SECURITY IN UNCERTAINTY:
ANALYSIS OF CLIMATE RISKS AND HOUSEHOLD RESPONSES TO FOOD INSECURITY IN NORTHERN GHANA

BY

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Abstract

Ghana represents an important case study for food insecurity research because of the high concentration of hungry populations in the country's north relative to the south. While the increasing climate change and weather variabilities in north Ghana explain the region's widespread hunger, there are also non-climatic factors that undermine households' vulnerability. This dissertation explores smallholder farming households' experiences with climate hazard events by emphasizing their vulnerabilities and response behaviours to climate and seasonality-induced food insecurities. It adopts a micro-level food systems lens integrated with livelihoods, vulnerability, and disaster risk theories. It is also informed by fieldwork and engagement with farming households in northern Ghana. A key argument of this dissertation is that food insecurity in northern Ghana is influenced by not only the climate-dependency of food system activities in the region but also the vulnerability in how food is produced, harvested, stored, and marketed. The findings reveal that climate change events lead to food crop productivity losses, cause damage to stored grain, and disrupt food prices, which affects food security. It also shows how households' and food systems' vulnerabilities intensify these climatic impacts and the concomitant variations in yearly food availability and access. The study further finds that poor households are not passive victims; they strategically adopt various actions to manage climate-induced food insecurity risks. In particular, the households' responses follow a sequential order to preserve critical assets for current consumption needs and for the sustainability of agricultural livelihood. However, some of the response actions are associated with excruciating costs that could rebound and erode efforts for sustainable food security, especially for women and youth. Overall, the research provides evidence-based knowledge to address climate-related challenges for food security in the northern part of the country and to minimize regional disparities, which have long-term political implications. It also makes a strong case to draw attention to the diversity, sequence, and gendered nature of household responses to food crises.

Keywords: Climate change, food security, risks, food systems, smallholder farming, household responses, northern Ghana

Dedication

To my Dear Mum and Best Auntie of blessed memory.

Hajia Safuna Issah Mohammed & Fati Mohammed

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Table of Contents

Abstract ..... **ii**
Dedication ..... **iii**
Acknowledgement ..... **iv**
Table of Contents ..... **vi**
List of Tables ..... **ix**
List of Figures ..... **x**
CHAPTER 1 ..... *1*
BACKGROUND AND PROBLEM SETTING *1*
1.1. Introduction **1**
1.2. The Problem of Hunger in Ghana **1**
1.3. Vulnerabilities and Risks **4**
1.4. Research Problem Statement **9**
1.5. Research Objectives and Questions **11**
1.6. Definition of Key Terms and Concepts **12**
1.7. Structure of the Dissertation **13**
CHAPTER 2 ..... *17*
THEORETICAL APPROACHES TO UNDERSTANDING FOOD SECURITY AND CLIMATE CHANGE RISKS *17*
2.1. Introduction **17**
2.2. Theoretical Formulations on the Concept of Food Security **17**
2.3. A Food Systems Approach to Researching Food Security **20**
2.4. Understanding Climate Change Risks **23**
2.4.1. Climate Hazards and Vulnerability 24
2.4.2. Vulnerability Assessment 26
2.5. Models for Assessing Risks in Rural Livelihoods and Food Security **29**
2.5.1. The Sustainable Livelihoods Framework 29
2.5.2. Pressure and Release Model 30
2.5.3. Access to Resources Model 31
2.6. Managing Risks for Food Security in Rural Livelihoods **33**
2.7. Conclusion **36**
CHAPTER 3 ..... *37*
RESEARCH METHODOLOGY *37*

3.1. Introduction 37

3.2. Study Area 37
3.2.1. Physical Characteristics 39
3.2.2. Population 40
3.2.3. Economy 42
3.2.4. Land Tenure System and Governance 43
3.2.5. Poverty Situation 45

3.3. Research Design and Approach 46
3.3.1. Fieldwork Timeline 48
3.3.2. Researcher's Role 50
3.3.3. Research Assistants 54
3.3.4. Sampling Methods and Profile of the Study Communities 55
3.3.5. Data Collection Methods 62

3.4. Data Analysis and Interpretation 66
3.4.1. Data Collection Ethics and Validity 66

3.5. Partnerships and Collaborations 67

3.6. Knowledge Mobilization and Dissemination 68

3.7. Conclusion 69

CHAPTER 4 70

A FOOD SYSTEM ANALYSIS OF DIETARY CONSUMPTION, FOOD AVAILABILITY, AND FOOD ACCESS IN NORTHERN GHANA 70

4.1. Introduction 70

4.2. Results 71
4.2.1. Timeline of Key Food-Related Activities in Rural Communities 71
4.2.2. Weekly Food Consumption 74
4.2.3. Monthly Food Availability 76
4.2.4. Households' Food Sources 79
4.2.5. The Distinctive Characteristics of Food System Activities 80
4.2.6. Challenges to Food Access and Availability 88

4.3. Discussion 90
4.3.1. Seasonality of Production and Dietary Choice 90
4.3.2. Ineffective Food Storage, Food Availability, and Seasonal Hunger 92
4.3.3. Underdeveloped Markets and Food Access in the Hungry Season 94

4.4. Conclusion 96

CHAPTER 5 98

CLIMATE AND FOOD INSECURITY RISKS IN NORTHERN GHANA 98

4.5. Introduction 98

5.1. Results 100
5.1.1. Climate Variability in the Study Communities 100

5.1.2. Perceived Exposure to Extreme Climatic Events and Hazards 102
5.1.3. Impacts on Food System Activities 103
5.1.4. Food System and Household Vulnerability to Climate Hazard Impacts.....107
5.1.5. Severity of Climate Hazard Impacts on Food Systems 116
5.1.6. Severity of Climate Hazards Impacts across the various Communities 120

5.2. Discussion 123
5.2.1. Climate Hazards and Food Insecurity Risks 123
5.2.2. The Fragile Food System Activities of Northern Ghana.....125
5.2.3. Communities with Unsafe Conditions for Food System Activities.....126

5.3. Conclusion 127

CHAPTER 6**.....*129***

HOUSEHOLDS' RESPONSE STRATEGIES AGAINST CLIMATE-INDUCED FOOD INSECURITY RISKS IN NORTHERN GHANA 129

6.1. Introduction 129

6.2. Results 131
6.2.1. Key Response Practices to Food Insecurity Risks 131
6.2.2. Gendered Nature of the Food Insecurity Responses.....134
6.2.3. Common Patterns in the Food Insecurity Responses.....136
6.2.4. The Importance of Livelihood Assets in the Households' Responses 139
6.2.5. The Outcomes of Households' Food Insecurity Responses.....141

6.3. Discussion 146
6.3.1. Diversity in Households' Responses to Climate-Induced Food Insecurities....146
6.3.2. Sequencing of Responses and Asset Preservation for Sustainable Livelihoods148
6.3.3. The Excruciating Cost of Responding to Food Insecurity Risks.....151

6.4. Conclusion 152

CHAPTER 7**.....*154***

SUMMARY OF FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS.....154

7.1. Introduction 154

7.2. Key Findings and Arguments 154

7.3. Theoretical Contributions and Direction for Future Research..... 156

7.4. Policy Contributions and Recommendations 161

7.5. Conclusion 162

REFERENCES**.....*165***

APPENDICES**.....*188***

Appendix A: Interview Guide 189

Appendix B: Focus Group Discussion 190

Appendix C: Household Questionnaire..... 195

List of Tables

Table 1.1: Mean annual temperature and precipitation trend for Ghana since 1950 5
Table 1.2: Structure of the dissertation 14

Table 3.1: Number of dams and land areas under irrigation in the study area 42
Table 3. 2: Calendar of main fieldwork activities, 2021 55
Table 3.3: Characteristics of the study communities 57
Table 3.4: List of sampled communities and number of participants for the household survey 61

Table 4. 1: Number, size, and means of securing farm plots for crop production 81
Table 4.2: Production input/service use 82
Table 4.3: Resources and services for food harvesting, processing, and storage practices ... 84
Table 4.4: Food crop sales and transportation 87

Table 5.1: Perceived exposure to climate hazards in northern Ghana 102
Table 5.2: Critical assets for food system activities in northern Ghana 110
Table 5.3: Mean food production asset score for communities in the Kassena Nankana Municipality 112
Table 5.4: Mean food processing and storage asset score for communities in the Kassena Nankana area 113
Table 5.5: Mean food marketing assets score for communities in the Kassena Nankana Municipality 115

Table 6.1: Households response actions for managing climate-induced food insecurities ..131
Table 6.2: Differences in response actions adopted by men and women household members 135
Table 6.3: Identified patterns in households' responses to food insecurity 137

List of Figures

Figure 1.1: Trends in global hunger 2
Figure 1.2: Regional disparity of food insecurity in Ghana 3
Figure 1.3: Map of Ghana's mean annual temperature (°C) (left) and mean annual precipitation (mm) (right) from 1991 to 2020 6

Figure 3.1: A single housing structure comprising a cluster of several individual family huts. 41
Figure 3.2: A cluster of housing structures in the study communities 41

Figure 4.1: Seasonal calendar of food production and postproduction activities 72
Figure 4.2: Household weekly food consumption 75
Figure 4.3: Monthly food availability for key food crops 77
Figure 4.4: Monthly food availability in households' food stores 78
Figure 4.5: Households sources of food for consumption 79
Figure 4.6: Challenges in households' access to food 89

Figure 5.1: Mean annual rainfall variability for the Kassena Nankana Municipality 101
Figure 5.2: Mean annual temperature variability for Kassena Nankana Municipality 101
Figure 5.3: Climate hazard impacts on food crop production activities 104
Figure 5.4: Climate hazard impacts on food crop harvesting and storage 105
Figure 5.5: Climate hazard impacts on food crop marketing and transportation 106
Figure 5.6: Percentage of households with access to assets for food production in communities across the Kassena Nankana Municipality 112
Figure 5.7: Percentage of households with access to assets for food processing and storage activities across communities in the Kassena Nankana Municipal 114
Figure 5.8: Percentage of households with access to assets for food marketing activities across various communities of the Kassena Nankana Municipality 115
Figure 5.9: The intensity of climate impacts on food crop production activities 116
Figure 5.10: The intensity of climate impacts on food crop processing and storage activities 118
Figure 5.11: The intensity of climate impacts on food crop marketing activities 119
Figure 5.12: The intensity of climate impacts on food crop production activities across the various communities of the Kassena Nankana Municipality 120
Figure 5.13: The intensity of climate impacts on food crop processing and storage activities across the various communities of the Kassena Nankana Municipality 121
Figure 5.14: The intensity of climate impacts on food crop marketing activities across the various communities of the Kassena Nankana Municipality 122

CHAPTER 1
BACKGROUND AND PROBLEM SETTING

1.1. Introduction

Hunger is humanity's oldest problem; it can be traced to environmental change factors, socio-economic conditions, and political decisions. Poor farming households relying on rain-fed agricultural systems and facing restricted access to land and other critical production inputs have become increasingly vulnerable to hunger. Recognizing the complex causes of hunger among these households should not limit researchers and policymakers from appreciating that poor farmers are resourceful, creative, and have the strengths to manage the risks of hunger. This dissertation focuses on one detailed case study of the interactions between climate risks and hunger as a way of learning more about the dynamics and entry points for intervention by policymakers and affected populations.

This first chapter of the dissertation sets the context for the research. It presents evidence of climate change and food security challenges, drawing attention to the progress but significant disparities in the case of Ghana. Following this contextualization, the chapter raises and situates the research questions within the broader context of climate change and food systems. It further outlines the structure of the dissertation.

1.2. The Problem of Hunger in Ghana

Around the world, many families are struggling to secure social, economic, and physical access to safe, sufficient, and nutritious food to meet their dietary needs and preferences. According to the 2022 State of Food Security and Nutrition in the World report, between 702 and 828 million people face hunger globally, corresponding to 8.9 and 10.5 percent of the world's population, respectively (FAO et al., 2022). While the worrying number of people without sufficient access to nutritious food could be attributable to the outbreak of the Covid-19 pandemic and associated impacts on the food supply chain, it is essential to mention that the global hunger situation was no better even in the pre-pandemic years. After decades of

steady decline, the global hunger trend reverted in 2015 with close to 600 million food-insecure people; after that, it slowly increased to about 620 million in 2019 (FAO et al., 2022 – see Figure 1.1).

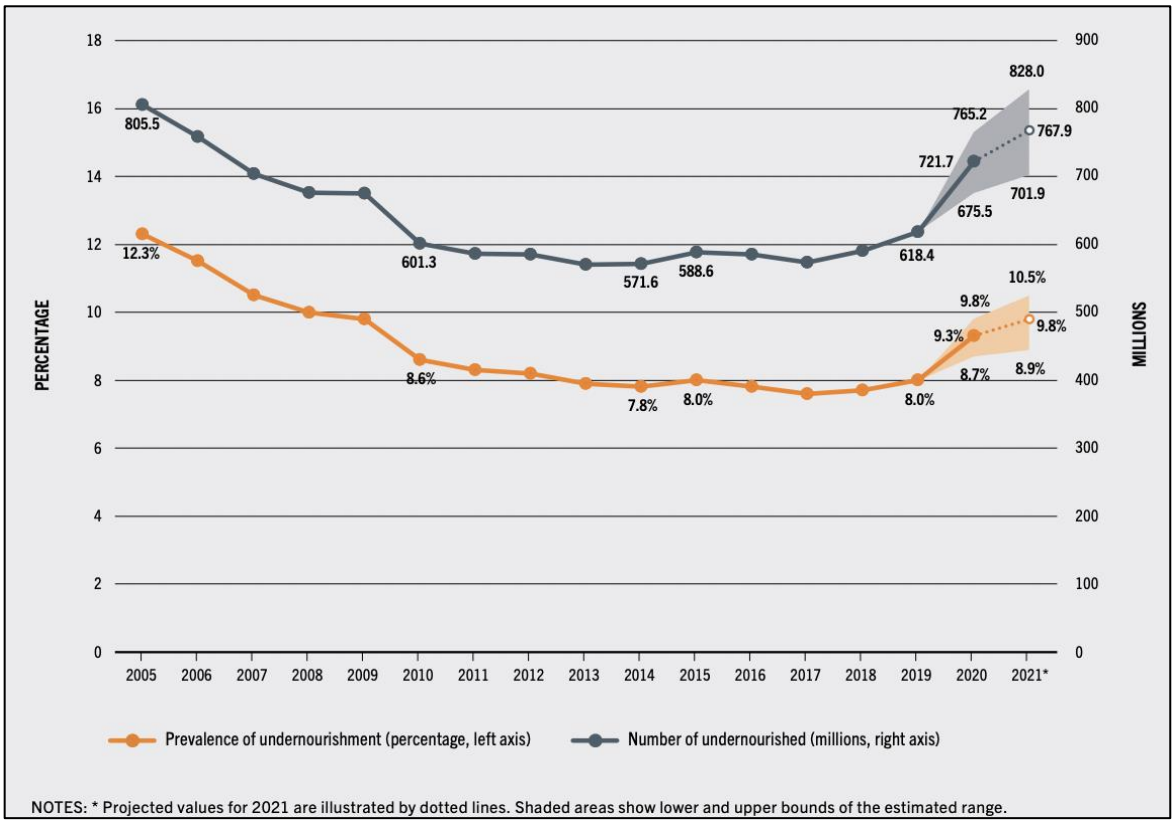

Figure 1.1: Trends in global hunger
Source: FAO et al. (2022)

In the pre-Covid-19 pandemic years, Ghana was counted as one of the few countries that have shown decades of progress in reducing the number of people without adequate food and nutrition. The available evidence indicates that the proportion of the hungry population in Ghana "decreased by 75 percent between 1990 and 2004. The malnourished population also reduced from 7 million in the early 1990s to less than 1 million in 2015" (WFP, 2017, p. xiv). However, in recent years, Ghana has shown a reverse in its promising progress. According to the WFP's food security assessment, conducted in late 2020, the number of hungry people is estimated at 3.6 million, representing 11.7% of the population, amidst the outbreak of the Covid-19 pandemic (World Food Programme, 2022). As a place to study the disturbing recent upward trend in hunger worldwide, Ghana thus represents an interesting case study.

Another reason making Ghana an interesting case study for food security research is that beyond these national statistics lies significant geographical disparity in hunger. While some regions can boast fewer malnourished and hungry people, others have more than the national average. In the northern part of Ghana, consisting of the five regions in the upper half of the country (see Figure 1.2), for example, the prevalence of food-insecure populations is more than 20% compared to less than 10% in the southernmost regions (WFP, 2022).

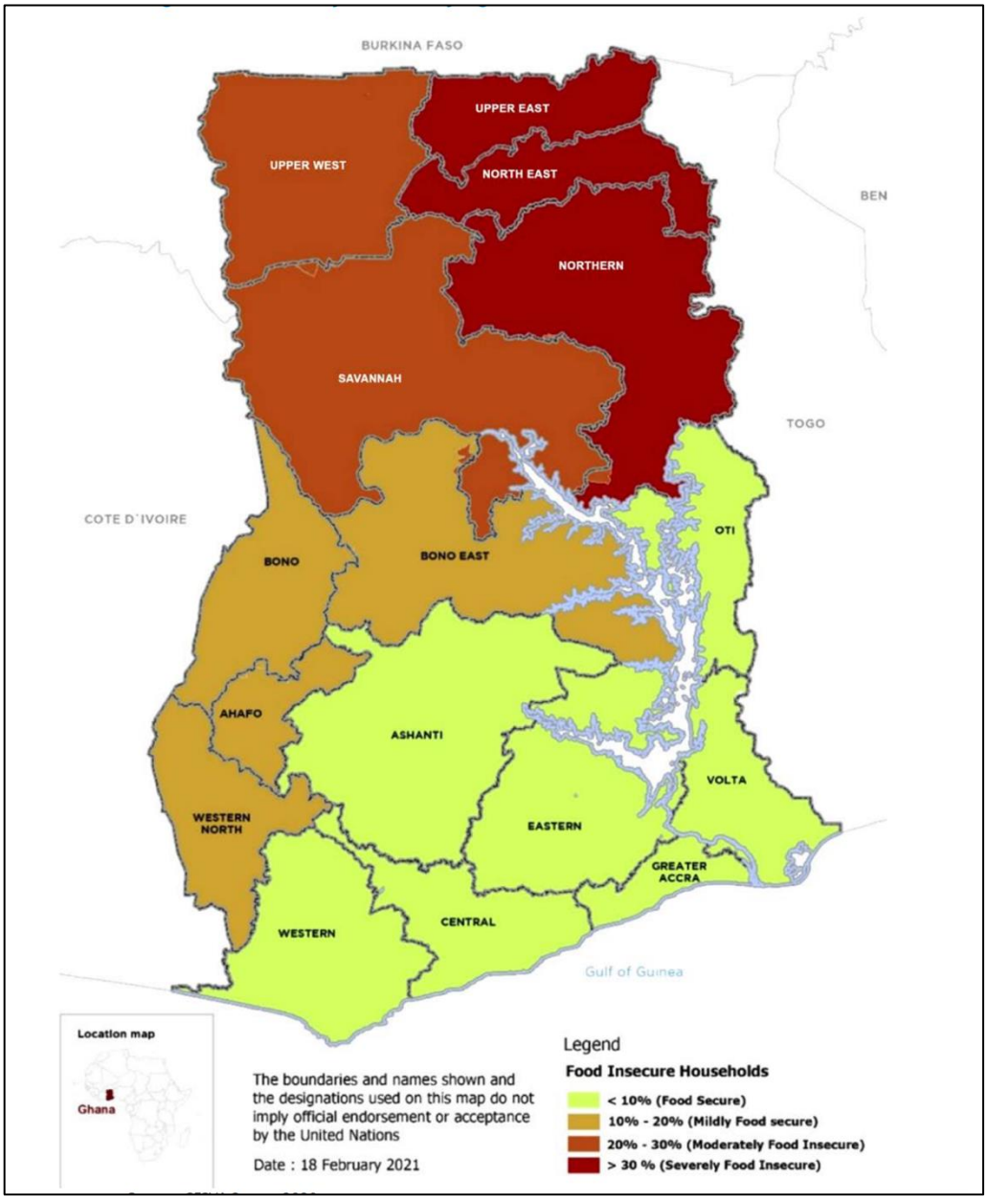

Figure 1.2: Regional disparity of food insecurity in Ghana
Source: World Food Programme (2022)

Even more disturbing is the high incidence of hunger in the three regions in the northeastern quadrant of Ghana, where more than 30% of the people are considered food insecure. This looming evidence of hunger in northern Ghana, particularly in the northeastern, presents a more compelling call for research action. What is more striking than the uneven geography of hunger in Ghana is that a staggering 80% of the households in northern Ghana (compared to 6%-50% in the rest of the country) earn their livelihood from agriculture and food-related activities (MoFA, 2019). These households primarily or partly depend on farms to produce food crops for their consumption and sell out surpluses for income. It is a bitter irony that the geographical area with such a high percentage of food producers has some of the hungriest populations in the country. Such regional disparities are echoed in other places worldwide, which is part of the story this dissertation investigates. Additional reasons for choosing the geographical region for this study are also given later in the dissertation (see section 3.2).

1.3. Vulnerabilities and Risks

Ghana has a tropical climate with an average mean annual temperature of 27.66 °C and precipitation of 1209.75 mm (World Bank Climate Change Knowledge Portal). Historical data shows increasing variability and changes in Ghana's climatic conditions over the past years – see Table 1.1. The mean temperature, for instance, has risen by more than 2°C since 1950, an average increase of 0.24°C per decade (World Bank, 2022). Although the mean precipitation increased in the years between 1950 and 1980 and again between 2000 and 2010, it has generally been lower since the 1990s, with an overall reduction in cumulative rainfall of 2.4% per decade since the 1950s (Ghana's Environmental Protection Agency, 2015; Issahaku et al., 2016; USAID, 2017; Abbam et al., 2018; World Bank, 2022). There is also evidence that these climatic changes will intensify in the coming years, with significant consequences for food systems and food security (Nicholson et al., 2013; Niang et al., 2014; Nicholson et al., 2018).

Table 1.1: Mean annual temperature and precipitation trend for Ghana since 1950

Year	Annual Mean-Temperature (°C)	Annual Precipitation (mm)
1950	26.02	1107.87
1960	26.52	1121.89
1970	26.79	1219.68
1980	26.81	1382.75
1990	27.07	1101.17
2000	27.08	998.58
2010	27.85	1159.74
2020	27.97	1009.96

Data source: World Bank Climate Change Knowledge Portal

Regarding the spatial representation of the average annual precipitation and temperature across Ghana, the northern part generally has a warmer and hotter climate than the south. As Figure 1.3 shows, the mean temperature in Ghana increases as one moves toward the north. Most northern regions experience above-average mean temperature, usually reaching 29°C or more in the dry season, compared to 25-26°C in the southern regions. Similarly, the average precipitation rate is less than 1000mm in the north compared to 1200mm in the south and even up to 1500mm in the far southeast. Because of the high mean temperature and reduced mean precipitation rates, the northern part of Ghana has one rainy season, which extends from May to September with varying intensity; the south has two rainy seasons, occurring from April to July and September to November.

These extreme climatic conditions and changes occurring in northern Ghana directly affect food crop yields, prices in the market, and long-term availability with extended impacts on the region's food security. For example, irregular rainfall patterns affect the timing of planting and the variety of crops, often resulting in decreased food production (Armah et al., 2011; Hjelm & Dasori, 2012). The occurrence of torrential rain-induced flooding causes damage to farmlands, displaces households, and disrupts road infrastructure and bridges (Afriyie et al., 2018). During the severe droughts of the 1970 and 1980s, food prices rose five to six times above regular market prices, forcing households to glen food from dried-out fields or decimate livestock to buy grains (Darnton, 1977).

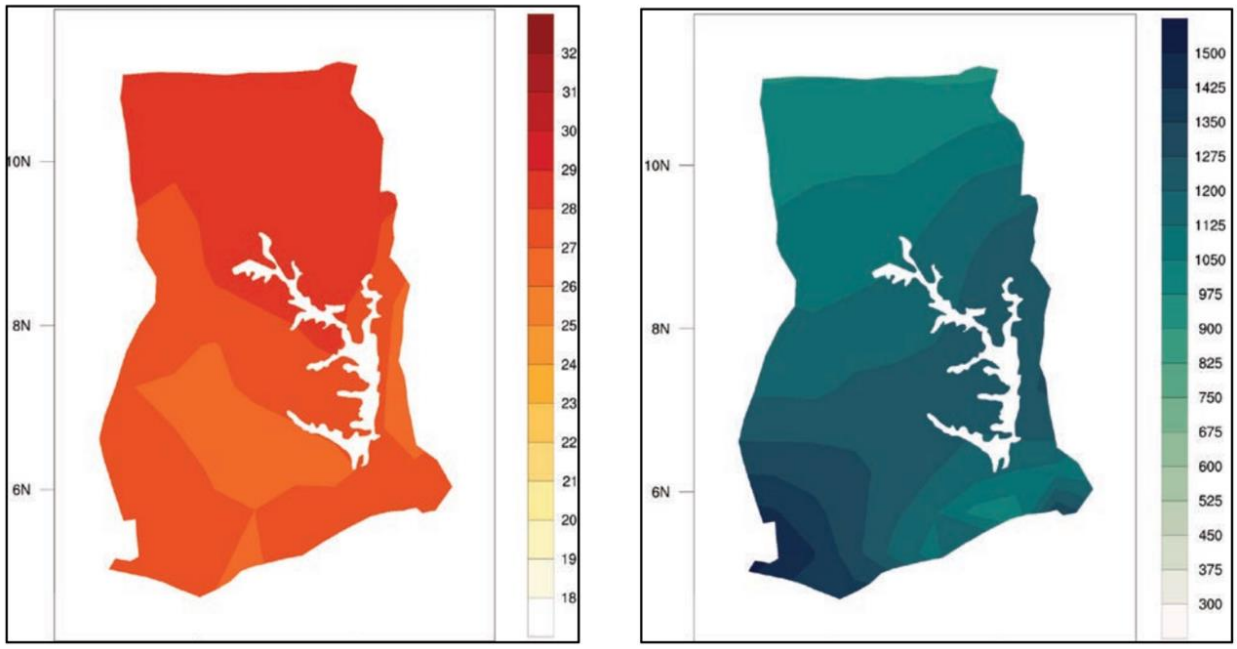

Figure 1.3: Map of Ghana's mean annual temperature (°C) (left) and mean annual precipitation (mm) (right) from 1991 to 2020
Source: World Bank Climate Change Knowledge Portal

Despite the solid physical and ecological manifestations of climate change impacts on food security in northern Ghana, some researchers argued that non-climatic stressors greatly influence smallholder farmers' vulnerability to hunger (Nyantakyi-Frimpong & Bezner-Kerr, 2015; Antwi-Agyei et al., 2017). The most prominently non-climatic explanations are often linked to the long-term historical development cont in northern Ghana. During the British colonial administration from 1874 to 1957, Ghana was characterized by a massive capitalist extraction of cocoa, timber, and mineral deposits for export. In support of the capitalist agenda, the colonial government pursued infrastructure development, including harbours, road networks, railroads, and administrative centers, in the resource-rich southern regions (Plange, 1979; Brukum, 1998). The northern regions received significantly less infrastructure development attention; they were mainly integrated into the colonial administration as a labour reservoir to serve the needs of the extractive and commercial agricultural activities in the south (Brukum, 1998; Yaro, 2013). Such economic development neglect and subordination of the North to the interests of the South led to significant consequences for agricultural productivity. Increasingly, households in the northern regions lost the helping hands of young men and women who assisted with their households' food production. With

the lack of infrastructure for mechanization, transport, and markets, the rural communities lost their economic potential to produce food or earn income to feed their households.

Postcolonial governments have further entrenched the unequal regional development and socioeconomic inequities between Ghana's northern and southern regions. After independence in 1957, successive governments designed and implemented ambitious policies to strengthen food sufficiency. The most prominent interventions for the northern regions included the establishment of the Gonja Development Cooperation, the Upper Region Agricultural Development Program, and the Northern Region Rural Integrated Project (NORRIP) (Nyantakyi-Frimpong & Bezner-Kerr, 2015). These ambitious projects, among other things, sought to promote mechanization and strengthen access to fertilizers, hybrid seeds, and markets for rural farmers. Additionally, two major irrigation projects[1] were implemented to support dry season farming and technology diffusion to small-scale farmers.

However, the potential of these interventions could only be sustained for a short time. By the early 1980s, a tail of crisis resulting from economic mismanagement, a fall in cocoa prices, and drought led to the collapse of Ghana's economy and the need for a bailout from the International Monetary Fund (IMF) and the World Bank. The Structural Adjustment Programs that accompanied these bailouts consisted of conditionalities, including the government's removal of subsidies on agricultural inputs and produce marketing, which forced many farmers to abandon food production completely; some also switched to export crops that had higher marketing value and better credit support (Konadu-Agyemang, 2000). Eventually, the deleterious effect of the adjustment policies on incomes and welfare became more severe for poor farmers in northern Ghana because of their food security dependency on small-scale agricultural production.

Over the last two decades, several of the Government of Ghana's policies and programs, including the Savannah Accelerated Development Authority (SADA), the Savannah

[1] The first is the Vea Irrigation Scheme established in 1965, covering an irrigated area of about 468 hectares in the Upper East Region. The second is the Tono Irrigation Scheme established exactly ten years later in 1975 to enhance the diffusion of technology to smallholder farmers in the Upper East Region.

Agriculture Value Chain Development Project (SADP), and the Savannah Investment Programme (SIP) are oriented to modernize agriculture in northern Ghana and connect farmers towards a larger market (Al-hassan, 2013). More specifically, the SADP aims to facilitate private-sector investment in commercial farming and out-grower[2] schemes to upscale the production of maize, soybean, and rice production. Looking at it critically, these input-intensive, commercial agriculture-oriented programmes are parallel to the "new Green Revolution[3]" development model championed by the Rockefeller and the Bill and Melinda Gates Foundations under its Alliance for a Green Revolution in Africa (AGRA) initiative.

Despite two decades of Ghana's "new Green Revolution," chronic food insecurity and malnutrition are grim realities in the northern regions. The introduction of market-oriented crops such as cowpea, groundnuts, maize, rice, and soybeans, resulted in a shift away from traditional crops, such as millets and sorghum (Yaro et al., 2021), consequently modifying the cultural preferences and the food and nutrition security outcomes of households. Another concern is that adopting high-input technologies undermined farmers' agency in solving everyday agricultural problems. Nyantakyi-Frimpong and Kerr's (2017) study of the Upper West Region in northern Ghana revealed that by growing a single or few newly introduced market crops, farmers are limited in their ability to improve soil nutrients, reduce crop pests, and ensure crop diversity. Lastly, while using improved and adaptable seed varieties could answer food insecurity problems in the dryland landscapes of northern Ghana, the domestic and broader politics offer little support for the technology uptake among small farmers (Vercillo et al., 2020). Many farmers face difficulty accessing resources, including credit, land, and alternative income to invest in agriculture. Women, in particular, have fewer entitlement rights to resources, although they contribute, in some cases, equally or more to agricultural labour. Thus, technologies are being promoted in a system where poor farmers lack the required capital investment.

[2] Outgrower schemes refer to farm contracts/agreements made between groups or individual farmers and an outgrower or aggregator prior to the planting season. In these contracts, the buyers/aggregators often specify the pricing system, quantity, and delivery time with little or no opportunities for farmers to bargain. These contracts also include the supply of agri-inputs and extension services, where needed, from the aggregators to the farmers.

[3] The new Green Revolution in Africa refers to the contemporary shift to high-input agriculture involving the use of improved seed together with increasing use of agro-inputs (e.g., fertilizers and agrochemicals) and mechanization (e.g., irrigation, tractors, combine harvesters) to increase productivity levels of farmers.

1.4. Research Problem Statement

The growing body of literature on climate change and agricultural livelihoods in northern Ghana presents pioneering insights into household vulnerability to climate change and adaptation strategies, with important learning opportunities related to food security (Laube et al., 2012; Yiran & Lindsay, 2016; Antwi-Agyei et al., 2018; Nagao & Alhassan, 2019; Lawson et al., 2020). For example, Yiran & Lindsay (2016) found that delayed onset of rains, heavy precipitation, and excessive heat during the planting season affect crop growth and culminate in poor harvests. Laube et al. (2012) identified that farmers adapt to erratic rainfall and drought conditions by intensifying agricultural production through expanding shallow groundwater irrigation using buckets and small motor pumps. The evidence from Antwi-Agyei et al. (2018) also highlights households' reliance on social networks in coping with poor harvests and reduced food availability caused by climate variabilities. Lawson et al. (2020) shed light on intragender barriers to responding to climate change, including cultural norms on access to land and restrictions on women's earning income outside agriculture.

Despite this broad evidence, there are other areas of potential research concern. The literature has focused almost exclusively on food production, with limited attention to climate change impacts on post-production activities, including food storage and marketing, which are equally crucial for smallholder farmers to obtain and maintain food resources for future needs (Armah et al., 2011; Ajala & Gana, 2015). Also, the studies focusing on climate change adaptation have overlooked households' dietary management responses and how these contribute to resilience against climate-induced food insecurity risks (Antwi-Agyei et al., 2018; Issahaku & Abdulai, 2019; Alhassan, 2020; Ansah et al., 2020). This dissertation addresses these identified gaps, while expanding the overall literature on the relationships between hunger and climate change, by exploring the experiences of climate and food insecurity risks among smallholder farmers in northern Ghana and identifying insightful household-level experiences, in terms of local farmers' strengths and creativity, in responding to and surviving climate-induced hunger.

While this research is specific to northern Ghana, the broader findings contribute to knowledge about the range of strategies farmers may use to address climate risks and household response behaviours to enhance food security in the Sahel and other dryland areas. The research findings also have relevance for policymakers and practitioners with ambitions to reduce hunger, malnutrition, and poverty. The Government of Ghana, for example, has climate-resilient agriculture and food systems as a key strategic focus area in its climate change policy (Ministry of Environment, Science, Technology, and Innovation (MESTI), 2013). The current paucity of research on climate change and food security in northern Ghana constrains the limited opportunities for the Government and other concerned stakeholders to act on these policy priorities. Such research limitations hinder the Government of Ghana and development partners' ability and access to information needed to develop innovative solutions to food and climate challenges. My research has an essential goal of providing evidence-based knowledge for the Government of Ghana and development agencies to specifically address climate-related challenges for food insecurity in Ghana's north and minimize inter-regional disparities, which have had long-term political implications.

I adopt a micro-level food systems lens (Ericksen, 2007), integrated with theories of vulnerability (Nunan, 2010; Birkmann et al., 2011; Ribot, 2014) and disaster risk (Wisner et al., 1996; 2004), to provide explanations for climatic challenges to food security. I present evidence to show that climate risks affecting food security in northern Ghana are not just a product of persistent climate change and associated hazards, as has been conventionally framed. Instead, the risks are inextricably connected to the micro-level social processes and underlying factors that shape how food is produced, harvested, stored, and marketed in the rural areas of northern Ghana. The findings from this study reveal that climate hazard events such as flooding and droughts may lead to a reduction in crop yields, damage to stored grain, and disrupt food prices, which affects food security. However, these impacts are not solely externally generated circumstances – the story is much more complex.

1.5. Research Objectives and Questions

This research is inspired by the paradox that smallholder farmers in northern Ghana are experiencing hunger despite their efforts to produce food to feed their families. The main objective of this dissertation is to examine smallholder farming households' experiences with climate change and to explore the underlying socioeconomic characteristics that influence their vulnerabilities to food insecurity. It also explores households' response practices for improving food security. Following the initial literature review, which deepened my knowledge about the subject matter, with the added advantage of conducting field research, including interviews with smallholder farmers in northern Ghana, I decided to explore in detail the complexities of climate impacts on food sovereignty and household risk and agency.

The main research question asks: How do farming households' experiences with climatic hazards interact with various forms of vulnerabilities to induce food insecurity risks, and what are their response practices for managing the climatic risks and threats to their food security?

The main research question is further divided into the following six sub-questions:

1. What is the nature and pattern of food security in terms of dietary consumption, food availability, and food access among smallholder farmers in northern Ghana?
2. How do food system activities in rural areas of northern Ghana shape the pattern of smallholder farming households' food security in terms of dietary consumption, food availability, and food access?
3. What are the key climatic hazards affecting food systems in rural areas of northern Ghana?
4. How do food systems' exposure and vulnerability to these climate hazards predispose smallholder farming households to food insecurity risks?
5. How are smallholder farming households responding to climate-induced threats to food security?
6. Are the smallholder farming households' responses contributing to reducing vulnerability and enhancing sustainable efforts to maintain food security throughout the year?

1.6. Definition of Key Terms and Concepts

Several key terms which recur throughout the dissertation are defined as follows:

Climatic hazards: This dissertation defines climate hazards as natural events detectably influenced by climate variability, climate change, and related weather conditions. These include droughts, wildfires, erratic rains, floods, extreme temperatures, and windstorms. Although the classification of climatic hazards differs among climate change researchers (see Dotto et al., 2010; Smith, 2013), my dissertation seeks to present an extensive analysis of the diversity of direct and indirect climate risks affecting poor people in developing countries.

Vulnerability: Ellis (2003, p. 5) defines vulnerability as "proneness to a sudden, catastrophic fall in the level of a variable, usually access to enough food for survival." This dissertation builds on this definition and conceptualizes vulnerability as the social context of a system exposed to climatic hazards, including a catastrophic fall in the level of food for a household's survival.

Food security: The United Nations (1996, p.3) defines food security as a situation "when all people, at all times, have physical, social, and economic access to sufficient, safe, and nutritious food that meets their dietary needs and food preferences for an active and healthy life." Food security rests on four pillars: availability, access, utilization, and stability. A detailed explanation for each of these pillars of food security is given in Chapter 2. Therefore, food insecurity occurs when there is a fall in a household's food availability, access, consumption, and stability below the accepted minimum required to meet consumption needs.

Food system: A food system comprises a set of activities ranging from production to consumption. These activities are often expressed with phrases like "farm to fork," "field to table," and "land to mouth" (Sobell et al., 1998; Heller & Keoleian, 2002). The principal objective of a food system is to guarantee sustainable and equitable food security. A critical

analysis of the food systems approach to food security and its applicability and use in this research is given in Chapter 2.

Response practices: In the context of climate change and risk management, response practices refer to various actions that a household adopts to absorb, cope with, adapt to, and recover from risk events (see Hansen et al., 2004; Aven & Renn, 2010; Agrawal, 2018).

1.7. Structure of the Dissertation

This dissertation is structured into six chapters. A schematic mapping of the key focus areas of each chapter is presented in Table 1.2. Chapter 1 presents an overview of the background and contexts for the dissertation. It draws attention to the broader disconcerting problems of extreme climate events in northern Ghana and the paradoxical connections to food insecurity among smallholder, subsistence food producers in the region. The chapter also presents the need for research on these issues, specifically for the chosen geographical location. Following this contextualization, the chapter raises the main research questions and situates them within the research's broader academic and policy contributions.

Table 1.2: Structure of the dissertation

<table>
<tr><td colspan="3">Research Problem</td></tr>
<tr><td colspan="3">Chapter 1: Background and problem setting

• Regional disparity in hunger
• Climate vulnerabilities and risks
• Research questions</td></tr>
<tr><td colspan="3">Theoretical Approaches and Methods</td></tr>
<tr><td colspan="2">Chapter 2: Theoretical Framing

• Theoretical formulations of food security
• Food systems approach to researching food security
• Perspectives on risk, hazard, and vulnerability
• Review of household-level risk management strategies</td><td>Chapter 3: Methodology

• Study area
• Research design and approach
• Data analysis
• Partnerships and knowledge dissemination</td></tr>
<tr><td colspan="3">Research Results and Discussion</td></tr>
<tr><td>Chapter 4: Food security context of the households in the study communities

Research Sub-Question (1) & (2)

1. What is the nature and pattern of food security in terms of dietary consumption, food availability, and food access among smallholder farmers in northern Ghana?
2. How do food system activities in rural areas of northern Ghana shape the pattern of smallholder farming households' food security in terms of dietary consumption, food availability, and food access?</td><td>Chapter 5: Climate and food insecurity risks

Research Sub-Question (3) & (4)

3. What are the key climatic hazards affecting food systems in rural areas of northern Ghana?
4. How do food systems' exposure and vulnerability to these climate hazards predispose smallholder farming households to food insecurity risks?</td><td>Chapter 6: Household response behaviours

Research Sub-Question (5) & (6)

5. How are smallholder farming households responding to climate-induced threats to food security?
6. Are the smallholder farming households' responses contributing to reducing vulnerability and enhancing sustainable efforts to maintain food security throughout the year?</td></tr>
<tr><td colspan="3">Conclusion</td></tr>
<tr><td colspan="3">Chapter 7: Summary of findings, conclusions, and recommendations

• Summary of findings
• Policy and theoretical contributions
• Directions for future research</td></tr>
</table>

Chapter 2 reviews the pertinent literature, engages with relevant theories and concepts, and presents the analytical framework guiding the dissertation. Some of the underlying theories and concepts based on which the research makes its substantive arguments include livelihoods (Chambers & Conway, 1992), disaster risk (Wisner, 2004), vulnerability (Ribot, 2014), food systems (Ericksen et al., 2008), and food security (Sen, 1982). Several frameworks have emerged from these theories, so the chapter emphasizes sustainable livelihoods and food systems frameworks. It also highlights how these two frameworks help build a theoretical and methodological guide in understanding the research problems, framing the research questions, and choosing appropriate methods for data collection.

