control pests and diseases?

Strategy	Yes	No
Intercropped		
Crop rotation		
Improve soil fertility		
Applied botanical sprays (e.g. tephrosia, chisoyo)		
Planted repellant plants		
Physical killing		
Smash or burn beetles to apply to field		
Adjust planting time		
Applied chemical pesticides/herbicides/ fertilizers		
Other (specify)		

A31a. Have you shared any seeds in the last planting season? ☐ Yes ☐ No

A31b. if yes, check all of the crops which you have shared and indicate what amount

Crop	Quantity
1.	
2.	
3.	
4.	
5.	
6.	

A32a. Have you received or borrowed any seeds in the last planting season? ☐ Yes ☐ No

A32b. If yes, specify source and quantity

Crop	Quantity	Source
1.		
2.		
3.		
4.		
5.		
6.		

Module B: HOUSEHOLD FOOD SECURITY

Instructions to the Enumerators: For each of the following questions, make sure that you refer to the past four weeks. If the answer is 'yes', explain whether: sometimes (once or twice), often (3-10 times), frequently (more than 10 times).

#	Question (Check only one response). Each of the following questions applies to past 4 weeks.	Never	Rarely (1-2 times)	Sometimes (3-10 Times)	Often (More than 10 times)
B1	In the past 4 weeks, were you ever worried that you may not have enough food in your household?	☐	☐	☐	☐
B2	In the past 4 weeks was there anyone in this household unable to eat the kinds of foods you preferred because of a lack of resources?	☐	☐	☐	☐
B3	In the past four weeks did you or any household member have to eat a limited variety of foods due to a lack of resources?	☐	☐	☐	☐
B4	In the past four weeks was there any household member who had to eat some foods that you really did not want to eat because of a lack of resources to obtain other types of food?	☐	☐	☐	☐
B5	In the past four weeks was there anyone in this house hold who ate less amount of food [or a smaller meal than you felt you needed] because there wasn't enough food?	☐	☐	☐	☐
B6	In the past four weeks was there any household member who ate fewer times per day because there wasn't enough food?	☐	☐	☐	☐
B7	In the past four weeks was there ever no food to eat of any kind in your household because of lack of resources?	☐	☐	☐	☐
B8	In the past four weeks, did you or any household member go to sleep at night hungry because there wasn't enough food	☐	☐	☐	☐
B9	In the past four weeks was there any household member who had spent a whole day and night without eating because there wasn't enough food?	☐	☐	☐	☐
B10	Have you or any household member had to do 'byday' for food in the past 4 weeks because you have run out of your own food sources? Have you or any household member had to do ganyu for food in the past 4 weeks because you have run out of your own food sources?	☐	☐	☐	☐
	Enough clean water for home use?	☐	☐	☐	☐
	Enough fuel to cook your food?	☐	☐	☐	☐
	A cash income?	☐	☐	☐	☐

#	Question (Check only one response). Each of the following questions applies to past 4 weeks.	Never	Rarely (1-2 times)	Sometimes (3-10 Times)	Often (More than 10 times)
B11	Did you run out of food last year?	Yes or no			
B12	At what month after harvest did last season's produce finish and your household started struggling with finding food?	Indicate in months (July to September is the harvest season)			
B13	Does your household harvest/process shea to support household food provisioning?	Yes/no			
B12	What quantity of shea did your household harvest last year				

Dietary Diversity

B13. Now I will ask you questions about food stuffs and drinks that any household member ate or drank yesterday from the time he/she woke up until he/she went to bed *[Do not include food or drink taken elsewhere].* Did any household member eat or drink any of the following yesterday?