Chapter 3 focuses on the profile of the research setting (the Kassena Nankana Municipality) and my methodology, including a description of the research design approach and procedures for selecting the study communities and participants. The chapter also describes the methods, strategies, and tools for collecting and analyzing the data to achieve the research objectives. It details my role as the researcher (including positionality and personality) and the participation of research assistants and key partners throughout the research fieldwork process. Given the need for a "do no harm" commitment in research, the chapter also highlights my procedures for integrating ethical considerations. It also identifies the procedures for validating and reinforcing the reliability of the research findings for broader applicability as well as plans for knowledge mobilization and dissemination.

Chapter 4 begins to discuss the results of the study. The focus here is on the research sub-questions (1) and (2). This section outlines what I learned about the food security context of households, particularly those relating to food consumption patterns, food availability situations, and food sources throughout the year. The chapter addresses two core objectives. The first objective is to understand the year-round food insecurity situation of the households and whether there are variations across specific months and periods of the year. The second objective is to identify food system activities in rural communities, especially those beyond production, and how they shape household food insecurity.

Chapter 5 presents, analyzes, and discusses the overall research sub-questions (3) and (4). The main objective of the chapter is to explore how climate change exacerbates food insecurity in northern Ghana. Specifically, the chapter identifies climate hazards and their impacts on food system activities and communities. It also examines the vulnerabilities of food systems across various communities. Overall, the chapter seeks to provide an empirical understanding of smallholder households and food systems' vulnerability to climate change to help guide a more general discussion on critical resources and services for enhancing food security against climatic shocks.

Chapter 6 presents stories and evidence on households' responses to managing climate-induced risks on food security in northern Ghana and identifies some of the distinctive characteristics and patterns in these response practices. It also examines household objectives for adopting specific response practices, the management of resources to meet these objectives, and the limits and effectiveness of the response practices. In particular, the chapter emphasizes the availability of support and challenges to adopting household responses, the sustainability of outcomes for food security, and the trade-off between maintaining food consumption in hungry months and protecting livelihood resources and well-being. Overall, this chapter addresses the research sub-questions (5) and (6).

Finally, Chapter 7 summarizes the overall key findings from the research and discusses their applicability and recommendations for international policies, the government of Ghana's investment in climate resilience initiatives, and grassroots-level awareness of sustainable climate protection measures. Specifically, the chapter outlines key arguments from the dissertation and their connection to gaps in literature and policy areas, including climate change, regional development policy, food security, livelihoods, disaster risk, and risk management. The chapter further proposes specific recommendations for application within Ghana and beyond. It also offers concluding remarks, summarizing the dissertation's contributions to local and international policies on climate resilience and grassroots-level awareness of sustainable climate protection measures. The next chapter focuses on the theoretical approaches and framework guiding this research.

CHAPTER 2
THEORETICAL APPROACHES TO UNDERSTANDING FOOD SECURITY AND CLIMATE CHANGE RISKS

2.1. Introduction

This chapter reviews and discusses the theoretical and conceptual framework for the dissertation. It begins with the theoretical evolution of the food security concept, then discusses the food system approach to food security and its applications. The chapter also reviews the concept of risks, examines models for assessing risks in livelihoods and food systems, and identifies categories of management options. It further presents the critical motivations for adopting the conceptual and theoretical framing that guides this dissertation.

2.2. Theoretical Formulations on the Concept of Food Security

The concept of food security has evolved and diversified over time, reflecting the complex nature and concerns over hunger problems affecting millions of people worldwide (Maxwell, 2001). Before the 1980s, food availability decline (FAD) theory dominated famine and hunger discussions, taking its roots from the centuries-old, flawed Malthusian thinking that championed "natural checks" on population growth deriving from limited food supplies (Malthus, 1798). According to the FAD approach, solutions to hunger problems should hinge on increasing the quantity of food available through production and other means of supply (Burch & De Muro, 2016). This approach provides an important starting point for understanding food security and draws attention to supply-side interventions to alleviate hunger (e.g., food production, commodity trade/import, and food aid). However, it overly focuses on the macro-level, which means that there is little or no attention to inequities in access to food, particularly at the intra-household level where unequal power relations may affect access to food for marginalized groups, e.g., women, children, and aged people (Sen, 1982; Fine, 1997).

Following Frances Moore Lappé's book Food First (1977) and Dan Morgan's Merchants of Grain (1979), the seminal work of Amartya Sen (1982) provided the intellectual and theoretical formulation to reveal the weakness in the food availability approach. Inspired by examples of famines in Great Bengal, Ethiopia, and the Sahel region in the 1970s, Sen produced a path-breaking analysis that shifted the focus of hunger and famine problems from national food availability to household-level access to food. Sen explains that famine and hunger occur not because of inadequate food supplies but due to a lack or decline in a person's entitlement (Sen, 1982). Entitlement refers to the set of commodity bundles, including food, that a person can acquire using the totality of rights and opportunities that he or she has through the various legal means of attainment possible in a society (Sen, 1982).

Sen recognizes four categories of entitlement in the context of food security: production entitlement, labour entitlement, trade entitlement, and transfer entitlement. Production-based entitlement refers to households' capacity to obtain food through farming, hunting, and gathering. In some cases, poor and landless households may work for food, exchanging their labour for a share of the farm proceeds. Sen refers to this as labour entitlement. Income-based entitlement is common in highly monetized and industrialized economies, where the source of food security for most people is to buy food from the market. On unfortunate occasions such as loss of income stream or job, households may gain access to food through food or cash benefit transfer from governments in the form of gifts, rations, coupons, and vouchers, among others. Typically, rural agricultural households combine production and labour-based entitlements to ensure year-round food security. Although, in some cases, households may secure income through farming and non-farming activities to buy food, it is argued that such approaches are often considered as coping and adaptation mechanisms to the seasonality in food production, crop failure, and out-of-season hunger (Chamber & Conway, 1998; Ellis, 2000).

The entitlement approach has advanced our understanding of food security, drawing critical attention to the need to address inequities in access to food, especially at the household level. However, it has drawbacks. Critics argue that the approach is silent on the struggles of poor people and how they survive hunger over time (De Waal, 1989; Devereux, 2001). They cite

Sen's note of the long-term formulations of entitlement, which states that people sometimes choose to starve or suffer persistent hunger now rather than sell their productive assets to enhance entitlement and reduce the danger of starvation in the future. Specifically, from an analysis of famine in Darfur, Sudan, De Waal (1989) contends that poor households do not 'choose to starve' and risk death, as Sen theorized. Instead, under enormous stress, poor households suffer hunger to preserve their way of life, which can be understood as a coping mechanism for food insecurity. For instance, when food stock is depleting in out-of-season months, farming households may prefer to reduce their quantity of food consumption in a way to preserve kilos of grains as seeds for the next farming season and cultivate their food than sell an animal or send young men (agricultural labour) away for jobs in the cities.

The livelihoods theory, which dominated the poverty reduction discourse in the 1990s, also contributed to the conceptualization of food security (Chambers & Conway, 1992; Bohle et al., 1994). The theory is discussed as an analysis of people's assets (natural, physical, human, financial, and social capital), the activities, and the access to assets (mediated by institutions and social relations) that together determine how people make a living (Ellis, 2000; Perkins & Osman, 2021). There is a vast body of literature that uses the livelihood approach, including research on causes of food insecurity (Hasselberg & Yaro, 2006), fisherfolks' mobility risks (Nunan, 2010), and climate change effects on food security (Cudjoe & Owusu, 2011). Among the proponents of livelihood theory, food security is seen as one part of the jigsaw of livelihood needs. Therefore, a sustainable livelihood is a necessary and often sufficient condition for food security (Maxwell 1988 and 1991, p. 22). The upshot of this proposition calls for strengthening the resilience of households' livelihood resources and reducing vulnerability to shocks, as these are the preconditions for fighting hunger and all forms of food insecurity (Devereux & Maxwell, 2001). The livelihood theory has since become a significant evolution in understanding food security, presenting a nuanced perspective on the real suffering of poor people in times of hunger. However, it is criticized for paying little explicit attention to equity issues in food problems (Swift & Kate, 2001; Yaro, 2004).

Along with these theoretical formulations and reformulations, food security became widely defined as a situation "when all people, at all times, have physical, social, and economic

access to sufficient, safe, and nutritious food that meets their dietary needs and food preferences for an active and healthy life" (United Nations, 1996, p.3). This definition integrates the notion that food availability and access are essential at the household level, as is the need for sustained and equitable access to, use and benefits from, and safety of food resources for all household members. The conceptualization of food security has shifted emphasis over different and overlapping paradigms, but there is predominant research emphasis on agricultural and food production systems rather than market-supplied food. While agricultural research has allowed remarkable gains in agri-technology and yields, this has overshadowed many other primary aspects of food security in rural communities. In recent years, scholars have therefore called for a food systems approach to researching food security as an appropriate research approach to capture the complete set of activities that underpin all households' food availability, equitable and sustained access, safe utilization, and stability for future needs (Ericksen, 2008; Ingram, 2011; Ingram et al., 2012).

2.3. A Food Systems Approach to Researching Food Security

A food system comprises a set of activities ranging from production to consumption. These activities are often expressed with phrases like "farm to fork," "field to table," and "land to mouth" (Sobell et al., 1998; Heller and Keoleian, 2002). Ericksen (2008) broadly categorizes four groups of food system activities: (i) food production; (ii) food processing and packaging; (iii) food distribution and retailing; and (iv) food consumption. Food production involves various practices, from accessing and buying farm inputs to preparing the land, planting, caring for crops/animals and harvesting. Processing and storage include milling grain, candling eggs, pasteurizing milk, and drying food commodities and their transformation into finished or semi-finished products. It also includes quality control and labelling for safety in packaging. Distributing and retailing involve transportation, trading, and selling food to consumers, while consumption consists of deciding, selecting, preparing, eating, and digesting food. It is important to note that these activities generally represent the chains of 21st-century food systems. However, there might be slight differences for specific locations, communities, and households. In rural households in northern Ghana, the most relevant food system activities include the production, processing and storage, and marketing of maize,

cereals, legumes, and vegetables. Many households typically produce significant portions of their food; they also cautiously maintain a food store to supply out-of-season consumption needs; and they rely on the market for confectionaries, condiments, seasonings, and foods which cannot be produced within the local area.

The principal objective of a food system is to guarantee sustainable and equitable food security. From the definition given earlier, food security rests on four pillars: availability, access, utilization, and stability (Gross et al., 2000: Sassi, 2018). Food availability is the quantity, quality, and type of food available for consumption. Food accessibility is the ability of individuals, communities, and countries to access the required type, quality, and quantity of food for consumption through the various legal, social, economic, and political means available. Food utilization refers to the proper biological use and benefits from food, regarding essential dietary energy, nutrients, and water, through available nutrition knowledge and complementary resources. Food stability is the adequacy and reliability of food supplies for all people "at all times" Sassi (2018). Sassi notes that stability is a recently added dimension because of concerns over current and future food security. Therefore, food availability, access, and utilization are necessary but not enough for food security without stability.

As rural households produce their food and depend on a wide range of activities to ensure stable access and sustained use, the food systems approach has become the most practical approach to analyzing food security. The approach has enabled scholars to identify priority research and investment areas in food security (Drimie et al., 2011; Ingram et al., 2013). Drimie et al. (2011), for example, use a food system analysis to offer an insightful examination of policies for overcoming environmental constraints that undermine food security in the Southern African region. Drimie and colleagues reveal that climate change is the key environmental driver of food insecurity; it affects food availability and accessibility through impacts on production, biodiversity, prices, and households' livelihoods. These findings suggested that resilience against climate change should be a priority in tackling food insecurity in the region. Recently, the approach has provided a practical interdisciplinary framework for

policy and activism among local and international actors alike (SARE[4], 2015; HLPE[5], 2021). Policymakers usually rely on a short-cut solution to food problems – opportunities for more food production. The food systems approach allows policy actors to recognize other important areas of food problems (retailing and affordability, production and nutrition, processing, and safety) and propose comprehensive policy interventions for food security.

The food system approach is not without limitations. Some authors have criticized the approach for lack of focus on issues of cultural relevance and justice, failure to integrate policy components, and limited attention to food system actors and governance (Haysom, 2014; Hospes & Brons, 2016). Governance of the food system is often complex, involving a diversity of actors and their competing agendas. For example, in South Africa's food system, Tammer et al. (2018) note the fragmentation and interdependency of institutions governing food system agendas, transcending boundaries, domains, and scales (Tammer et al., 2018). This partly explains the minimal consideration of governance and institutions in the food system framework. Theoretically, Chase and Grubinger (2014) find the food system approach to be an "enormous, complicated entity" (p.15) because it is based on systems thinking – which is usually complex. Meanwhile, one of the earlier proponents of the food systems concept explains that "while the term "food system" is common, the concept of a system is often used loosely and not linked with systems theory, although the latter has been incorporated in agricultural farming systems" (Sobal et al., 1998, p. 853). Indeed, all these legitimate arguments strengthen the food system approach's analytical and policy purchase in food security discussions as they underscore the many opportunities for bringing theory and policy together to improve food security.

While much of the discussions and applications of the food systems perspective focus on national, regional, and global levels (Ericksen, 2008; Burchi et al., 2011; Smit, 2016; Ingram & Zurek, 2019), this dissertation adopts the food system approach for a micro-level analysis of climate change, food insecurity risks, and households' responses in northern Ghana. Specifically, the approach is used to identify key activities, processes, and operations that

[4] Sustainable Agriculture Research and Education (SARE)
[5] The High Level Panel of Experts on Food Security and Nutrition (HLPE)

households pursue to achieve food security and how these activities shape dietary consumption patterns (Swindale & Bilinsky, 2006; FAO, 2011) and variations in food availability and food sources (Quaye, 2008; Devereux et al., 2008) over the year.

The household-level food system in northern Ghana is often tied to family labour and seasonal changes in climatic conditions. Most farmers produce, harvest, store, and market food crops, relying on labour from families and friends. Thus, all household members, including men, women, young boys, and girls, play important roles as actors in the food system. The labour intensiveness implies that climate change and weather variabilities significantly impact the household-level food system. This dissertation adopts a micro-level analysis of the food system of northern Ghana to examine how climate change and weather variabilities affect households' ability to produce, harvest, store, and safely maintain food stores for future consumption needs. Specifically, the analysis identifies where vulnerability arises for household food security. Households' access to assets (resources and services) is one of the most widely used determinants of vulnerability (Etwire et al., 2013; Antwi-Agyei et al., 2013; Opiyo et al., 2014; Panthi et al., 2016). Therefore, the food system analysis of food security vulnerability gives critical attention to where assets are lacking in food system activities, the most exposed climate events for food systems, and how the combined impacts exacerbate food insecurity risks for households.

2.4. Understanding Climate Change Risks

The conventional use of the term 'risk' relates to a chance of injury, damage, or loss from a particular hazard for a given area and reference period (Vatsa, 2004; EM-DAT, 2020). The Third Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) defined risk as "the probability or chance of occurrence of damaging events such as flood, drought, strong winds, heatwave, subfreezing temperatures, or forest or bush fire" (IPCC, 2001, p. 90). It describes the negative impacts of climate change as "risks" or "chance occurrences" beyond critical values or thresholds. This conventional view of risk presents a probabilistic notion of the concept and assumes that objective and quantifiable processes and methodologies are adequate to assess risk events (Vatsa, 2004; Gaillard, 2010). In addition, the view presents an

understanding of risk that excludes the internal functioning of a system exposed to the risk event. Thus, the idea indirectly relates pain and suffering from risk events to the occurrences of the hazard events rather than making a connection to the underlying social processes (such as class differentiation, gender, and power relations) that connect the impact of a hazard on a system (which can be a nation, community, or household).

The IPCC has since expanded its definition of risk over the years. In 2012, the Special Report on "Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation (SREX)" defined risk as "the likelihood over a specified period of severe alterations in the normal functioning of a community or a society due to hazardous physical events interacting with vulnerable social conditions, leading to widespread adverse human, material, economic, or environmental effects…." (IPCC, 2012, p. 4). Another definition of risk was adopted in the IPCC Fifth Assessment Report as "the potential for consequences where something of value is at stake and where the outcome is uncertain, recognizing the diversity of values" (IPCC, 2014, p. 1048). These recent definitions exhibit the social construction of risk by integrating the concept of vulnerability into perspectives on risk. The definitions also recognize that risk characterization and perception may be diverse and vary among people with different value judgements. The advances underscore that risk from climate change is not solely related to externally generated circumstances linked to climate systems and hazards. Instead, risk includes the combined interaction between societies, ecosystems, and hazards arising from climate change (IPCC, 2014; Welle & Birkmann, 2015).

2.4.1. Climate Hazards and Vulnerability

Studies on vulnerability have contributed to advancing the concept of risk. Within the vulnerability formulation, researchers consider the inherent features of a system as having a contributive role in its susceptibility to a hazardous event (Welle & Birkmann, 2015; Wisner, 2016; Fakhruddin et al., 2020). For example, in human systems, poverty and inequality, marginalization, food entitlements, access to insurance, and housing quality are critical factors determining the extent of damages from natural hazards (Wisner et al., 2004; Adger, 2006). By this, the vulnerability researchers established that risks from hazard events are not

independent of a system's internal social functioning and components. This explanation paved the way for a renewed understanding of risk, defined as the interaction of hazard and vulnerability, in other words, a product of both a system's exposure to extreme natural events and its vulnerability (e.g., UNDRO, 1980; UN/ISDR, 2004, 2009; Birkmann, 2006). Most researchers who work on vulnerability and natural disasters emphasize this concept of risk, pointing out that "there is no risk if there are hazards, but vulnerability is nil, or if there is a vulnerable population but no hazard event" (Wisner et al., 2004, p. 21).

A hazard is generally defined as a threatening event or the probability of occurrence of a potentially damaging phenomenon, activity, or process within a given period and area. Hazards may vary in severity, frequency, and likelihood of occurrence. Most researchers assess threats from hazards as a function of the occurrences of an event and the severity of its impacts in terms of the total losses/damages to an identified system (e.g., resources, communities, livelihoods) (see Zhang & Zhang, 2016; Prabnakorn et al., 2019). The International Disaster Database (EM-DAT) is one of the primary sources of data on disasters, providing information on the occurrences of hazard events, the number of people killed and affected, and property losses in monetary terms (EM-DAT, 2020). Although the database relies on the reporting capacities of countries, there are limitations as it does not capture the remote effects of hazard events.

While the broader explanation of hazards encompasses threatening events from natural and technological (man-made) sources, this dissertation focuses mainly on natural hazards originating from climatic and hydro-meteorological sources. Examples include droughts, floods, bushfires, windstorms, and extreme temperatures. It is important to note that while natural hazards have ‘natural’ causes, human actions may influence their outcomes (Smith, 2013; Epule et al., 2013).

Vulnerability is the degree to which a system is likely to suffer harm from a hazard (Forbes-Mewett & Nguyen-Trung, 2019). According to Adger (2005) and Smit and Wandel (2006), the vulnerability of a system is characterized by three elements: exposure, sensitivity, and capacity to adapt. The authors explain that exposure denotes the extent to which a system

falls within the geographical range of a hazard. Sensitivity describes the degree to which a system will likely suffer harm or significantly change its state when a hazard strikes. Capacity to adapt or cope is the ability to take advantage of, accommodate, or recover from the consequences of a hazard. Many scholars in natural hazards and environmental change research also explain that vulnerability has different dimensions (Adger, 2006; Cutter et al., 2012; Birkmann et al., 2013). Birkmann et al. (2013), for instance, identify four key dimensions: social, economic, institutional, and environmental.

The social dimension of vulnerability describes a household's ability to withstand unexpected shocks based on characteristics such as race/ethnicity, social class, poverty, age, and gender. The economic dimension deals with aspects of economic status and the bundle of assets in place to protect or reduce a community or a household's susceptibility to damages from shocks. The institutional vulnerability relates to governance, political stability, and organizational and cultural capacity or lack of capacity for social learning and innovative actions against shocks. For instance, through governments' provision of critical services such as irrigation facilities, early warning and climate information services, communities in arid areas can be less susceptible to the threats of droughts. Biophysical/environmental vulnerability refers to the likelihood of harm to ecological goods and services that strengthen protection from shocks and hazards.

2.4.2. Vulnerability Assessment

The literature on vulnerability presents different approaches for assessing a system's (e.g., a livelihood, community, or household) vulnerability to hazards. Vulnerability assessment can be quantitative, qualitative, or an integration of both, depending on the objectives and scale of analysis (Agrawal et al., 2020). Quantitative vulnerability assessment uses theoretically developed measurable characteristics or indicators to establish indices for representing the vulnerability of a system (see World Food Programme, 2005; Opiyo et a., 2014; Antwi et al., 2015; Birkmann & Welle, 2015). For instance, Birkmann and Welle's (2015) World Risk Index (WRI) assesses vulnerability based on three components: susceptibility, coping capacity, and adaptive capacity. The variables for each component are carefully selected in

line with the globally agreed Millennium Development Goals and the Hyogo Framework for Action (e.g., undernourishment, access to sanitation, gender parity, adult literacy, and extreme poverty).

Quantitative vulnerability assessments have proven helpful in providing a clear picture for comparing vulnerability situations among human and ecological systems. The WRI approach, for example, presents a benchmark for the 173 focused countries to plan and prepare for disaster risks effectively. However, the weakness of a quantitative vulnerability assessment is that the indicators are developed based on 'experts' knowledge with little input from vulnerable communities directly affected by hazards. Quantitative assessments also rely on data from national or regional censuses computed at a broader scale and can mask the real vulnerability situations in micro-level systems (Morse & Fraser, 2005). In the case of the globally focused assessment of the WRI, data to quantify the social variables of vulnerability may not be available in some countries or incompatible for comparison purposes across all 173 countries. This can influence the selection of variables for inclusion in the assessment approach.

Qualitative assessments of vulnerability, on the other hand, emphasize the involvement of local communities to identify and unpack information regarding local level perception and analysis of the impacts of hazards (Tschakert, 2006; Ayantunde et al., 2015; Antwi-Agyei et al., 2016; Agrawal et al., 2020). Most of these qualitative vulnerability assessments rely on participatory approaches and tools such as focus group discussions, interviews, and community workshops in collecting data on the causes, timing, and frequency of hazards, severity of impacts, as well as the strategies, resources/assets, and institutional support for reducing vulnerability. Commonly used techniques for facilitating data collection in qualitative vulnerability assessments include resource mapping, impact scoring, impact ranking, historical timelines, seasonal calendar, and conceptual mapping or mental models (Tschakert, 2006). This dissertation uses seasonal calendars in the data collection process, which has permitted a nuanced identification of changes in food system activities and livelihood resources and how the changes impact food availability and access.

The strength of qualitative vulnerability assessments is that they engage key subjects for an in-depth examination of vulnerability, focusing on the context-specific experiences regarding the impacts of a hazard on people or communities affected. Because of this, non-governmental organizations are inclined to use qualitative vulnerability assessment in baseline studies to engage with communities and foster relations to assist the design and implementation of interventions in reducing vulnerability to hazards (Care International-Ghana, 2008; ActionAid International, 2005). This strength has also led to increased adoption of participatory vulnerability approaches for understanding risks from natural hazards in developing countries.

Vulnerability studies have increased our understanding of the concept of risk, but there is still some ambiguity in the operational use of the term. It is unclear whether researchers and practitioners should refer to risk as the probability of a hazard event or the probability of a particular outcome (Brooks, 2003). Sarewitz et al. (2003) addressed this ambiguity by distinguishing between event and outcome risk. The former represents the "risk of occurrence of any particular hazard or extreme event," while the latter is the "risk of a particular outcome." Sarewitz and colleagues further note that outcome risk "integrates both the characteristics of a system and the chance of the occurrence of an event that jointly results in losses" (p. 805).

The above discussions on risk, hazard, and vulnerability suggest that the social context of risk is critical in our understanding, yet social factors are greatly underrepresented in the literature. Thus, this dissertation frames climate risk as a potentially threatening or damaging outcome of the occurrences of a climate hazard interacting with the social context of the system. Defining risks in the context of a hazard outcome and not a hazard event allows this dissertation to present risks comprehensively. It also permits more attention to the internal components of a system, which are mainly ignored in traditional hazards and risk studies (Zhang & Zhang, 2016; Prabnakorn et al., 2019).

2.5. Models for Assessing Risks in Rural Livelihoods and Food Security

The concept of risk is used in various natural and social science disciplines, using several models to understand the chain of explanations for its causes and assessment. This section presents a short overview of the three most widely cited models for assessing risks in rural livelihoods, climate change, and natural disasters: the Pressure and Release (PAR) model, the Sustainable Livelihoods Framework (SLF), and the Access to Resources model.

2.5.1. The Sustainable Livelihoods Framework

The Sustainable Livelihood Framework (SLF), which is widely rooted in poverty, development, and agrarian research, embraces the concept of risk, mainly in rural people's livelihoods. The main components of the SLF are vulnerability context, livelihood assets, and institutions (processes and structures) that mediate access and use of assets to build livelihood strategies for livelihood goals, including those relating to increasing income and food security (Carney, 1998; Scoones, 1998). According to Nunan (2010), the vulnerability context of the SLF summarises the risk factors surrounding a livelihood, represented by shocks, trends, and seasonality. Shocks are generally the same as hazard events from a natural disaster research perspective (Chambers & Conway, 1992). Livelihood assets and the institutional structures and processes component of the SLF are the main causal factors influencing households' sensitivity to shocks. Therefore, risk assessment within the purview of the SLF involves the analysis of shocks that strike poor people's livelihoods, together with the socio-economic and political factors that mediate the impact of the shocks on households' well-being, income, and food security.

A key strength of the SLF is that it directs attention to institutional processes and structures that shape the risk context of vulnerable people. Also, the focus on assets presents pathways to reducing vulnerabilities to mitigate risks in all forms. Despite these strengths, the use of SLF for risk analysis at the micro-level may have some limitations. Primarily, the framework considers only five broader forms of livelihood assets – social, human, natural, physical, and financial. It does not recognize the critical contributions of political capital to poor people's

livelihoods (Baumann, 2000). Most poor people draw on their political connections and power relations to build robust livelihoods – which goes far beyond their 'social capital.' Unbalanced power dynamics between the poor and non-poor can critically influence access to assets supporting livelihood strategies. Consequently, excluding political forms of assets makes risk analysis within the SLF incomplete.

2.5.2. Pressure and Release Model

Research in natural hazards and disasters has also relied on Wisner et al.'s (2004) Pressure and Release (PAR) model to explain why and how risks occur in vulnerable communities. In the context of this model, "Pressure" represents the generation of risk and "Release" is the reduction of risk. The "Pressure" from two opposing forces of hazard and vulnerability converges to generate risk. A household is likely to experience food insecurity risks if exposed to a hazard and pursues its food system activities in vulnerable conditions or situations. Wisner et al. (2004) acknowledge that hazards are probabilistic events of which knowledge is incomplete but argue that historical records can help analyze the likelihood in time and space. Wisner et al. (2004) further suggest that vulnerability analysis, on the other hand, should involve tracing the progression of a series of social factors that mediate the impact of a hazard on people, starting with the root causes and dynamic pressure that turn into unsafe conditions over long periods. In reality, most vulnerable people pursue their livelihoods in unsafe conditions/contexts, such as farming in drylands without irrigation and fishing in the ocean using small boats. Vulnerability analysis, in this case, should focus first on tracing the underlying root causes (such as economic systems and political ideologies), then the dynamic pressures (such as population changes and environmental degradation) that give rise to farmers' or fishers' decisions to live and pursue their lives in such unsafe conditions.

Like SLF, the PAR model permits analysis of the vulnerabilities of social groups within the broader national and global shifts in the political economy of resources and power (Wisner et al., 2004; Ndah & Odihi, 2017). Moreover, the application of the model emphasizes the need to go beyond focusing on physically visible contexts (unsafe conditions) of vulnerable people to explore historical precedents and structural and broader processes that give rise to

vulnerability. Despite its strengths, however, the PAR model is not without limitations. It is a static framework that provides little detail on the nested scales of interactions and the causal sequence of a hazard on a dynamic scale. Furthermore, differentiating between the various stages of the progression of vulnerability – the root causes, dynamic pressures, and unsafe conditions – can be confusing because of fluidity in social processes (Turner, 2003; Michellier et al., 2020).

2.5.3. Access to Resources Model

The Access to Resources model (or Access model) was also developed by Wisner et al. (2004) in the context of critiques on the PAR model for being static and lacking details on the causal sequence of a hazard. The Access model analyzes the hazard and vulnerability characteristics of risk-prone households and their "resource profiles" (regarding capabilities, assets, and livelihood opportunities), which enables them to become less vulnerable, protect themselves, or avoid disaster risks. The Access model aims to facilitate a holistic understanding of disaster risk management and the importance of households' access to resources for food systems and livelihood security in times before, during, and after disasters (Nirupama, 2012; De Silva & Kawasaki, 2018). Key components of the model are hazards, unsafe conditions, and adjustments or responses to an unfolding disaster situation. The hazard component represents the main trigger event that occurs and impacts households' livelihoods. Unsafe conditions arise from inequity in economic, social, and political processes that mediate access to livelihood resources, including assets, income, and property rights. Unsafe conditions influence the transition of hazards into disaster risks. Adjustments to disasters may include a combination of coping, adaptation, relocation, and supports from governments.

It is worth emphasizing that the Access model is dynamic; it iterates through time (days to year) to provide a precise understanding of how a hazard event impacts people and the trajectories through and beyond that event (Nirupama, 2012; De Silva & Kawasaki, 2018; Michellier et al., 2020). This enables the framework to understand the amount of "access" that people have to the capabilities, assets and livelihood opportunities critical to enable them (or not) to reduce their vulnerability and avoid disaster and whether recovery and rebuilding

efforts focusing on strengthening these access profiles can make a difference in times of disasters. It also permits an in-depth look at how hazard events are triggered, the extent of the impact on vulnerable people, coping mechanisms, and future regional scenarios for livelihood sustainability (Nirupama, 2012). However, the Access model in isolation does not directly incorporate the range of macro-level social and political factors that influence the impact and transition of hazards into risks for vulnerable people. These include national land reforms, international food policies, and relief programs that shape access and resource profiles for many vulnerable people.

From the above, it is apparent that each risk analysis and assessment model has its strengths and weaknesses in specific contexts. While the SLF and Access model pay little or no attention to political factors that influence households' vulnerability situations, the PAR model does not emphasize the causal sequence of a hazard, which is key to understanding the concept of risk. Given these limitations, some researchers recommend integrating different approaches to capitalize on diverse strengths. Nirupama (2012), for example, proposes the integration of community knowledge and experiences of hazards and disaster management with various qualitative (PAR and SLF) and quantitative (including risk ranking methods) models to provide a comprehensive approach to disaster risk evaluation that takes people's perceptions into account. This dissertation draws on these three models to analyze climate risk and response to food security in northern Ghana. Specifically, the dissertation engages with the SLF perspective in its vulnerability analysis to understand the sensitivity of smallholder farming households' livelihoods (by extension, food system activities) to hazard events and how they are predisposed to risks. With this background, the dissertation situates the broader risk assessment within the PAR framework to better understand how food insecurity risks occur when climate hazard events affect households pursuing vulnerable livelihoods and food system activities. Lastly, the notion of "adjustments" and "resource access," as explained in the Access to Resources model, provides a direction for the dissertation to pay attention to the diverse capabilities, assets, and opportunities that farming households draw on when coping with climate change adversity protecting their food resources against risks.

2.6. Managing Risks for Food Security in Rural Livelihoods

Risk management is generally defined as a process, action or mechanism implemented to avoid adverse outcomes and enhance opportunities for positive benefits in times of risk events (see Hansen et al., 2004; Aven & Renn, 2010; Agrawal, 2018). In rural areas of Africa, where food system activities are acutely sensitive to weather conditions, the accelerating climate change and variabilities induce significant food insecurity risks for households. For example, farmers' reliance on rain-fed food production increases their exposure to droughts and dry spell events and the likelihood of reduced crop and animal productivity. At the same time, heavy reliance on sun-drying activities leads to tendencies of food crop losses in times of erratic (out-of-season) rains and flooding events. Therefore, risk management is necessary to cushion vulnerable households and improve their resilience to climate change and the consequences of food insecurity risks. Also, the impact of climatic hazard events on livelihoods and food security is generally complex. Thus, focusing on risk management offers researchers, policymakers, and community members opportunities to learn and relearn about emerging problems and how they affect people and food resources – a great opportunity for effective research and innovation.

Studies on sustainable livelihoods and food security identify three broad categories of household-level responses to shocks, crises, and risks: adaptive strategies, coping strategies, and insurance strategies (Rancoli et al., 2001; Davies, 2016; Antwi-Agyei et al., 2018). The IPCC defines climate change adaptation as "adjustments in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities" (2014; p. 6). Therefore, adaptive strategies denote conscious and deliberate (anticipatory) responses to reduce the severity of impact and offset expected risk events. They aim to reduce the vulnerability of households' production or livelihoods to collapse over a longer timescale. Adaptive strategies are basically what disaster risk management researchers refer to as disaster mitigation strategies (Vermaak & Van Niekerk, 2004). A World Bank methodological note on agricultural sector risk assessment highlights risk mitigation (adaptive) strategies as particularly useful for managing risks with higher frequency and lower intensity of impacts (World Bank, 2016). Such strategies include

adopting improved agronomic practices, diversifying agricultural production (crop and livestock), and planting drought-resistant varieties.

Coping strategies are short-term (reactive) responses that households undertake to survive and spread risks from a periodic or sudden shock event (Rancoli et al., 2001: Shiferaw et al., 2014; Hansen et al., 2019). In a typical smallholder farming household in Ghana, coping strategies are employed once the principal production has failed to meet expected levels; the households have to "cope" until the next harvest. Examples of coping strategies may include dietary management practices (e.g., cutting down consumption or voluntary skipping a meal), economic diversification into non-food production activities, liquidating productive assets such as livestock, and temporary or permanent migration. Coping strategies are nothing new to farmers in northern Ghana who, for generations, have autonomously adjusted their livelihoods to the seasonal hungry months resulting from increasingly erratic rains and production failure. However, as the climate stressors become more severe, coping responses have, over time, become longer-term anticipatory strategies (Lee et al. 2014; Berman et al. 2015).

Several researchers identified a sequential pattern in coping strategies (Watts, 1983; Corbett, 1988; Davies, 2016; Munas & Lokuge, 2016; Abid et al., 2020). Corbett (1988) suggests that households begin with self-insurance practices (like selling a small stock), followed by the disposal of productive assets, and finally, destitution. Watts (1983), for example, explains that households in Nigeria cope with risks by holding onto their most important assets as long as possible and resorting to mass (distress) migration only after all other options have been exhausted. Thus, informal, self-managed risk response or management strategies are complex and situation dependent. According to Ellis (2000), a typical pattern in coping might involve five steps, with households diversifying income sources, drawing social networks (family and friends), decreasing resident household size through temporary migration, decreasing the size of movable assets (e.g., livestock), and selling of fixed assets (e.g., land). Sequencing in coping strategies is a tactical effort to stabilize consumption and preserve critical assets to sustain livelihoods. Ellis (2000) defined assets as the "basic building blocks upon which households can draw for production, engage in labour markets, and participate in reciprocal exchange

with other households" (p. 31). Typical farming livelihood assets include farmland, labour, savings to purchase fertilizer, livestock, and access to water resources, roads, and markets. Generally, households may build up assets in non-crisis or bumper seasons, which they rely on in distress seasons. Therefore, asset management is an important feature of household response.

In general, insurance strategies are implemented by individuals or groups of households, the private sector, and government and related development agencies to assist vulnerable households in transferring and sharing the consequences of risk events (Sissoko et al., 2010; Davies, 2016). One example of insurance strategies is market-led financial insurance and hedging mechanisms through which households can transfer the cost of risk to insurance firms. Another example is informal group-based arrangements through which households pool their resources together to assist one another (either in cash or kind) in times of shock. Although informal group-based activities are important forms of insurance for most farming households in rural areas of Africa, they tend to be most effective for managing idiosyncratic risks (affecting one to a few people) because they depend on interpersonal connections and relationships (Sissoko et al., 2010).

It should be noted that this dissertation makes references to the term "household responses," referring to both coping and adaptive strategies and actions undertaken by households in response to shocks. This term seeks to facilitate a better understanding of the creativity and strength of resource-constrained farmers in managing risks, which are often seen as inherent and pervasive in agrarian livelihoods.

Although there is evidence of the rationality and resilience of rural households' responses to climate risks, the long-term implications for food security and sustainable development bear more examination within specific contexts (Hussein & Nelson, 1998). Rancoli et al. (2001) stated that household risk responses might entail excruciating trade-offs, additional risks, and unequally distributed costs. Juhola et al. (2016) also identified that responses to climate change could deliver adverse outcomes that either rebound or shift vulnerability or erode sustainable development. The researchers explained that a rebound vulnerability occurs when

a risk response induces negative consequences for specific groups or sectors; a shifting vulnerability arises when the response compromises the ability of different groups or sectors to respond to climate change. Risk responses erode sustainability from the failure to promote sustainable development and reduce environmental degradation.

These consequences could compromise the ability of households to respond to existing and future risks and lead to structural, political, economic, and psychological lock-in effects (Wilson, 2014). As yet, there is a lack of empirical evidence on how and to what extent farming households' responses to climate change and food insecurity risks in northern Ghana provide opportunities to reduce vulnerability, enhance development benefits, and avoid potential lock-in effects. This dissertation addresses this gap by considering the implication of risk responses and decision-making in the context of the household level.

2.7. Conclusion

This chapter has shown how the conceptual and theoretical understanding of food security has changed and expanded, and the recent discussions on a food system approach to food security. The chapter has also discussed the food system approach and explained its applicability in the context of this dissertation to capture the complete set of food-related activities relevant to smallholder farmers' food problems in northern Ghana. Reviewing the concept of risk, hazard, and vulnerability, the chapter also indicated the need to incorporate the social context of poor people's livelihoods in understanding climate and food insecurity risks. Three models for assessing risks in livelihoods and food systems contribute insights to our analysis of climate risks and households' responses to food security. The remainder of the dissertation presents the methodology, results, findings, and arguments guided by the theories and concepts reviewed, explained, and discussed in this chapter.

CHAPTER 3
RESEARCH METHODOLOGY

3.1. Introduction

This chapter focuses on my research methodology, describing the research area, design approaches, and procedures for selecting the study communities and participants for data collection. The chapter also describes the methods, strategies, and tools for collecting and analyzing the data to achieve the research objectives. It further details my role as the researcher throughout the research fieldwork process and the various means through which I involved research assistants, secured partnerships, and carried out activities for knowledge mobilization and dissemination. The chapter finally highlights the procedures for integrating ethical considerations and the principles for validating and reinforcing the reliability of research findings.

3.2. Study Area

Northern Ghana is the broad location of the frame of reference for this research. Geographically, it comprises five administrative regions – the Upper West, Upper East, Northeast, Northern, and Savannah regions. My study focused on the Upper East region, which borders Burkina Faso to the north and Togo to the east. The region's total land surface area is 8,842 square kilometres, equivalent to 2.7% of the total land area of Ghana. It is predominantly rural and divided into fifteen local government areas (districts/municipalities), with Bolgatanga as the regional capital.

Several factors influenced the geographical focus of this study. First, northern Ghana is economically deprived and experiences widespread food insecurity, but the Upper East region has the highest incidence. According to the World Food Programme's 2020 assessment, 49% of people in the Upper East Region are food insecure compared to 23-33% in the remaining regions in northern Ghana (WFP, 2022). The World Bank also estimates the poverty rate in the Upper East region at 55%, which is the second highest in Ghana, as most of the population

does not have access to health, electricity, toilets, employment, and many other social services and basic needs (World Bank, 2020). Second, the Upper East region features Ghana's most fragile environments. Vegetation is dispersed (or absent), and the region records the country's highest temperatures and lowest rainfall per annum (see Issahaku et al., 2016). Therefore, the combined exposure to climate hazards, high poverty rate, and striking evidence of food insecurity make the Upper East region a compelling setting for studying and understanding climate and food insecurity risks. Figure 3.1 presents a map showing the relative location of the Municipality and specific research communities.