Food group	Examples	Yes	No
a) Cereals	Any food such as TZ, porridge, bread, spaghetti, scones, biscuits, rice, boiled whole maize grain, pito/sweet beer, or any food made from finger millet, sorghum, bulrush millet, maize and wheat?	1	0
b) Vitamin A rich tubers & vegetables	Any food such as: pumpkins, carrots or sweet potatoes having yellow pigment, including local orange maize? *[please check here if they indicate that they ate local orange maize]*	1	0
c) White tubers and roots	Any food in the group of: white sweet potatoes, coco yams, cassava, Irish potatoes, yams or any white roots and tubers?	1	0
d) Dark green leafy vegetables	Relish of dark green leafy vegetables as well as the indigenous vegetables including, Cat's whiskers leaves, cassava leaves, sweet potato leaves, mustard, rape, local rape, pumpkin leaves, cow peas leaves, bean leaves, black jack leaves	1	0
e) Any other vegetables)	Any kind of relish from leafy vegetables e.g. Chinese cabbage, okra, cabbage, egg plants, tomatoes, onions, green pepper and green beans?	1	0
f) Vitamin A rich fruits	Any fruits like papaya (pawpaw	1	0
g) Other fruits	Any other fruits including the indigenous wild fruits e.g. oranges, tangerines, lemons, tamarind, elephant fruits, avocado pears, bananas and baobab fruits?	1	0
h) Meats	, pork, goat meat, rabbit meat, mice, wild game, poultry duck, flying insects e.g. guinea fowl or any other bird, liver, kidney, heart, offal or any other meat.	1	0
i) Eggs	Eggs of any kind?	1	0
j) Fish	Fresh or dried fish	1	0
k) Legumes, nuts & seeds	Any type of beans and peas e.g. beans, cow peas, pigeon peas, nkhungudzu, peas, ground beans, soya beans, ground nuts, green gram, custard apple, Nseula, chickpeas?	1	0
l) Milk and milk products	Milk and Food made from milk e.g. yoghurt, sour milk?	1	0
m) Oils and Fats	Any type of fats or oils e.g. cooking oil, animal fats and margarine used for cooking or added to food?	1	0
n) Sweets	Any sweet, sugar, honey, soft drinks such as Fanta, Coca-Cola, sprite, and other drinks to which sugar was added or sugary foods e.g. chocolate, sweets?	1	0

o) Coffee/tea	Any tea or coffee?	1	0

Module C. HOUSEHOLD EXPENDITURE

C1.			About how much did your household spend on_____for domestic consumption **during the last 30 days.** **(If "Don't know", go to next item)**		
1	Maize		9	Milk and dairy products	
2	Beans		10	Sugar/Salt	
3	Bread		11	Milling	
4	Rice		12	Alcohol & Tobacco	
5	Fruits & vegetables		13	Household items (soap, batteries, etc.)	
6	Fish/Meat/Eggs/ poultry		14	Transport and fuel	
7	Oil, fat, butter		15	Cooking & lighting fuel (wood, paraffin, etc.)	

C3.	About how much did your household spend on_____**during the last 12 months**.
	(If "Don't know", go to next item) 0 = None
Medical expenses, health care	**-7 = Don't know**
Education (books, school fees, uniform, etc.) Clothing, shoes	
(excluding those required for school) Equipment and tools	
1 (including for agriculture) Construction, house repair	
2	
3 Debt repayment	
4 Celebrations, social events (funerals, weddings, etc)	
Remittances/gifts	
9	— — — —
10 Raising crops (includes the cost of inputs – excluding equipment and tools - and labor)	— — — —

8	Water		16	Soda/drinks (including tea)	

Module D. LIVESTOCK

D1. During the past 12 months, did your household raise any livestock, either for sale or for your own consumption? **(If "No", go to next section)**		__		1 = Yes 0 = No

D2.	What types of livestock has your household owned during the past 12 months?	How many of [animal type] do you have now?	How many of [animal type] did you buy during the past 12 months? **(If "0", go to e)**	Considering both c ash and the value of in-kind payments, how much did you spend purchasing these animals?	How many of [animal type] did your household consume or give aw ay during the past 12 months?	How many of [animal type] did you sell or barter during the past 12 months? **(If "0", go to h)**	Considering c ash and the value of in-kind payment, what is the total amount you received for the sale of these animals?	During the past 12 months, did you earn any money renting this animal or selling products from this animal? **(If "No", go to j)** **Yes=1, No=0**	In total, how much did you earn (in c ash and the value of in-kind payment) from renting these animals or selling their produces during the past 12 months?	Considering c ash and the value of in-kind payment, how much did you spend on feed for these animals during the past 12 months?	Considering c ash and the value of in-kind payment, how much did you spend on other costs for these animals such as veterinary supplies, taxes, and hired labor during the past 12 months?
	a	b	c	d	e	f	g	h	i	j	k
1											
2											
3											
4											
5											
6											
7											
8											
9											

Module E. LIVELIHOOD ACTIVITIES AND OTHER INCOME

E1	Other than agriculture and livestock that you've already told me about, **(mentioned in Modules Band D)**, what other sources of cash and in-kind income did your household have during the past 12 months? **(List top three livelihood sources first)**	How many members of your household worked at this activity during the past 12 months? **(Enter "not applicable" for remittances or gifts or other types of income that did not require work)** **-8 = not applicable**	What was the total amount the entire household or household members earned during the past 12 months from this activity considering both cash payments and the value of in-kind payments? **(Enumerator: ask about number of household members who worked how many days/ months worked, payment, etc. to arrive at the answer)**	Did the household incur any expenses with this activity? **(Probe about hired labor, purchasing items to sell, renting market space, transportation, etc.)**. **(If "No", go to next row/ activity)** 1 = Yes 0 = No	About how much were these expenses during the past 12 months?
	a	b	c	d	
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					

E1a /E3: Livelihood activity codes

Cash or in-kind income from…

1 = Remittances

2 = Trading staple commodities or cash crops

19= Production & sale of staple

7 = Petty trade

8=Pension/social grants

9 = Formal salary/wages

10 = Fishing

11 = Vegetable /fruit

14 = Cash, food, or other assistance

15 = Gathering natural products for sale e.g. medicinal herbs, mushrooms, etc.

16 = Collecting scrap / waste material for re-sale

crops 13 = Beer brewing/distillation 21= Sale of livestock & livestock products 4 = Casual labor/piece work 5 = Begging/gifts 6 = Own business		
E2. Was your household's total income from all sources (including agriculture and livestock) during the past 12 months higher, lower, or about the same as in the 12 months prior to that time? **(If "About the same" or "Don't know" go to Module F)**	|||	1 = Higher 2 = About the same 3 = Lower -7 = Don't know
E3. Which of your household's livelihood activities was most responsible for the change **(reported in E2)**?	|||	Use codes from **E1a/E3**

Module F: ACESS TO CREDIT

F1.	Has any member of your household borrowed any cash or goods during the past 2 years? **(If "Yes", go to question F2)** **(If "No", go to question H1)**	|__|	1 = Yes 0 = No

F2.		Has any member of your household borrowed any cash or goods for_____in the past 2 years? **(If multiple loans of the same type/category, enter information for most recent)** **(If "No", go to next row)** 1 = Yes 0 = No	What amount did you ask for? **(If loan was in-kind (i.e., goods or services instead of cash), enter the monetary value of the goods or services requested)**	What amount did you receive? **(If the loan was in-kind (i.e., goods or services instead of cash), enter the monetary value of goods or services received)**	Which household member signed for the loan? 1 =Female 0 = Male 2 =Joint loan	What was the source of the loan?	In what form (did you/will you) rep ay the loan?
		a	b	c	d	e	f
1	To purchase agricultural inputs (seed/fertilizer/chemicals)	|__|			|__|	|_|	|__|
2	To invest in agriculture (e.g., buy tools, equipment, livestock, buy or rent land, etc.)	|__|			|__|	|_|	|__|
3	To start or invest in a non-agricultural business	|__|			|__|	|_|	|__|
4	To pay school fees/supplies	|__|			|__|	|_|	|__|
5	To purchase staple food for household consumption	|__|			|__|	|_|	|__|
6	To pay for health care / medical expenses	|__|			|__|	|_|	|__|
7	To pay for social event (funerals, weddings)	|__|			|__|	|_|	|__|