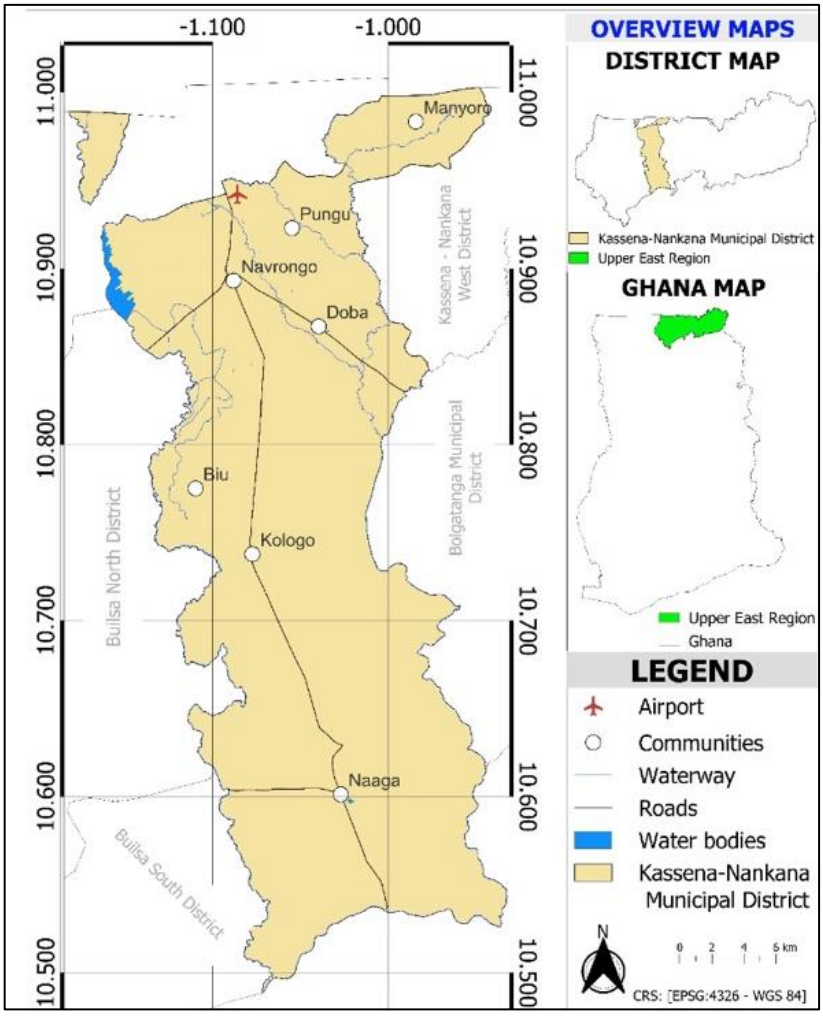

Figure 3.1: Map of Ghana showing the Kasssena Nankana and the study communities.
Source: Prepared by Franklin Cudjoe, Cartographer at KNUST, Ghana

The Upper East region is an extensive area, and it is only possible to research some of the region's communities and households with limited resources. Focusing on a single locality

within the region allows an in-depth study of the climate and food security. My study focused on communities in the Kassena Nankana Municipality, where I had extensive knowledge, experience, and existing contacts with households and research assistants from my previous fieldwork and research dissemination activities.

The Kassena Nankana Municipality's capital town is Navrongo, roughly 30.5 km from the Upper East region's capital town, Bolgatanga, and about 799.5km away from Ghana's capital, Accra. The Municipality includes 99 communities, spanning a land area of 767 sq km. It shares a border with one district and a neighbouring country (Kassena Nankana West District and Burkina Faso) to the north; four districts (Kassena Nankana West District, Bolgatanga Municipality, Talensi District, and Bongo District) to the east; two districts (Builsa South and Builsa North Districts) to the west; and one district from the North-east Region (West Mamprusi District) to the south.

3.2.1. Physical Characteristics

Kassena Nankana Municipality has a semi-arid Sudan Savannah agro-climatic zone. The climatic pattern consists of a short rainy season and a long dry season. The rainy season spans from May to September, with the mean monthly precipitation between 600 and 1300mm. Though the rains are heavy during this period, they last for a short duration, resulting in soil erosion. The dry season is associated with hot daytime and nighttime temperatures, with maximum temperatures ranging from 38°C to 43°C (Adiku et al., 2015; Incoom et al., 2020). The vegetation of the Municipality is mainly grassland with open woodlands of short trees and shrubs alongside drought-resistant trees such as Dawadawa[6], Baobab, Shea, and Mango trees. Over the years, human-induced activities and poor climatic conditions have affected the natural vegetation cover (Quaye-Ballard et al., 2020). Nevertheless, forest reserves of about 164.09km^2 clustered around the Dedoro, Saboro, Aseblika, Kologo-Naaga, and Tankwidah West areas (Kassena Nankana Municipality, 2021).

[6] In Ghana, Dawadawa is the widely referred name for the African locust bean tree.

The topography of Kassena Nankana Municipality is generally low-lying savannah plains with undulating and isolated hills in the western and southwestern areas. The major river in the Municipality is Sissili, with four tributaries: the Afumbeli, Bukpegi, Beey, and Asibelika, dammed for irrigation (Tono Irrigation Project). During the fieldwork, participants mentioned that a few temporary streams run through some communities. The streams usually have water in the rainy season and may completely dry for about 2-4 months each year (Fieldwork Notes, 2021). The Municipality's soil morphology comprises mainly groundwater laterites (almost 60 percent) and savannah ochrosols of great significance for agricultural production. The savannah ochrosols are porous, well-drained, loamy, mildly acidic, and interspersed with black or dark grey clayey soils. These soils account for the arable land areas, including most parts of the Tono Irrigation Dam site (Carrier et al., 2011; Tetteh et al., 2016).

3.2.2. Population

The recent Ghana Population and Housing Census estimated that 99,895 people reside in the Municipality, out of which 48,658 (48.7%) are male and 51,237 (51.3%) are female (Ghana Statistical Service (GSS), 2021). According to the GSS, the Municipality has consistently maintained a population increase since 1960 with an average growth rate of 1.8 % per census year – usually ten years intervals. According to the Census, about 23,176 households reside in the Municipality, with an average household size of approximately 4.1 persons (Ghana Statistical Service, 2021). A household is "a group of people who own the same productive resources, live together, and feed from the same pot" (Yaro, 2006, p. 129). In northern Ghana, households may consist of a single family or a group of family units that share blood ties. In my observation during the fieldwork, the households in the Kassena Nankana Municipality are generally large, with complex compositions. A typical household comprises the family head (an elderly father), his wives (polygamy is not uncommon), unmarried sons and daughters, married sons and their wives, and grandchildren. Sometimes, a household may also have brothers and sisters of the head, and their immediate families, living together.

Most households' housing structure comprises groups of individual family huts, forming a circular structure with an open space in the middle for family gatherings. Most huts are built in circular or rectangular shapes with clay and thatch roofs; a few new types of buildings are

emerging across the Municipality constructed with cement blocks and aluminum roofs (see Figures 3.2 and 3.3). Also, the housing structure consists of a kitchen, storage barn, animal pen, kraal, and a shaded shed at the entrance to the compound. The compound settlements are surrounded mainly by seasonally and intensively cultivated agricultural fields. Men within the household farm together to produce food crops for the entire household's consumption. Women mainly support with day-to-day farm activities, and daughters-in-law are additionally responsible for cooking the entire household's meal under the supervision of the mothers-in-law and other elderly female members.

Figure 3.1: A single housing structure comprising a cluster of several individual family huts.
Source: Author's fieldwork photos, Kologo, 2021


Figure 3.2: A cluster of housing structures in the study communities
Source: Author's fieldwork photos, Kologo, 2021

In terms of the rural-urban split, the Municipality is predominantly rural. About 73% (71,159) of the population resides in rural areas, defined as towns/communities with less than 5,000

people (Ghana Statistical Service, 2021). Navrongo is the only urban area with a high concentration of people, although there is limited data on its current population density. The rural nature of the Municipality is also reflected by the population density of 115.4 persons per square kilometre - lower than the national and regional population densities of 129.3 and 147.2 persons per square kilometre, respectively. The ethnicity is also diverse and clustered, consisting of Nankani (40%), Kasem (30%), Dagomba (9%), Builsa (7%), and other minority ethnic groups (Ghana Statistical Services, 2014). The main languages spoken are Kasem, Nankani, and Builli – each group speaks its language.

3.2.3. Economy

The Municipality is predominantly an agricultural economy. A vast majority (82.7%) of the households live by overlapping agricultural activities, mainly livestock farming (83.2%), food cropping (96.1%), tree farming (0.3%) and fish farming (0.3%) (UNDP, 2011; Ghana Statistical Services, 2014). Farm sizes range from 0.4-4.0 hectares (1-10 acres). The main cultivated crops are cereals (maize, rice, millet, and sorghum), legumes (soya bean, cowpea, groundnut, and Bambara beans), and root crops (sweet potato). Horticultural crops such as tomato, pepper, onions, cabbage, eggplant, okra, sesame, kenaf, and mango are important sources of household food and income security. Access to irrigation facilities is critical for the cultivation of these crops. However, the number and distribution of these facilities within the study area are limited (see table 3.1), implying that most farmers need support accessing irrigation.

Table 3.1: Number of dams and land areas under irrigation in the study area

Type of irrigation	**Total number (or land area)**	
	Upper East Region	**Kassena Nankana Municipal**
Dams	147	24
Dugout water reservoir	129	10
Land area of informal Irrigation	957.05 (Ha)	20 (Ha)
Land area of formal Irrigation	2,873 (Ha)	2,023 (Ha)

Source: Ministry of Food and Agriculture (MoFA, 2017)

Farmers mainly cultivate for subsistence, storing their harvest in heaps and sacks packed in their rooms/houses, silos, and barns. Post-harvest losses are widespread because of the poor storage facilities and handling of stored crops which attract rodents, birds, weevils, and grain borers. In addition to agriculture, households in some communities trade food crops, semi-processed food, and crafts. The buying and selling mainly occur in the Municipality's only central market, at Navrongo, and seven satellite/small markets in Manyoro, Gaani, Natugnia, Kologo-Nayire, Kologo-Kulengo, Biu, and Naaga. Also, the common livestock raised in the Municipality includes cattle, goats, sheep, and pigs. Households also rear poultry and guinea fowl, which they often sell for income in the dry season.

3.2.4. Land Tenure System and Governance

Like other areas of northern Ghana, land ownership in Kassena Nankana Municipality is guided by customary practices. There is no specific data on the percentage of land ownership under customary systems in the Municipality. However, the evidence suggests that more than 80% of the land in Ghana is held under customary tenure. Most of this land is held in trust by the chief, head of the family, or Tindana/Tigatus (land priest) for the benefit of members. While family lands are held in the trust of the family head for all the members, only adult men can inherit lands. By custom, women have no opportunity to inherit lands as they are expected to be married and be taken care of by their husbands or their husbands' families. They can only farm on land owned by their husbands, brothers, and fathers or borrow lands from other men. Women who are divorced may have a usufruct[7] right to a portion of paternal land through a traditional system called "Kapurepaara," but only if they stay unmarried (KNM, 2017).

Traditionally, land in Kassena Nankana, like other parts of northern Ghana, signifies a strong connection between families or communities and their ancestors; the transfer of ownership through sale indicates a break in ancestral ties. For this reason, the land is not for sale but offered on customary terms for farming and residential purposes. The customary process of

[7] A usufruct is a legal right – the temporary right to use and derive income or benefit from someone else's property, including land.

acquiring land involves several visits: to express interest in the land to the landowner/land priest, to introduce the farmer requesting the land to the rest of the community or family, and to view the land and perform sacrificial rites to request permission from the ancestors. For each visit, the farmer is expected to bring customary items such as tobacco, kola nut, red or black fowl or cock, and drink. Once access to land is granted, a farmer can cultivate the land for as many years as possible. Access may only be denied if a farmer leaves the land uncultivated for three consecutive farming seasons or does not observe all the taboos of the land (such as restrictions on the killing of specific animals or trees) or does not offer a sacrifice (fowl and drink) to the gods at the beginning of each farming season.

Both locals and strangers can access land for farming through the customary process (Kasanga & Kotey, 2001). In the case of strangers seeking land for housing, the chief is important in deciding the place for building and securing permission to be part of the community. New settlers are often required to introduce themselves to the chief of a community where they intend to settle, along with offering customary items to request permission to live in the community.

In recent times, the commodification of land is fast taking place. In some communities of northern Ghana, land is sold for cash, and customary charges have become exorbitant, with individuals interpreting the required in-kind exchange of customary items arbitrarily to meet their needs. Yaro's (2010) study on contemporary access to land in the northern part of Ghana, which included case studies from the Kassena Nankana area, shows that the determinants of accessing land vary spatially depending on the level of urbanization of the location. In urban and peri-urban locations such as Navrongo, the district capital, the ability to pay was the main determinant cited by land acquirers for their successful land acquisition. In rural areas, on the other hand, land size, availability, and knowledge of customary procedures play important roles.

Because of the increasing commodification of land, leasing or renting is becoming common in villages surrounding the Tono Irrigation Dam area. Farmlands located along water canals connected to the dam have readily accessible water for irrigation. As a result, landowners may

often charge farmers a yearly rent of up to 600 cedis per season per acre of land. To secure access to land for the next season, a farmer must pay rent ahead of the season, usually by the end of May. After payment of rent, a farmer receives the plot number, which is used to pay for the water access and irrigation development levy[8] to guarantee access to water from the Dam. This process of renting or leasing land is also commonly used in protecting family and community lands from investor grabbing. During a discussion with one of the agricultural extension officers, it was revealed that when approached by investors, the community leaders and land priests offer their lands on lease agreements that only guarantee access and use but not a transfer of land ownership to investors. Most investors are offered long-term access to use the land for commercial crops like mango and cashew.

3.2.5. Poverty Situation

The Kassena Nankana Municipality, like most districts in northern Ghana, is mired in persistent poverty, often manifested in the high level of illiteracy, poor nutrition, lack of access to healthcare, improper housing, sanitation, and unsafe water. According to the Ghana Poverty Mapping Report, nearly 30% of the people in the Kassena Nankana Municipality live on less than $1/day (Ghana Statistical Service, 2015). Poverty in communities of northern Ghana, like those in the Kassena Nankana Municipality, is a scar showing the uneven spatial development path instituted by the British colonial policies and further entrenched by post-colonial development strategies. In recent times, moreover, poverty in the Municipality is evidenced by higher levels of hunger and malnutrition. According to the 2020 assessment by the World Food Programme, about 39.7% of the population is severely or moderately food insecure (WFP, 2022), which is a 6.7% increase since the previous assessment in 2016 (see Dasori et al., 2016). It is important to note that the extended years of the Covid-19 pandemic and the recent rocketing trend in food prices are expected to push even more households into situations of less or no access to a better diet than the estimated numbers.

[8] In the 2022 farming season, farmers paid a water access levy of 220 Ghana cedis (CAD$ 26) in the dry season and 180 Ghana cedis (CAD$ 22) in the raining season. The exchange rate at the time fluctuated between CAD$ 1 = 8-5 Gh Cedis.

Several local non-governmental organizations (NGOs) have been implementing development projects to improve the livelihoods, health, and well-being of households in the Municipality. Most notable among them are the Organization for Indigenous Initiatives and Sustainability (ORGISS[9]), Association of Church-Based Development NGOs (ACDEP), Rural Initiatives for Self-Empowerment Ghana (RISE), Trade Aid, and Youth Harvest Foundation Ghana (YHFG[10]). Although these local NGOs are established and managed by individuals or groups from the Upper East region of Ghana, international donors often fund the operations through partnerships with international and faith-based NGOs. Because of the reliance on international donor funding, the activities of these NGOs are often ad-hoc. Nonetheless, they still have a high presence in rural communities; their closeness to farmers and other vulnerable groups represented an excellent resource for contacting potential respondents for my research. YHFG, for example, was a key partner in the research fieldwork process; it provided diverse support, including assistance on community entry and data collection. Details of YHFG's involvement in this research are provided later in section 3.5.

3.3. Research Design and Approach

I adopted a mixed-method research approach, combining quantitative and qualitative data collection methods plus varied types of analysis and interpretations. The mixed-method research approach, also known as multi-method, assumes that using qualitative and quantitative approaches to inquiry provides a complete understanding of a research problem than either approach alone. In the case of this research, the subsequent application of the qualitative design approach helps gather narrative data to explain or interpret numeric findings, especially those that are unexpectedly revealed from the quantitative data analysis (Creswell & Creswell, 2017). Contemporary application of mixed-method research can be traced back to the 1950s when psychological studies mainly adopted the approach to minimize weaknesses and seek convergence across qualitative and quantitative methods

[9] Organization for Indigenous Initiatives and Sustainability (ORGISS) is a local non-governmental organization (NGO) that aims to reduce poverty in the northern part of Ghana through sustainable use of resources.
[10] Youth Harvest Foundation Ghana (YHFG) is a local NGO that works in the Upper East region of Ghana to empower young people to explore their potential through education, entrepreneurship, agriculture, and market systems development. https://yhfg.org/programmes/

(Creswell & Creswell, 2017; Hesse-Biber, 2010). The mixed-method approach is gaining importance across many fields of work (including agricultural studies, rural development, and poverty studies) to analyze social phenomena from different perspectives (Strijker et al., 2020).

Adopting a mixed-method approach in this study was determined by the research questions and the theoretical frameworks guiding the research - the sustainable livelihoods and food systems frameworks. The sustainable livelihoods approach demands methodological flexibility and employs various methods, using diverse information and building on existing tools and skills while avoiding unfounded preconceptions and undue sectoral bias (DfID, 1992). The research questions intersect various social, economic, and environmental issues within community/households' livelihoods and food environments. Empirically, addressing such a multiplicity of factors requires multi-method and multi-stages of data collection. This study used two different design methods in two stages: 1) household surveys; and 2) participatory approaches. The first stage of household surveys involved administering questionnaires to gather information about the individual households' livelihoods, dietary diversity, asset composition, and value judgments on exposure to climatic hazards in terms of the type, frequency of occurrence, direction of impacts, and severity. The surveys helped identify broad trends and patterns and capture a picture of climate hazards and vulnerability across individual households and the study communities.

Climate change is a complex challenge for rural livelihoods and food security. Adopting multiple methods provided opportunities to dissect the complex contexts and realities within which rural people live. Participatory approaches built on actionable activities and direct engagement with community members (Kemmis & Wilkinson, 1998) can be combined with quantitative research to help achieve this methodological goal. Thus, the second stage of the fieldwork focused on organizing focus group discussions and interviews to explore people's knowledge and views about climate change issues, social relations, cultural dynamics on gender, and access to resources. Insights from these procedures and methods helped to gather detailed information that could not be gleaned from surveys. Examples of these issues include how households perceive changes in climatic conditions and impacts and how certain

powerful yet often unrecognized acts, such as reliance on family and friends, are constructed, operated, and maintained during a household's response to climate impacts. This latter research stage helped me gather broader opinions from local people and triangulate and shed new light on information gained during the first stage.

In essence, using a mixed-method research approach enabled the research to generate systemic and synergistic insights into the overall research questions. However, multi-methods application in the field, as noted by Creswell & Creswell (2017) and Strijker et al. (2020), required more work, a huge financial commitment, and necessitated mastering each technique and method.

3.3.1. Fieldwork Timeline

The fieldwork was conducted over six months, from January to June 2021. My first field visit was initially planned for 15th January 2021. However, it could not materialize because of delays for ethical approval from York University, citing Covid-19 risks. By early January 2021, there were improvements in the Covid-19 situation across Ghana, with minimal reported cases in the Upper East Region. The Government of Ghana's Covid-19 Update No. 21 (on 3rd January 2021) allowed the reopening of schools and in-person meetings with social distancing and mask-wearing. Because of the news release, I resubmitted my research plans for ethical review and included plans to follow Covid-19 protocols and guidelines of the Government of Ghana. The research received ethical approval on 18th January 2021.

Prior to the fieldwork, I contacted the key government and non-governmental organizations directly working at the intersection of climate change and agricultural livelihoods in Kassena Nankana Municipality, including the local government Department of Food and Agriculture, Youth Harvest Foundation Ghana, ACDEP, IFAD-Ghana, and SEND-Ghana for the opportunity to partner with them for my fieldwork. I secured an eight-week unpaid voluntary research placement with the YHFG, through which I secured office space for my day-to-day planning and meetings. YHFG supported my fieldwork with great enthusiasm. The officials provided helpful advisory support, especially in reviewing my survey questionnaires,

community selection, household sampling process, and research assistant recruitment. They also contacted some women's groups and key informants in the research communities. With their experience in community engagement activities, the organization specifically dedicated one of their staff to assist me with the community entry and related processes.

The role of the Kassena Nankana Municipal Assembly must be emphasized. The involvement of the Department of Food and Agriculture and the Planning Unit was essential to secure maps of the potential communities and contacts of the Assembly Members. I also had the opportunity to engage with the agriculture extension workers, some of whom I collaborated with for my data collection activities – see section 3.3.3 for details.

Upon arrival in the Upper East Region on the 20th of January 2021, I spent the first two weeks presenting my research proposal to research partners in the field, including officials from Youth Harvest Foundation Ghana, the local government Department of Agriculture, and local researchers and students from the study communities, some whom I hired and further trained for data collection – see section 3.3.3 for details. I also spent some days seeking advice on community selection and testing the survey questionnaires. The pilot testing with twenty household heads took place in Doba Gayingo village and helped to gain a first-hand insight into what to expect during the fieldwork.

In early February 2021, I focused on training prospective research assistants to use the research questionnaires, confirming community selections, pilot testing, and planning logistics, including transportation, stationery, and refreshments. Following these activities, I took a week off from the field to reflect on my progress. Afterward, the rest of February 2021 was dedicated to reaching out to the selected communities for informed consent, which involved visiting each community and holding meetings with the community leaders to explain the purpose of the study and express interest in interacting with households. After obtaining verbal consent from the leaders in each community, I proceeded with the first questionnaire administration phase, focusing on two communities.

This first phase provided valuable insights and learnings regarding the timing and days expected to be spent in each community. For instance, I realized that using tablets (with open-source software – ODK Collect[11]) instead of the printed-out questionnaire would save time spent with each respondent, although there are cost implications. Such insights were incorporated into the second phase of the questionnaire administration carried out throughout March 2021, where I relied on tablets. Also, visiting each community during the questionnaire administration was an excellent opportunity to establish contacts with key informants, including the chiefs, elders, and women group leaders. It facilitated participants' selection for the focus group discussions in April and the interviews from April through May to June 2021. The interviews mainly lasted this long because of the difficulties in confirming appointments with key informants and the government and non-governmental agencies.

3.3.2. Researcher's Role

In human geography (development/rural research) literature, there is a critical discussion about the desirability and liabilities of conducting fieldwork as an insider versus an outsider (Limb and Dwyer, 2001; Dwyer & Buckle, 2009; Adu-Ampong et al., 2020; Dosu, 2021). One argument is that a researcher familiar with the research setting by birth or personal ties (as an insider) can benefit from the ease of access, understanding, empathy, and integration of cultural sensitivity throughout a research process. On the other hand, being unfamiliar (an outsider) with a research setting may provide space to detect patterns insiders may overlook in their communities. In my case, I introduced myself as a researcher affiliated with an academic institution in Canada – York University. At the same time, I informed the research participants that I am a Ghanaian born and raised in the country's south, and I can speak both English and Twi, which most of the people in northern Ghana understand. Also, throughout my interaction with the community leaders, I positioned myself as someone with lived experiences growing up in a rural farming community, a similar but different setting from the north, regarding the extent of climate change and livelihood opportunities. Thus, the

[11] Open Data Kit (ODK) is an open-source suite of tools that allows researchers to collect data using Android mobile devices and data submission to an online server even without an Internet connection.

communities simultaneously received me as an outsider and an insider – these two positions enriched and complicated my research in different ways.

Before collecting data in each community, I planned community entry visits and held consent meetings with the community leaders, primarily the chiefs, elders, and Assembly members[12]. A typical welcome response I received at the end of one of my community entry meetings was: "You are welcome, our sister; we will inform the community about your mission" (Naaga). In some cases, the community leaders expressed the duality of my position, saying, "We know you are from the south, but we are all one, so feel free to do your work here. We usually receive many students like you" (Manyoro). These comments also came up during my interactions with individual households. Nonetheless, there were instances where some communities said to me: "You are here to gather your data and go, but we will still be here; it is our community. So, we want to know what this research will bring to us" (Pungu). Throughout the fieldwork, I constantly reworked these two subjective positions as a "Ghanaian insider" and "researcher outsider." In responding to the Pungu community leaders and those from the other communities, I clarified that my enthusiastic interest in the research topic stems from my lived experience of the social impacts of climate change and food insecurity in a rural farming community in the middle belt of Ghana. I also explained the research goal: to inform academic learning and policy attention on environmental change and hunger problems in the community and other parts of northern Ghana. Sharing these personal, academic, and policy motivations for the research repeatedly in all the communities helped to remind the community leaders and respondent households of my position as an engaged academic occupying the "space between" (Dwyer & Buckle, 2009, p. 60) and working for a just and sustainable future for vulnerable people.

The inhabitants of Kassena Nankana Municipality speak either Kasem or Nankani or both as their first language. Most people also understand English or Twi. However, only a few can sustain a decent conversation in one or both "lingua francas," especially those who have attended school or travelled for work in the south. Therefore, I recruited research assistants

[12] Assembly members are community/neighbourhood level political representatives. They present the interests of their immediate communities in the local governance system.

to interpret the research instruments into Kasem and Nankani while I co-led the process as much as possible.

My role thus included training research assistants and corresponding with the Assembly Members for informed consent and community entry coordination. I also participated in the questionnaire administration in each research community, accompanying the research assistants, in turn, to provide support on any emerging issues and provide contexts and clarifications during the research process. In a few cases where we met respondents that could communicate in English or Twi, I administered the questionnaires myself. During the focus group discussion activities, I fully participated as a co-moderator and relied on interpretations from the research assistants. Although I faced a language barrier as someone who could neither speak Kasem nor Nankani, I was attentive; I looked out for facial expressions, body language, and different tones of voice during questionnaire administration and focus group activities. I also asked research assistants about the meanings behind these subtle cues and responded with humour where possible.

Given that Kasem and Nankani societies are patriarchal, there are clear boundaries on women's and men's spaces. Women's spaces at home are generally limited to the kitchen environment. Thus, seeing a Ghanaian female researcher was novel and empowering for most women respondents. My presence mainly represents what Pini (2002) described as making the invisible visible to women. I challenged the dominant belief; I provided a productive space for discussion and reflexivity about power dynamics and unequal household division of labour. For instance, during the focus group discussions, the women felt more comfortable speaking than if the researcher had been a male. They responded openly to questions relating to the household division of labour and the gendered nature of ownership over livelihood assets, including land.

On the other hand, crossing into the men's spaces,[13] and particularly probing into the social relations of households' production was challenging. I felt some men often saw my role as

[13] Men's spaces often include selected areas under trees and the sheds built in front of the homestead. These spaces usually serve many purposes as a place for leisure, conversing, and sharing communal ideas.

bossing and intruding into men's affairs throughout the process. Despite all attempts and efforts to make a patriarchal bargain[14] (Kandiyoti, 1988), negotiating in the best interest of getting my research done and not offending the respondents, I still encountered several problems that I feel would likely not have been experienced by male researchers. My attempt to be informal, more friendly, and make the process fun and less interrogative was sometimes misinterpreted as someone open to being a "potential wife." On several occasions, after finishing the research questioning and asking respondents if they had any comments, male respondents replied with questions such as "Are you married?" To them, I portrayed "too much" openness, not expected of a married woman in traditional Ghanaian societies like those in the north. These men viewed me as a "readymade" bride, passing comments such as "You do not have to go back; you have to stay here so I can marry you and add to my wives" or "We will give you a husband here in our community." Seeing me as a young woman travelling far to the north alone, they assumed I was not married. To them, young women should either be home helping their parents or be married and supporting their husbands instead of taking trips far away for research.

Although such remarks came across as fun, they represent unwelcomed behaviours that often make female researchers vulnerable to emotional risks (Chiswell & Wheeler, 2016). My experience as a female researcher interacting with male respondents in the highly patriarchal society of Kassena Nankana represents the many aspects of researcher positionality and safety issues that have received limited attention in agrarian research and development discussions. Irrespective of the drawbacks, these interactions have helped me recognize how researcher positionalities might influence research encounters and understand how to mitigate and address the risks in my future fieldwork.

[14] Patriachal bargain is a term coined by Deniz Kandiyoti in the article, "Bargaining with Patriarchy," to refer to a woman's decision to conform to the patriarchal demands in order to gain some benefits – either financial, psychological, emotional, or social. In the case of my research, I had to dress modestly, curtsey halfway in greetings, introduce myself as a sister to them, and speak in a low tone.

3.3.3. Research Assistants

The data collection for this research involved the support of six research assistants, four males and two females. They were grouped into two teams: Kasem-speaking communities and Nankani-speaking communities. Aside from helping break the communication barrier, recruiting this number of research assistants allowed each person to visit only one community throughout the data collection process. This helped to minimize contact with respondents and potential Covid-19 risks. The research assistants included three agricultural extension workers with the Kassena Nankana Municipality, a volunteer nutrition analyst with the YHFG, a teacher with a degree in Integrated Development Studies, and a student of Navrongo Community Health Nursing School. All spoke fluent Twi and/or English and the Kasem and/or Nankani languages.

The recruitment of research assistants followed a robust process. I contacted colleagues who reside or work in the Kassena Nankana Municipality and consulted the YHFG and the Department of Agriculture for recommendations. Then, I contacted prospective applicants for meetings and training on the research. The final selection was based on the applicant's interest in food and agriculture issues, experience in fieldwork, language, and availability. The training occurred in Bolgatanga (at the YHFG premises) and Navrongo (at the Department of Agriculture office). Three training sessions were organized: two on questionnaire administration and one on focus group activities for each team. The training lasted between two and three hours with breaks for refreshments.

The research assistants were very impressive throughout the process. Aside from administering questionnaires, co-moderating, and taking notes in focus group discussions, they also provided interpretative insights into the Kasem and Nankani cultural connections, which proved helpful for the research analysis. For example, in several cases, the research assistants I followed around took time to explain the cultural similarities and differences between the two main ethnic groups. They also described people's connection with their lands, food, agricultural practices, and inter and intra-household relationships with labour allocations and in-kind supports. More importantly, they built remarkable rapport with

various they came across during the research. The male research assistants played invaluable roles whenever I needed to negotiate access to men's spaces, such as meeting with the chiefs or older adults in the community.

Working with these research assistants was not without challenges because of their already committed schedules as either employees or students. I had to make hard choices between each research assistant's schedule and the availability of communities for engagements/discussions. The agricultural officers, for instance, had their weekly work meetings on Wednesdays, which automatically became an off day for our fieldwork. Alternatively, they could work on any other day, but if such days also fell on a market day[15], it meant another off day. Table 3.2 summarises the timeline of the main activities carried out throughout the fieldwork.

Table 3. 2: Calendar of main fieldwork activities, 2021

Activities	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**
Arriving in Bolgatanga						
Meeting with officials of YHFG and KNM.						
Training local researchers and students						
Pilot testing						
Survey						
Preliminary result review						
Focus group discussion						
Interviews						

3.3.4. Sampling Methods and Profile of the Study Communities

Kassena Nankana Municipality comprises six major communities/townships that also represent the zonal divisions for local government administration: Navrongo, Doba, Manyoro, Pungu, Kologo, and Naaga. These communities share common climatic

[15] In the Kassena Nankana Municipality (an in other parts of the Upper East region of Ghana), market days are held periodically (usually every other three days). For instance, if the market day falls on Monday, the next is Thursday, then Sunday – in that order.

conditions and economic activity of growing crops and rearing livestock. The main cultivated crops are maize, rice, millet, guinea corn (sorghum), beans and groundnuts. All the crops are predominant across the communities except rice, which is less commonly cultivated in Manyoro because of limited access to waterlogged areas. Vegetable crops such as tomatoes, peppers, cabbage, and kenaf are also grown in the dry season. Despite the economic similarities, the communities vary dramatically in location, population density, soil type, availability of water resources for crop production, and market and transport accessibility. A detailed description of each community is given below, with identified differences presented in Table 3.3.

Navrongo is the capital of the Kassena Nankana Municipality, located on the northwestern side. The dominant ethnic group is the Kassem. In 2010, the estimated population was 52,997 people, with 9,535 households (GSS, 2010). As the major town in the Municipality, it doubles as the administrative and commercial hub, with major infrastructure such as the central market, supermarkets, banks, fuel stations, educational institutions, and hotels. Navrongo has a comparatively better transport network and service connectivity than the other zonal councils because of its strategic location at the intersection of the Ghana-Burkina Faso highway and several secondary roads. Most of Navrongo is covered by poor groundwater laterite soil[16], except of the Tono area, which has rich Savannah ochrosol soil[17]. Crops are grown under rain-fed schemes, but farmers also rely on water from the Tono Irrigation Dam. Farmers with lands adjacent to canals connected to the Tono Dam can access water for dry season farming.

[16] Groundwater laterite soil appears pale brown to pale grey sandy loams and contains 10 to 40 percent ironstone concretions. It is abruptly underlain by boulders of the iron pan. It is well known for its poor internal drainage conditions, often resulting in temporal water logging during heavy rains, thus affecting the availability of oxygen to plant roots. The majority of the land in northern Ghana is covered with groundwater laterites. Although the soils are poorly aerated, they support the production of maize, sorghum, millet, groundnuts, cowpea and Bambara beans.

[17] Savanna ochrosol is characterised by a generally thin (<20 cm), greyish brown, sandy loam, weak granular and friable topsoils with decomposing rock or hard rock within 150 cm depth. The bulk of the food crops in northern Ghana are grown on these soils. The soil is suitable crops such as yams, maize, sorghum, millet, cowpea, groundnuts and cassava. It has very limited moisture and the fertility or nutrient availability reduces quickly after continuous cropping without long term fallow.

Table 3.3: Characteristics of the study communities

Communities	**Soils**	**Water sources**	**Market**	**Transport**
Navrongo	Mostly groundwater laterite and a few portions of rich Savannah ochrosol soils	Tono Dam, dugout water reservoirs, and mechanized boreholes	Navrongo central market	Ghana-Burkina Faso highway, Kologo-Naaga road, Chuchuliga road and a few minor paths to link farmers to market centers.
Doba	Completely covered with rich Savannah ochrosol soils	Dugout water reservoir and streams	No available market but has proximity to Navrongo and Bolgatanga markets.	Ghana-Burkina Faso highway cuts through the community
Manyoro	Mostly Savannah ochrosols and a few portions of groundwater laterite soil	Dugout water reservoir and stream	Three niche markets in Manyoro Central, Natugnia, and Yua villages	Dusty laterite road connected to the Ghana-Burkina Faso highway.
Pungu	Completely covered with the Savannah ochrosols	Dugout water reservoir, streams, dugout wells, and mechanized boreholes	No available market but has proximity to theNavrongo market.	Dusty laterite road with 5 kilometers of asphalt connected to the Ghana-Burkina Faso highway
Kologo	Completely covered with the Savannah ochrosols and a very small patch of laterite soils to the West	Tono Dam, streams, and dugout water reservoir	Two niche markets at Kologo Station and Biu Station	Dusty, rugged Kologo-Naaga road and two minor roads that connect Kologo main township to distant villages
Naaga	Mostly groundwater laterite and portions of Savannah ochrosols to the West and alluvial deposits at the southernmost fringes.	Dugout water reservoir and White Volta River	A niche market at the community center	Dusty, rugged Kologo-Naaga road and a minor road connect to the Bolgatanga section of the Ghana-Burkina Faso highway.

Doba is one of the nearest communities to the district capital, located about 8 kilometres east of Navrongo Central. There is generally poor access to social amenities and infrastructure such as markets, water facilities, health centers and schools. However, the community has comparatively easier access to both the Navrongo and the Bolgatanga central markets than the rest of the Municipality because of its location on the Ghana-Burkina Faso highway. It is inhabited mostly by Nankane ethnic group and has an estimated population of 12,767 people with 2,297 households. The community is completely covered with rich Savannah ochrosol soil, which is suitable for the cultivation of all crop types. Unlike Navrongo, Doba farmers do not have access to water from the Tono Dam. The only available water sources are streams and a community dugout dam; they are often dry or contain less water for most part of the year. Thus, farmers largely depend on rain to cultivate crops.

Manyoro is located in the far northeastern most part of the Municipality and shares a border with Burkina Faso. It is inhabited mostly by the Kassem ethnic groups. According to the 2010 Population and Housing Census, Manyoro is the second largest in the Municipality, with an estimated population of 21,023 people with 3,782 households. The community is connected to Navrongo through a dusty lateritic road linking the villages to Paga, a tourist town in the north, and the Ghana-Burkina highway that passes through Paga and Navrongo. Although Manyoro is only about 16 kilometres from Navrongo, there is generally limited commercial activity between the two communities, not only because of the rugged, dusty roads but also the lack of access to vehicular transport. Households market their crops at niche markets in the Manyoro Central, Natugnia, and Yua villages. Manyoro is covered with both Savannah ochrosols and groundwater laterite soils. Although these soil types are well-suited for all the main crops cultivated in the Municipality, farmers have minimal access to water sources and have become overly dependent on rainfed agriculture. During my fieldwork from January to June 2021, the community had the driest and barest of lands in the Municipality, with hardpan soils and very limited access to water sources. There are streams and an over-silted dugout in Natugnia, which are only filled with water during the rainy season when the Bagre Dam in Burkina Faso overflows its banks. Given the limited access to water for irrigation, farmers barely cultivate crops in the dry season. Most resort to migration to Tumu, where they work on large-scale farms in return for baskets of crops.

Pungu is one of the Kassem-dominated communities in the Municipality. It has an estimated population of 7,836 people with 1,410 households. In terms of location, it is about 6 kilometres east of Navrongo Central. Like Doba, Pungu has no market. The households rely on the central market in Navrongo for buying and selling food crops. Most farmers in this community combine farming with trading activities, routinely buying food produce from farmers and selling at the Navrongo market. Soil in the community generally comprises of the Savannah ochrosols, which is well suited for all the crops grown in the Municipality. Like Manyoro and Doba, Pungu does not have access to the Tono Dam. However, the community has diverse water sources compared to Manyoro and Doba. During my fieldwork visit, I observed that households had dugout wells and mechanized boreholes on their compound farms, which serve as water sources for irrigation. Because of their income from trading and the diversified water sources, dry season vegetable farming is a common practice among farmers in Pungu.

Kologo is centrally located between Navrongo and Doba to the north and Naaga to the south. According to the 2010 Population and Housing Census, the community has about 10,453 people with 1,881 households. The population is dominated by Nankane-speaking people with a few visible ethnic minorities, especially the Builsa. Although the community is only about 18 kilometres away from the Municipal capital, farmers can hardly access the central market because of the lack of vehicular services and the poor nature of the road linking the community to the Municipal capital. As a result, most farmers rely on the two niche markets – at Kolingo and Zuo stations – that serve as converging points for buying and selling small quantities of food crops and small livestock. Occasionally, traders and middlemen and women from Navrongo may come to the community to buy crops from groups of farmers, usually during the harvesting season. Kologo is covered entirely with rich savannah ochrosols soil, enabling farmers to cultivate various cereals and legumes. Additionally, the community has access to canals connected to the Tono Dam, which provide farmers with access to water for dry season irrigation farming to cultivate vegetables. During focus group discussions, participants mentioned a few streams and rivers they depend on for farming, including Asisiga, Achawilisa, Asirisire, Ayubuliga, and Amongya. There is also a dugout dam located at Kologo-Nayire that provides access to water for multiple uses. However, the community

prioritizes it for livestock use over crop irrigation in the dry season. This is because livestock farming is an important source of income for farmers in the dry season.

Naaga is also a predominantly Nankane-speaking community, like Kologo and Doba. In 2010, the community had an estimated population of 4,868 people with 875 households, making it the least inhabited community. It is the furthest community located on the south side of the Municipality, about 35 kilometres from Navrongo. Two feeder roads connect Naaga to other communities: the Kologo-Naaga and Naaga-Bolgatanga stretch. Although these roads are important for linking farmers to larger markets in Navrongo and Bolgatanga, most households hardly use them because of the poor road network, long distance, and lack of vehicular services operating on these routes. As a result, farmers prefer to sell and buy food crops at the niche market in the community center. Like Kologo, Naaga has some of the Municipality's green landscapes. The adjoining land between the two communities is full of dispersed green trees and has an undulating landscape with isolated hills of sedimentary rocks rising to about 300 metres. Soil generally comprises laterites, with a few patches of Savannah ochrosols to the southwest. Towards the southern end, the land is filled with seasonally flooded alluvial deposits from the White Volta River, which borders the community. The alluvial deposits in the flood plains are of great agricultural significance as they are used for the dry season and flood recession farming. In addition to the White Volta River, the community has a dug-out water reservoir, but the water is reserved for livestock use and not dry season irrigation farming. Like Kologo, Naaga is also well-known for rearing livestock and supplying the Navrongo and Bolgatanga markets. Thus, the community has locally enforced rules on water use for livestock.