8	To build or add on to a house	|__ |			|__ |	|_ |	| |
9	Other	|__ |			|__ |	|_ |	| |

F2e: Codes for sources of credit

1= Friend/relative
2 = Money lender
3 = Commercial bank
4 = Informal savings group
5 = Farmers' organization
6 = Local trader/ shopkeeper
7 = Buyer/ trader (contract farming)
8 = Government/Rural Credit fund
9 = International development organization
10 = NGO
11 = Micro-credit institutions
12 = Other

F2f: How credit was/will be repaid

1 = In c ash
2 = In kind
3 = Both c ash and in kind

Module G. HOUSEHOLD ASSETS

H1. How many of each of the following assets that are in working order does a member of your household own? **(If an asset is not owned or belongs to a non-household member, write 0)**

		a			a
1	Chair (excluding traditional stools and benches)		15	Hand Mill	
2	Table		16	Bicycle	
3	Bed		17	Harrow	
4	TV/ satellite dish/DVD		18	Plough	
5	Radio		19	Sewing machine	
6	Fishing nets		20	Hammer mill	
7	Canoes		21	Mobile phones/ landline	
8	Axe		22	Maize thresher	
9	Machete		23	silos	
10	Backpack sprayer		24	Tricycle motor/motorking	
11	Hoe		25	Vehicle (car/pick up/motor cycle)	
12	Ox Cart		26	Stove (electric or gas)	
13	Tractor		27	Fridge	
14	Generator		28	Water pump/ treadle pump	

Module H. HOUSING AND AMENITIES

H1. Please indicate the major material of the roof, floor and walls of the main house? **(based on observation – Don't ask)**

1	Roof	
2	Floor	
3	Walls	

Roof
1 = Thatch
2 = Iron sheets 3 = Tiles
4 = Plastic

Floor
1 = Dirt/ mud/sand 2 = Wood
3 = Concrete 4 = Asbestos

Walls
1 = Concrete/fired brick
2 = Mud or mud brick
3 = Mud/wattle

H2. What is the main source of drinking water for your family? **(If "Piped into dwelling", go to question H5)**		1 = Piped into dwelling, yard or plot 2 = Public tap/neighboring house 3 = Well/spring	4 = Pond, lake, river, or stream 5 = Tanker 6 = Borehole 7 = Rain water 8 = Other

H3. On a typical day, what is the total number of trips all members of your household make to fetch water for household use?	

	a		b	
H4. Including waiting time, about how much time does one trip to fetch water for household consumption usually take?	**(Enter "-7" for "Don't know")**	**Record units for|_ | time**		1 = Minutes 2 = Hours

H5. What type of toilet facility does your household use?		1 = Flush/ pour flush 2 = Ventilated Improved Pit latrine (VIP)	3 = Pit latrine (unimproved) 4 = None (bush or field)

H6. What type of cooking fuel does your household use		1 = Charcoal 2 = Firewood 3 = Kerosene/paraffin	4 = Gas cylinder 5 = Electricity 6 = Other

H7. What type of lighting fuel does your household use?		1 = Kerosene/paraffin, oil, or gas lantern 2 = Generator/ car battery 3 = Candles, firewood	4 = Solar panel 5 = Electrical network 6 =Torch 7 = Other