For the purposes of the data collection, a multi-stage stratified purposive sampling procedure was used to select villages that are representative of the whole Municipality. Two villages were purposively selected from each of the six communities described above based on four main criteria; 1) the most exposed to climate change extremes; 2) most food-insecure; 3) accessibility for the research data collection; and 4) willingness to participate. Consultations and expert advice from local government officials from the Department of Agriculture and

the Planning Unit, non-governmental agencies, community-based organizations, and local researchers helped finalize the selection process.

The selected villages were recommended for their recent exposure to extreme climate hazards (e.g., the 2019 disastrous floods in Gware, Akumbisi, and Biu). They were also more accessible and open to participating in research because of their ongoing or prior experiences with NGOs and student projects (e.g., Nimbasinia, Wusungu, Naaga, Doba Gayingo, Gingabnia, and Chaaba); and had developed robust strategies to deal with climate extremes through their efforts on community-managed water resources for crop and livestock farming (e.g., Bonia and Korania). In total, twelve villages were selected for the research from across the six communities/townships to provide a good representation of the Municipality – see Table 3.4 for the list of villages where data was collected for this research.

Table 3.4: List of sampled communities and number of participants for the household survey

Study communities/townships	**Villages visited**	**Sample size for household survey**
Navrongo	Korania and Bonia	48
Pungu	Wusungu and Nimbasnia	48
Manyoro	Gware and Akumbisi	48
Doba	Gayingo and Gingabnia	48
Kologo	Biu and Nayire	48
Naaga	Naaga and Chaaba	48
Total	12	288

The selection of research participants - involved a mix of random, purposive, and snowballing methods because of the diversity of the data collection methods – survey, interviews, and focus group discussants. These sampling methods permitted the research to reach many potential research respondents for a high response rate (Bryman, 2008). The target participants were smallholder farming households, defined as those cultivating food crops on less than 2 hectares (that is 5 acres of land)[18], mainly to feed their families (Chamberlin, 2007; MoFA, 2019). In the survey, a total of 288 smallholder farming households were sampled for

[18] 1 acre=0.4 hectares. Therefore, 2 hectares is equivalent to 5 acres.

the questionnaire administration. The sample size estimation procedure was adapted from the sampling guideline of the World Food Programme's (WFP) Comprehensive Food Security and Vulnerability Analysis (CFSVA)[19]:

$$n = (D)(Z^2 * P *(1-P))/d^2$$

Where n is the sample size, D is the design effect, ideally represented by 2 for a two-stage sampling. Z is the z-value for a confidence level of 95 percent, which is 1.96, and P is the prevalence level of food insecurity in the Municipality, which is 39.7% as per a recent assessment (WFP, 2022). The d is the desired precision level of 5%, based on the WFP recommendation for one-time studies for advocacy. By substituting these parameters into the formula, the minimum sample size required is 265.4. Also, anticipating a possible nonresponse rate of 8% yields a sample of approximately 288, representing 0.8% of the Municipality's total population of households. Based on the sample size, a quota sampling method was used to select 48 participants from each zonal council, that is, 24 participants from each of the 12 communities – (See table 3.3).

3.3.5. Data Collection Methods

The data collection methods incorporated a sequential, multi-method triangulation technique that helped balance different accounts from households and cross-checked against potential biases inherent in each method (Creswell & Clark, 2011). It began with an initial review of zonal profiles, interactions with students and researchers from selected communities, and a survey of the 288 selected smallholder farming households, followed by focus group discussions and interviews. While in the communities conducting the surveys, I took a stroll in each community and visited key resource sites, including farms, dam/dugout sites, irrigation sites, clinics, and schools. I had conversations with residents, especially those who understand some English or Twi or through translations by the research assistants, to

[19] WFP (2009) Comprehensive Food Security & Vulnerability Analysis Guidelines. See Page 85: https://documents.wfp.org/stellent/groups/public/documents/manual_guide_proced/wfp203208.pdf

familiarize myself with the communities and prepare for focus group discussions and interviews. Such informal talks also enabled me to secure contacts for any future follow-ups.

I used questionnaires for the survey data collection. The questionnaires were developed through a literature review and pre-tested for content, context, and clarity before the main exercise. The survey occured under sheds and trees nearby or in front of participants' homes, lasting about 20-30 minutes per participant. The survey questionnaire consisted of 42 structured questions covering five main themes: household demographic background, food security context, vulnerability situation, climate change, and response practices. The questionnaire precisely captured information on the availability of and access to most essential food items in a typical household and supporting resources and services crucial in shaping household food access, food availability, and resilience against climate risks.

Local researchers hired as research assistants administered the questionnaire under my coordination and supervision. They helped translate the questions to Kasem and Nankani and collected the data using Open Data Kit (ODK) – open-source software that allowed offline data collection and management with mobile devices in remote areas. The questionnaires were designed to be answered by a household head on behalf of the entire household. In the absence of a household head, adult household members available and willing to participate were invited to answer the questions. The process was meant to involve a single household member to ensure consistency and save time. However, other members voluntarily responded to some of the questions, especially when the primary respondent needed to clarify an answer or provide a comprehensive response. In most instances, for example, male respondents called on their wives or female members of the households to provide inputs when asked questions relating to food consumption – e.g; "how many times in a week does your household consume cereals, legumes, and other classes of food crops." Initiating the fieldwork with a survey exercise and engaging with diverse households in the Municipality was very important to identify broad trends and familiarize me with the participants before the exploratory, more qualitative phase.

Following a preliminary analysis of the survey data to identify themes and trends, I carried out focus groups with the farming households and in-depth interviews with key informants for more detailed information to help situate the meaning of the survey findings. The focus groups took place in all six communities. The selection of communities for these group discussions was purposive, based on the availability of existing groups (e.g., Korania Women's Group and Nimbasnia Result Project Women's Group) and people's willingness and availability to organize and participate in such discussions. Also, noting that the gender composition of group discussions can compromise women's ability to voice opinions on all issues, especially on matters related to gender, I organized separate focus group discussions for men and women in each community. In all, I worked with 95 participants in twelve separate focus groups, each consisting of six to twelve people – see Table 3.4. Each focus group lasted 2-2.5 hours, and participants were all adults of more than 20 years but not more than 70 years of age. All the focus groups took place with the help of two research assistants, who co-moderated and took notes with me in turns.

Table 3.5: Sampling characteristics for the focus group discussion activities

Community	**No. of participants**		
	Men's Group	**Women's group**	**Total**
Navrongo	8	6	14
Pungu	7	8	15
Manyoro	10	8	18
Doba	6	7	13
Kologo	6	10	16
Naaga	7	12	19
Total	44	51	95

The overall purpose of the focus group discussions was to identify the timing of key food-related activities, evaluate communities' resources and institutions, assess the severity of climate hazard impacts, and highlight key household responses and challenges. The discussion relied on a range of participatory tools, including a seasonal calendar, vulnerability matrix, and adaptation pathways, which build on previous approaches by Care International (2019), Tschakert (2007), and van Aalst et al. (2008). Questions asked included key food-related activities that community members carried out throughout the year in the seasonal

calendar activity. For the seasonal calendar exercise, the key food-related activities were plotted against the months when they took place, as confirmed by the focus group participants. During the vulnerability matrix exercise, the participants were also asked to score the degree of impacts of climate hazards on key food-related activities based on a scoring system, where 0 denotes no impact, 1 for low impact, 2 for medium impact, and 3 for high impact. Positive (+) and negative (–) signs were used to denote the direction of impacts. The adaptation pathways exercise was an intuitive activity, during which participants identified changes they make to their food-related activities to reduce the negative impact of climate hazards on food security. All the responses were recorded on flip charts using masking tape and markers.

I also interviewed 15 key informants, including government and non-governmental organizations' staff or officials, community representatives, and community-based group leaders. Discussions proceeded until responses reached theoretical saturation, a point where no new ideas emerged from the interviews (Patton, 2002). I used maximum variation sampling to select participants for the in-depth interviews. This sampling is not intended to be statistically representative but rather to allow the identification of theoretical points about everyday experiences cutting across communities' food security issues and response practices. The participants in these interviews were purposively sampled because of the nature of their work as leaders or officials involved in agriculture and food security initiatives in the Kassena Nankana Municipality. Interviews centred on unstructured but direct questions on patterns of production, storage, and marketing activities, as well as climate impacts and institutional support available for climate resilience. All the interviews were conducted by telephone, in English and Twi. The interviews varied in duration between 20 and 60 minutes, depending on the respondents' interests in the discussion, the richness of information shared, and also the phone network connectivity. Interviews with these informants helped triangulate the results of the surveys and the focus group discussions.

I drew extensively upon the above data collection methods during my fieldwork. However, I also gathered some of the most interesting insights from unstructured/informal talks and conversations with participants and the research assistants. It is essential to mention that none

of the individual data sources would have been empirically sufficient to explain the complexity of climate, agriculture, food security, and agrarian change in the study communities. The study was thus exploratory as well as statistical.

3.4. Data Analysis and Interpretation

Quantitative data were analyzed with SPSS Version 21.0 using descriptive statistics, including frequencies, cross-tabulations, custom tables, and tests of means. Tables and graphs were generated from these statistical tools to show the results. Qualitative data from focus groups, in-depth interviews, and field notes were analyzed following the methods outlined by Miles and Huberman (1994) and Berg (2004). This involved summarizing, hand-coding, and categorizing interviews and field notes for relevant themes. All key themes, coding categories, and the number of participants were recorded to articulate a particular category. I also used a narrative analysis method involving stories and quotations to show and explain the real life context of a participant's opinion. The interpretation of qualitative data features direct quotations representing the actual words of the respondents to give voice to participants' views on agricultural practices, climate, and food security. Quotes are selected based on three criteria: the ability to represent divergent perspectives, typical opinions expressed by many respondents, and the depth or clarity with which the idea was conveyed.

3.4.1. Data Collection Ethics and Validity

All the fieldwork procedures, including the sampling of participants, obtaining consent, and data analysis, were reviewed and approved by the Office of Research Ethics at York University. During data collection, each research participant was informed about the research objectives, plans for dissemination, rights to anonymity, and the possibility for participants to opt out of the discussion at any time. We also followed COVID-19 protocols and guidelines and sought permission from participants to record and store transcripts for up to five years following the fieldwork. The use of a multi-method approach permitting triangulation of data and the prolonged field engagement (six months), which enabled me to experience some of the issues in the communities, helped ensure the validity and trustworthiness of qualitative

data. Additionally, the two feedback workshops organized separately with the YHFG and the Agricultural Officers to present the preliminary survey results in March and June 2021 helped solicit further comments to verify and validate the preliminary research results. More dissemination and feedback workshops will also be scheduled in January-March 2023.

3.5. Partnerships and Collaborations

Participatory research plays a critical role in building the agency and constituencies of local communities to address the impacts of climate change on the poor (Perkins, 2011). While my field research was not participatory in the sense of being co-designed with local community members, it was community-based and premised on the principles of respectful and open community engagement, knowledge exchange, and communication through extensive partnerships with smallholder farmers, local researchers, government agencies and NGOs.

The research design strove for significant involvement of the research participants. In each study community, I raised concerns about climate and food security. I also shared stories of my lived experiences of similar issues in southern Ghana to establish a strong rapport and trust and encourage full participation. Women farmers are particularly vulnerable because of their limited access to assets and exclusion from decision-making processes. I empowered women farmers to understand the research contexts, reasons, motivations and the importance of their participation and genuine responses. I also organized separate gender-differentiated focus group discussions to give women an equal chance to speak out as their male counterparts did. Together, these inclusive strategies permitted me to address the potential pitfalls of power relations between myself and the study communities and between men and women participants. The strategies also maximized opportunities for various women's groups to share and grow knowledge and apply it in their daily lives.

Partnerships with local researchers involved meetings and discussions on my research objectives and theoretical and methodological framework. The partnership enabled me to recruit research assistants whose roles were advantageous in strengthening communication and facilitating the use of locally appropriate words for subjective concepts such as "climate,"

"risk," "risk response," "hunger," and "food security" (Smith et al., 2000; Inskip et al., 2013). Local researchers also helped prepare me for cultural complexities and sensitivity issues that may distort data or hinder research participation. In all, I believe my collaborations with local researchers also benefitted them. They were able to control the data collection process and gain knowledge of fieldwork methods for climate change and food security research.

The partnerships with YHFG and other local non-governmental and government agencies were helpful for the fieldwork and the long-term application of the research findings. For instance, the YHFG expressed interest in using my research findings for their agribusiness and market system development program.

3.6. Knowledge Mobilization and Dissemination

This research prioritized every opportunity to bridge the knowledge gap between research, policy, and practice. During the data collection stage, I organized bi-weekly reflections with research assistants and partners, including YHFG and the local Department of Agriculture. The bi-weekly reflections focused on reviewing data collection processes, ensuring consistency of research approaches across the study communities, and improving quality communication at each stage. Sharing my research results and experiences at conferences and other events has also helped improve public knowledge of the food security experiences of farmers in northern Ghana and feedback to advance various sections of the dissertation. Among these events include the York University Climate Research Month event on "The African Diaspora and Climate Change: New Global Scholarship" (March 2022), the Ontario Graduate Student Research Showcase (April 2022), the annual conference of the Environmental Studies Students Association of Canada (May 2022), Forum for Global Challenges organized by the University of Birmingham & The City of Birmingham, UK (May 2022), and the International Fund for Agricultural Development's (IFAD) Jobs, Innovation, and Value Chains in the Age of Climate Change (June 2022).

In addition to conference presentations, I have submitted a comprehensive review article titled "A review of climate risks and management strategies for food and livelihoods security in

West Africa" for publication in the Journal of Climate Resilience and Sustainability as well as short research finding report on "Why smallholder farmers in northern Ghana go to bed hungry" to The Conversation media. In the coming months, I am also planning other forms of dissemination activities, including workshops and outreach activities in the study communities, publication of the research findings in academic journals, repurposing relevant content and experiences into blog posts, policy briefs, infographics, oral stories (in the local language), and presentations at the Harriet Tubman Institute, York University, and graduate seminars at the Kwame Nkrumah University of Science and Technology, Ghana. The combination of textual, visual, and oral approaches to dissemination ensures that the research knowledge reaches wider audiences, including academics, policymakers, and, most importantly, the individual households who generously shared their knowledge and experiences and availed themselves for different aspects of this research.

3.7. Conclusion

This chapter has described the research setting in Kassena / Nankana with details of the physical characteristics, population, economy, and land tenure systems. It has also explained and justified the use of mixed methods research design and the community-based approach for the study; and presented the experiences of the researcher and the role of research assistants throughout the fieldwork processes. The methods adopted have helped reveal some of the challenges young female researchers face in field-based research. Sharing my experiences from the fieldwork presents opportunities for future researchers to learn from and better prepare for community-based, participatory research in agrarian societies. The next chapters present the results and findings from this study.

CHAPTER 4
A FOOD SYSTEM ANALYSIS OF DIETARY CONSUMPTION, FOOD AVAILABILITY, AND FOOD ACCESS IN NORTHERN GHANA

4.1. Introduction

In northern Ghana, where farming activities depend on unimodal rainfall (one rainy period per year), smallholder farmers mainly cultivate food in the harvesting season and rely on their harvests for year-round subsistence. As a result, most households face food insecurity challenges each year as food stocks run out before the next harvesting season. The main objective of this chapter is to present results and discuss findings addressing the first two of my research sub-questions, which are: (1) What is the nature and pattern of food security explained in terms of dietary consumption, food availability, and food access among smallholder farmers in northern Ghana? and (2) How do food system activities in rural areas of northern Ghana shape smallholder farming households' food security?

The chapter presents two main arguments that evolved from the food systems framework (Ericksen, 2008; 2012) and are integrated with the concept of seasonality (Ellis, 2000; Devereux et al., 2013; Anderson et al., 2018; Blackmore et al., 2021). The first argument is that there are distinctive variations in households' food access and availability throughout the year. Three factors intensify these variations: 1) the seasonality of food crop production, 2) the ineffective food harvesting, processing, and storage activities, and 3) the underdeveloped food markets of most rural areas of northern Ghana. By extension, the second strand argument is that to understand rural households' food (in)security context, explicit consideration ought to be given to the deeply entrenched smallholder food system activities beyond food production. My research results demonstrate that food production activity enables households to harvest food crops that they can depend on, but that alone does not guarantee food security. Instead, other activities, including food crop harvesting, processing, storage, transportation, and markets, are equally important for household food security. Specifically, the results show that proper storage and functional markets are critical in

ensuring that households have better food availability, access, and affordability beyond the harvesting season.

My research argument does not downplay the key role of food production in northern Ghana, where smallholder farmers' output per capita is already low. Overall, the findings contribute to the emerging perspectives to advance food systems for food security by bringing to the fore other activities that loom equally large with respect to household food access, availability, and dietary consumption.

4.2. Results

4.2.1. Timeline of Key Food-Related Activities in Rural Communities

The seasonal calendar of food-related activities – which emerged during focus group discussions with men and women farmers in the six study communities – reveals the seasonality of food and livelihood activities in northern Ghana. Figure 4.1 shows the compiled results of the seasonal calendar activities month by month.

As can be seen in the calendar, farming households mainly cultivate food crops once a year, during the months of June-September, in line with the unimodal rainfall pattern of northern Ghana. Harvesting activities (including cutting, picking, and gathering crops) occur in August-December. Some crops (e.g., millet and guinea corn) may be harvested as early as August and again in December by farmers who cultivate these crops twice in the season. The same is true of pearl rice – it may be harvested in early September and again in early December.

Figure 4.1: Seasonal calendar of food production and postproduction activities

Activity	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Land acquisition/preparation				✓	✓	✓						
Ploughing				✓	✓	✓						
Manure/Fertilizer application				✓	✓	✓	✓	✓				
Seeding/sowing/transplanting					✓	✓	✓	✓	✓			
Fertilizer application						✓	✓	✓	✓			
Weed control						✓	✓	✓	✓			
Pest control								✓	✓			
Earthing up[20] (drawing soil around the base of crops)							✓	✓	✓	✓		
Harvesting – cutting, picking, and gathering								✓	✓	✓	✓	✓
Post-harvesting – threshing, winnowing, and drying										✓	✓	✓
Post-harvesting – bagging and storage	✓										✓	✓
Selling			✓	✓	✓					✓	✓	✓
Buying					✓	✓	✓	✓		✓	✓	✓
Non-farm activities (trading, labour jobs, migration, construction and renovation of houses, storage facilities, and pen)	✓	✓	✓	✓	✓							
Dry season farming[21] - as farmers or labourers	✓	✓	✓	✓								

Source: Fieldwork Data

[20] Earthing up is technique where soil is drawn up around the base of a plant to keep it stable in windy weather.
[21] Dry season farming was reported mainly in a few communities – Kologo, Naaga, and Korania

Post-harvesting activities of threshing, winnowing, drying, and marketing (buying and selling) crops occur concurrently between October and December. Although prices are lower at harvest time, farmers often sell crops or exchange them to defray their debts and to pay for the services of mechanized harvesting service operators. Creditors usually prefer to take their money immediately after harvest and reinvest it into food crop trading for more profit. Farmers may also need cash to cover emergency expenses like healthcare and school fees for their kids. Also, during harvesting, a few households, particularly those of the poorer, less productive, and/or landless farmers, may buy food crops – with money from by-day work[22] or remitted from relatives working in the south of Ghana and elsewhere – to supplement their low production. By May-August, however, almost all households buy food because they are out of food stocks from the last harvest.

Despite limited access to proper storage, farmers use the immediate post-harvest month (November-January) to fumigate and store crops for future sales when prices appreciate. Although fumigated grains can be stored for up to 12 months, farmers usually sell after three to four months (March-May) for fear of market uncertainties and due to their need for cash. Because of the limited opportunities for a second harvest, most farmers use the post-harvest months (January-May) to rebuild their houses, barns, and animal pens. Additionally, women may engage in firewood, charcoal, and shea nut hunting and trading, while men may seek day labour jobs (mostly on dry season irrigation farms and construction worksites) elsewhere or within their communities to earn income.

Farmers generally cultivate and harvest food crops once a year – in the rainy season. However, a few (31.5%, see table 4.2, under section 4.2.5) may additionally engage in dry season farming/gardens (January-April) for a second harvest. These are primarily those who can afford alternative water sources for irrigation, such as water from dugout wells, dams, canals, and mechanized boreholes. Such farmers cultivate only vegetables (peppers, lettuce, tomatoes, carrots), usually on a much smaller land area than wet/main season farming.

[22] By-day is a commonly used term in Ghana to refer to day labour jobs, especially those offered on farm.

Farmers explained that the limited (and sometimes unreliable[23]) access to water sources, high cost of investment (fertilizer and pumping machine to draw water from dams, dugouts, and wells to irrigate crops), and frequent disturbances from livestock discourage them from cultivating on sizeable scales[24] during dry season farming.

4.2.2. Weekly Food Consumption

The diversity of food groups a household consumes is an important proxy for nutrient adequacy and food security. A household may consume different food groups throughout the month or year, which can often be impossible to remember. Thus, this study limits the analysis of dietary diversity to weekly consumption. The process involved the research participants recalling the number of times their household consumed foods from 10 identified food groups (adapted to the local context) over a typical week[25]. The grouping of these foods is adapted from the guidelines presented by Swindale and Bilinsky (2006), FAO (2011), and the International Dietary Data Expansion Project of Tufts University (2018). The result of the weekly food consumption analysis is shown in Figure 4.2.

[23] In most communities, dams and dugout wells may be closed at some point, depending on rainfall, to regulate the water use among farmers and between crop farming and livestock use. According to one of the local government appointees in Manyoro, this system of water governance has existed for decades, often regulated by the local chiefs with support from members of the communities. The appointee further added that the unpredictable water access issues can sometimes occur in the middle of the dry season when farmers have already invested much into the dry-season vegetable crops, adding to the risks incurred by such entrepreneurial farmers.

[24] As noted, dry season farms are very small-scale, far less than what the farmer cultivates during the main farming season. During fieldwork, dry season farms that I came across ranged from 0.2-1.5 acres, compared to the regular 2-4 acres (see section 4.2.5) that most households cultivate during the main farming season.

[25] Households were asked to reflect on the food they eat in a typical week, but some of them mostly based their responses on what they ate in the immediate past weeks preceding the survey, which took place in the month of February-March. This raises the question of how different their responses would have been at other times of the year, which I was able to investigate further – see section 4.2.3 below.

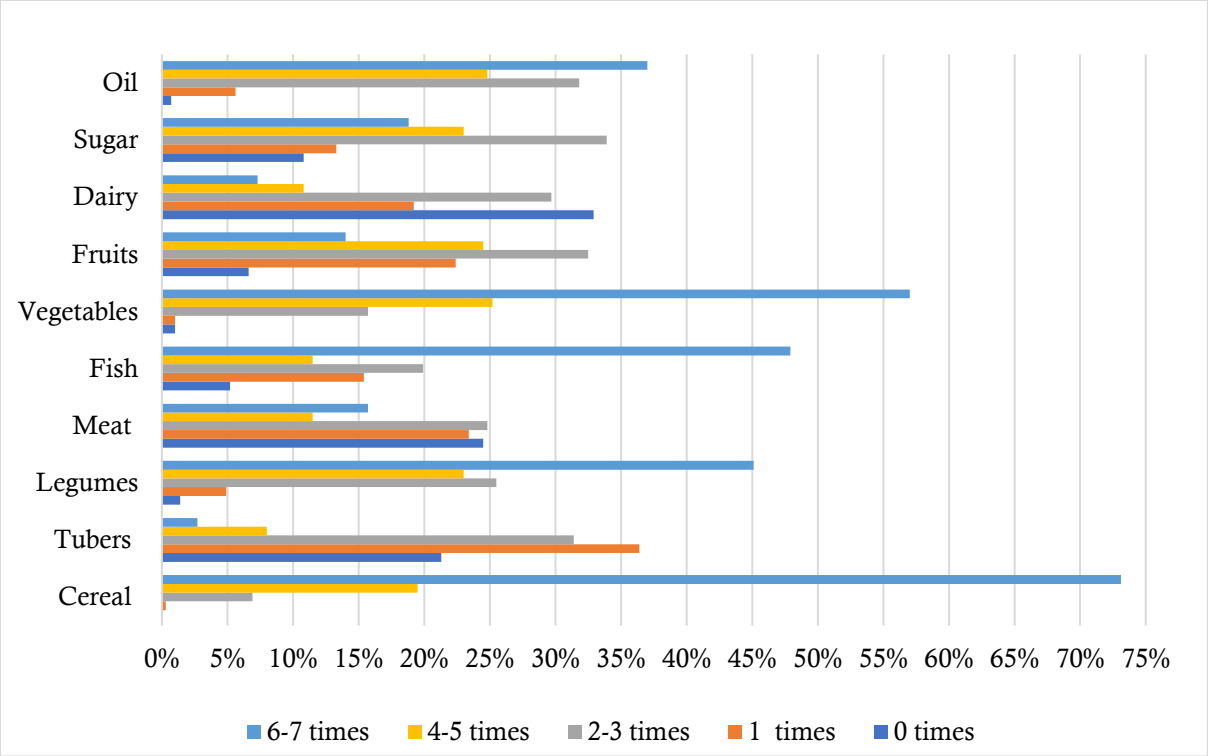

Figure 4.2: Household weekly food consumption
Source: Fieldwork Data

It is evident from the stacked graph in Figure 4.2 that cereals and vegetables are the most consumed foods during the week. About 73.1% and 57% of the households, respectively, indicated that they consume these two food groups 6-7 times a week. Fish and legumes are also essential food groups consumed 6-7 times a week by about 47.9% and 45.1% of the respondents. Contrary to the recommendations that a healthy diet should include a balanced, diverse, and appropriate selection of different food groups (WHO, 2020), it was observed that quite a good number of the households do not consume meat (24.5%) or dairy products (32.9%) at all within the week. Although the households cultivate legumes (beans and groundnuts) and keep livestock and fowls, their non-consumption of meat and dairy products and low consumption of legumes compared to cereals and vegetables are attributable to these foods' economic value. In other words, a household makes more money from selling livestock, fowls, and legumes than cereals and vegetables, and hence prefers to sell rather than consume them. As one respondent revealed during the focus group discussion with men in the Naaga Community:

> Here in our community, the prices of crops are low, especially in the harvesting season. But during the dry season when prices are better, one bowl of rice could sell for 7 cedis and beans could sell for 12 cedis. If I need 50 cedis, I must sell six to seven bowls[26] of rice. But I must sell only four bowls of beans or one guinea fowl to make the same amount. Also, I have three wives, many children, and grandchildren, so cereals – rice and maize – are very important for me and a lot of us here to feed our families. If I fetch one bowl of maize or rice from my storage, I can feed my family for one day, but if I kill one chicken, guinea fowl or even a sheep, it will not be sufficient for my family. No, it is not even possible to feed on sheep; that is expensive (an older man who also doubles as a community organizer in the Naaga community, 2021).

While a farmer's decision to sell fowls has an economic motivation, their consumption of cereals stems from dietary preferences. Instead of keeping livestock and fowls for protein or consuming more legumes for a better diverse diet, farmers prefer to sell for money and use part of the proceeds to buy dried fish from the market. Also, the non-consumption of tubers is attributable to the fact that the communities lie in Ghana's driest areas, with soil quality unsuitable for tuber/root crop cultivation (Sagoe, 2006). The local production of these crops is thus limited, and households must rely on market supply from neighbouring regions at prices only a few can afford.

4.2.3. Monthly Food Availability

The above results (in section 4.2.2) indicate that dietary consumption among farmers is skewed towards cereals and vegetables. In terms of the broad range of crops commonly cultivated and consumed in the study communities, the research identified maize, rice, groundnuts, beans, millet, vegetables, and guinea corn. Mainly, maize, rice, and millet are used in preparing the main dishes; beans are served as a relish; vegetables and groundnuts are the main components of the side sauces/soup. A closer examination of the monthly availability of each of these most consumed food crops is necessary to identify the months of hunger in the study communities. Figure 4.3 presents results on the monthly availability of the most consumed food crops.

[26] A bowl of cereals and legumes in Ghana weighs about 2.10 kg-2.40 kg depending on the size of the bowl and the crop.

Crops	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1.Rice												
2.Maize												
4.Beans												
6.Millet												
3.Groundnuts												
5.Vegetables												
7.Guinea corn												

Not available		Rarely available		Available		Highly available

Figure 4.3: Monthly food availability for key food crops
Source: Fieldwork Data

The discussions with households revealed that all food crops are generally highly available in September-December (see Figure 4.3), coinciding with the harvesting and the immediate post-harvest months. While most food crops are only highly available up to the immediate post-harvest months, millet and guinea corn availability may extend to February or March. This is because these two traditional staple crops are resistant to dry spells; some farmers can cultivate them twice within the farming season. April-August is when all food crops are rare or unavailable, but some crops (such as millet and vegetables) may be available for a few weeks or months throughout the period. Beans and groundnuts, for instance, are rare or unavailable throughout April-August because they are usually the most important crops marked for market and are sold during harvest or in the immediate post-harvest. Hence, households run out of these crops faster than the others. In contrast, vegetables are somewhat available throughout April-August because of the dry season irrigation gardening activities commonly practiced in the study communities. There is also a supply of some vegetables, such as tomatoes and onions from neighbouring Burkina Faso, which increases their availability in the market for the reference months.

While Figure 4.3 shows monthly availability for specific food crops, it does not give us information about the number of households that may or may not have these crops in their food store. Figure 4.4 shows these results regarding the aggregate availability of food stores.

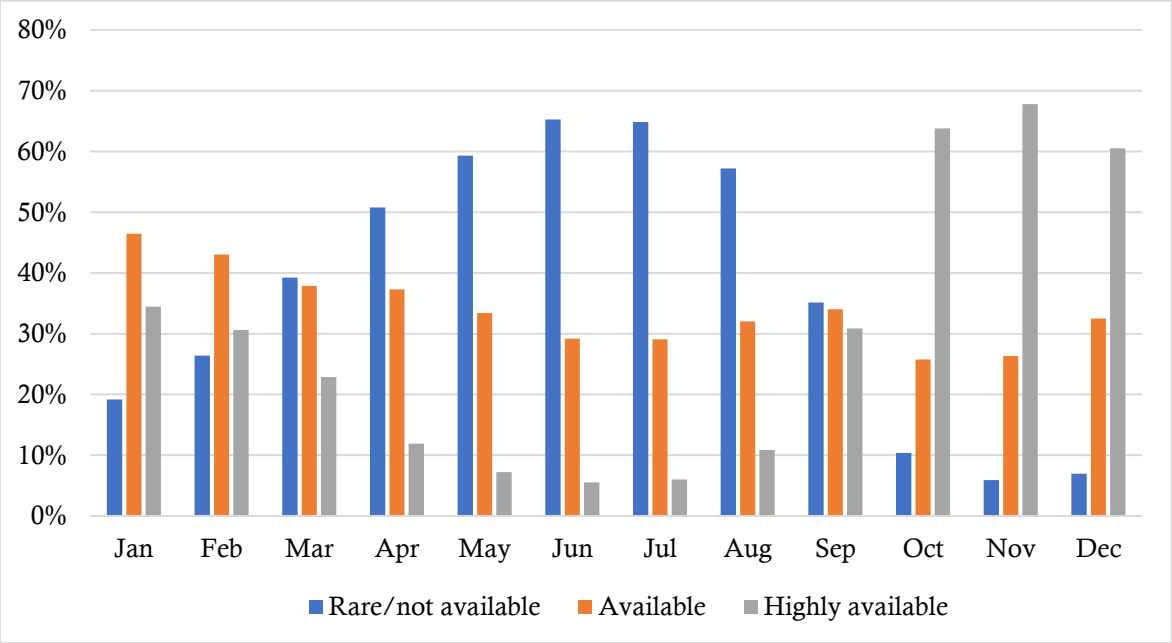

Figure 4.4: Monthly food availability in households' food stores
Source: Fieldwork Data

The results in Figure 4.4 reveal that throughout April-August, more than 50% of the households reported rare food availability in their food store. Although this period coincides with the rainy season, which is also the farming season in the study communities and other areas of northern Ghana, it is also the time when farmers experience hunger. During this time of the year, most households usually finish or nearly finish consuming food crops from the previous harvest and have yet to cultivate crops for the next harvest. With the lack of irrigation and limited opportunities for a second harvest, households must patiently wait for the next harvest for food.

September is the dominant harvesting month when most crops are available or become highly available, as shown in Figure 4.3. Yet, about one-third (35.1%) of the households reported that food might be unavailable or rare in their food stores. This is because only a few crops are harvested by this month, particularly millet and guinea corn, which are planted early

because of their resistance to dry spells. Besides, most farmers usually do not cultivate these crops in large quantities because of high sensitivity to windstorms and changing dietary preferences to rice and maize.

As could be expected, more than half of the households (60-70%) reported high food availability in October-December – the time when all crops are harvested and transported home. However, beyond the immediate postharvest month, households reporting high food availability decreased to 34.4% in January and further to 22.9% by March. Subsequently, more and more households face food scarcity problems and must look for other food sources to feed their families until food becomes available again after the next harvest.

4.2.4. Households' Food Sources

The results on food availability suggest that households must explore sources other than their own production to feed their families throughout the year. Figure 4.5 shows the various sources of food and how reliance on them varies throughout the year.

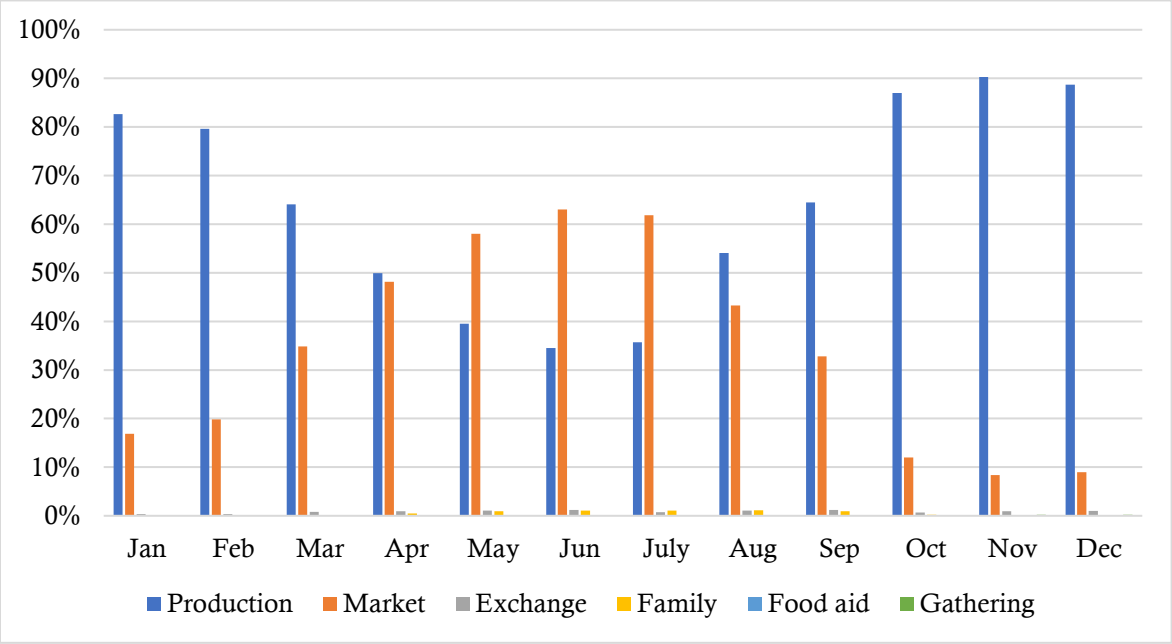

Figure 4.5: Households sources of food for consumption
Source: Fieldwork Data

Households often rely on their own production and supplement with market purchases. Those with limited or no financial resources to buy from the market may seek assistance from families/friends or scavenge other people's farms for leftover crops in the harvesting season. Such households may also travel to work on commercial farms in neighbouring towns (e.g., Tumu and Fumbisi) in exchange for money or baskets of harvested food. Although Ghana is not a food aid recipient country, farmers occasionally may get food hampers from the government when a disaster strikes and their sources of livelihoods are threatened (Antwi-Agyei & Nyantakyi-Frimpong, 2021).

From Figure 4.5, it is apparent that households' reliance on their own production is exceptionally high in October-January, which is the harvesting and immediate post-harvest months. Almost all (90%) of the households confirmed they get their foods from their own production, but surprisingly, about 9-11% still indicated that they buy from the market. This is the case among farmers with low agricultural productivity; they often prefer to purchase food crops during harvesting and immediate post-harvest periods when prices are lower and keep their meagre harvest for future consumption. Own production remains a significant source of food throughout the post-harvest months until April, when market purchases become nearly as important as own production for the households. By May-July, when food is rarely available in households' food stores (as shown in Figure 4.4), most (58-63%) buy food from the market. The increasing importance of market purchases in the months after immediate post-harvest is attributable to the lack of proper storage and effective food processing techniques (see session 4.2.5) to safely keep food crops longer after harvesting.

4.2.5. The Distinctive Characteristics of Food System Activities

As explained in Chapter 2, food systems comprise a range or network of activities from growing, harvesting, storing, processing, packaging, transporting, and marketing to consuming food (Ericksen et al., 2008; Ingram, 2011). In the case of the study communities, food system activities critical for food security are food production, food processing and storage, and food marketing and transportation. The following subsections present the characteristics of these food system activities.

4.2.5.1. Food Crop Production

The descriptive statistics in Tables 4.1 and 4.2 illustrate key characteristics of food crop production in the study communities, including the number and size of farms, means of securing land, harvest volumes, and input use. For this analysis, the study did not use any measuring instrument to record the real numbers and sizes of land and volume of harvest. Rather, it is purely based on the personal judgement of the participant households; they were asked to indicate the range of options that possibly explain their individual situations.

Table 4. 1: Number, size, and means of securing farm plots for crop production

Average number of farm plots cultivated per season	**% of respondents**
1 farm plot	16.8%
2-4 farm plots	72.7%
5 or farm plots	10.5%

Average size of each farm plots	**% of respondents**
Less than 2 acres	25.2%
2-3 acres	38.8%
4-5 acres	14.3%
5-6 acres	9.4%
More than 6 acres	12.2%

Means of securing farm plots	**% of respondents**
Inheritance/Family	90.6%
Purchase	0.3%
Gift	1.0%
Borrow/Lease	8.0%

Average volume of maize harvest per farm plot	**% of respondents**
Less than 4 bags	18.2%
5-7 bags	27.6%
8-10 bags	22.4%
More than 10 bag	31.8%

Source: Fieldwork Data

From Table 4.1 above, most households (72.7%) reported that they produce food on 2-4 different farm plots; the average farm size per plot is less than 4 acres for the majority (64%) of the farmers; accrued harvest volume per farm plot is usually less than ten mini bags[27], translating into an average of two and a half mini bags of harvested crops per acre of land. The popular means of securing land for farming in the study communities is through family ties or inheritance – that is among more than 90% of the households surveyed. Since most of the households are large in size, with many individual families, it is somewhat impossible for members to secure large tracts of land for food cultivation. This explains why farm sizes in the study communities are smaller – less than 4 acres among the majority, as revealed in Table 4.1.

It is important to note that production inputs also significantly contribute to harvest volumes and food security, irrespective of a household's farm size and means of securing land. Table 4.2 shows results on input use among households.

Table 4.2: Production input/service use

Inputs/services	**% of respondents**
Dry season farming/irrigation	31.5%
Bullock for ploughing	83.6%
Tractor for ploughing	54.9%
Weedicides	91.6%
Pesticides	87.4%
Chemical fertilizers	80.1%
Organic fertilizers (farm manure)	75.2%
Improved seeds	52.1%
Family labour	94.1%

Source: Fieldwork Data

The results presented in the above Table 4.2 reveal that compared to tractors (54.9%), more households use bull-drawn ploughing machines (83.6%) to harrow soil matter and prepare for sowing. The limited use of tractors is attributable to the lack of access, long waiting time for service delivery, and high cost of services (when available), as demand exceeds supply.

[27] These are nylon bags weighing 25-30 kilos of maize and other grains.

Tractor operators come from far away cities like Tamale, Techiman, and Walewale. They usually do not attend to farmers in the study communities on time after serving those in their towns. Therefore, farmers prefer to use the bull-drawn plough to avoid being too late for sowing.

Although my study did not record the quantity/amount of fertilizer used, approximately 80-92% of the households reported using chemical inputs, higher than those who reported using organic manure (75.2%). These results are understandable considering that most households[28] reiterated the high cost of preparing a compost site, difficulties of accessing water to aid decomposition, and low livestock density, which discourage the use of organic manure and compost. Chemical fertilizer application is necessary for the improved varieties of maize and rice, which are now increasingly being adopted by farmers in northern Ghana to protect production against climate change. Because of their limited financial conditions, farmers buy chemical fertilizers on credit from local input services providers. A few may buy fertilizer at a discounted price from specified dealers with the passbooks/coupons obtained from the local government office of the MoFA[29] in Navrongo. It is important to note that while most farmers use chemical fertilizers, the higher usage rate does not translate into high yields. Interviews with the agriculture extension officers reveal that yields per acre are still low despite the fertilizer use rate. They explain that most farmers lack the knowledge to apply fertilizers in the right amount and/or the finances to purchase enough fertilizers. These challenges help explain the low harvest volumes among smallholder farmers; they are also partly the reason food becomes rare or not available in most households a few months after harvest when they are feeding an average of 7 or more people[30] daily.

[28] During the focus group discussion with women in Manyoro and Doba, the participants expressed that many buckets of water are required to facilitate the decomposition of compost materials. And particularly for Manyoro, there is only one borehole serving all their water needs and a nearly dried up dugout dam for animal use, and therefore most households cannot afford to invest their time and money in compost even if they are interested.

[29] Through the Ghana's Fertilizer Subsidy Program, MoFA aims to make fertilizer more accessible to encourage appropriate fertilizer use. The program offers a 50% price subsidy on fertilizers purchased by rural farmers. However, there have been cases of corruption and smuggling of fertilizers to neigbouring countries, which limits access for most beneficiary farmers including those in Kassena Nankana Municipality.

[30] Average household size in the study communities is 7 persons per household. This number excludes those who have travelled temporarily to work elsewhere, because the fieldwork was conducted in February-May, which falls in the dry season and the time when some household members might have travelled to seek

4.2.5.2. Food crop harvesting, processing, and storage

In terms of food crop harvesting, processing, and storage, households rely on traditional ways of threshing, drying, dehusking, winnowing, and bagging. Table 4.3 illustrates the type and use of resources and services for these activities to understand the key features that affect households' food availability and access.

Table 4.3: Resources and services for food harvesting, processing, and storage practices

Resources/services	**% of respondents**
Threshing/shelling machines and harvesters	39.5%
Access to grinding mill	65%
Pots/Gourds	28.3%
Barn	47.2%
Storeroom	76.6%
Warehouse	0.7%
Chemical for storage	37.4%

Source: Fieldwork Data

The results presented in Table 4.3 indicate that about one-third of the households (39.5%) reported using mechanized harvesting and threshing services. This result is not surprising as the problem of access to goods and services, including mechanized agriculture, is very limited across northern Ghana. During the household surveys in Manyoro, for example, participants highlighted the complete lack of threshing and harvesting machines for agricultural activities in the community. One of them reported that:

> "We thresh our crops manually by hand and with sticks. I have not seen anything like a machine for threshing yet. Most farmers here will dry their harvested food crops and use hard sticks to thresh them. Some farmers specifically use mortar and pestle to pound the crops to get rid of the husk or cobs. Even farmers who harvest large sizes of farm plots sometimes hire people or rely on friends and family to support them with manual threshing, but the small-scale farmers only use their families to do it" (Young male farmer/teacher, Manyoro).

opportunities in other communities or towns. Also, during the fieldwork, I came across several households that were far more than 7 people: some had up to 15 or more household members.

In communities where mechanized services are available, the farmers were also quick to express the limitations of these services to a few crops and the financial challenges associated with seeking such services. At one of the focus group discussions, a participant elaborated on the challenges of access to threshers and harvesters, explaining that:

> "The harvesters only work on rice farms and not all crops. It is also just a few people who can afford the services because there is no money during the harvesting months. The harvesting period is the most challenging time for everyone in our community – no money until we sell the crops. Some of the operators may request portions of the harvest as a payback for their services. Because of this, most farmers prefer to rely on organized labour and help one another in rotation" (Woman farmer and group leader, Bonia).

In view of the above reasons, farmers harvest crops with intensive manual labour in cutting, stooking, and, sometimes, transporting crops home over the head. They also thresh the crops by beating loaded sacks of maize cobs with sticks or packs of millet and guinea corn by hand. Besides the significant time commitment involved, the pressure exerted on crops in these labour-intensive activities leads to physical damage that exposes crops to pest infestation (Sugri et al., 2021).

The results also show that only 65% of the households reported using grinding mill services, indicating that the remaining households use alternative services to dehusking rice paddy and milling grains like maize into flour for *Tuozaafi* (*a thick maize gruel*), which is the most commonly consumed dish in northern Ghana. The problems households face in accessing grinding mills and some of the alternatives they resort to were best captured in the following statement by a young lady in Naaga:

> "I am pounding this rice to remove the chaff. It is hard, but I will finish soon. I must finish pounding and go and cook it for the evening meal. The grinding mill service is far away and costs a lot of money. Sometimes the grinding mill operator is not available. Most afternoons, he closes the mill to go buy fuel or go for extra jobs elsewhere" (Young Woman, Naaga).

In terms of storage, most farmers (76.6%) reported storing their crops in regular rooms or reserved spaces in their bedrooms or homes (see Table 4.3). A good number (47.2%) of them

also reported storing crops in mud-constructed barns/silos. Both room storage and traditional barns enable farmers to keep crops for a few months after harvest, allowing marketing flexibility and food availability during out-of-season periods. However, the stores are mostly built of mud and plant materials, usually dilapidated and unable to maintain the required airtightness to prevent insect pest attacks at storage. Only a few households (0.7%) store their crops in an adequately maintained warehouse. A primary reason for the limited use of grain warehouses is the lack of access for farmers. There are only two grain-storage warehouses in the entire study district with a total capacity of 1120MT – not adequate to serve all the farmers. Besides, the two warehouses are all located in the Navrongo zonal area, far out of reach for most farmers to store their crops. Owing to these storage infrastructure challenges, some farmers (37.4%) fight pests using chemical fumigants, including Actellic, Malathion, Etrimfos, Gardona, and Methacrifos. The majority of the farmers do not use any chemicals – see Table 4.3 – as they consider them toxic or might not have money to acquire them. These storage problems in the study communities explain why farmers may experience losses of up to 35% of their grains per harvest, as reported by Sugri et al. (2021), equivalent to weeks' worth of consumption.

4.2.5.3. Food crop marketing and transportation

Table 4.4 presents the key characteristics of food crop marketing and transportation activities. About 38.8% of the households reported always selling portions of their food crop harvests. In comparison, another 17.1% sometimes sell depending on the circumstances, such as needing money for emergencies, healthcare, or school fees. The reasons why most farmers cultivate for subsistence include the low harvest volumes (see Table 4.1), inability to afford or access water for dry season farming, and limited access to the market.

Table 4.4: Food crop sales and transportation

Selling part of the harvest	% of respondents (n=288)
Yes	38.8%
No	44.1%
Sometimes	17.1%

Form of transport to the market	% of respondents
Walking	20.3%
Bicycle	20.6%
Motorbike	24.5%
Tricycle	30.4%
Vehicle	4.2%

Distance to the market	% of respondents
Less than 10 km	35.3%
10-20 km	18.9%
20-30 km	12.2%
More than 30 km	33.6%

Source: Fieldwork Data

Across the study district, there is only one central market in Navrongo, the district capital, and seven satellite markets serving various scattered communities. Compared to the central market, the satellite markets act as a converging point for a small number of buyers and sellers offering a few bowls of grains. Also, in some cases, farmers in remote communities may arrange with a buyer to sell grains in bulk. One of the participants in the women's focus group discussion reported that:

> If a farmer wants to sell something small, one to five bowls, they take it to the Kologo stations (Kolingo and Zuo stations), which we usually call the Kologo market. Those who want to buy can buy from there. Most people go to the Kolingo station to buy and sell, so that is why they call that place a market. If someone has something in bulk to sell, they must call somebody from the big cities (Navrongo or Bolgatanga) or wait for buyers from down south to come because it is difficult to transport the crops to market – the roads are in bad conditions, and trucks will charge much money. (Woman in Biu, April 2021)

Even though households have access to satellite markets, they still find the central market important for a comparatively better income from crop sales and fair prices for food purchases. Some may travel long-distance to the Navrongo market to buy or sell crops at reasonable prices instead of relying on niche markets. As shown in Table 4.4, almost half of the households (45.8%) reported travelling more than 20 km to the nearest market and even more to the central market. Households in Naaga, for instance, are more than 35 km away from the central market, and those in Manyoro are about 16 km. Besides the rather long distances, transport services are also not available. Most households rely on tricycles, motorbikes, bicycles, and walking; only a few (4.2%), especially those residing within the Navrongo zone, have access to and may travel by vehicle. The limited reliance on vehicles is mainly because of households' lack of access to vehicle services. It can also be attributable to the poor nature of the road network, particularly during the rainy season[31], which discourages vehicle owners from providing services to remote communities.

4.2.6. Challenges to Food Access and Availability

The farming households in the northern part of Ghana experience myriads of challenges that affect their food system activities – as explained in Chapters 1 and 3. Based on the review of existing studies in northern Ghana, five key challenges were identified and integrated into the survey probing process. Participant farmers were asked to indicate which challenges they find most adversely impactful for their food system activities. The results of their responses are presented in Figure 4.6.

[31] The peak of the late rainy season (August-September) coincides with the harvesting time for early millet, guinea corn, and maize. Farmers wanting to early harvested crops for cash to take care of emergency expenses like healthcare may face challenges transporting their produce to the market.

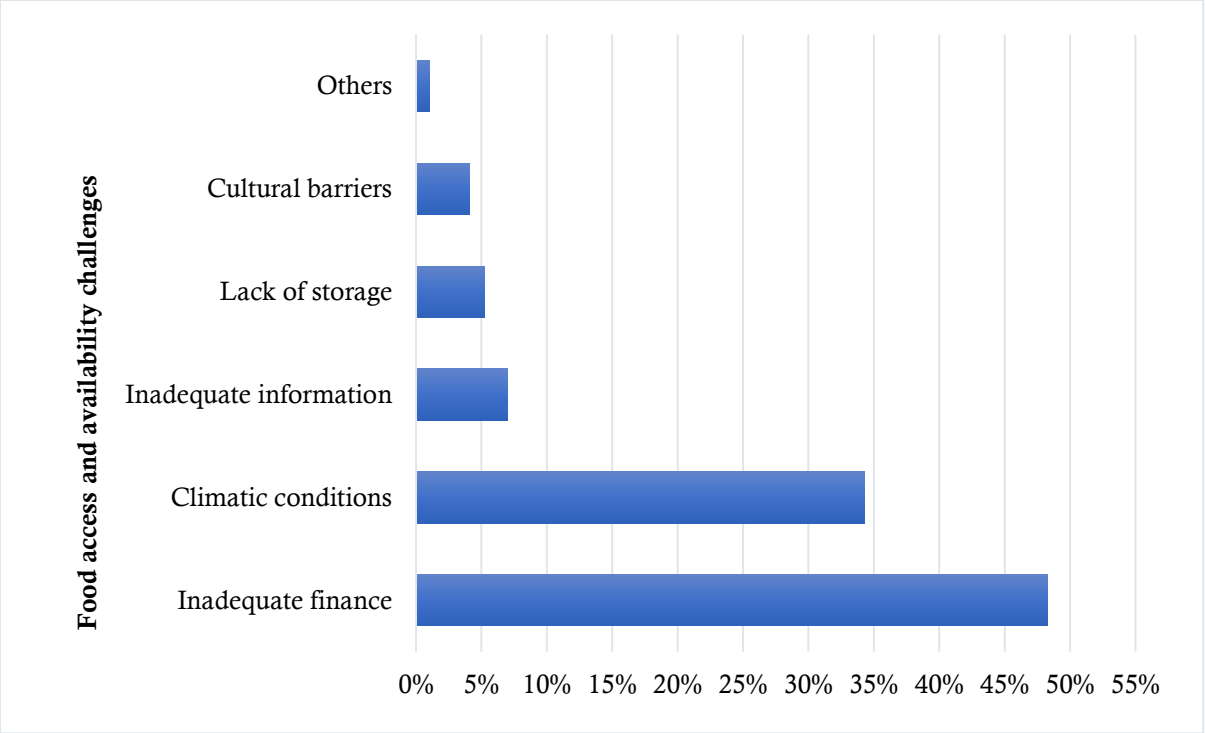

Figure 4.6: Challenges in households' access to food
Source: Fieldwork Data

The most significant challenge reported by the households is inadequate access to finance. Most respondents (48.3%) report that lack of finance limits their ability to invest in food production activities and purchase food from the market when their own-produced supply runs out. A reasonably large number of households (34.3%) also indicated the changing climatic conditions as a significant problem, followed by limited access to information (7%), the lack of better storage facilities (5.2%), and cultural barriers (4.1%).

Although farmers in the study communities pursue their livelihoods in Ghana's driest and most climatically vulnerable environment, they perceived inadequate finance as a more significant challenge than climate change per se. This is because most poor farmers often view climatic changes as occurrences outside their control but consider the issues and problems of access to finance as more of a systemic institutional and economic failure with adverse effects on their ability to manage climate change problems.

While inadequate finance and climate change are general problems in the communities, affecting all farmers, cultural barriers are more likely to affect women than men, particularly the problem of limited access to land to produce food. As indicated earlier, traditional norms in Kasem and Nankani cultures, like others in northern Ghana, restrict women's access to land. It is uncommon for women to acquire land for agricultural production. Instead, they only work with their husbands, brothers, and fathers. During focus group discussions, women reiterated that cultural norms limit their opportunities to secure land for food crop production. As one of the women leaders said, "If you are a woman in this community, you cannot access more than 1 acre of land. Even if you can farm more than 5 acres and have the money to invest in it, you will not get anything more than 1 acre. The men believe that if a woman gets a large tract of land to farm and make money, she becomes over-empowered and disrespectful." The study thus reveals that cultural barriers to women's access to land and the other constraints highlighted above limit households' ability to produce more food crops and ensure year-round food access and availability.

4.3. Discussion

Overall, the study results presented in section 4.2 reveal that farming households in northern Ghana have poor dietary consumption patterns and wide seasonal variations in food availability and sources. It further shows that the food systems of the study communities are characterized by highly fragmented food production, ineffective food harvesting and storage, and underdeveloped markets – all of which reinforce households' inability to meet their food and nutritional needs throughout the year. This section discusses these results along three main themes: 1) seasonality of production and dietary choices; 2) ineffective food storage and limited food availability culminating into seasonal hunger; and 3) underdeveloped markets and food access in the hungry season.

4.3.1. Seasonality of Production and Dietary Choice

My study finds that smallholder farming households in northern Ghana have poor dietary patterns. They consume cereals and vegetables almost daily, but meat, tubers, dairy, legumes,

fish, and fruits are limited to only a few days a week. Even more staggering is that many households do not consume meat or dairy products in a week, although most rear livestock. The most consumed cereal crops are rice and maize; the vegetables are tomatoes, onions, pepper, and kenaf. Undeniably, cereals and vegetables provide some form of nutrition, but a more diverse diet is required for a household to maintain a healthy and nutritious diet. This observation stresses the existing evidence of the burden of malnourishment in sub-Saharan Africa, which is concentrated disproportionately among poor farming households because of their poor diets overwhelmingly dominated by cereals (Kennedy et al., 2011; Khoury et al., 2014; FAO, 2021). My findings corroborate research evidence from several rural communities in Ghana and other parts of Africa, where households reportedly consume mainly cereals and vegetables (see WFP, 2016; Nantakyi-Frimpong, 2017; Ntakyo & van den Berg, 2019; Matita et al., 2021).

My study further finds that households mainly produce food crops once a year, with a few additionally cultivating vegetable gardens in the dry season for a second harvest. Primarily, farmers secure their food and income during the main farming season – that is, the rainy season. Consistent with existing studies, these findings suggest that the poor dietary pattern of households in the study communities is linked to the seasonality of food production and agricultural income (Savy et al., 2006; Abizari et al., 2017; Ecker, 2018; Ayenew et al., 2018). The seasonal nature of food production activities in the study communities, like other rural areas in Africa, permits farmers only to produce diverse food crops in the main farming season; it also restricts farmers' income earnings to the harvesting and immediate postharvest months (Savy et al., 2006; Abizari et al., 2017). This forces farmers to keep the low-priced crops (mainly cereals, e.g; maize and rice) for consumption and sell those with high economic value (legumes, livestock, fowls) to maximize their seasonal income earnings. In essence, the seasonality of production and income also explains why, although farmers cultivate different types of crops (cereals, fruits, vegetables, legumes) and raise farm animals (livestock and fowls), they tend to rely comparatively more on cereals and vegetables in their weekly dietary consumption pattern. Instead of keeping legumes, livestock, and fowls for better, diverse, and nutritious diets, farmers prefer to use them as income assets to cover non-consumption expenditures like school fees and healthcare.

While my focus in assessing food security centers around seasonality, the study also acknowledges that farming households pursue their livelihoods in a contested political landscape that may affect their dietary diversity. As evidenced in earlier studies (Apusigah, 2009; Nantakyi-Frimpong, 2017; Vercillo, 2020), power relations, gender norms, and power dynamics may intimately shape the contributions of seasonality to poor dietary patterns. In the patriarchal society of northern Ghana, it is common for husbands to control households' resources and decision-making, including those relating to food crop production, marketing, and consumption. Despite women's high labour contribution, there is evidence that they have limited control over food system decisions (Apusigah, 2009; Vercillo, 2020). For example, data from the fieldwork shows that households have a combined labour arrangement, with both men and women contributing equal labour for food production, harvesting, and storage activities. However, women's labour contribution exceeds men's in marketing (66.1%) and food preparation (85%). Despite women's high contribution, men hold power to decide which harvested crops to mark for sale and household consumption. During focus group discussions with women, it was reported that their husbands often prefer selling legumes, livestock, and fowl for income. While this income could help women buy various food items to improve their household's nutrition, only a small portion (and sometimes nothing) is allocated to buy fish and condiments for meal preparations. The women groups added that the men often use the farm income as discretionary funds, some of which is spent on alcoholic beverages – which do not contribute to households' nutrition. In essence, intra-household power and politics provide further explanations for understanding the contested contributions of seasonal income to poor dietary consumption for all household members.

4.3.2. Ineffective Food Storage, Food Availability, and Seasonal Hunger

Consistent with findings from previous research in northern Ghana and other rural areas of Africa (Nsafoah, 2008; Aggreh, 2015; Dafour, 2019; Abass et al., 2014; Martey, 2020; Sugri et al., 2021), this study reveals that food crop harvesting and storage practices in the study communities are not sufficient and effective to guarantee the safe keeping of cereals, legumes, and grains beyond the harvesting and immediate post-harvest season. Most households lack

access to proper warehouse storage facilities; they are compelled to store food crops in regular rooms, barns, and pots, usually without proper ventilation or protection. Indeed, a study on postharvest losses in the district has shown that these poor storage practices expose food crops to pests and moulds, causing losses of up to 35% of crop volume (Sugri et al., 2021), equivalent to weeks' worth of consumption. Although some households use chemicals to fight pest attacks during food storage, these chemicals are unsafe and affect human health (Nsafoah, 2008). For these reasons, farmers cannot keep cereals, legumes, and grains to meet their food availability needs throughout the year.

The results further reveal that most households have high food availability in the harvesting and immediate post-harvest months (September-December). Beyond this period, food availability decreases and becomes less available or completely unavailable in most households by April-August. This is the period often described as the hungry season – the time when most households have entirely or nearly finished consuming or sold out their food stock from the previous harvest and must rely on other sources, such as markets (see Brown et al., 2009; Thompson et al., 2010; Connolly-Boutin & Smit, 2016).

These findings are comparable to reports of reduced food availability and months of hunger in rural farming communities across northern Ghana and other deprived areas of Africa and the world. In the study on the food security situation in northern Ghana, Quaye (2008) noted five to seven months of inadequate food provisioning at the household level and argues that some regions experience more prolonged food shortages than others. According to a feasibility study report by the Mennonite Economic Development Associate (MEDA), a Canadian international non-profit organization working in Ghana, communities in the northwestern part of the country experience three to six months of food shortage in a year (MEDA, 2012). There is also a report of predictable seasons of hunger in rural areas of Malawi, Niger, India, Ethiopia, Ghana, and Namibia, occurring in the pre-harvest months when food stocks are low (Devereux et al., 2008). These findings reveal the intensity of supply-side hunger issues in rural farming communities of Ghana and the developing world, which warrants strong policy interventions to enhance food storage practices for farming households.

4.3.3. Underdeveloped Markets and Food Access in the Hungry Season

It is often perceived that rural farmers in sub-Saharan Africa primarily rely on their own produced food to meet their household food needs (Yaro, 2006; Baiphethi & Jacobs, 2009). This study's results show that growing food is not the only way farmers obtain food; they also buy from the market. Indeed, the results on households' food sources reveal that farming households in northern Ghana only rely heavily on their own production during the four to five months of the harvesting season (August-December); they depend on market purchases and in-kind payments in food during the five-month hungry season (April-August). In the three months (January-March) between the harvesting and hungry seasons, households supplement their depleting own produced stock with purchases from the market. These findings reaffirm evidence in previous studies which report the significant contributions of market purchases for food security in rural areas of Africa (Baiphethi & Jacobs, 2009; WFP, 2017; Sibhatu & Qaim, 2017). In Ethiopia, for example, Sibhatu & Qaim (2017) assert that purchased foods account for significant portions of calorie consumption in rural areas throughout the year. They further elaborate that purchased foods are more than half of the households' food consumption during the lean season and about one-third during the harvesting and post-harvesting seasons. Although my research did not quantify household purchases from the market, it corroborates existing evidence from Baiphethi & Jacobs (2009), WFP (2017), and Sibhatu & Qaim (2017) that reliance on the market increases during out-of-season months.

Similarly, the WFP's comprehensive food security assessment indicates that more than 50% of households rely on the market to meet their food needs in northern Ghana. The reliance is as high as 55% among agro-pastoralists and 57.8% among agriculturalists (WFP, 2017). It is important to note that the WFP's assessment was conducted in February-March, the beginning of the lean season, confirming this study's finding that households' reliance on the market is high in the hungry season.

Food markets are essential in smoothing rural households' year-round food access, safety, and availability (Timmer, 2017; Hatzenbuehler et al., 2016; Ngare et al., 2016; Balineau et

al., 2021). My findings reveal, however, that food market opportunities and transport infrastructure are underdeveloped in the study communities. Households must travel long distances (more than 20 km) to access the central market, and vehicle services are limited or non-existent in some communities because of poor roads. As a result, farmers cannot sell their immediately harvested crops in the central market where there are many buyers to secure better prices. Instead, they are forced to sell to the few traders who come with their trucks to the rural communities to buy crops at farmgate prices. Price offers from these traders are usually low due to the supply from many farmers looking to sell their newly harvested crops. The consequence is that farmers earn little income, which cannot compensate for the variable but predictably high food prices in the dry season. Also, in the hungry months, due to limited transport options, farmers cannot buy food crops from the central market in Navrongo, where prices are comparatively lower because of supply from traders in Bolgatanga and Burkina Faso. They are limited to buying from the satellite markets, where prices are higher because very few farmers have crops to sell. Poor transport networks thus contribute significantly to food insecurity.

The problems of high seasonal food prices, poor access to the market, and underdeveloped rural transportation infrastructure are consequences of British colonialism and the lingering impacts of the infamous structural adjustment programs (Devereux et al., 2008; Nantakyi-Frimpong, 2013). As indicated earlier (see Chapter 1), the British colonial administrators' interest in preferentially developing infrastructure in Ghana's southern regions for natural resources exploitation led to a neglect of the impoverished northern regions. This history of unequal development between the south and north permeates Ghana's regional development policies even in current times, with limited investments in rural transport networks and markets in the northern regions. Moreover, the structural adjustment policies in the 1980s and the consequent elimination of state marketing agencies serving rural farmers with a fixed buying and selling price for food crops, irrespective of the season, intensified seasonal food insecurity in northern Ghana. Rural farmers have become vulnerable to excessive dry season price fluctuations without regulated food prices. This situation is even more severe among smallholder farmers, most of whom have limited opportunities for employment outside of the agricultural season.

4.4. Conclusion

This chapter presents evidence of food insecurity among poor farmers in northern Ghana, which is characterized by restricted dietary patterns and seasonal hunger resulting from a food availability decline and increased reliance on market purchases in the post-harvest months. The results show that food insecurity exists in the study communities because of the labour-intensive, low-input investment, and small-scale food production. Besides, farmers only have limited access to effective harvesting, processing, and storage facilities; they are highly exposed to pot-harvest loss, constraining year-round food availability. Although access to the market could allow farmers to sell their harvest surplus and buy when needed, the fluctuating pricing and limited market access make it costly for them to rely on food purchases.

Furthermore, the chapter presents empirical evidence demonstrating the micro-level application of the food system framework for researching food security. In particular, the food system context of the case study district, characterized by labour-intensive seasonality-dependent production, ineffective storage, and underdeveloped markets, helps explain the food insecurity situation of northern Ghana. The evidence presented here affirms insights from Ericksen's (2006) proposition of the food system concept that activities from production to consumption underpin food security; it runs counter to the production-focused approach and the logic put forth by neo-Malthusian advocates that have neglected other activities that loom equally large in household food security. Also, this case study shows that the seasonal production of food crops combined with the lack of proper storage facilities often results in decreasing food availability and the consequent occurrence of hungry months. Besides, the difficulties household face in accessing markets despite their high reliance on market sources constrain their food accessibility, with important implications of intensifying the hardships in the hungry months. These pieces of evidence presented here not only shed light on the importance of a food system analysis but also helps enlighten us about the importance of the United Nations' definition of food security, which emphasizes both the notion of people having food "at all times" and the ability to have "sufficient access" (United Nations, 1996).

The evidence also confirms that the poorly developed food systems in rural areas of northern Ghana compel farmers to make difficult decisions, leading to small short-term returns and negative long-term consequences that constrain their ability to afford food in the lean season. Revealing such evidence is important to guide the Government of Ghana and donor communities on how to transform rural food systems into more productive and profitable activities for farming households, who play a double role as producers and consumers in the rural food milieu. In particular, the evidence points to the need for government and development agencies to act in terms of policies, regulations, and investment support for ecologically innovative means to increase food production, build rural transportation networks, storage, and processing infrastructure, and link farmers to market and finance, including smallholder affordable insurance schemes. Also, efforts to introduce community-based grain reserves and social protection mechanisms will be critical to protecting rural people against the variations in food prices and food losses, which are significant obstacles to their year-round food availability and access.

The results in this chapter confirm these conclusions about food insecurity in northern Ghana. The next chapter further examines this situation from the perspective of climate change and food systems vulnerability of the research communities. Specifically, it focuses on how climate change hazards and the households' poor access to resources and services for food system activities exacerbate food insecurity in northern Ghana.

CHAPTER 5
CLIMATE AND FOOD INSECURITY RISKS IN NORTHERN GHANA

4.5. Introduction

The focus of this chapter is to present the main original contributions of this dissertation in relation to climate hazards and food insecurity risks for smallholder farming households and communities in northern Ghana. The chapter presents detailed evidence of how climate change exacerbates food insecurity in northern Ghana. Specifically, the chapter addresses the overall dissertation research sub-questions (3) What are the key climatic hazards affecting food systems in rural areas of northern Ghana? and (4) How do food systems' exposure and vulnerability to these climate hazards predispose smallholder farming households to food insecurity risks?

This chapter adopts a micro-level analysis of food systems (Ericksen, 2007) integrated with theories of vulnerability (Nunan, 2010; Birkmann et al., 2011; Ribot, 2014) and disaster risk (Wisner et al., 1996; 2004) to provide answers to the above research sub-questions. As explained in Chapter 2, food systems encompass all activities and actors involved in the production, processing, storage, distribution, marketing, and consumption of food (Ericksen, 2007). Food systems contribute to many outcomes, including food and nutrition security. Climate change has complex interactions with food system activities, which can result in food insecurity instead of food security through impacts on food availability, access, food utilization, and stability. The vulnerability of food system activities determines the impact of climate change on food security.

Within the livelihood approach, vulnerability is the state of a household or communities' proneness or susceptibility to harm, which is influenced by their access to and ownership over assets and institutions that mediate access to assets and livelihood activities. Vulnerability is also about the risk factors (e.g., shocks, long-term trends, and seasonal variations) surrounding people's livelihoods (Nunan, 2010). For disaster risk researchers working on livelihoods, a key question has been how to distinguish between risk and vulnerability

(Birkmann et al., 2011; Ribot, 2014; Wisner et al., 2016). Wisner et al. (1996; 2004) describe risk as a causal chain of interactions constituting the occurrence of a hazard and the vulnerability conditions that connect a system to the potential adverse impacts. Thus, the concept of risk is the intersection of two opposing forces: a hazard event and vulnerability. Putting it all together, a food system lens combined with perspectives on vulnerability and disaster risks enables the research to address how climate change leads to food insecurity risks.

The key argument from this chapter is that climate-induced food insecurity risks in northern Ghana are not just products of the persistent climate hazards as have been conventionally framed. Instead, risks are inextricably connected to the socio-economic situations within which food is produced, harvested, stored, and marketed in rural communities. The findings reveal that climate hazard events such as flooding and droughts may lead to a reduction in crop yields, damages to stored grain, and disruptions to food prices, which affect food security. However, these impacts are not solely externally generated circumstances. Most households in northern Ghana do not use irrigation, improved seeds, threshing machines, and vehicular services for transporting food crops to the market. They also have inadequate access to farm management and crop storage information. Indeed, these underlying characteristics of the food system activities, which are ultimately quite remote from climate change, exacerbate the risks of climate hazards inducing adverse impacts on food security.

Overall, this chapter is not intended to understate the direct impacts of climate hazards, which derail lives, properties, and the environment. Instead, the chapter seeks to contribute knowledge to the broader scholarship that critically analyzes the concepts of climate risks, hazards, and vulnerability by revealing some of the climate change impacts on food security in northern Ghana and affirming the importance of integrating a social lens into climate and food insecurity risk analysis.

5.1. Results

5.1.1. Climate Variability in the Study Communities

It is important to understand the climate change patterns in the study communities to better analyze how they affect food system activities and exacerbate households' vulnerabilities to food insecurity. For the purposes of such analysis, Ghana Meteorological Agency (GMA) provided me with climate records for the Navrongo Synoptic Station, which is the only available weather station in the Kassena Nankana area. Climate records gathered at this weather station are often used to represent the entire Kassena Nankana area, and therefore, this study acknowledges that such aggregate-level data may hide important spatial variability between the study communities.

The records received from GMA for this study consisted of data on mean temperature from January 2000 to May 2020; and total monthly rainfall from January 2000 to December 2020. Since the temperature data for 2020 was incomplete, I limited my analysis to 2019. This twenty-year climate record is long enough to examine the temporal variabilities and changes that have occurred in the local climate[32] in the most recent decades.

Figure 5.1 illustrate that the mean annual rainfall in the Kassena Nankana Municipality for the past two decades is characterized by sporadic surges and relapses. For instance, the Municipality received one of its highest mean annual rainfall in 2007 (1203.8mm) after periods of lower rainfall, that is, from 2000 to 2006. However, in the subsequent years, the mean rainfall decreased, reaching as low as about 617.3 mm in 2014, before increasing again up to 1363.4mm in 2019. The variability in temperature in the broader study area is also illustrated in Figure 5.2. Overall, the mean temperature has increased by 0.5°C in the two decades, from 29°C in 2000 to 29.5°C in 2020. But this increase is also characterized by

[32] The World Meteorological Organization often recommends a thirty-year period to be the minimum required number of years to calculate the average climate of a locality. However, this study only analyzes the twenty-year record of rainfall and temperature data since it does not seek to present a full-fledge climate analysis for the study areas. Rather, the focus is to use the rainfall and temperature records to show the evidence of change in weather conditions in the most recent past years as well as how the households are exposed to climate hazards often associated with the changes in weather conditions.

significant fluctuations. For example, in 2005, the mean temperature increased sporadically by 0.8°C relative to the record in 2000 and remained high until 2008, when the mean temperature dropped by 0.1°C below the record in 2000. The mean temperature has since risen, reaching as high as 29.8°C and 29.5°C in 2014 and 2020, respectively.

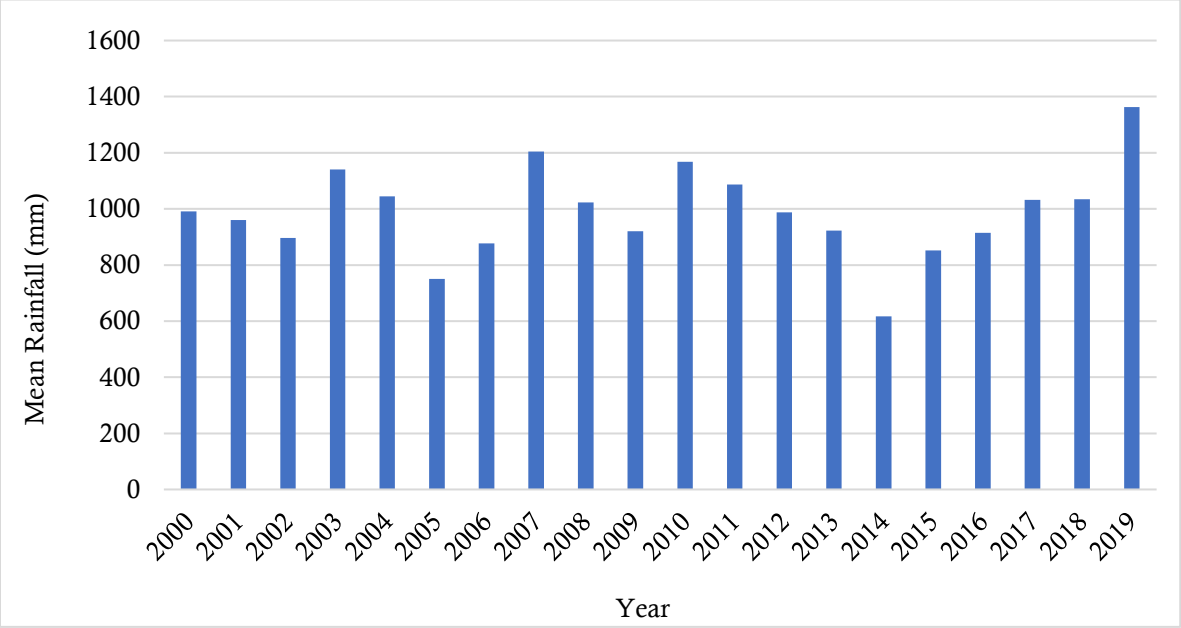

Figure 5.1: Mean annual rainfall variability for the Kassena Nankana Municipality
Source: Author's construct based on data from Ghana Meteorological Agency

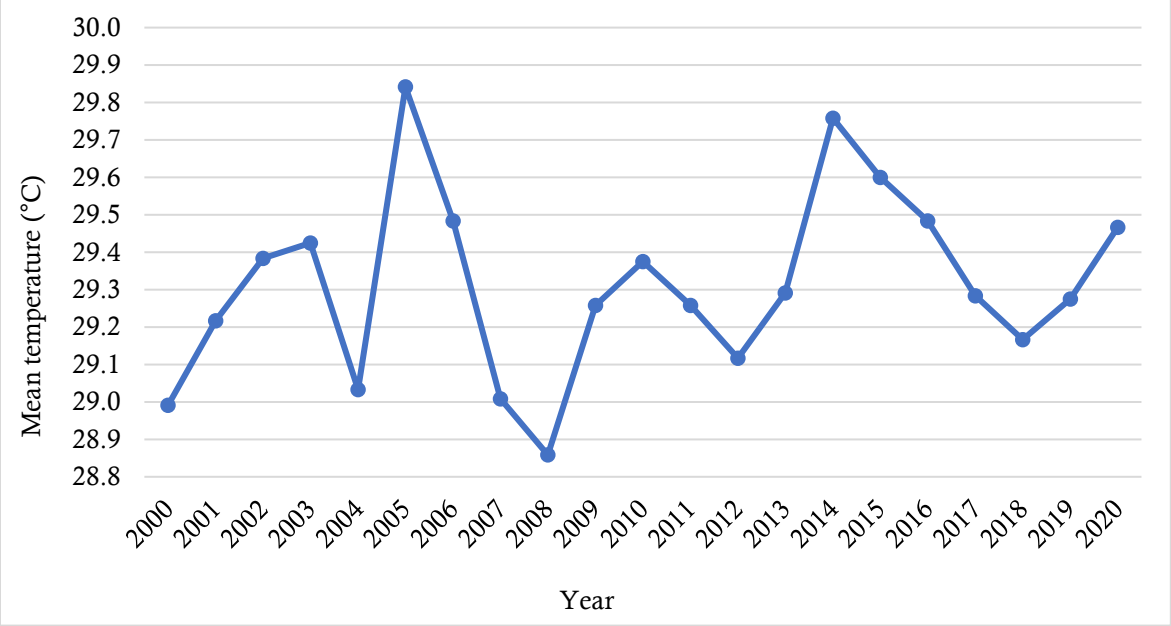

Figure 5.2: Mean annual temperature variability for Kassena Nankana Municipality
Source: Author's construct based on data from Ghana Meteorological Agency

5.1.2. Perceived Exposure to Extreme Climatic Events and Hazards

Available assessments of climate change identify five critical hazard exposure in the northern part of Ghana: extreme temperature, drought/dryness, floods, windstorms, and erratic rains (see Barry et a., 2018; Yiran et al., 2016; Osman 2020; Ogunrinde et al., 2021; Antwi-Agyei & Nyantakyi-Frimpong, 2021). This study assesses farmers' perceptions of these climatic hazards and their impacts on food system activities. It is essential to understand farmers' perceptions because such views shape the risk of adverse impacts and households' response strategies (Boillat and Berkes, 2013; Mortimore, 2010; Tschakert, 2007). As part of the survey questions, I asked the participant farmers a YES/NO question to confirm whether each of the five notable climatic hazards occur in their communities. Table 5.1 below presents the results of farmers' who responded to the questions in affirmative.

Table 5.1: Perceived exposure to climate hazards in northern Ghana

Climate hazards	**Study communities**						**Total**
	Doba	**Manyoro**	**Kologo**	**Naaga**	**Navrongo**	**Pungu**	
Extreme temperature	89.60%	93.80%	83.30%	87.50%	85.40%	77.10%	86.12%
Droughts/dry spells	89.60%	95.80%	97.90%	95.80%	83.30%	79.20%	90.27%
Windstorms	93.80%	93.80%	91.90%	92.00%	90.90%	89.60%	92.00%
Floods	92.80%	95.80%	95.50%	91.70%	88.80%	79.20%	90.63%
Erratic rains	89.60%	91.70%	79.20%	68.80%	97.90%	91.70%	86.48%
Total	91.08%	94.18%	89.56%	87.16%	89.26%	83.36%	89.10%

From Table 5.1, the result indicates that almost all the research participants reported being exposed to all five climate hazards. More households confirmed exposure to windstorms (92%), floods (90.6%), and drought/dry spells (90.2%) than extreme temperature (86.12%) and erratic rains (86.48%). During focus group discussions, households reiterated that

windstorms are widespread and occur throughout the year. They differentiated between two windstorm types: 1) the dusty/harmattan windstorms occurring in November-March, and 2) the moist windstorms in August-October. The households described the moist windstorms as heavy, noisy, destructive, and associated with heavy but short rains. Also, exposure to floods is high because of the seasonal torrential rains, which most often submerge farmlands and houses along the Tono Irrigation Dam canals, rivers, streams, and dugouts. Overall, the general biophysical characteristics of northern Ghana, consisting of large tracts of bare lands, sparse vegetation cover, and non-porous soils, explain the study communities' overall high exposure to climate hazards.

There are variations in the overall exposure to climate hazards across the study communities. More households in Manyoro (94.2%) and Doba (91.3%) reported greater exposure to climate hazards than those in other communities (see Table 5.1). Although the entire study area is semi-arid, the high exposure of households in Manyoro and Doba to climate hazards is attributable to the high rates of land degradation, increasing desertification, and location. Manyoro and Doba are the driest areas of the Kassena Nankana Municipality. During field observation, it was noticeable that these two communities have the vastest bare land areas without vegetation cover. Some pieces of land consist of baked soil surfaces, forming hardpans that render lands uncultivable. Additionally, Manyoro lies in the northernmost part of the district, sharing a border with the Sahel region of Burkina Faso. This means it experiences relatively more extreme heat conditions than the rest of the study communities.