Module I: HOUSEHOLD GENDER RELATIONS

11	In your household who is considered to be in charge of decision making?	Everyone contributes equally	1
		Male Head/Father	2
		Female Head/Mother	3
		Male relative	4
		Female relative	5
		Both female and male	6
		Other (Specify)	7
		Don't Know	8
		Refused	9
12	In your household who makes decisions about making large household purchases? (Example: Vehicle, furniture etc.)	Everyone contributes equally	1
		Male and Female Heads decide together	2
		Mostly the Males	3
		Mostly the Females	4
		Other (Specify)	7
		Don't Know	8
		Refused	9
13	In your household who makes decisions about making household purchases for daily needs?	Everyone contributes equally	1
		Male and Female Heads decide together	2
		Mostly the Males	3
		Mostly the Females	4
		Other (Specify)	7
		Don't Know	8
		Refused	9
14	In your household who makes decisions about visits to distant families and relatives?	Everyone contributes equally	1
		Male and Female Heads decide together	2
		Mostly the Males	3
		Mostly the Females	4
		Other (Specify)	7
		Don't Know	8
		Refused	9
15	In your household who makes decisions about what food to eat each day?	Everyone contributes equally	1
		Male and Female Heads decide together	2
		Mostly the Males	3
		Mostly the Females	4
		Other (Specify)	7
		Don't Know	8
		Refused	9
16	In your household, who contributes most of the income?	Children	1
		Male Head/Father	2
		Female Head/Mother	3
		Male relative	4
		Female relative	5
		Other (Specify)	7
		Don't Know	8
		Refused	9
17	In your household who contributes **THE SECOND MOST** of the income?	Children	1
		Male Head/Father	2
		Female Head/Mother	3
		Male relative	4
		Female relative	5
		Other (Specify)	7
		Don't Know	8
		Refused	9
18	In your household who usually makes decisions on paying for any health-related expenses?	Everyone contributes equally	1
		Male and Female Heads decide together	2
		Mostly the Males	3
		Mostly the Females	4

		Other (Specify)	7
		Don't Know	8
		Refused	9
19	Who usually decides what and where to plant?	Everyone contributes equally	1
		Male and Female Heads decide together	2
		Mostly the Males	3
		Mostly the Females	4
		Other (Specify)	7
		Don't Know	8
		Refused	9
110	Who usually decides what farm products to sell?	Everyone contributes equally	1
		Male and Female Heads decide together	2
		Mostly the Males	3
		Mostly the Females	4
		Other (Specify)	7
		Don't Know	8
		Refused	9
111	Who usually decides whether you can participate with different local organizations?	Everyone contributes equally	1
		Male and Female Heads decide together	2
		Mostly the Males	3
		Mostly the Females	4
		Other (Specify)	7
		Don't Know	8
		Refused	9

112 Can your wife (*or you if it is woman*) ever decide to plant crops on own?	Yes	No
113 Can your wife (*or you if it is the woman*) ever decide to sell crops on her own?	Yes	No
114 Can your wife (*or you if it is the woman*) ever decide on her own to join an organization such as a village bank?	Yes	No
115 Can your wife (*or you, if it is the woman*) ever decide to visit family or friends outside the village on her own?	Yes	No
116a. Do you (*or your husband*) ever help with childcare?	Yes	No
16b.1 If yes, how often per month? (circle response) (write any details provided):	Daily	
	Frequently	
	Rare Occasions	
	Never	
117 Would you (*or your husband*) be comfortable with your wife being in a leadership position in an organization that led her to travel away from home?	Yes	No
118a. Do you (*or your husband*) ever help with food preparation?	Yes	No
118b.1 If yes, how often per month? (circle response)	Daily	
	Frequently	
	Rare Occasions	
	Never	
119a. Do you (*or your husband*) ever do the laundry?	Yes	No
119b. If yes, how often? (circle response) (write any details provided):	Daily	

	Frequently	
	Rare Occasions	
	Never	
I20. Does anyone in the household drink alcohol?	Yes	No
I21 If someone drinks Can you estimate how often per week this person usually drinks?	Daily	
	Frequently	
	Rare Occasions	
	Never	