5.1.3. Impacts on Food System Activities

Climate change hazards affect food security through the impacts on food system activities of production, harvesting, processing and storage, and marketing. From the review of literature and interactions with community representatives, twelve main directions of climate impact on food system activities were identified: five for food production, four for food harvesting, processing, and storage, and three for food marketing. During the survey process, participant farmers were asked to indicate which one of the identified challenges they perceived as having

the most adverse impact on food system activities. The results of their response are presented below in Figures 5.3, 5.4, and 5.5.

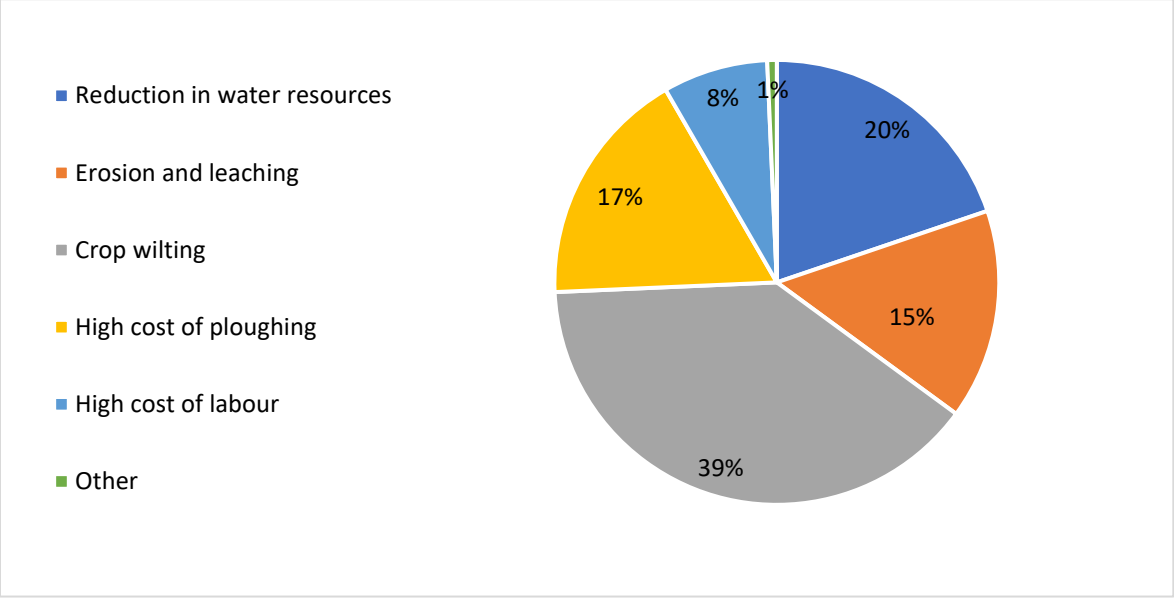

Figure 5.3: Climate hazard impacts on food crop production activities

Figure 5.3 shows that at the food production level, more than half of the participant households reported that climate hazards cause crops wilt (39%) and reduction in water resources for crop cultivation (20%). These two impacts were the most reported because, as identified in Table 5.1 above, drought/dry spells and erratic rains are among the most cited climate hazard events. According to the participants, these hazards are increasingly becoming common in the first half of the rainy season – when farmers have sown their crops and need an appreciable amount of water for crop growth. Thus, leading to significant impacts on food production. Also, the participants confirmed high cost of ploughing (17%), soil nutrient erosion and leaching (15%), and high cost of labour (8%) due to climate change. The high cost of labour can be attributed to the extensive reliance on family labour, which was confirmed by 94.1% of the households (see Table 4.2 of Chapter 5), for food production activities in the study communities. The labour impact of climate change is significant, especially for households whose able-bodied youths fail to return on time for land preparation following their migration to the cities during the long dry season months. This evidence affirms existing studies reporting that climate-induced seasonal out-migration of young people

from rural communities of northern Ghana to larger cities in search of "greener pastures" results in labour shortages, which raises the cost of hiring local agricultural labour, especially during the farming season (Rademacher-Schulz et al., 2014; Antwi-Agyei & Nyantakyi-Frimpong, 2021).

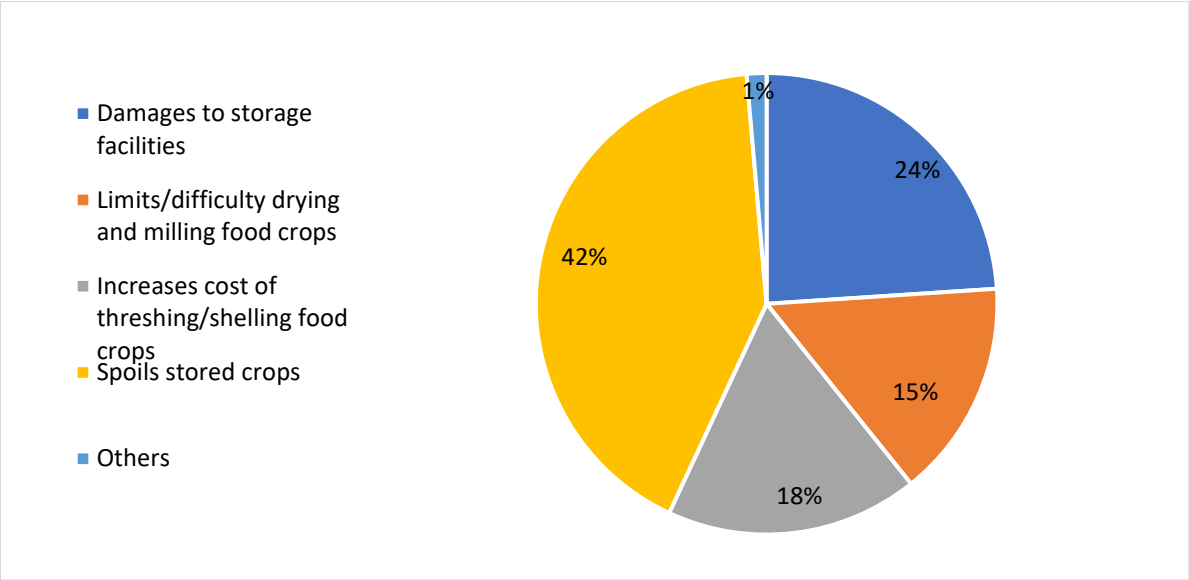

Figure 5.4: Climate hazard impacts on food crop harvesting and storage

In terms of food harvesting and storage (see Figure 5.4), over one-third of the households stated that climate hazards lead to crop spoilage/losses (42%). This impact is significantly felt by the majority of the farmers because the out-of-season and unpredictable rains occurring in the harvesting months often lead to dampness in ready-to-harvest crops and consequently increase stored grains' susceptibility to mould attack. Also, the general lack of proper facilities for food crop storage can explain why most of the farmers reported crop losses. As presented earlier in Table 4.3 of Chapter 5, only 0.7% of the farmers reportedly store crops in a warehouse facility. In the absence of a proper storage facility, farmers rely on alternative spaces, such as rooms and barns. During focus group discussions, the participants reported that food crops stored in these alternative facilities become highly susceptible to pests and moulds when temperatures rise to the extreme. These reasons explain why most households experience food storage losses due to climate hazards.

Nearly one-fourth of the participants (24%) reported damages to storage facilities due to climate change. During focus group discussions, the participants reiterated that floods, rainstorms, and windstorms blow away the roofing and create cracks in storage structures that allow rainwater leakages. The higher reliance on storerooms (76%) and barns (47%) storage than warehouse storage at 0.7% (as shown in Table 4.3 of Chapter 5) is a key reason why most households face storage facility damages from climate hazards.

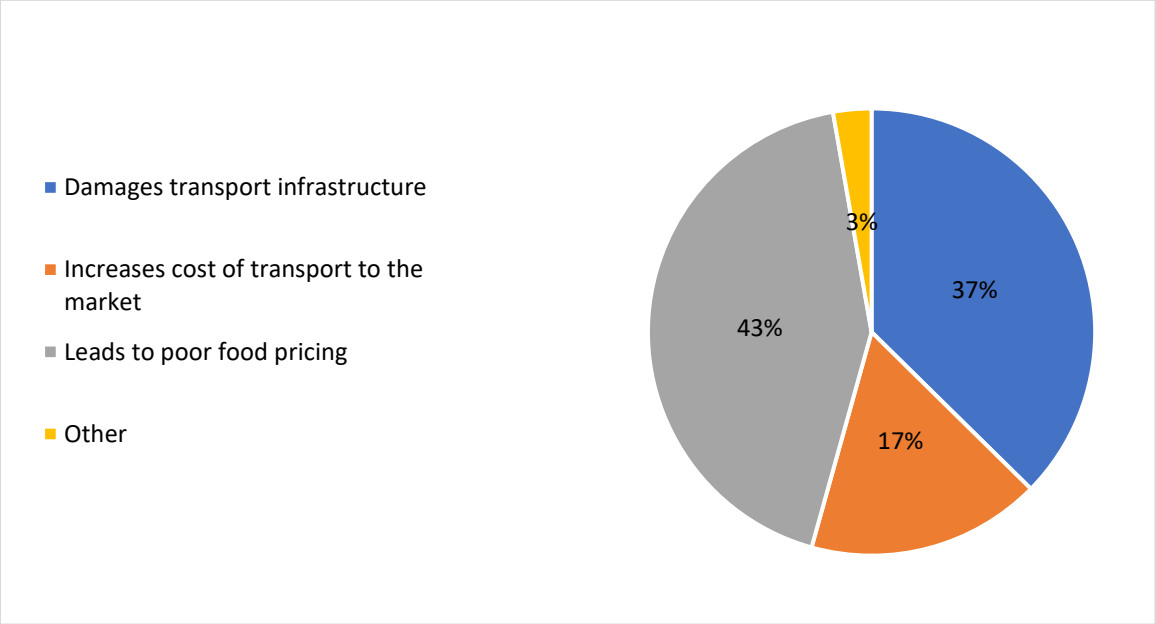

Figure 5.5: Climate hazard impacts on food crop marketing and transportation

Figure 5.5 presents the reports on climate impacts on food marketing activities. Nearly half of the participants (43%) indicated poor food pricing due to climate change. This impact on food prices is often experienced by farmers when selling or buying food crops. During the field interviews, households explained that floods and unpredictable rains occurring in the early harvesting period cause cosmetic damages to grain crops, limiting farmers' ability to bargain for fair farmgate prices. At the same time, the decreased crop yields resulting from hazard impacts on production activities generally lead to low food stocks in the later post-harvest months. As market demand exceeds supply, food prices soar to levels unaffordable for poor households. Additionally, the results also show that over a third of the participants (37%) reported climate change leads to damage to transport infrastructure. This impact may

explain why there are limited vehicular transport services in the study communities, as shown in the results presented in Table 4.4 of Chapter 5.

5.1.4. Food System and Household Vulnerability to Climate Hazard Impacts

It is widely noted in the literature on rural livelihoods that a household's vulnerability is influenced by access to and ownership over assets critical to guaranteeing livelihood security against climatic variations and associated hazards. As indicated in Chapter 2, several approaches to carrying out a vulnerability assessment exist. Most researchers, including Hahn et al. (2009), Etwire et al. (2013), Antwi-Agyei et al. (2013), Opiyo et al. (2014), and Panthi et al. (2016), adopt an asset-based approach involving the use of socio-economic characteristics of a household to determine the extent of exposure and sensitivity to a particular shock. In this section, I draw on these existing asset-based approaches to analyze food system vulnerability to climate hazards in Kassena Nankana Municipality. Adopting this approach allows the study to integrate the internal socio-economic characteristics of food system activities implemented at the micro-level into the climate and food insecurity risks analysis for the study communities.

The research expresses the asset-based approach to food system vulnerability analysis as a composite of assets (resources and services) critical to help food production, processing and storage, and marketing activities withstand and recover from adverse impacts of climate hazards. Seventeen assets were identified as critical for the food systems vulnerability analysis in the Kassena Nankana area based on the focus group discussions with the participant households. Out of these assets, seven were for food production, six for food processing and storage, and four for food marketing activities. The roles of each of these assets are presented in Table 5.2. The construction of an asset-based index to analyze the vulnerability of food system activities in the study communities follows the works of Hahn et al. (2009), Etwire et al. (2013), Antwi-Agyei et al. (2013), Opiyo et al. (2014) and Panthi et al. (2016). Here the mean asset index for each food system activity is calculated as follows:

$$\text{Food production} = \frac{(\text{Prod}_a1 + \text{Prod}_a2 + \text{Prod}_a3 + \text{Prod}_a4 + \text{Prod}_a5 + \text{Prod}_a6 + \text{Prod}_a7)/n}{\text{Number of assets critical for food production activities}}$$

$$\text{Food processing and storage} = \frac{(\text{PSt}_a1 + \text{PSt}_a2 + \text{PSt}_a3 + \text{PSt}_a4 + \text{PSt}_a5 + \text{PSt}_a6)/n}{\text{Number of assets critical for food processing and storage activities}}$$

$$\text{Food marketing} = \frac{(\text{Mkt}_a1 + \text{Mkt}_a2 + \text{Mkt}_a3 + \text{Mkt}_a4)/n}{\text{Number of assets critical for food marketing activities}}$$

Where Prod_a1 = the number of affirmative responses for the use of irrigation facilities, Prod_a2 = the number of affirmative responses for the use of tractors, Prod_a3 = the number of affirmative responses for the use of weedicides, Prod_a4 = the number of affirmative responses for the use of pesticides, Prod_a5 = the number of affirmative responses for the use of fertilizers, Prod_a6 = the number of affirmative responses for the use of improved seeds, Prod_a7 = the number of affirmative responses for access to education/training on crop production management.

In terms of the equation for the mean asset index for food processing and storage activities above, PSt_a1 = the number of affirmative responses for the use of threshing machines, PSt_a2 = the number of affirmative responses for access to warehouse storage, PSt_a3 = the number of affirmative responses for the use of chemical storage, PSt_a4 = the number of affirmative responses for the use of storeroom for grain storage, PSt_a5 = the number of affirmative responses for the use of grinding mills, PSt_a6 = the number of affirmative responses for access to education/training.

The equation for the mean asset index for food marketing above consists of variables where Mkt_a1 = the number of affirmative responses for access to a market center, Mkt_a2 = the number of affirmative responses for the use of vehicle transport, Mkt_a3 = the number of affirmative responses for the availability of non-farm income, Mkt_a4 = the number of affirmative responses for their reliance on remittances. In all estimations, n = the sample size,

the value for the total number of assets for food production = 7, food processing and storage = 6, and food marketing = 4.

Using the above equations, the mean asset index score was estimated for food production, processing and storage, and marketing activities in each study community. The estimates are based on the data gathered from the household survey. An overall estimated asset index score of 0 corresponds to the lowest asset capacity and, thus, high vulnerability. Similarly, a score of 1 indicates the highest asset capacity, hence low vulnerability. Interpreting the results in this manner allows for easier understanding by a diverse audience, including policymakers and farmers. In a nutshell, estimating the vulnerability index using the asset framework helps predict households' susceptibility to crises and resource profiles for recovery.

Table 5.2: Critical assets for food system activities in northern Ghana

Food system activities	Assets	Role/Importance
Food crop production	1. Irrigation facilities	Pumping shallow groundwater from well or canals connected to a dam or dugout helps households cultivate food crops, especially vegetables in the dry season. Also, in the wet season, which is also the growing season, irrigation can help farmers manage dry spells.
	2. Tractor	Tractors are excellent equipment for ploughing and soil preparation; they also play important roles in helping farmers transport farm inputs and food crops after harvest.
	3. Weedicides	The safe application helps control weed growth and reduces the money and time for clearing weeds and preparing land for sowing.
	4. Pesticides	Reduces exposure to insect pests and helps control infestations caused by water stress
	5. Fertilizers	Provides nutrients for soil fertility and crop growth; plays a significant role in helping farmers revive their crops in the aftermath of a dry spell and erratic rains.
	6. Improved seeds	With the proper application of other inputs, improved seeds provide better yields and are resistant to pests and dry spells.
	7. Education/training	Education enables farmers to know when, how, and what kind of farm practices to adopt and the proportions of fertilizer, pesticides, and weedicides to apply to manage climatic stress at each stage of crop growth.
Food crop processing and storage	1. Threshing machines	Rice and maize threshers enable farmers to quickly process their harvested crops and prepare for storage without getting damp from uncertain rains.
	2. Warehouse	Enable farmers to safely store and protect food crops against insect pests and theft. Proper warehouse handling allows food crops to be stored throughout the year and beyond. Crops stored in warehouses are usually marked for the market during off-season periods to stabilize seasonal prices and smoothen household consumption.

	3. Chemical storage	Protect food crops against insect pest attacks or suppress the growth of insects in stored grains, allowing farmers to keep crops for up to eight or more months after harvest.
	4. Storeroom	Some households have dedicated rooms for storing threshed grains and paddy. Crops may be kept in the storeroom for up to six months or more, depending on farmers' knowledge of proper storage techniques, the use of chemicals to protect pests, and the conditions of the storeroom.
	5. Grinding mill	Access to a grinding mill provides convenience for a household to mill grains. In communities without access to grinding mills, households may spend hours pounding rice to remove husks.
	6. Education	Access to knowledge and training on proper harvesting and storage techniques helps reduce post-harvest losses and crop damages and helps save a household from days to months' worth of food for consumption.
Food crop marketing	1. Market center	Market centers serve essential roles as converging points for buyers and sellers; households also get access to more diverse food crops than what they produce. More accessible market centers can help lower transaction costs when buying food crops to smoothen consumption in out-of-season months.
	2. Vehicle transport	Access to roads and vehicles linking rural areas to the market centers enables poor farmers to sell their surplus produce at better prices and earn income that can supplement household food needs in the post-harvest season.
	3. Non-farm income	Non-farm works such as trading and day labour jobs in construction, weaving, and pottery are great opportunities for households to shift surplus agricultural labour to earn income during the dry season. Income from non-farm work helps resource-poor households secure money for investment in climate-resilient food production activities.
	4. Migrant income (Remittances)	Remittances from migrant relatives (either in the south or agricultural-rich communities in the north) enable households to buy more food and replenish food stock to deal with insecurities associated with yield losses from climatic hazards and disasters.

5.1.4.1. Food production vulnerability

Food production vulnerability was conducted using the asset-based index constructed in section 5.2.3 above. The results presented in Table 5.3 reveals that food production vulnerability differs significantly among the various communities. Manyoro showed the lowest mean asset index score for food production (0.4524), indicating its relatively lower asset capacity and hence higher food production vulnerability than the other communities.

Table 5.3: Mean food production asset score for communities in the Kassena Nankana Municipality

Zone	Mean	N	Std. Deviation
Doba	0.5744	48	0.16797
Manyoro	0.4524	48	0.18482
Kologo	0.6935	48	0.15023
Naaga	0.6935	48	0.13819
Navrongo	0.8363	48	0.19545
Pungu	0.6577	48	0.23342
Total	0.6513	288	0.21482

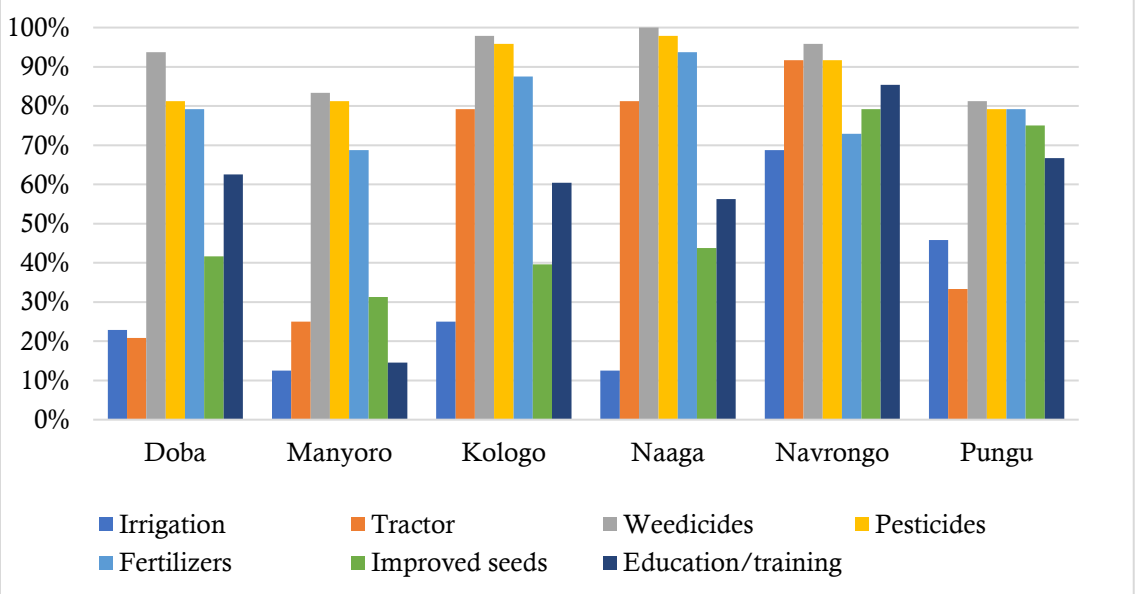

Figure 5.6: Percentage of households with access[33] to assets for food production in communities across the Kassena Nankana Municipality

[33] The vulnerability analysis is based on household access to and use of assets. The assumption here is that households are willing to pay for the services of these assets when available.

Figure 5.6 presents statistics on the percentage of households using each of the seven assets critical for food production in the study communities. In Manyoro, for example, only a few households have access to education/information on on-farm management (14.6%) and use irrigation facilities (12.5%), tractor services (25%), and improved seeds (31.3%). The comparatively lower use of these production assets directly explains Manyoro's comparatively higher vulnerability than other communities. Overall, the results presented here suggested that most households in Manyoro have limited capacities to undertake climate-resilient production activities, and, thus, they are less likely able to manage climatic stress during food production.

5.1.4.2. Food processing and storage vulnerability

Table 5.4 presents the food processing and storage vulnerability analysis computed using the asset-based index constructed in section 5.2.3 above. Again, the results show Manyoro had the lowest mean asset index score for food processing and storage (0.2014) and, therefore, the highest vulnerability. In practical terms, Manyoro has less asset capacity than other communities to protect crops from dampness and cosmetic damage associated with unpredictable and out-of-season rains during harvesting and post-harvesting months.

Table 5.4: Mean food processing and storage asset score for communities in the Kassena Nankana area

Zone	Mean	N	Std. Deviation
Doba	0.3507	48	0.16927
Manyoro	0.2014	48	0.13734
Kologo	0.5660	48	0.16751
Naaga	0.5451	48	0.15275
Navrongo	0.6354	48	0.19946
Pungu	0.5208	48	0.22182
Total	0.4699	288	0.22959

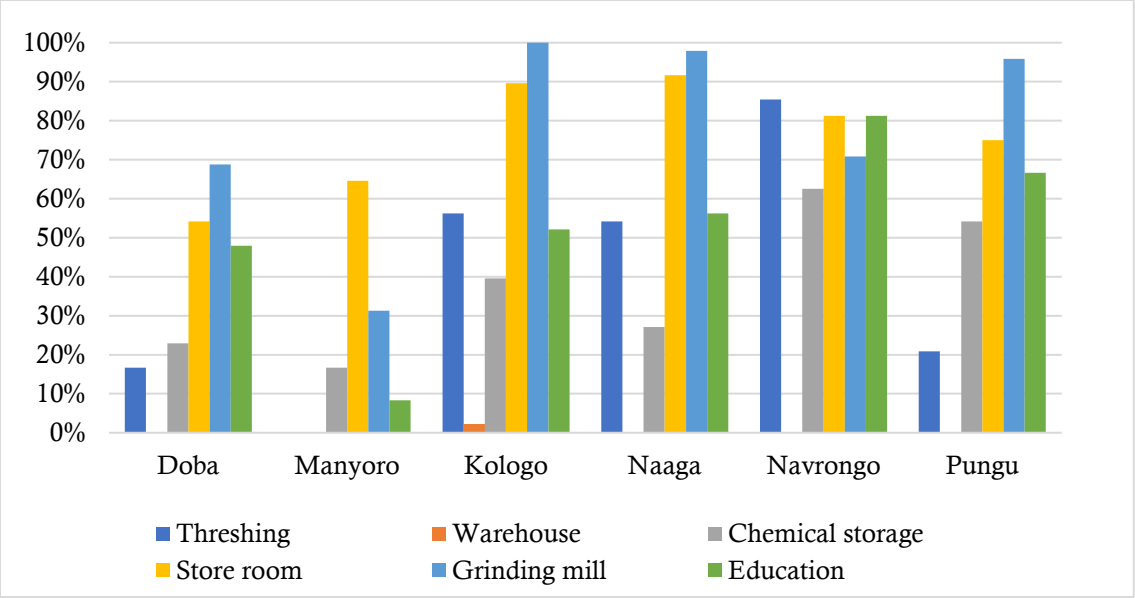

Figure 5.7: Percentage of households with access to assets for food processing and storage activities across communities in the Kassena Nankana Municipal

Figure 5.7 presents detailed information on the percentage of households using each of the six assets critical for food processing and storage in the study communities. In Manyoro, no household reported using threshing machines for food crop harvesting or warehouse services for storage. Additionally, access to grinding machines and training on post-harvest management is 31.3% and 8.3%, respectively, compared to far more than 50% in other communities. The households' lower use of timesaving harvesting and post-harvesting resources in Manyoro explains the high vulnerability to climate hazards. Overall, the result here suggests that Manyoro is prone to post-harvest losses, which can directly hinder households' ability to achieve food availability in the out-of-the-season months.

5.1.4.3. Food marketing vulnerability

Food marketing vulnerability analysis was conducted using the asst-based index constructed in section 5.2.3 above. The results presented in Table 5.5 show that Naaga recorded the lowest mean asset score for food marketing (0.3385) and, therefore, the community with the highest food marketing vulnerability. This implies that compared to the other communities, households in Naaga have limited capacity to deal with food market price, affordability, and accessibility challenges in the dry season.

Table 5.5: Mean food marketing assets score for communities in the Kassena Nankana Municipality

Zone	Mean	N	Std. Deviation
Doba	0.4219	48	0.20077
Manyoro	0.4219	48	0.17225
Kologo	0.4688	48	0.20385
Naaga	0.3385	48	0.25521
Navrongo	0.5417	48	0.22081
Pungu	0.3698	48	0.21257
Total	0.4271	288	0.22062

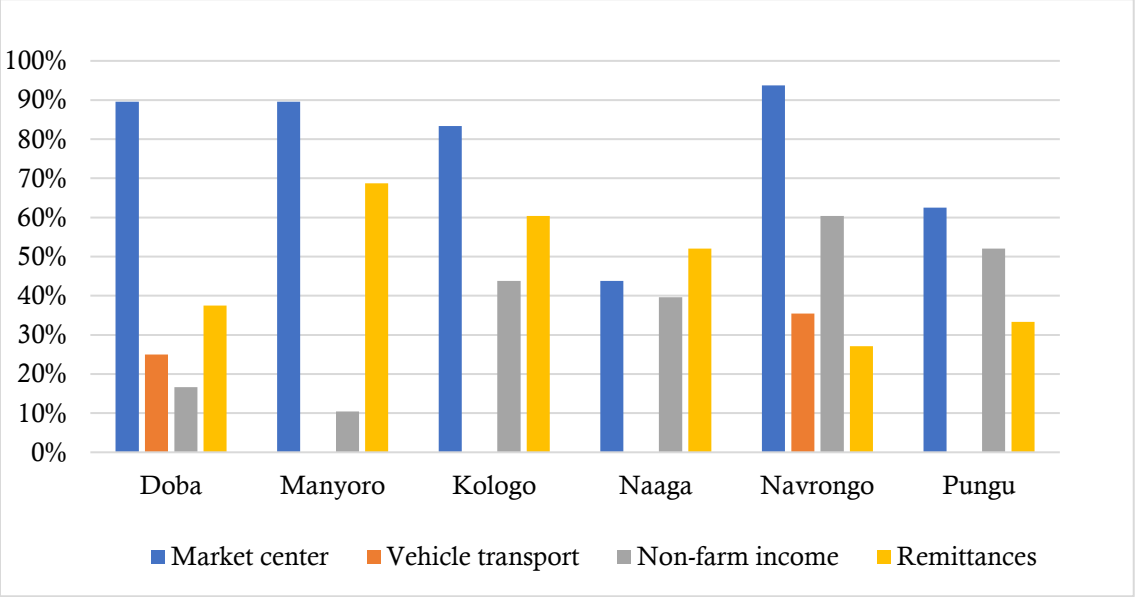

Figure 5.8: Percentage of households with access to assets for food marketing activities across various communities of the Kassena Nankana Municipality

Figure 5.8 shows the background statistics on the percentage of households with access to the four key assets category critical for food marketing in the study communities. These statistics help identify the assets with significant contributions and explanations for food marketing vulnerability. As shown in Figure 5.8, vehicle transport and non-farm income contribute more to food market vulnerability across all the communities. The impacts of these resources are even more pronounced in explaining the higher vulnerability of Naaga, where no household (0%) reported access to vehicle transport and only a few (10.4%) have income opportunities to buy food in the out-of-the-season months.

Overall, the food system vulnerability analysis presented here reveals that the food production, processing and storage, and marketing activities of the Kassena Nankana Municipality are generally vulnerable to climate change hazards. However, some communities are more prone to adverse impacts than others. Communities with the most households lacking access to and use of tractors, irrigation facilities, threshers, warehouses, market centers, and non-farm income are the most vulnerable to climate hazards and vice versa. This suggests that policy intervention to improve food security must target specific communities or households over others.

5.1.5. Severity of Climate Hazard Impacts on Food Systems

The analysis presented earlier under section 5.1.3 reveal climate impacts on food system activities. Further analyses in this section seek to identify variations in the severity of impacts of each climate hazard event. During the survey administration process, research participants were asked about their perceived level of climate hazard impact for each food system activity and requested to indicate whether the impact is low or moderate or high or no impact or don't know (that is, have no knowledge). The results of the research participants' responses are presented in Figures 5.9, 5.10, and 5.11.

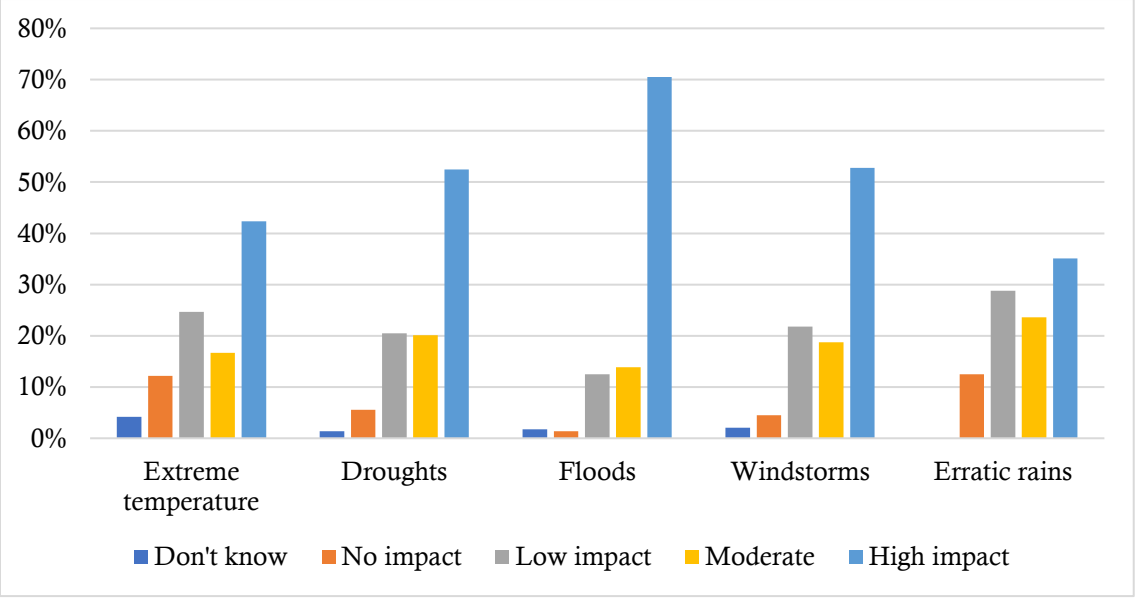

Figure 5.9: The intensity of climate impacts on food crop production activities

Figure 5.9 shows that generally, most households believe all climate hazards have high impacts on food crop production activities. More than half of the participants reported that droughts/dry spells (52.4%), floods (70.5%), and windstorms (52.4%) have high adverse impacts on food production. Although crop cultivation occurs in the rainy season, households still experience drought/dry spells with intensifying impacts on yields. In-depth interviews with the agricultural extension officers revealed that farmers might experience up to three continuous weeks of no rains; such events occur at least twice in the farming season. Without irrigation, most farmers lose their crops at the early stages of germination. Also, windstorms have high adverse impacts because of their high likelihood of dislodging crops with long panicles (e.g., guinea corn and millet), leading to significant losses as the grains of these crops are smaller and difficult to gather/collect once they fall off.

Two reasons explain why floods have a high impact on crop production activities in the study communities: (i) the seasonal overflow of running water and reservoirs after every heavy downpour and (ii) the poor porosity of the dryland soils of northern Ghana. During focus group discussions, participants indicated that they prefer to cultivate on lands adjacent to water sources because of the presence of moist and nutrient-rich soils. Cultivating on these lands, however, expose crops to floods when the rivers and streams overflow their banks, with losses reaching as high as half or even more of the crops on the farmland. Also, northern Ghana is known for its vast clay and silt soils with poor porosity, often increasing the likelihood of communities getting soaked in water, compound fields[34] becoming saturated, and crops being lodged or washed after heavy rain.

The impacts of extreme temperature and erratic rains were also confirmed by 42.4% and 35.1% of the households, respectively. During the focus group discussions, the participants mentioned that temperatures are sometimes higher than usual at the beginning of the farming season, often leading to sown seeds dying off in the soil before the germination stage.

[34] In rural areas of Ghana, particularly in the northern regions, households deliberately use plots around their homesteads or family compounds as farms. These farms are usually referred to as compound farms. Compound farms are intensively cultivated, usually under mixed cropping (grains and legumes) or mixed farming (crops, livestock, and poultry) or agroforestry systems. Compound farms provide an essential source of ecosystem services, including food provisioning, medicine, and income to supplement household needs.

Additionally, extreme temperatures peak in February-April, the time for dry season gardening, resulting in vegetable plant wilt and stunted growth. A recurring report from the households describes erratic rains as having severe impacts on crop production; the increasingly fewer days of showers and irregular downpours affect water availability for crop flowering and grain setting, leading to yield losses. Although this impact is significant for farmers, only a few households were concerned about erratic rains because the out-of-season showers at harvesting are sometimes good for farmers engaging in late/second cultivation in the farming season.

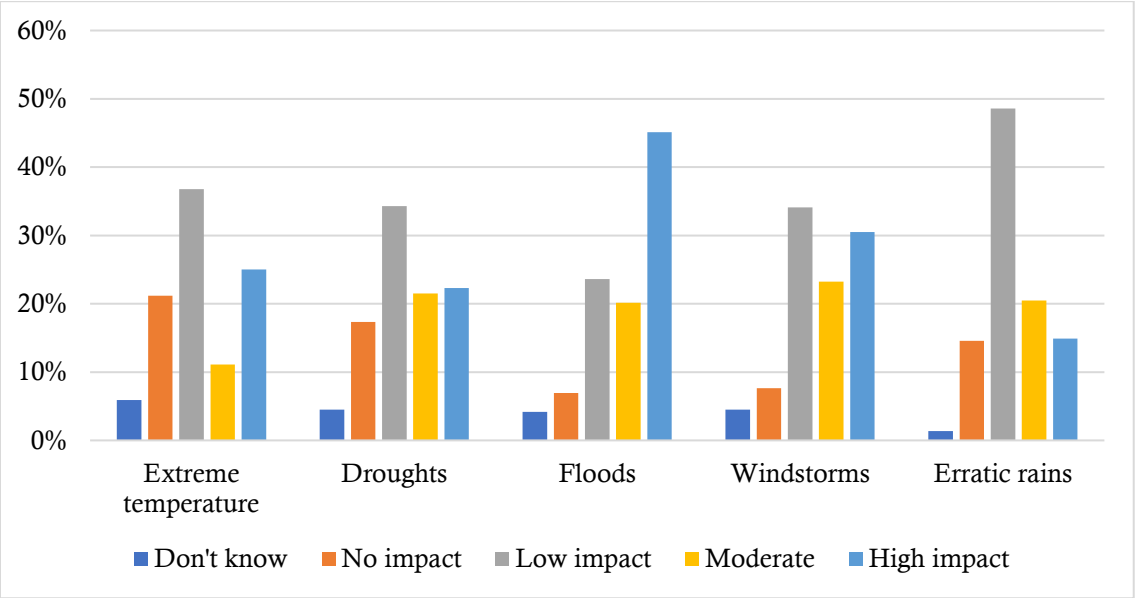

Figure 5.10: The intensity of climate impacts on food crop processing and storage activities

Figure 5.10 above shows that all climate hazards, except for floods, generally have a low impact on food processing and storage activities. Nearly half of the households perceive that floods (45.1%) have a high impact on food crops processing and storage activities because the farmers sometimes practice a combination of early and late cultivation to secure good harvests in each farming season. Harvesting early cultivated crops usually coincides with the peak of the rainy season when floods are not uncommon, making it difficult for crops to dry before harvesting. Damp crops are difficult to thresh; they are more susceptible to insect pests and moulds in storage. Besides, food crop processing and storage in the study communities involve traditional practices of beating sack loads of maize cobs or packs of rice/millet straws, drying under direct sunshine, and bagging, all of which require a good amount of temperature

and dry weather. Therefore, periods of extreme temperature, drought/dry spells, reduced rains, and windstorms are suitable for these activities – an explanation for why most households reported low adverse impacts of these hazards on food crop processing and storage activities. However, it is essential to note that extreme temperature, in particular, might sometimes lead to over-dryness, weight loss in grains, or mouldiness in stored grains, consequently reducing the quantity of stocks.

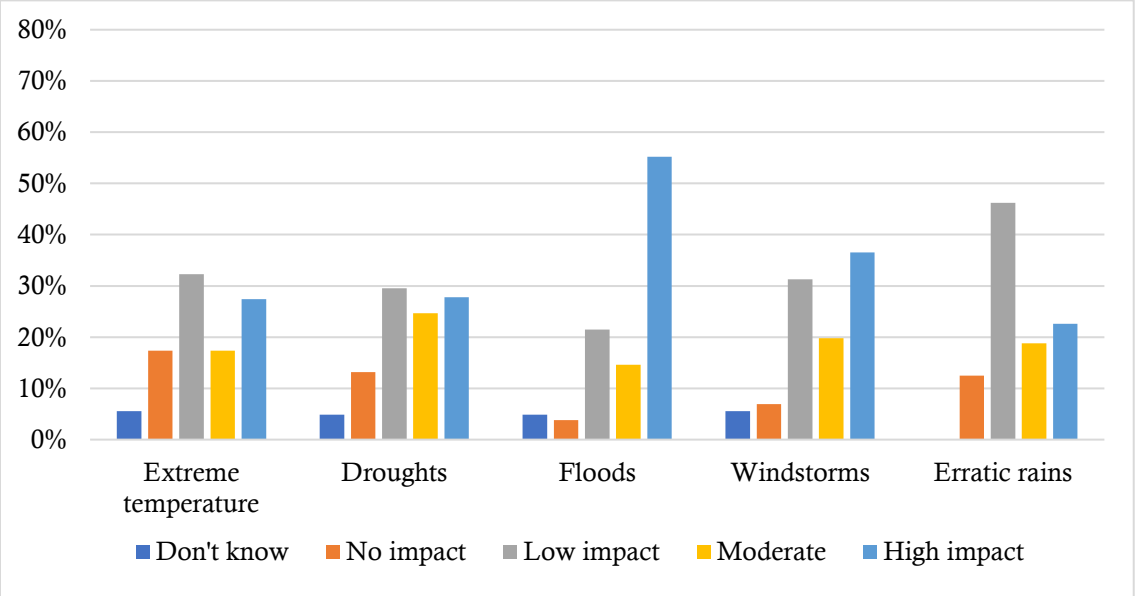

Figure 5.11: The intensity of climate impacts on food crop marketing activities

Figure 5.11 indicates that most households perceive all climate hazards as having a low impact on marketing activities, except for floods and windstorms. More than half of the households (55.2%) reported that floods induce high adverse impacts on their ability to travel to the market to buy or sell food crops. In the rainy season, floods leave behind pools of water on untarred feeder roads linking communities to the market, making roads impassable for vehicles, tricycles, and motorbikes, and consequently blocking farmers from transporting their crops home and market. For instance, communities in Kologo and Naaga areas get completely cut off when water overflows the main bridge linking them to Navrongo. In the case of windstorms, the impacts are high for most households (35.6%) because the occurrence is usually intense and obstructs travel to the market as the sand particles from the storm blow into people's eyes, block the views of motorcycle riders, and can lead to accidents.

In contrast, many households reported that extreme temperatures (32.3%), drought/dry spells (29.5%) and erratic rains (46.2%) have a low impact. During the focus groups, households explained that dryness and reduced rains enable them to travel to the market on motorcycles, bicycles, or by walking on the untarred dusty lateritic roads without any or little disruption, unlike when heavy rain occurs. Although temperature reportedly has a low impact on food crop marketing activities, the discussions in focus groups revealed a more complex picture. Participants from various communities reiterated that extreme temperature discourages them from travelling to the market center for trading activities, mainly in open spaces and on streets with very few properly built sheds to provide shade from the scorching sun.

5.1.6. Severity of Climate Hazards Impacts across the various Communities

Data collected on the severity of climate impacts were further analyzed to identify the study communities that face the most significant impacts from climate hazard events. The results of the community analysis are presented in Figures 5.12, 5.13, and 5.14.

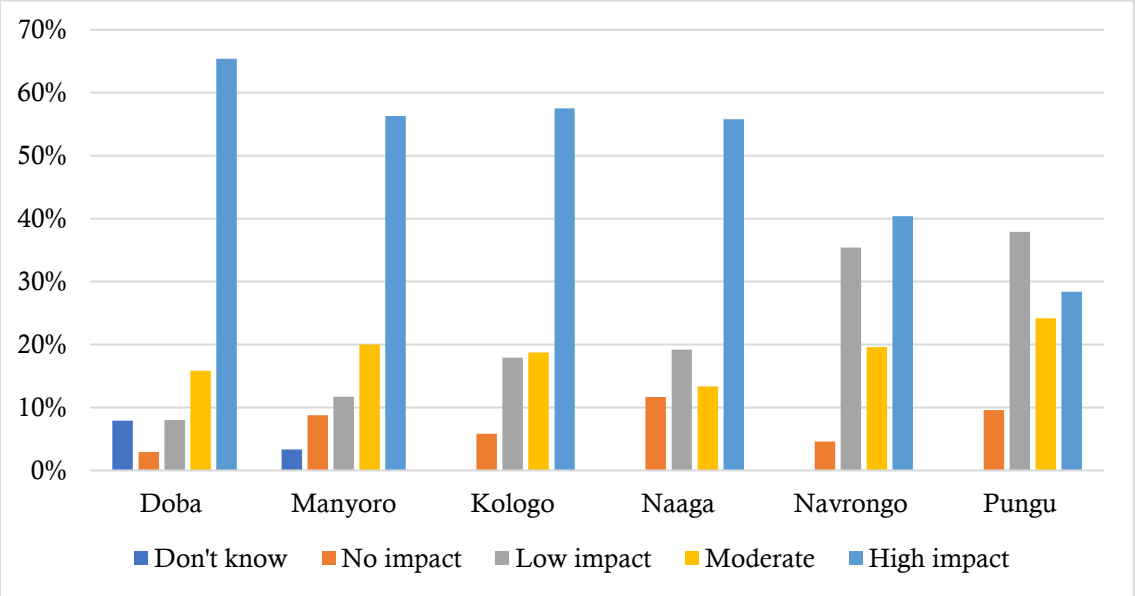

Figure 5.12: The intensity of climate impacts on food crop production activities across the various communities of the Kassena Nankana Municipality

Figure 5.12 shows that most households (over 40%) in all the communities reported high impacts, except in Pungu, where the majority (37.9%) reported low impacts. These results can be attributable to Pungu being the least exposed to climate hazards among the six communities, as presented earlier in Table 5.1. During focus group discussions in Pungu, the households reported some of the reasons for the low impact of climate on their food production, including their preference for late cultivation – waiting until after the mid-rainy season before sowing to prevent crop plants from getting flooded – and use of improved seeds from which crops can be harvested within a short duration of 90 days. It is important to note that households in Pungu do not have direct access to water from the Tono Dam or any running water source. Still, they have a diverse water supply from mechanized boreholes, wells, and dugouts to irrigate their crops when rain fails. In essence, the comparatively higher use of improved seeds and irrigation in Pungu (as evidenced earlier in Figure 5.6) helps explain the low impacts of climate change on the food production activities of most households there.

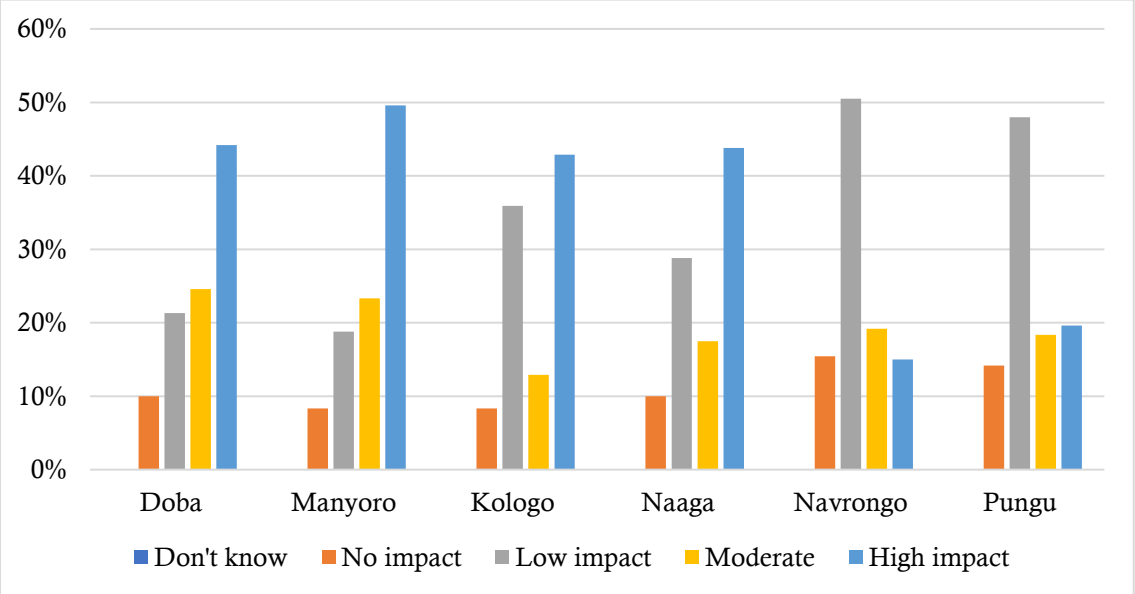

Figure 5.13: The intensity of climate impacts on food crop processing and storage activities across the various communities of the Kassena Nankana Municipality

Figure 5.13 shows that many households in Manyoro (49.6%), Doba (44.2%), Naaga (43.8%), and Kologo (42.9%) reported high impacts of climate hazards on food crop processing and storage, compared to Navrongo (50.5%) and Pungu (48%), where the majority indicated low

impacts. The results reported in Manyoro, Doba, Kologo, and Naaga can be attributed to these communities' comparatively higher exposure to flooding (see Table 5.1) than the other hazards. As reported earlier in Figure 5.10, flooding is a severely impacting hazard for food processing and storage activities in northern Ghana; it is no surprise that those communities highly exposed to flood reported severe impact of climate hazard on food processing and storage.

Manyoro, Kologo, and Naaga are exposed to flooding because farmers cultivate crops along White Volta River[35], canals connected to Tono Dam, and waterways for spillages from the Bagre multipurpose hydro dam in neighbouring Burkina Faso, respectively. The perennial heavy rains and corresponding overflow of these water bodies flood nearby farms, sometimes for weeks, during the mid to late stages of maize growth, leading to lodging in crop plants and disrupting harvesting activities. Although the Municipal disaster management office sent out early warning alerts via radios, households cannot protect their crops because they lack flood-proof harvesting and storage facilities.

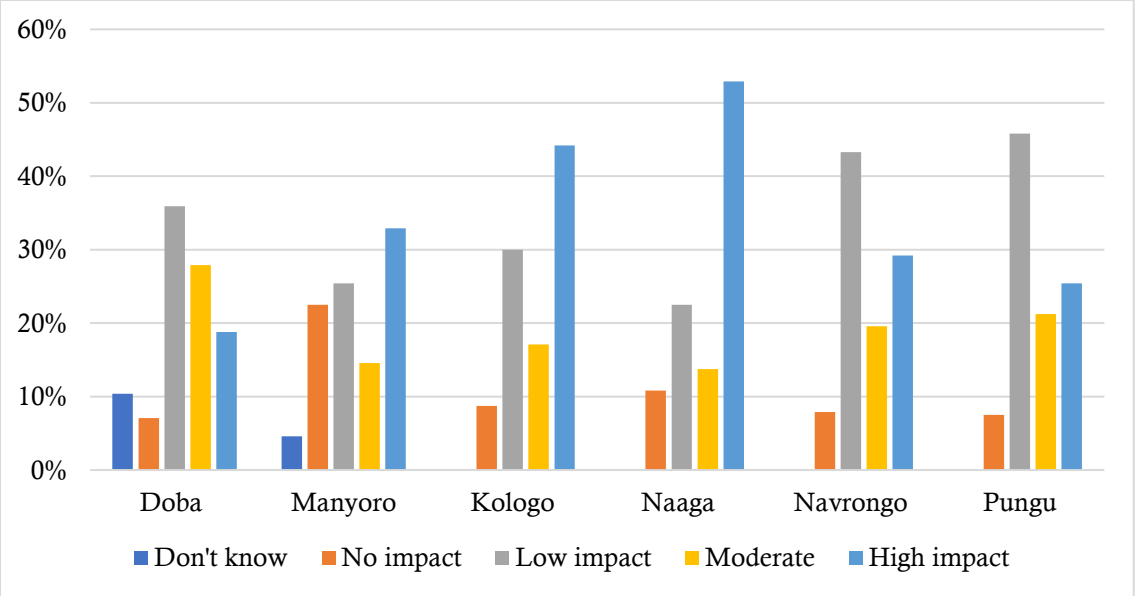

Figure 5.14: The intensity of climate impacts on food crop marketing activities across the various communities of the Kassena Nankana Municipality

[35] White Volta River is Ghana's third-largest river in size, stretching 855 kilometres.

Figure 5.14 shows variations in the severity of the impact of climate hazards on food marketing activities across the study communities. Many of the households in Naaga (52.9%), Kologo (44.2%), and Manyoro (32.9%) reported high impacts from climate hazards, while those in Pungu, Navrongo, and Doba reported lower impacts. The high impact of climate hazards on food marketing in Naaga, Kologo, and Manyoro could be attributable to the fact that these communities have more households exposed to floods and windstorms – the two most impactful hazards on food crop transportation and access to the market. While the three communities are distant from the central markets in Navrongo and Bolgatanga, they also have limited access to vehicular transport services. These problems intensify the severity of climate hazard impacts on access to food markets, especially the seasonal floodwater overflowing narrow bridges and untarred roads often impede transportation to the market.

To sum up, there are considerable variations in the severity of climate impacts on food security among the study communities. These differences can be explained by the specific circumstances relating to the communities' food system exposure to climate-related hazard events.

5.2. Discussion

Climate hazards have a range of adverse impacts on northern Ghana's micro-level food system activities. This study's results reveal the underlying vulnerabilities and varying severity of climate hazard impacts on various food system activities and across the study communities. This section discusses the study results along three themes: key climate hazards contributing to food insecurity in the study communities, the fragility of food system activities of northern Ghana, and the characteristics of communities with unsafe conditions for food security.

5.2.1. Climate Hazards and Food Insecurity Risks

Communities in northern Ghana are highly exposed to climate hazard events as almost all farming households (89%) reported their exposure to the five identified climate hazards – windstorms, droughts, erratic rains, extreme temperatures, and floods. The findings are

consistent with past studies highlighting the persistent climate hazards in the northern regions of Ghana (EPA, 2009; Yiran & Stringer, 2016; Dumenu & Obeng, 2016). For instance, Yiran & Stringer's (2016) spatial, time-series analysis of climate hazards from 1983–2012 identified constant occurrences of high and increasing temperatures, frequency but varied seasonal droughts, dry spells, and floods, and windstorms in the Upper East region of Ghana. Also, Dumenu and Obeng's (2016) study on the social impact of climate change reveals that respondents in northern Ghana frequently mention prolonged drought, erratic rainfall, and flooding as the most observed climate change events in their communities. The study district's geographical characteristics explain households' high exposure to climate hazards. The district is a semi-arid area at the margins of the West Africa Sahel, characterized by sparse vegetation, hot temperatures, and virtually non-existent rainfall to irregular rainy seasons (CILSS[36], 2016).

The study reveals that climate hazard events generally adversely affect food production, processing and storage, and marketing activities of smallholder farming households and rural communities in northern Ghana. The most notable adverse impacts on food production include increased crop wilting, reduced water resources, and increased cost of ploughing. Regarding food processing and storage, this study reveals that climate hazards cause significant damage to smallholder storage facilities and spoilage in stored crops. Likewise, the impacts on food marketing include disruptions to transport networks, increases in the cost of transport, and rising food prices. All these impacts suggest high risks of low food crop harvest, reduced quality and quantity of food crops, declining food stores, disruption in food pricing, and income losses. These risks make it virtually impossible for smallholder households to maintain constant food availability and access from one harvesting season to another. The findings confirm the IPCC's high confidence that observed climate change through extreme temperatures, changing patterns of rains, and frequent extreme events are already affecting food security in drylands, particularly those in Africa, including northern Ghana (Mbow et al., 2019). The evidence does not only reinforce previous studies of climate impact on food production (Antwi-Agyei et al., 2012; File, 2019; Dumenu & Obeng, 2016) but it is also the

[36] CILSS – Comité Inter-états de Lutte contre la Sécheresse dans le Sahel (The Permanent Interstate Committee for Drought Control in the Sahel)

first documented report of complex climate change impacts on overall food systems in northern Ghana, which provides an important reference for future studies.

5.2.2. The Fragile Food System Activities of Northern Ghana

A key insight from this research is the wide variations in the severity of climate impacts on food system activities, even within one fairly small area of northern Ghana – the Kassena Nankana Municipality. The findings reveal that climate hazards have more severe consequences on food production than processing, storage, and marketing activities. All five identified climate hazards have high adverse impacts on food production, but only floods significantly affect processing and storage, while floods and windstorms affect marketing activities. The high impact of all climate hazards on food production demonstrates northern Ghana's food crop production sensitivity. Most research in the northern part of Ghana attributes the climate sensitivity of food production systems to the farmers' high dependence on rain-fed schemes and the limited opportunities/resources for dry season irrigation (see Armah et al., 2011; Antwi-Agyei et al., 2012).

There is generally scattered information on the impacts of climate change and extreme events on food processing and storage activities. The available studies raise concerns about the adverse impacts of wet and hot spells on crop harvesting and storage, especially the increasing exposure to aflatoxins, with consequences for food security and human health (Paterson& Lima, 2010; Vermeulen et al., 2012; Warnatzsch et al., 2020). In the case of this study, results show that climate change may induce both adverse and beneficial impacts on food processing and storage activities, implying lesser risk than in food production activities. This finding is comparable to the available empirical evidence on how climate change affects various aspects of food security, such as food storage and rural transportation in Ghana. For example, Codjoe and Owusu (2011) found that climate change provides varied opportunities for households' food processing and storage activities in the Afram Plains of Ghana. According to their findings, drying is essential for food storage techniques in the Afram Plains. Therefore, extreme temperatures and windstorms facilitate the drying of food crops during processing

and storage, while flooding may hamper food storage. This evidence reinforces existing calls to pay attention to climate change opportunities related to certain aspects of the food system (Vermeulen et al., 2012: Fanzo et al., 2018).

5.2.3. Communities with Unsafe Conditions for Food System Activities

A key insight from the study is that there are dynamic "pressures" that converge to underpin climate impacts on household food security in northern Ghana. Most importantly, the findings reveal that the "pressures" from the opposing forces of communities' high exposure to climate hazards and high food system vulnerability combine to exacerbate food insecurity risks. For example, the results show that all the study communities are exposed to climate hazards that affect food systems activities. However, Manyoro, Kologo, and Naaga face high impacts of climate change because of their comparatively higher vulnerability situations than the rest of the communities. As per Wisner et al.'s (2004) Pressure and Release Model, explained in Chapter 2, a high vulnerability situation means that a household or a community lives in an unsafe condition that can give rise to or exacerbate disaster risks. Generally, unsafe conditions include poor people living in hazardous areas, unable to afford safe buildings, being inadequately protected by the state, and engaging in precarious livelihood activities. In the case of this research, the results show that most households in Manyoro cultivate food crops without irrigation facilities, tractors, and threshing machines. Also, those in Kologo and Naaga are generally far from the district capital, with impassable roads and a lack of vehicular services to connect households to Navrongo town, where they can buy improved inputs and market their crops. Together, the "pressures" from the high vulnerability situations of households in these three communities and the generally high climate hazard exposure of the entire Kassena Nankana Municipality converge to produce climate-induced food insecurity risks in the three communities.

The evidence on food system vulnerability resonates with climate vulnerability and livelihood studies demonstrating that asset endowment shapes the impact of climatic variations, shocks, and trends on households' food security (Antwi-Agyei et al., 2012; Opiyo et al., 2014; Dumenu & Obeng, 2016; Shaibu et al., 2020). The gender-disaggregate data on access to

assets for food system activities gathered as part of this study shows that only a few women have access to irrigation facilities (37.8%), improved seeds (34.2%), and threshing machines (39.3%) compared to 62.2%, 65.8%, and 60.7%, respectively for men. Women's comparatively low access to assets means that food security situations of female-headed households are more likely to be severely impacted by climate change than male-headed households. The study would have failed to reveal the above-explained results and findings if the research had not attempted to collect data on the differential access to critical resources and services for food system activities in the selected communities of northern Ghana. Overall, the findings provide compelling evidence that policymakers need to facilitate interventions that foster asset building for women (and poorer communities) to build safe conditions to protect food system activities against climate impacts.

5.3. Conclusion

This chapter has examined how and why climate change and variability induce food insecurity risks in northern Ghana with insights from disaster risk, food systems, and livelihood vulnerability research. It concludes that climate change and associated hazards affect all food system activities. The effects can be negative and sometimes positive, especially as households may be better able to harvest, dry, winnow, and store crops during droughts, rising temperatures, and windstorms. In the case of northern Ghana, this chapter emphasizes that the negative effects of climate change and associated hazard events overshadow the positive effects, as most households reported a high severity of adverse impacts. Aside from the exposure of communities to climate hazards, the high vulnerability context contributes to explaining the overall adverse impact of climate on food systems in northern Ghana, like other parts of Africa. Among the factors defining the vulnerability of the households in the study communities include a limited or lack of access to irrigation, mechanization, and information on climate extremes. These assets are necessary for households to take advantage of the opportunities that climate change offers for food system activities.

As policymakers formulate solutions to address the social impacts of climate change and hunger, far-reaching results could be achieved with an integrated approach that recognizes

the interlinked challenges of climate change and growing food insecurity. By this approach, policymakers could promote sustainable agricultural technologies and techniques, such as solar-powered irrigation systems and organic manure/compost production, to help poor farmers adapt food production and post-production activities to the changing climatic conditions. The results and discussions presented in this chapter contribute to understanding how climate change exacerbates food insecurity in northern Ghana. In the next chapter, I explore some of the household-level responses to managing climate-induced food insecurity risks in northern Ghana. In particular, I emphasize the diversity, gendered nature, and outcomes of these responses for sustainable food security.

CHAPTER 6
HOUSEHOLDS' RESPONSE STRATEGIES AGAINST CLIMATE-INDUCED FOOD INSECURITY RISKS IN NORTHERN GHANA

6.1. Introduction

The northern part of Ghana is a climate change hot spot. Studies covering various communities in the region show increasingly truncated growing seasons, windstorms, and heavy flooding events and their intensifying impacts on food security (Yiran & Stringer, 2016; Afriyie et al., 2018). The immediately preceding chapter of my dissertation provides evidence that climate events are leading to increased crop wilting, increased cost of ploughing, damages to smallholder storage facilities, spoilage in stored crops, increases in the cost of transport, and increases in food prices. This chapter analyzes reports and stories from my focus group discussions, interviews, and household surveys to answer the overall research sub-questions (5) and (6), which ask: How are smallholder farming households responding to climate-induced threats to food security? Are the smallholder farming households' responses contributing to reducing vulnerability and enhancing sustainable efforts to maintain food security throughout the year?

The literature on sustainable livelihoods, rural development, and climate change commonly use the terms "adaptation" and "coping" to describe various measures households adopt when faced with livelihood shocks or risks. As indicated in Chapter 2 (on the theoretical frameworks of my dissertation), researchers, including Rancoli et al. (2001), Davies (2016), and Antwi-Agyei et al. (2018), tend to differentiate between these individual adjustment measures and their outcomes on farming livelihoods. My research, however, puts these measures under the umbrella of "household response," which entails all those strategies and actions adopted to manage climate-induced food crop failure, harvest and post-harvest losses, and seasonality-induced stresses on food availability and prices. The term "response actions" is widely used here, referring to each response undertaken by a household and "response strategies" describes the careful planning of various actions towards specific objectives. In this sense, a household may undertake several response actions, including seeking casual labour

jobs, firewood harvesting, and shea nut picking, as a part of its diversification strategy to earn income for food.

The analysis presented in this chapter echoes and advances studies documenting households' coping and adaptation to climate change and consumption-related shocks in West Africa. In the study on famine and coping strategies, which presents case studies from Nigeria and other countries, Corbett (1988) argues that household responses are not adopted haphazardly or randomly but typically fall into a distinct sequence. Some response options are adopted at the beginning of a crisis, while others follow later. This is because households are concerned about meeting not only current consumption needs but also their future goals. Similarly, others have also explored and highlighted how coping and adaptation responses might deliver maladaptive or unintended outcomes that could exacerbate the vulnerabilities of agrarian livelihoods to climate change (Roncoli et al., 2001; Antwi-Agyei et al., 2018). This chapter draws upon insights from these studies to analyze and discuss households' responses to climate-induced food insecurity in northern Ghana.

The findings presented in this chapter indicate that households' responses to food insecurity in northern Ghana are diverse, sequential, and associated with hidden costs. Specifically, the pattern of households' response involves a sequence of strategies, usually undertaken in the following order: diversification into non-farm income (e.g., trading and labour jobs), consumption management (e.g., eating and cooking less), asset disposal (e.g., selling fowls and livestock), and migration (travelling to search for work in neighbouring towns and larger cities). This finding from the study affirms existing evidence (see Corbett, 1988), showing that sequencing in households' response actions is a tactical way of managing critical assets for both current consumption needs and agricultural livelihood sustainability. Lastly, the evidence reveals that some response actions contribute negative impacts that could rebound or increase food security vulnerability for women and youth and erode efforts for sustainable food security. Such evidence validates the occurrences of unintended consequences in the climate adaptation process.

6.2. Results

6.2.1. Key Response Practices to Food Insecurity Risks

Across the northern part of Ghana, farmers adopt coping and adaptation strategies to manage the impacts of climate on their livelihoods. Table 6.1 summarises the report on some of the strategies adopted by farmers in the study communities, mainly to deal with food insecurity risks of climate change.

Table 6.1: Households response actions for managing climate-induced food insecurities

Response practices	**Frequency (n=288)**	**Percentages**
Increased manuring and mulching	268	93.10%
Irrigation farming	179	62.20%
Tree planting and conservation (no bush burning)	263	91.30%
Planting drought-resistant varieties	117	40.60%
Planting early maturing varieties	169	58.70%
Selling farm animals (fowls and livestock)	218	75.70%
Engaging in casual labour jobs	173	60.10%
Trading/business	135	46.90%
Cutting down (reduce) daily food intake	215	74.70%
Changing diet (eating other foods)	225	78.10%
Supervising grain/food allocations more strictly	165	57.30%
Relying heavily on women's contributions	122	42.40%
Relying on family & friends for money/food	106	36.80%
Migration to other towns/cities	88	30.60%

Table 6.1 shows that most farmers reported using mulching (93%) and tree planting (91%) to manage food insecurity risks. Mulching involves spreading protective covering (e.g., cow dung and compost) on farmlands to shield the topsoils from extreme heat and windstorms. Besides being considered an environmentally friendly practice of improving soil fertility, mulching helps reduce the need for water and irrigation in the dryland environment of northern Ghana. Likewise, tree planting/conservation provides shade and shelter to protect crops against extreme heat and frequent windstorms during the planting seasons.

Irrigation is an important adaptation strategy in dryland environments. Particularly in the case of northern Ghana, this practice helps households secure access to vegetables in the out-of-the-season months. Although only 34 dams and small dugout water reservoirs are available in the entire Kassena Nankana Municipality (MoFA, 2017), the results show that 60% of the research respondents indicated they had relied on irrigation in the past. This reasonably high use of irrigation is attributable to the responses of research participants in two communities, Navrongo and Naaga communities, with respective access to the Tono irrigation dam and the White Volta. Farmers also switch to different crop varieties to manage the impacts of climate change and weather variabilities on food production and yield. The results showed that 58% of the respondents indicated they are planting early maturing varieties of seeds. During focus group discussions, participants explained that early maturing crops, such as the Obatanpa maize, can be harvested in less than 90 days, allowing them to cultivate twice in the farming season or delay the time of planting until there is continuous rainfall.

The results also show that about 74% and 78% of households may, respectively, cut down daily food intake or change diets. Some of the practices for cutting down food intake include cooking only once daily or a few meals a week, skipping one or two meals (mainly breakfast or lunch) and reducing the quantity of food served to each household member. Typically, a household may cook an evening meal and save some for the next morning and afternoon. Because of the lack of refrigerated storage, a leftover soup pot is often submerged in cold water and Tuozaafi[37] is wrapped in plastic bags.

A household may change its diet by eating different food or substituting one crop for another in preparing a meal. The community leaders interviewed pointed out that most households consume more of *Kamana di souna* (in Kasem) or *Kamana na twa* (in Nankani) – a meal from coarsely cracked maize with a mix of few beans – in the dry season when harvest stocks have depleted, and food price rises. They explained that maize is comparatively cheaper than the other staples (e.g; beans and rice) and coarsely cracking the maize significantly saves the quantity of food, particularly the fibre content, and thus makes people feel full when cooked.

[37] Thick gruel (dish) made by cooking a combination of maize or millet flour and water.

A participant from one of the women's focus group discussions also reported that most households might substitute portions of groundnut with millet in preparing groundnut soup. This is because millet is sold at a lower price than groundnut and can help attain the same quantity and thickness of soup as desired when mixed with groundnut.

Another important strategy is seeking work as casual labour. About 60% of the respondents indicated they seek work as casual labourers on wealthier neighbours' farms, construction sites, and chop bars[38], where they could earn up to 20 Gh cedis per day, equivalent to $4.5[39]. Some households (46%) also reported engaging in trading activities involving shea nuts, baobab pods, dawadawa fruits, and mangoes, which they collect from the wild. They usually sell these economic non-food crops to the Organisation for Indigenous Initiatives and Sustainability (ORGIIS GHANA), a not-for-profit committed to economically empowering women in the northern part of Ghana. Income earned from the causal work and trading activities helps women buy additional grains to supplement their household's harvest and help cope with the predictable decline in food stores in the dry season. In some cases, portions of the income may also be saved towards supporting their households to pay for agri-inputs – improved seeds, fertilizers, and ploughing services – to manage food production and climate uncertainties in the next farming season.

Few respondents (30%) indicated that a household member had migrated in the past because of climate-related food stress. Responses from the focus group participants revealed that most of these migrants are young men and women. They travel to seek work as head porters or loading boys in the cities (Kumasi, Takoradi, and Tamale) and other casual jobs on gold mining sites in Amansie West District and large-scale farms in Tumu and Fumbisi. These migrants may send home bags of grains or cash to stabilize their families' access to food.

Additional response actions were reported during the focus group discussions. One elderly man revealed a response practice that is generally common among farmers who could not

[38] Chop bar refers to traditional roadside eateries in Ghana. Most chop bars serve soup-based foods. The women in the research communities often work at these chop bars rendering labour-intensive support by preparing food, washing dishes, and cleaning up activities at the chop bar

[39] The exchange rate at the time of fieldwork (January-July 2021) was 1 CAD$= 4.5 Gh Cedis

successfully adapt to climate impacts on production. He stated that "If a farmer loses crops during production and realizes the harvest would not be enough, he or she may offer to help those with good harvest and request to search for leftovers from those farms." The revelation of this participant suggests that scavenging for leftovers is an action pursued by not only the landless but also landowning farmers in the community. The increasing climate change is therefore expected to further push more farmers into scavenging for crops to feed their families. In the initial discussions on climate trends in the communities, farmers highlighted the increasing occurrences of unpredictable out-of-season rains and windstorms in October-November, which affect harvesting and post-harvesting activities and cause crop losses. When asked about how they manage these crop losses at harvest, a farmer stated that "Sometimes we harvest early as soon as we see that our crops are starting to dry. We also do not leave the harvest on the farm but transport directly home and cover with tarpaulin."

Seasonal food price variation is a common perturbing problem across Ghana. Particularly in the northern regions, food prices increase during the dry season and reach excessively higher levels around the few weeks before harvesting (Fearon, 2013; Wossen & Berger, 2015). Most households manage these risks by cutting daily food consumption or changing diets to reduce pressure on food stocks. During the focus group discussions, participants reported additional actions they employ to manage the seasonality-induced food price risks. For instance, one farmer mentioned that "When we look at our harvest and sense that it will not be enough to feed the households, we try as much as possible to keep everything for the house; we do not sell at all. Some of us do not even make the mistake of selling even a bowl of the harvest." Another farmer also noted the households' behaviour in relying on the market, specifying that "Food crop prices are lower in the harvesting season, so we also buy right after harvest when there is the need to supplement our own production." When asked about their primary source of income to buy food at harvest, he added that "We may send a word to a relative in the south for money or do by-day work in the harvesting month." This signifies the role of social networks as a tool for surviving hardship in rural communities of northern Ghana.

6.2.2. Gendered Nature of the Food Insecurity Responses

Other studies in northern Ghana have shown that female farmers are less likely to adopt climate resilience practices than their male counterparts (Adzawla et al., 2019; Lawson et al., 2020). This research analyzed whether responses to climate-induced food insecurities in the study communities vary between men and women. Table 6.2 below presents the results of the analysis of gender differences in households' responses.

Table 6.2: Differences in response actions adopted by men and women household members

Response actions	**Men**		**Women**	
	Frequencies (n=161)	**Percentages**	**Frequencies (n=127)**	**Percentages**
Mulching/manure	152	94.4%	116	91.3%
Irrigation	109	67.7%	70	55.1%
Tree planting and conservation (no bush burning)	151	93.8%	112	88.2%
Growing drought-resistant varieties	67	41.6%	50	39.4%
Switching to early maturing (improved seed) varieties	96	59.6%	73	57.5%
Selling farm animals	127	78.9%	91	71.7%
Engaging in labour jobs	95	59.0%	78	61.4%
Trading/business	66	41.0%	69	54.3%
Cutting down daily food intake	112	69.6%	103	81.1%
Changing diet (eating other foods)	121	75.2%	104	81.9%
Supervising grain/food allocations more strictly	84	52.2%	81	63.8%
Relying heavily on women's contributions	67	41.6%	55	43.3%
Relying on family & friends for money/food	62	38.5%	44	34.6%
Migration to other towns/cities	50	31.1%	38	29.9%

Table 6.2 shows that more men than women reported adopting mulching practices, switching to early-maturing varieties, irrigation, and selling livestock for food. Women's low adoption of irrigation and early maturing varieties of crops can be explained by the unequal gender roles and the generally women's limited access to assets in the study communities. Additional

data from the fieldwork reveal that access to irrigation facilities and improved seeds is very low among women, respectively at 37.8% and 34.2%. Because men hold ownership over family lands; about 52% of the female farmers surveyed for this study secure land through borrowing involving in-kind customary exchange of items such as Kola nuts, fowls, and baskets of cultivated crops. The limited rights to land and unsecured tenure over burrowed lands, together with the constraints in access to finance, restrict women's capacity to invest in irrigation agriculture or switch to improved seeds to manage climate risks on food production.

On the contrary, more women go in for labour jobs and trading activities (61.4% and 54.3%, respectively) than men (59% and 41%, respectively). This high percentage of women pursuing labour jobs and trading activities is quite startling, considering that the study communities are traditionally patriarchal, confining women's work to childcare and various house chores. Nevertheless, a likely explanation for these results is that women's restricted access to land limits the economic opportunities they can seek to farm labouring and trading activities.

Also, the results reveal that women are more inclined to change their diet or cut food intake. For instance, only 69.6% of the male farmers reported cutting down their daily food intake compared to 81.1% among the female farmers. These results reflect the unequal eating patterns and food distribution between men and women. In the study communities, husbands decide the quantity of grains allocated for meals; the wives take over food preparation and must ensure that every family member gets something to eat. Traditionally, women prioritize serving the adult male household members first, then the aged women and children, before taking care of themselves once the meal is ready; they are often left with smaller portions after serving the household. This hierarchical pattern of food distribution forces women to eat less or reduce their meal intake, especially when grain stock is low.

6.2.3. Common Patterns in the Food Insecurity Responses

The above findings regarding the diverse nature of household response actions prompted a closer examination of whether some actions are adopted simultaneously or in sequence. Table 6.3 shows comments from community leaders' interviews.

Table 6.3: Identified patterns in households' responses to food insecurity

Sample comments from research participants	**Pattern of household response actions**
Farmers try to protect their crops as much as possible to get good yields to feed their families. Like when their maize plants dislodge because of heavy rain or windstorms, they earth up. If they harvest and the volume of grains is not enough to feed the family, the women will also do their part. Women support their husbands with their *income from trading* (searching and selling shea nuts, baobab pods, firewood, charcoal, and dawadawa) to buy food for the households. There are no jobs around, so most people do not have income. When someone cannot buy at harvest to supplement, they will just manage what they harvest, like *eating less*, not letting the children waste food, or cooking in small portions. Every household has a *goat or sheep*, which they sell in the hungry season, especially from June-July, and use the money for food. When things are getting difficult most of our boys go to *Tumu*; they work on commercial farms and get bags of maize (Interviewed community leader # 2, Manyoro)	• Women's income from trading – charcoal, firewood, shea nuts • Eating less and cooking in small portions • Sell livestock – goat sheep • Migrate - to Tumu
When our crops fail us in the farming season, we usually manage with the little we have until the next season. Like we do *not waste our food* (that is, cook less or once a day). There is not proper dam here to support dry season garden, just a dugout and a dried-up stream. So, most people keep livestock and sell it later in the dry season to buy food. Some of us with relatives employed in larger towns/cities and farming-rich communities may ask for food or cash support when situations become unbearable. These are the only strategies we adopt. Apart from *owning an animal* or *relying on family* for support, there is no other way to survive hunger (the predictable seasonal hunger in the dry season). Our animals, in particular, are our World Bank. If a family does not have animals to depend on, it means they must *travel* (that is, migrate to search for work) in the dry season. (Interviewed community leader # 1, Doba)	• Not wasting food or cooking less • Sell livestock • Rely on relatives – for cash or food support • Migrate
We do not rely on one crop; we grow millet, rice, maize, ground nuts, and many other crops in small portions. When the food is getting finished and we buy from the market and change the way we cook. In some houses (referring to households), the women will prepare food in the evening and leave some for breakfast the next day. Others may cook and eat only in the mornings and evenings instead of a three-square meal. We usually buy the food with money we earn from *by-day (day labour jobs).* When finding by-day in the community becomes difficult, then we begin to *manage our food*. Some people may *sell their animals* (referring to livestock) for money to buy food or *travel to do gallamsey* (a local term for illegal small-scale mining activities, usually common in the southern part of Ghana) (Women's group leader, Kologo)	• Casual work • Change cooking • Sell livestock • Migrate – to Kumasi and mining towns

The community leaders' comments presented in Table 6.3 reveals that farmers employ their response actions in the following sequential order: trading or casual work, eating or cooking less, selling livestock, and travelling to search for work elsewhere. It is important to note that the farmers ultimately prioritize production management actions such as earthing up crop plants, irrigation, diversified cropping, and using early maturing varieties to enhance their climate resilience and protection against food crop productivity losses. As soon as they realize a significant shortfall that may constrain their ability to feed the entire household before the next harvest, they begin to strategize their responses sequentially, starting with a heavy reliance on trading activities and casual work. Pursuing trading and casual work is an important means of diversifying households' portfolios to other alternative means of securing income to buy food and supplement their own production.

As earlier indicated, eating or cooking less is critical for households to manage their depleting food stocks by spreading supplies across the out-of-season months. Most households start to ration their consumption as soon as they begin buying food crops from the market. In some cases, using income from trading and labour jobs might not be sufficient to meet daily food needs. This may, therefore, necessitate households to sell livestock assets for cash to protect their families against starvation.

All the community leaders pointed to migration as the last resort when all options are exhausted. Members of the households who migrate may return early for the next farming season to support their families with money to invest in crop production activities or bags of food to manage hunger in the preharvest months. Despite the potential contributions of migration in stabilizing households' food consumption in hungry months, the research participants often identified it as a terminal response action. This is because of the high economic cost of the migration for farm production – in case the young men and women do not return or delay their return. Additionally, the social cost involved in either leaving families behind or moving with them, as well as the poor working conditions migrants find themselves in the destination towns or cities, are possible explanations. Detail analysis of these effects of migration as a response option is given in section 6.2.5.

6.2.4. The Importance of Livelihood Assets in the Households' Responses

Insights from the research participants' narratives reveal that the availability and access to livelihood assets or resources influence households' ability to adopt response actions.

Across the study communities, the primary water source for irrigation is from the canals connected to the Tono Irrigation Dam and the White Volta River. Seasonally flowing streams, wells, and small dugout wells also serve farmers for only a few months after the rainy season. As a result, most households consider access to reliable water resources and pumping machines significant assets to irrigate crops and cultivate vegetables in the dry season. A recurring comment from the interviews and focus group discussion is summarized in the report of a community leader in Manyoro:

> To cultivate in the dry season, for example, a farmer must have a pumping machine and access to water. Only those who can afford the pumping machines for pulling water from the ground or dam can cultivate vegetables in the dry season. Water is key because it helps farmers reduce the risk of crop failure in the dry season when there is no water. This year the water in our dam (pointing to the direction of the dugout) is drying up quickly. We must stop the farmers so our animals can get water to drink. Because of this, farmers are discouraged from cultivating in the dry season – even if they have a pumping machine (Community leader, Manyoro).

Although the research communities are generally dryland areas, there are patches of forest vegetation consisting of shea, baobab, acacia, mango, and dawadawa trees. These trees serve as a source of food and income for households. One participant from the women's focus group explained the importance of the tree resources by saying:

> We also depend on the trees in the bushes, especially the shea, baobab, and dawadawa trees. They are everywhere, and we usually earn some income from selling the nuts and pods from these trees and use the money to buy food in the dry season. Without the trees, I do not think we can process shea butter and sell it – maybe we will do something or nothing. These economic trees help us a lot – even we sell the dried branches for firewood and charcoal. (Women's focus group participants #6, Pungu)

In all the focus group discussions, the participants echoed their reliance on social networks and reciprocal obligations from village associations, neighbours, relatives, and friends. Across the communities, women organize themselves into groups and pool their savings to have a source of lending funds for members. Men also form solidarity groups to assist one another with labour needs for farming and house construction activities as part of a longstanding *Awarevela* (in Kasem) or *Bapooslakarba* (in Nankani) tradition. These social resources and mutual aid are essential assets for households in rural areas of northern Ghana, where government support is often unavailable. The following quotation from a participant in one of the men's focus group discussions reflects some of the importance of social network support:

> If a farmer is a member of a village group or has a good relationship with neighbours and families, that also helps. Because when it is time for sowing or harvesting, and you cannot afford to pay for by-day, we call on our friends to help us speed up the work. If not, rain can fall anytime, causing microbes to grow and destroy our crops. Sometimes, too, people may ask their friends for food or borrow a bowl of grain when they run out of stock. That is why we always keep and value our friends and neighbours (Men's focus group participant #3, Naaga)

The research participants also highlighted how households' ownership over livestock assets is essential to facilitate responses to food security threats. Most households keep guinea fowls, chickens, goats, sheep, cattle, and donkeys as insurance. When the crop fails or harvest stock depletes in out-of-season months, they sell off livestock for cash to buy food or invest in dry-season irrigation gardens. For example, one of the community leaders reported that:

> When you look around the community, there is livestock or, at the minimum, poultry in every house. Do you know why (asking rhetorically)? They are very important to us, especially in the dry season. There are no jobs here, so when we are hungry, we sell one or two animals to buy food to feed the family. Without an animal, there is no other way to survive the hungry months. So, every household depends on guinea fowls, goats, or cattle. We also use part of the money to pay debts, support our children in school and pay for the cost of medications. (Community leader #3, Kologo)

These findings show that households require diverse assets to implement various response actions successfully. Generally, they must have access to a water source, own a pumping

machine, maintain a network of friends and families, and preserve livestock to depend on during periods of food stress.