Module J: ADAPTIVE CAPACITY AND RESILIENCE

Now I would like to ask you about what you do to manage or cope during drought, flood events and storm surges.			
J1	Which of these events have you experienced in the past 12 months?	Drought	0
		Flood	1
		Storm Surge	2
		Erratic rainfall	3
		None	4
		Other	5
J2	Do you have any coping strategies?	No	0
		Yes	1
		Don't	8
		Refused	9
J3	What specific things did you do to manage the most recent drought/flood/ storm/ other climate event you experienced?	Nothing	0
		Relocate	1
		Sand filling	2
		Drain water	3
		Rely on family or friends	4
		Rely on social network	5
		Rely on government	6
		Rely on humanitarian aid	7
		Sell crops or livestock	8
		Sell assets	9
		Don't know	97
		Refused	98
		No	99
J4	In the past 12 months have you received early warning information about drought, flood/storm events?	No	0
		Yes	1
		Don't know	8
		Refused	9
J5	From whom would you get this early warning information? (Circle as mentioned)	Friends, neighbors, and family	1
		Community leader/ lead farmer	2
		Social networks	3
		Media	4
		Local government	5
		Central government	6
		Private organization	7
		NGOs	8
		Don't know	98
		Refused	99
J6	What changes (if any) in your household have you made because of drought/flood/storm/ erratic rainfall?	None	0
		Relocation out of flood/storm prone area	1

		Change job	2
		Change school for children	3
		Construct flood/storm barriers	4
		Clearance of drainage channels	5
		Change planting times	6
		Changing cultivation methods	7
		Others (specify)	8
J7	How would you rank drought/flood/storm / erratic rain problems relative to other problems in your area?	Low	2
		At par (same)	3
		High	4
		Top priority	5
		Don't know	8
		Refused	9
		Very poor	1
J8	How would you rate your ability to handle flood/drought/ erratic rain related stress?	Poor	2
		Satisfactory	3
		Good	4
		Very good	5
		Don't know	8
		Refused	9

Appendix C: Curriculum Vitae

EVANS SUMABE BATUNG

Department of Geography and Environment
University of Western Ontario
1151 Richmond St, London, ON N6A 3K7

Education and training

Sept 2019 — Aug 2021(Expected)	MSc. Candidate (Specialization in Environment and Sustainability) Department of Geography and Environment University of Western Ontario, Canada Supervisor: Dr. Isaac Luginaah
Jan 2017 — Feb 2017	Certificate in Fundamentals of GIS University of California Davis on Cousera
Aug 2014 — May 2018	B.A. (First Class Honors) Major in Geography and Resource Development Minor: Archaeology University of Ghana Supervisor: Dr. Kwadwo Owusu

Teaching and professional experience

Teaching Assistant
Western University
Aug 2019 — present

Teaching weekly tutorial sessions; moderating online and in-class discussions, holding office hours and proctoring; and grading of assignments, quizzes and final examinations.

TA Courses:

- GEOG 2430A: Public Health and Environment
- GEOG 3432B: Environmental Hazards and Human Health
- GEOG 1500F: Environment and Development Challenges

Guest lecturer

GEOG 3432B: Environmental Hazards and Human Health

Research Assistant
Center for Climate change and Sustainability Studies (C3SS)
University of Ghana

Main duties:

Sept 2018 — Aug 2019

- Led the creation of climate change awareness for diverse age groups via public presentations and the development of brochures and posters
- Conducted literature reviews for sustainability projects
- Assisted in the creation of an inventory for unsustainable student practices and climate change related courses taught within the university.

Research internship
University of Alberta, Edmonton, Canada
May 2018 — Aug 2018

Industrial attachment
Centre for Remote Sensing and Geographic Information Services (CERSGIS), Ghana
Jun 2017 — Aug 2017

Main duties:

- Assisted with field data collection (plant gas emissions, soil moisture content, plant heights and eddy covariances)
- Assisted with setting up and conducting efficiency tests of the laboratory equipment.

Global Haulage Company Limited
Jun. 2015 — Aug. 2015

Main duties:

- Maps and shapefile creation; model building
- Assisted with the testing of GIS applications developed at the center.

Main duties:

- Monitoring the progress of long-distance haulages.

Research publications

1. Dekker, I., Sharifyazd, S., **Batung, E.,** & Dubrawski, K.L., (2021). Maximizing Benefits to Nature and Society in Techno-Ecological Innovation for Water. Sustainability, 13(11), 6400.

2. Mohammed, K., **Batung, E.,** Kansanga, M.M., Nyantakyi-Frimpong, H., & Luginaah, I. (2021). Livelihood diversification strategies and resilience to climate change in semi-arid northern Ghana. Climatic Change, 164(3), 1-23.

Peer review papers (under review)

1. Mohammed, K., Gazali, S.M., **Batung, E.,** Amoak, D., Avoca, V.A., Kansanga, M.M., & Luginaah, I. (2021). Climate matters: Understanding climatic correlates of malaria prevalence

among children in Ghana. *The Journal of Climate Change and Health* (ID: JOCLIM-D-21-00054).

2. **Batung, E.,** Mohammed, K., Kansanga, M. M.., Nyantakyi-Frimpong, H., & Luginaah, I., (2020). Credit access and perceived climate change resilience of smallholder farmers in semi-arid northern Ghana. *Environment, Development and Sustainability* (ID: ENVI-D-20-02449).

3. **Batung, E.,** Mohammed, K., Kansanga, M. M.., Nyantakyi-Frimpong, H., & Luginaah, I., (2020). Intra-household decision-making and perceived climate change resilience among smallholder farmers in semi-arid northern Ghana. *SN Social Sciences* (ID: SNSS-D-20-01321).

4. Mohammed, K., **Batung, E.,** Kansanga, M. M., Nyantakyi-Frimpong, H., & Luginaah, I., (2020). Intra-household decision-making arrangements and food security in semi-arid Ghana. *African Geographical Review* (ID: RAFG-2020-0119).

5. Kansanga, M. M., **Batung, E.,** Mohammed, K., Sano, Y., Taabazuing, M., Luginaah, I., (2021). Beyond purchasing power: The association between sense of community belongingness and food insecurity among the elderly in Canada. *Journal of Aging and Social Policy* (ID: 212466140).

6. Kansanga, M. M., **Batung, E.,** Konkor, I., Kpienbaareh, D., Mohammed, K., Nyantakyi-Frimpong, H., & Luginaah, I, (2021). Gender and timing to seasonal food insecurity: Evidence from semi-arid northern Ghana. *World Development* (Ref: WD-19839).

7. Kansanga, M. M., Konkor, I., Kpienbaareh, D., Mohammed, K., **Batung, E.,** Nyantakyi-Frimpong, H., Kuuire, V., & Luginaah, I, (2021). Time matters: correlates of timing to food insecurity among smallholder farmers in semi-arid northern Ghana. *Food Security* (ID: FOSE-D-21-00059).

Manuscripts in progress

Batung, E. Farm power and food security outcomes among smallholder farmers in semi-arid northern Ghana.

Conference presentations and participations

April 2021	Session chair: American Association of Geographers (AAG, 2021), Virtual conference. Session: Agricultural Geographies of Africa
April 2021	American Association of Geographers (AAG, 2021), Virtual conference. Presentation title: *Intra-household decision-making and perceived climate change resilience among smallholder farmers in semi-arid northern Ghana*
March 2021	Moderator: EnviroCon (2021), Western University, Canada.
March 2021	EnviroCon (2021), Western University, Canada. Presentation title: *Intra-household decision-making and perceived climate change resilience among smallholder farmers in semi-arid northern Ghana*
November 2020	Africa-Western Collaborations Day (AWC, 2020), Canada. Presentation title: *Credit access and perceived climate change resilience of smallholder farmers in semi-arid northern Ghana.*
November 2020	Moderator: GIS Day (2020), Western University, Canada.
November 2019	Africa-Western Collaborations Day (AWC 2019), Canada. Poster title: *Influence of rainfall on major crop production in the Nadowli-Kaleo district, Ghana.*

Honors, awards and funding

Sept 2019 — Sept 2021	Western Graduate Scholarship, Western University — $31,000 per year for two years.
May 2018 — Aug 2018	University of Alberta Research Experience Award— $6,000.

Service

May 2021	Texting Volunteer, Western University
June 2020 to Date	Student Coordinator, Ghana Association of London and Middlesex.

Feb 2020 to Date	Volunteer Instructor (Grade 4), GALM Weekend Homework Club for London and Middlesex area. London, ON.
Sept 2019 to Date	Member of graduate student committee: International Student Issues Committee, Western University.