6.2.5. The Outcomes of Households' Food Insecurity Responses

Despite farmers' efforts to manage food insecurity risks, they face severe costs, trade-offs, and risks, some of which were pointed out and openly discussed during the focus groups. For example, switching to early maturing (short duration) varieties requires the substantial application of fertilizer, pesticides, and weedicides – to support plant growth, clear weeds, and control pest – which farmers cannot afford. Although the government's planting for food and jobs program[40], offers fertilizers at a 50% discount for smallholder farmers, the focus group participants expressed their disappointment in the high politicization and corruption issues. Besides, the discount coupons can be picked up only at the district office in the capital city of Navrongo. Since most of these poor farmers reside within more than 20 km radius of the city, the cost of transportation also disincentives them from the program. For these reasons, farmers find it convenient to borrow money from family and friends, traders, and money lenders to buy fertilizers at the full price and pay them off immediately after harvest. One of the farmers interviewed explained this problem below:

> Switching to the 90 days varieties (improved seed) like Obaatampa and the rest is difficult. The cost of acquiring the seed is very high, and you need to buy new seeds every year (farming season) instead of recycling them. Moreover, these varieties of seeds also require the intensive application of fertilizer. It might cost twice the amount of fertilizers used in uncertified or regular seeds. So, this leads to a high cost of inputs. (Men's focus group participant #5, Pungu)

Also, the household's decision to seek casual day labour jobs directly impacts farm productivity and yields. In all the study communities, regular employment is unavailable, and at the same time, casual labour jobs are scarce (and poorly paid[41]) in the out-of-season months.

[40] Planting for food and jobs is a flagship initiative introduced by the Government of Ghana in 2017 to provide a 50% subsidy on seed and fertilizer subsidy to boost smallholder agricultural production and create jobs along agricultural value chains through complementary interventions such as access to seeds and extension services.
[41] In Manyoro, farmers may earn 15GH ($3.2) per day working on other people's farms during the agricultural season. The rate may fall to 8-10GH ($1.7-2.2) in the out-of-season months when more people do not have work on farms, and the labour supply is high.

As a result, poor households usually grab every opportunity to work as by-day labourers during the farming season to earn cash or baskets of crops. However, it comes at the expense of their farm productivity. For example, households taking up work to support wealthy farmers may face delays in preparing their land for sowing and threshing or bagging their own crops and, consequently, suffer post-harvest losses due to theft, unpredictable rains, and pest infestation. One of the focus group participants revealed:

> When crops fail, we must make a proactive decision to go for by-day (casual labour work) and work on other people's farms for money. During the harvesting time, the demand for labour is high. However, labour exchange can affect one's farm yields. Sometimes, when I go for by-day, I get so tired that I cannot go back to work on my farm the next day. So, you see, one cannot achieve much progress on his/her own farm work when doing the by-day. (Men's focus group participant #1 Manyoro)

Regarding relying on social networks and reciprocal obligations, the households reported that the time and food crop resource sacrifices they render in return sometimes affect farm productivity and food security. As part of a long-standing labour solidarity tradition within the research communities, a host farmer requesting for labour support from peers must cater for the feeding, usually breakfast and lunch or only lunch for those volunteering their labour. The host farmer must also reciprocate the support as a show of respect and integrity. But since landless farmers may not have their own cultivated plots to request for labour support, the host farmer must also give out baskets of crops in exchange. This system of reciprocal obligation is generally acknowledged and respected by all farmers. However, in some cases, a farmer may be unavailable to reciprocate their support, especially when the time of labour request from others coincides with a difficult circumstance such as a critical need on the farm or the death or illness of a family member. As one respondent revealed below:

> If you rely on relatives or organized labour support from the community members, it can sometimes delay the harvesting of crops. Everyone is busy. Some farmers want to finish their farms before they come and support their neighbours or friends. By the time they finish their work and attend to you, it will be almost late in the day, and very little work can be done to support you. So, it will take time to finish the harvest if you rely on the neighbours. Also, when we call on neighbours to support farm activities, we must think about how to feed them or give them something (referring to baskets of crops) from the harvest. (Men's focus group participant #2, Doba)

In addition to the unreliability and cost of reciprocal obligations on households' food stock, there were even more concerning issues raised during the focus group discussions in the Korania area within Navrongo community. For instance, a participant reported that:

> Here in our community (Korania), and even in Bonia (referring to the nearby village), people do not usually rely on family and friends for labour or food assistance. It is a strictly cash-based system. We ask or negotiate for a by-day labourer and pay cash. If someone is hungry, they will just go and do by-day work on a rice farm or look for work in a chop bar or construction. People even feel shy to beg or ask a friend for maize or rice because it may be used against them. They can be insulted or looked down upon for begging. (Women's focus group participant #1, Navrongo).

While the other communities were more concerned about the unreliability and commitment of neighbours and families, those in Navrongo were worried about the implications of such assistance on a household's status. With the latter, there are social pressures and pride among households who move towards market provisioning, and, therefore, farmers are reluctant to rely on a social network to maintain their dignity and self-respect. This shows that the availability and cost of relying on social networks differ across communities.

During the focus group discussion, it was also evidenced that farmers were concerned about how the disposal of livestock may cause a decline in assets and reduce their potential to invest in farming activities. Although selling a sheep or a cattle from a herd makes it possible to secure cash for food during the out-of-season/hungry months and capital for investment in adaptive food production, the participants expressed their worries about diminishing livestock herds year after year. Their concern stems from the poor pricing at the animal market. According to them, the prices offered by buyers in distress sales are often low and sometimes not enough to cater to their consumption expenses or allow them to reinvest the money to expand the herd population later. During the focus group discussion in Manyoro, it was mentioned that the main reason for the low-priced stock is the influx of sellers from villages in Burkina Faso and households' inability to transport their animals to larger markets in Navrongo and Bolgatanga. The comment below was reported during one of the men's discussions:

> Animal prices are often low. After selling a cow, the money we get can only cater to some of the household expenses we plan to take care of. For instance, the average price we can get for cattle is Gh cedis 1,000-1,600 ($238-380). A goat is about Gh cedis 200 ($48), but it depends on the size. Sometimes too, the offers we get are even far lower – the buyers usually have the final say. We can take an animal to the market, and the buyers may identify a problem and not want to offer a good price. Because we need the money, we have no choice but to accept the offer, especially, when the supply of animals is high, the buyers offer very low prices. The money is not usually enough, and we cannot buy a calf or lamb to add to the herd. We must rely on someone's ram or bull to multiply our herd. (Men's focus group participant #3, Manyoro)

The research participants also raised the health and well-being consequences of consumption adjustment or dietary-based response actions. According to them, reducing the number of meals a day and cutting the quantity of food have growth and development effects, especially on young children and other vulnerable groups, including pregnant women, lactating mothers, and older people. This point is best captured in the comments of an older woman responding to the survey questionnaire:

> Reducing food consumption has led to weight loss in our children. Look at this child (pointing to a small girl lying on the floor covered with cloth), she has been sick for months because we do not have good food. Every day, we eat maize and maize and maize; we do not even have enough groundnuts. Our Bambara beans are already finished. We are managing the maize, groundnut, and some guinea corn until the next harvest. They (referring to the health workers visiting their community) say she needs good food, but we do not have the money, so what can we do? (asking rhetorically). (Survey participant, Manyoro)

In addition to human health, the households acknowledged the environmental consequences of relying on income from firewood and charcoal production. Mainly, there were concerns that these short-sighted income-generation practices have devastating consequences that worsen climatic pressures in the community. During focus group discussions and interviews, participants reiterated that charcoal production has resulted in deforestation and worsened desertification. They were also prompt in expressing that cutting down trees for firewood and charcoal increases their exposure to rainstorms and rising temperatures. Some showed a willingness to support local-level efforts against deforestation. However, there is a great sense

of community solidarity and concern for others who do not have alternative ways to make income to feed their families. The concern expressed by one focus group is presented below:

> There is a considerable fine if you cut trees from the forest and are caught. We even have a traditional rule here that no one should cut down fresh branches of trees. It is believed that this will cause windstorms. The forestry office comes around for monitoring from time to time. Yet still, many people cut the trees for firewood and charcoal. These activities are causing us many problems. It is the main reason why we do not have rain. The sun is very high, and when it rains, there are no trees to protect us from the storms. Sometimes, we want to report those who cut fresh tree branches for firewood or charcoal to the appropriate authorities, but it is not possible because we understand that is the only way they can get money to buy food. (Men's focus group participant #3, Kologo)

Another unprompted but recurring remark from the focus group participants worth mentioning is the emotional, social, and economic costs of migrating to seek job opportunities elsewhere. A significant problem for young men and women travelling to big cities is the high cost of living and no known relatives with whom to stay; those who travel to promising farming communities also face difficulties in accessing potable drinking water and are forced to overly exhausting workloads. These problems often expose the migrants to water and sanitation-related diseases (e.g., malaria and cholera) and waist and spinal-related injuries. Women, in particular, face sexual abuse; those who end up pregnant hardly return home because of societal stigma and shame to families. Irrespective of these health problems, travelling to the cities offers exciting opportunities for young women and men. As a result, most youths are usually reluctant to return early to assist with land preparation and sowing; households must rely on paid labour, which they cannot afford. These concerns with seasonal migration were widely expressed in all focus group discussions. A participant, for instance, reported that:

> Some women go to other communities to work and end up staying and not returning, especially when they get pregnant out of wedlock. It is not their fault that they get pregnant because some of them are harassed and sexually abused, especially those who go to work on tomato farms in Wajia, Burkina Faso. Over there, there is no accommodation; people sleep and work on the farms. Access to water can also be challenging. Going to the city is better, but some people fail to return when they go to big cities, which can lower productivity. (Men's focus group participant #5, Doba)

These identified concerns show the complicated experiences of farming households as they try to manage the unusually severe and sometimes unexpected climatic risks to food security.

6.3. Discussion

The research results and findings reveal that households' responses to climate-induced food threats are diverse, sequential, and associated with hidden costs. This section discusses these findings in detail.

6.3.1. Diversity in Households' Responses to Climate-Induced Food Insecurities

A major finding from the study is that households in northern Ghana adopt diverse strategies to manage climate-induced food stress, including production intensification, land management, harvest/post-harvest loss prevention, market-based strategies, income diversification, consumption management, reciprocity-based strategies, asset liquidation, and migration. Evidence from the survey results shows farmers are adjusting crop varieties, soil, or vegetation components to reduce the uncertain impact of climate change on food production. Some of these adjustment practices include switching to early maturing varieties of crops, applying fertilizer, and irrigation. This is what Clay and King (2019) refer to as a production intensification strategy. Likewise, sustainable land management strategies consist of actions to manage production-level threats to food security but are more oriented toward environmental stewardship (Binam et al., 2015; Garrity et al., 2010) than production intensification strategies. They include household adoption of mulching, composting, and tree conservation practices.

Also, discussions in focus groups revealed that households might harvest crops early, transport them immediately to the house, or cover harvested crops with tarpaulin to cope with the unpredictable out-of-season rains. These actions can be seen as harvest and post-harvest loss prevention strategies. On the other hand, those actions, such as keeping harvest stock for own consumption and buying crops during harvesting when there is a need to supplement

own production, are market-based strategies for managing climate-induced disruptions to food security.

In addition, the study reveals that most households diversify their livelihoods across agricultural and non-agricultural activities by seeking jobs as casual labourers (on farms, construction sites, and chop bars) and selling mangoes, shea nuts, and baobab pods. Studies, including Roncoli et al. (2001) and Ellis (1998), have termed these response actions as income diversification strategies because they aim to increase households' access to varied income sources to buy food. Consumption/dietary management strategies include actions to ration consumption or change diet to survive seasonal hunger and food deficits. Roncoli et al. (2001) confirm in their study on coping with droughts that consumption management practices involve control, conflict, compliance, and cooperation among men and women, young and older people within a household. In this case study, more women confirmed adhering to consumption management practices than men, consistent with other studies (see Antwi-Agyei and Nyantakyi-Frimpong, 2021) suggesting that primary caregivers of food-insecure households forfeit their current consumption for other members of the household.

The study also identified reciprocity-based strategies, including reliance on social networks and relations for labour, cash, and food needs. According to the research participants, neighbours offer support as a form of social responsibility, but they must recognize the obligations to reciprocate the support or give something in return as per the traditional arrangement. Consistent with other studies (Wossen et al., 2016; Dapilah et al., 2020), the research results reveal that social networks and reciprocal obligations contribute to community resilience and food security. Yet again, as the study showed, reliance on social networks, particularly for labour support, can exacerbate vulnerabilities. In the research communities, farmers find it more difficult to reciprocate their support as they may prioritize finishing up with their farm tasks, in the face of the uncertainties in rainfall, before offering to support their neighbours. This evidence echoes those presented by Wossen et al. (2016) that food security is less likely to be achieved through social capital when a shock affects the whole risk-sharing network. Asset liquidation entails actions to keep livestock and poultry as a form

of insurance and purposefully drawing on these assets – by selling for cash to buy food – during the seasonality-induced hungry months (Corbett, 1988; Davies, 2016).

The above findings resonate with other research in agrarian studies, showing rural agricultural households adopt diverse livelihood strategies in a dynamic process to meet various needs at different times. According to researchers, diversity in rural livelihoods is often driven by either necessity or choice (Ellis, 2000; Davies, 2016). Choice explains the voluntary and proactive reasons that may guide an individual or a household's decision to pursue different strategies. In this case, the objective might not be for survival per se but also to accumulate assets for livelihood and well-being. Necessity, on the other hand, is because the decision could be involuntary or a result of distress or desperation. In the context of the study communities, protecting food consumption against climate stress drives households to adopt diverse, varied response strategies, which eventually become central to their survival (Ellis, 2000). Additionally, climate change plays a significant role in the balance among the diverse response strategies reported by households. For example, the recurrence of droughts and the drying up of dams leave farmers with limited choices/options to cultivate food in the out-of-season months. Consequently, this creates the necessity to juggle several options possible to secure food to feed their families. Another important case to highlight is the increasing scarcity of agricultural employment in the dry season months, which the research participants repeatedly mentioned. Such seasonal challenges necessitate households to venture into various ways to secure income to buy food, including seeking non-farm casual work, trading, and migration.

6.3.2. Sequencing of Responses and Asset Preservation for Sustainable Livelihoods

This research finds that all households try their best to protect their food crops against the adversities of climate change, but some may still face food deficit problems in the out-of-season months. To manage seasonal hunger risks, households sequentially implement their response actions in the following order: diversification into non-farm income (e.g., trading and labour jobs), consumption management (e.g., eating and cooking less), asset disposal (e.g., selling fowls and livestock), and migration (travelling to search for work in neighbouring

towns and larger cities). These findings affirm past famine, drought, and seasonal hunger studies in the West Africa Sahel that have observed a pattern in households' responses to food crises. For instance, Corbett (1988) noted that household response behaviours start with insurance mechanisms (collection of wild food) and are followed by asset disposal (sale of livestock) and destitution strategies (distress migration) only after possible options for gaining access to food at a lesser opportunity cost are exhausted. Devereux (1999) also suggested that households first adopt low-cost and easily reversible practices (e.g., changing diet and collecting wild foods) which are not damaging to livelihoods before resorting to high-cost and less easily reversible practices (e.g., the sale of productive assets), which are highly damaging to livelihoods, before moving on to survival strategies (such as migrating or selling off the land), which reflect economic destitution. These past studies' suggestion that sequencing is determined by the cost and reversibility of each response action is also evidenced in the study communities. For example, the participant households' decision to first engage in trading or by-day labour jobs within the community is influenced by the perceived lower direct cost of such activities than selling their livestock or migrating to find jobs elsewhere.

In addition to reversibility and cost, my research suggests that sequencing is a tactical effort for managing assets critical for both consumption needs and agricultural livelihood sustainability. Within the broader SLF, assets can be categorized into five forms of capital which are human, social, natural, physical, and financial (DFID, 2001; Reed et al., 2013; Osman, 2020). To improve food security, a household may rely on human capital such as skills, knowledge, and ability to labour and produce food or income to buy food during out-of-season months. Social capital developed through networks and relations with family, friends, and village associations can provide labour support to harvest crops or in-kind or cash assistance for food. Natural capital stocks such as land, forest, and water resources are important inputs for food production and income. Physical capital, which includes the basic infrastructure (e.g., roads, rails, and buildings) and financial capital, such as cash, savings, and remittances, enhances household access to food resources.

The livelihood capital concept of the SLF provides a nuanced understanding of how households combine, transform, and interchange assets in pursuing their livelihoods and

managing the risks they face. However, the framework is criticized for its lack of inclusion of political and cultural forms of capital that are critical in helping people mobilize other forms of assets (Bebbington, 1999; Baumann, 2000). In adopting the livelihood capital concept to analyze household response strategies, this study also recognizes that poor households may depend on diverse resources to manage climate impacts on food security. Attention is thus given to the farmers' reliance on longstanding cultural traditions to request labour, cash, and various in-kind support from their social networks. Also, the analysis reflected on some household-level power relations and gender politics on access to assets that shape women's low adoption of improved seeds, use of irrigation, and reliance on livestock assets to manage climate impacts. Thus, the analysis of livelihood resources reflects on the broader livelihoods capitals/resources that households depend on, not only the ones captured in the SLF.

Findings from the study reveal the diverse forms of capital assets critical for household responses to hunger, which include land, livestock, access to water resources, pumping machines, women's savings, economic non-food crops like shea trees, and a network of family friends, among others. Generally, households hold these different forms of assets for various purposes, and therefore, the sequencing of response actions also corresponds with the values a household attribute to the dominant capital assets supporting these actions. In northern Ghana, bullocks are held for directly productive purposes; donkeys can be thought of as a luxury; sheep and cows as savings and brideprice. Thus, the size of one's flock indicates wealth and status in the community (Yaro, 2010; Wossen & Berger, 2015). Additionally, farming households prefer to build up a large family size as an incentive to get an adequate supply of family labour for agricultural activities. Given these critical roles of livestock and farm labour assets, the study argues that households prefer to initially resort to trading or bye-day jobs or eating less in order not to sell their livestock or push young men to migrate in search of jobs elsewhere right after harvest. The need to keep family labour and livestock assets represents an important form of insurance for agricultural households to manage seasonal hunger in the post-harvest months. The research argument regarding the sequential pattern of households' responses presented here is consistent with De Waal's (1989) evidence from Darfur that poor households may choose to subsume immediate food needs to preserve assets for future production. Drawing on the SLF and the Access model, the argument on the

sequential pattern of household responses underscores how poor farmers in northern Ghana use their access profiles to shape responses in anticipation, during, and after a potential climate-induced food crisis. Specifically, the finding supporting this argument sheds light on the forms of access to resources that are prioritized immediately in the harvesting season when food is in abundance and those that are reserved for the beginning and terminal stages of the climate-induced hungry months.

6.3.3. The Excruciating Cost of Responding to Food Insecurity Risks

The study demonstrates the likely negative impacts of household responses and how they can exacerbate vulnerability to food insecurity by revealing that household response practices such as changing diet, cutting down consumption, and migrating temporarily to find work in Tumu and Wajia could rebound and reinforce food security vulnerability for children, women, and the youth. This corroborates insights from Juhola et al.'s (2016) perspective that responses to climate change risks could deliver adverse outcomes that either rebound, shift vulnerability, or erode sustainable development. Specifically, the findings show that women may endure the costs of other household members' survival, depriving themselves of portions of food to feed their husbands and children or drawing down income from trading activities to buy food to supplement household production. These actions increase women's likelihood of undernourishment and low economic stability compared to men. Indeed, the issue of women's poor nutrition is a persistent problem in northern Ghana (Nyarko et al., 2021; Freude & Henning, 2019), which needs critical attention.

Similarly, as noted, migrating to find jobs elsewhere is popular among the youth in some communities (e.g., Manyoro and Naaga). Migrant youth work as casual labourers on commercial farms and market stalls; they send back money or bags of food to support their families back home. However, they work under poor conditions, sleeping on farms, bus stations, and streets where they are exposed to water and sanitation-related diseases that could affect how nutrients from foods are absorbed and used in their body (Fanzo et al., 2018). This suggests that migrant youth facing health risks are unlikely to gain appropriate nutrition, thus compromising their food security.

There is evidence that planting early maturing and drought-resistant varieties increases farm yield by 35% (Rahman & Connor, 2022; Di Falco et al., 2011) and, thus, food availability for households. This study's findings confirm this existing evidence, but it also notes that such agricultural intensification response strategies can erode efforts for sustainable food security. As the study shows, early maturing varieties require farmers to apply more fertilizers and continuous use of pesticides to control pests and disease infestations. These agri-inputs emit greenhouse gases and leach toxic minerals into the environment, including phosphorus and nitrate, which can compromise oxygen levels for algae growth (Balmford et al., 2019). Another environmental cost was noted relating to the likelihood of trading in firewood and charcoal activities leading to deforestation and exacerbating food production vulnerabilities.

The above findings indicate the need for environmentally friendly fertilizers (EFFs) to enhance nutrient efficiency and reduce pollution. Other practices that have the potential to deliver ecological sustainability and food security in the context of changing climate include conservation agriculture, planting pits (zai and half-moon techniques), erosion control techniques, drip irrigation, agroforestry, and climate information services (Partey et al., 2018). There is evidence of farmers' adoption of these ecologically sustainable practices in some communities of northern Ghana as part of the indigenous knowledge of agriculture (Apuri et al., 2018; Nyantakyi-Frimpong & Bezner-Kerr, 2015). Yet, scaling up of best practices is still low due to limited institutional and policy support (Nyantakyi-Frimpong, 2020), and thus, making it unlikely for poor farmers to leverage these options in building their own food security.

6.4. Conclusion

This chapter has explored households' responses to climate-induced food insecurity. The findings contest the view that rural farmers in marginal areas of West Africa are inherently vulnerable. The evidence indicates the proactiveness, rationality, and resilience of rural farmers. However, this appreciation of the resourcefulness and strengths of African farmers does not overlook the possibility that household response actions and strategies may entail

excruciating trade-offs, additional risks, and unequally distributed costs. As the findings show, some response actions can rebound or reinforce the vulnerability of women and migrant youth or erode sustainable efforts to conserve forest resources.

Overall, the findings depict a pattern of household behaviour that could be leveraged to design shock-responsive climate change adaptation, food security, and risk management programs. Over time, the government of Ghana and partner organizations prioritized food distribution to disaster-affected farming communities[42]. While this action could provide immediate relief to disaster victims, it may not be sufficiently effective in stabilizing household consumption. To improve northern Ghana's food security in post-food crisis months, policy attention could focus on not only investment in climate-resilient food production but also livelihood protection interventions for households to build livestock herds and broaden their skills beyond agricultural production. Together, these interventions can improve households' resilience to rapidly changing climatic conditions and lead to more sustainable food access and availability. Overall, the study findings presented in this Chapter contribute to the emerging literature on climate change adaptation, household response behaviours, and food security in northern Ghana.

[42] In the aftermath of the September 2019 floods and windstorms in the Kassena Nankana Municipality, affected households across Manyoro received bags of maize, sugar, and rice from the National Disaster Management Organization (NADMO) and the Red Cross.

CHAPTER 7
SUMMARY OF FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

7.1. Introduction

This final chapter summarizes the study findings and key arguments that help answer the overall dissertation research question: How do farming households' experiences with climatic hazards interact with various forms of vulnerabilities to induce food insecurity risks, and what are their response to climate-induced food insecurity risks? It further presents the implications of the findings and recommendations for food security and climate change policy and practice. The chapter also outlines the theoretical and methodological contributions and directions for future research on climate change, climate resilience, food systems, and food security.

7.2. Key Findings and Arguments

As indicated in Chapter 1, this research is guided by six sub-questions. The first and second sub-questions, which are aimed at examining the pattern in households' food insecurity throughout the year and how it is shaped by food system activities in northern Ghana, are primarily addressed in Chapter 4. Based upon the findings presented in Chapter 4, I argue that in northern Ghana, food insecurity is shaped by various food system activities, including food crop production, harvesting, processing, storage, transportation, and markets. This argument recognizes the importance of extending explanations of food insecurity beyond food production to include other equally important activities that underpin households' food availability and accessibility. More specifically, I have shown that smallholders are subsistence producers, cultivating different crops (cereals, fruits, vegetables, legumes) and raising farm animals (livestock and fowl). Yet, they have poor dietary patterns dominated by cereals and vegetables. I also discussed that although the seasonality of production activities explains why smallholders face decreasing food availability from May to August and rely heavily on the market during these months, it is the households' lack of access to proper warehouse storage facilities, functional markets, and effective transportation systems that form the roots of the food insecurity problems. These findings and arguments from chapter 4

of my dissertation emphasize the importance of broadening the definition of food security beyond food production.

The third and fourth research sub-questions, which sought to investigate the extent of climate hazard exposure and analyze key food system vulnerabilities that predispose households' food security to climatic threats, are addressed in Chapter 5. In the analysis in Chapter 5, I identified the communities' exposure to climate hazard events. I also characterized food systems' vulnerability to climate hazards, centring it around the households' access to and ownership over assets critical for food production, harvesting, storage, and market. Drawing on the findings from the analysis, I argue that climate-induced food insecurities among smallholders are not just products of only the households' exposure to persistent climate events. Instead, they are also inextricably connected to underlying socio-economic and political processes and factors, which are somewhat remote from climate change, but shape how food is produced, harvested, stored, and marketed.

The above argument is based on the study finding that the communities are highly exposed to climate hazard events, with almost all the households confirming the occurrences of floods, dry spells, extreme temperatures, erratic rains, and windstorms. I also found evidence that households cultivate food crops without irrigation facilities. They also have limited or no access to tractors to plough the hard-pan-formed farmlands and mechanized threshers or combined harvesters. In some communities, households must travel long distances (more than 20 km) to the bigger towns to buy inputs and market their crops, usually on roads that are in poor conditions and by motorbikes. These poor conditions of food system activities combine with climate hazard events to exacerbate food insecurity problems, including low food crop harvests, reduced quality and quantity of food crops, reduced food stocks, seasonal food price hikes (disruption), and income losses.

The fifth research sub-question, which explored households' responses to climate-induced food threats, is addressed in Chapter 6, where I argue that households adopt diverse strategies and sequences of actions not solely to meet current food consumption needs but also to preserve the agrarian livelihoods that they depend on for food, income, and well-being. I

presented two key findings to explain and validate this argument. The first finding reveals the diverse strategies adopted to manage food stress, including production intensification, sustainable land management, harvest/post-harvest loss prevention, market (price) stabilization, income diversification, dietary management, reciprocal exchange and obligations, and asset liquidation. With this finding, I discussed how desperation to survive the hungry months influences the households' decision to adopt these diverse strategies. The second finding is that the sequence of household response actions occurs in the following order: trading and casual labour, eating/cooking less, selling livestock, and migration. I draw on various literature (Corbett, 1988; De Waal, 1989; Devereux, 1999;) to explain why this sequence is based on not only the cost and reversibility of each action but also the economic values a household attributes to the dominant capital assets supporting these actions.

The sixth research sub-question, which sought to assess household response actions and determine which outcomes could negatively affect long-term food security goals, is also addressed in Chapter 6. Some of the findings in Chapter 6 reveal the contribution of response actions and strategies in reducing the uncertain impact of climate change on food production and losses at harvest. Specifically, seeking trading and casual labour help increase households' access to varied income sources to manage seasonality-induced market-based disruptions to food security. However, further evidence suggests that certain strategies may also have negative consequences. According to the analysis of comments from the research participants, actions such as eating/cooking less and migration can increase the likelihood of undernourishment in women and youth. Similarly, switching to early maturing crop varieties can lead to greenhouse gas emissions. Based on these findings, I argue that some response actions could rebound and increase food security vulnerability or erode progress on building sustainable food security and resilient food systems.

7.3. Theoretical Contributions and Direction for Future Research

The findings from this research attempt to contribute to various strands of literature and accompanying debates in different ways.

First, this dissertation affirms the important components of the food system concept by revealing the way in which various activities, from production to marketing of food crops, support household food security. Specifically, the analysis and discussions shed light on how the seasonality of food production affects dietary choice, ineffective harvesting and storage activities shrink food availability, and underdeveloped markets reduce access to food crops in the hungry season. Also, the dissertation reinforces the importance of thinking about different actors within the household-level food system and their roles, especially in each food system activity. It highlights explicitly how various household members are taking up important roles to enhance households' capacity to produce food during the farming season and access to income to buy food for consumption in the hungry season. For instance, the findings reveal that women contribute not only to food production but also significantly to harvesting, marketing, and preparing food. Additionally, women may pursue trading activities and draw on their income to purchase food to supplement household production. Ultimately, these findings reflect the fact that the food system concept needs to pay detailed attention to actors in the food landscape. Recognizing the actors and disaggregating their specific contributions is critical to ensure that food system analysis does not unintentionally neglect or ignore actors with important resources to support household food security (Tameer, 2018).

Second, the research advances the theorization and general understanding of food insecurity. Agricultural researchers tend to frame hunger and food insecurity as a problem of food availability decline arising from inadequacy in food production. This research provides an alternative and comprehensive way of thinking about food insecurity. By using the food systems approach to analyze food access and availability issues, this study demonstrates that food production is one but not the only activity that underpins food security. In the case of rural areas of northern Ghana, like many areas across sub-Saharan Africa, the various activities influencing how food is stored and marketed also determine household food security. As the study shows, food crop production outputs are generally low, but some households reap a good harvest that would be enough to feed their families. Yet, these households still face seasonal hunger problems. Further analysis identified two reasons for this. One, smallholder farmers lack appropriate storage facilities to store harvested crops for future use. Two, food supply shortages in the market during the postharvest months push

food prices up to price ranges unaffordable for poor households. This evidence, presented in Chapter 4, validates the importance of situating food insecurity analysis within the broader food system rather than viewing it solely through a food production lens. Alongside works by Eriksen (2007), Ingram (2011), and Cudjoe and Owusu (2011), the research findings provide food security researchers with evidence about the diversity of food system activities beyond food production that loom large in determining households' food availability and access, both in farming season and out-of-season months.

Third, findings from this study contribute to research on climate change, disaster risks, and food security. The findings reveal how a social lens is a powerful component of analyses to understand the impacts of climate change on household food security. As indicated in Chapter 2, the conventional use of the term 'risk' presents an understanding that excludes the internal functioning of a system exposed to a risk event. This idea connects risk events to only the occurrences of the hazard. But over the last few decades, researchers have used various models to advance our understanding of how risk occurs when a natural hazard affects vulnerable people. Drawing on the Pressure and Release Model developed by Blaike et al. (2004), this research echoes and advances the current understanding of disaster risk by offering a specified and detailed analysis in the context of food security. In Chapter 5, the research presents evidence that climate impacts and risks to food security are not solely externally generated circumstances; they are also connected to the underlying processes that shape how food is produced, harvested, stored, and marketed. In light of the findings and argument presented in Chapter 5, this research contributes knowledge to reject the traditional notion of risk. Although the Pressure and Release Model focuses on disaster risks for broader livelihoods, its application to the food security context of farmers in northern Ghana has helped present a nuanced understanding of climate-induced hunger risks for dryland communities in the Sahel and other marginal regions of the world.

Fourth, this research broadens knowledge on food security vulnerability to climate change, which is practically given less attention in agrarian livelihood vulnerability studies. Currently, most of the research on household vulnerability studies in agrarian societies, including Hahn et al. (2009), Etwire et al. (2013), Antwi-Agyei et al. (2013), Opiyo et al. (2014) and Panthi et

al. (2016) focus on households' capacity to adapt or recover from shocks. While these studies help understand how households can protect their food provisioning during crises, often in terms of production, their application for food security vulnerability analysis is limited. One major limitation is that these studies analyze vulnerability using capital assets critical for sustaining a household's livelihood but not those specific for food security. My research adopted a food security vulnerability analysis that relies on the overarching social, economic, and environmental elements and questions of road accessibility to transport food to the market, why households are not using cars/trucks for transportation but motorcycles, and the quality of soil for food production. Other elements related to whether households can access and use tractors, harvesting machines, and storage facilities to help sustain their crop harvest for future consumption. These details give life to the concept of vulnerability in relation to food security. In essence, this study exemplifies how food security vulnerability analysis should be conducted in the context of changing climatic conditions in northern Ghana and other marginal areas of the world.

Fifth, this research presents ample evidence to revive studies on household responses to climate-induced food crises. Despite progress in identifying households' coping behaviours during droughts and famines in the 1980s and 1990s, there has been limited research and, thus, outdated evidence to support knowledge and policy. In the face of the rapidly worsening climatic conditions and the uncertainty in the global political economy that intersect to influence climate and food security problems, there is the need for new research to understand the continuity or emerging changes in household behaviours. This dissertation contributes to revitalizing evidence in this regard. It reveals explicitly in Chapter 6 how households adopt response actions in sequence in order to preserve assets critical for future production. Through these findings, this research advances earlier studies (see Corbett, 1988) and presents evidence to attract current and future researchers' attention. Future studies could further examine how the availability and value of specific assets influence the sequence of household actions.

Sixth, this dissertation affirms the applicability of the Access Model, which is originally a framework for disaster risk management, to strengthen understanding of climate change impacts on the farming households' food security in northern Ghana. It does so by revealing

the resources critical for managing climate-induced hunger and the ways in which poor farmers sequence their response strategies or options in order to maintain their continued access to critical livelihood resources. Particularly, the analysis in Chapter 6 sheds light on the key response practices adopted by farmers in the study communities and the resources/assets that play important roles in these practices. The examination of these response actions includes a thorough identification of the broader list of assets/resources beyond the SLF's five categories. It also extends to explaining how households' interest in maintaining a "good" access profile compels them to sequence their response options in a manner that helps preserve agricultural labour for resilient food production in the future. Thus, the use of the Access Model in this dissertation has helped draw attention to the important components of poor households' access to resources to cope with and adapt to risks, which is often ignored in climate change and food security research.

Lastly, my personal experiences gathering data for this research present valuable methodological lessons for emerging scholars seeking to navigate fieldwork activities, particularly in rural communities of Ghana and other sub-Saharan African countries. As a Ghanaian female researcher affiliated with a university abroad, leading the fieldwork processes and co-producing this knowledge with both male and female members of the research communities did not come easy. The simultaneous identities I held as an outsider and an insider throughout the fieldwork enriched and complicated my research in different ways, which I have outlined and explained in detail in Chapter 3. For example, my position as a co-moderator in the women's focus group discussion was inspiring as women felt more open and comfortable discussing power dynamics and unequal household division of labour. On the other hand, I encountered several unwelcoming behaviours in my interactions with the men's groups that I believe would not have been experienced by male researchers. The personal experiences I present in this dissertation can help emerging female researchers foresee some of the challenges they are likely to face and identify possible strategies to mitigate them in ways that would not influence research outcomes.

7.4. Policy Contributions and Recommendations

This dissertation offers different contentions to inform climate-resilient agriculture and food systems policies. Primarily, it presents evidence to show that food insecurity in northern Ghana can be explained by the seasonality of production (and low input use), inefficient food harvesting practices, poor storage, and underdeveloped markets. This evidence can help steer a shift in Ghana's food and agricultural sector policies and programs, which have long been centred around increasing food production with minimal attention to post-production activities. Ghana's most recent flagship program for food security, which is the Planting for Food and Agriculture, tends to focus on increasing access to improved seeds, fertilizers, extension services, marketing, and e-agriculture for smallholders. Although this program has great potential to strengthen food availability and access among smallholders, it prioritizes production intensification more than market and storage effectiveness. It is thus unclear how the program would translate into the desired outcomes for food security on the ground. The above contention suggests the need for balanced investment across various food system activities, from production to storage and markets, all of which are critical for food security in northern Ghana. Of particular importance is the need for increased investments in rural transportation networks, decentralized farmer-managed warehouses, community-based food reserves, microfinance, and insurance (including attention to livestock) to protect rural people against the variations in food prices and losses, which have been significant obstacles to their year-round food availability and access. Doing so would ensure that agricultural policies achieve diverse wins.

The patterns and objectives of households' response behaviour (in times of food crises) revealed in this dissertation could help the Government of Ghana and other key actors supporting food security and poverty reduction in northern Ghana understand how smallholders attempt to cope with and adapt to threats – their priorities and plans toward food crisis response and recovery. For example, the fact that households' response during out-of-season months starts with casual labour jobs and trading suggests the need for policymakers and practitioners to prioritize investment in non-agricultural economic opportunities in rural areas of northern Ghana. Similarly, the smallholders' decision to migrate at the terminal stage

of hunger indicates that most of them prefer to stay close to home at the beginning and during periods of distress as much as possible. This implies that grassroots actors and communities should be more involved in food crisis prevention and preparedness planning efforts to help better identify interventions that meet the emergency response needs of poor households. Of particular importance is youth inclusion in climate action. Young people have the creativity and agency to initiate actions and innovations to address climate and food insecurity challenges. Instead of being tokenized or neglected, the talent and experiences of young people in northern Ghana could be harnessed. The government could invite them for open discussions and active participation in the climate and food security policy decision-making process.

Although smallholders have shown rationality and resilience in their response behaviour, this dissertation contends that some responses, such as migration and changing diet, could rebound and exacerbate food security vulnerability, especially for women and youth. At the same time, a response involving production intensification, such as switching to early maturing varieties, could also erode or defeat global efforts toward sustainable agriculture and resilient food systems. These additional and unequally distributed adverse outcomes of response actions serve as useful information for policymakers, practitioners, and grassroots activists to draw upon to build inclusive and sustainable interventions. In other words, development policy and projects need to analyze intra-household vulnerabilities when formulating and implementing crisis response programs so that interventions do not further aggravate the existing burden on women and other marginalized groups. It also suggests that climate change and food crisis response interventions should be assessed for their long-term effect and ensure they do not exacerbate existing vulnerabilities in poorer communities.

7.5. Conclusion

This research has examined smallholders' experiences with climate risks and responses to food insecurity in northern Ghana. It reveals the hunger and food insecurity problem among smallholders in northern Ghana. Further analysis also shows how socio-economic vulnerabilities intersect with extreme climatic events to exacerbate these insecurities and the

households' responses to coping with and adapting to food crises. The research provides recommendations for future researchers, policymakers, practitioners, and grassroots leaders based on the findings and key arguments.

For future researchers, a key takeaway is to situate food (in)security analysis within the broader framework of food systems instead of limiting it to only food production. Many researchers have reported on households' responses to climate change impacts on overall livelihoods. What this research suggests is the need for researchers to consider issues specific to food security – particularly how households respond to the intensifying impacts of climate change may vary throughout the year in response to the levels of food availability and access at a specific point in time, and whether the intrinsic value of a household's asset bundle influences the sequence of response behaviour adopted.

Also, it is important to highlight the need for future research to integrate aspects of youth action for climate and food system resilience in northern Ghana. The important role of youth in climate action is gaining momentum in international development discourse. Most recently, high-level events such as the United Nations Youth Climate Summit of 2019 and the COP27 brought together young activists, innovators, and entrepreneurs to showcase their solutions and meaningfully engage with global leaders on defining climate change issues. While this study identified the significant roles young men and women play in their households' access to food in crises months, it neither specifically engaged with youthful members of the participant farming households nor intentionally explored how their skills and talents could be harnessed to build household and community resilience to climate and food crises. Future studies could explore this potential area of research, with a particular focus on identifying existing opportunities and challenges for youth-led solutions to climate and food crises in northern Ghana; and exploring how government can invest in these youth-led solutions and encourage the participation of young people in climate policy decision making at the local, regional and national levels.

The study recommends that policymakers and development practitioners prioritize investments in sustainable food systems and climate resilience, including efforts to build rural

transportation networks, promote decentralized farmer-managed warehouses and community-based food reserves, and strengthen access to finance (credit, savings, and insurance) to protect rural people against the variations in food prices and food losses, which have been critical obstacles to their year-round food availability and access. These investment recommendations should match the existing and planned efforts to increase sustainable food production. Additionally, the study shows that the striking evidence of hunger among smallholder farmers in northern Ghana will persist unless the government of Ghana and its development partners prioritize the above-mentioned recommended investment in food storage and marketing activities. The evidence presented throughout the research will help strengthen grassroots actors and agents' awareness of factors exacerbating climate impact on food security and guide smallholder farmers in devising additional practical tools, approaches, and strategies to protect their consumption levels against climatic stress.

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APPENDICES

Appendix A: Interview Guide

Study Name: Security in uncertainty: an analysis of climate risks, household responses, and sustainable food security in northern Ghana.

Researcher: Balikisu Osman, Faculty of Environment and Urban Change, York University, Canada
Email: bosman6@yorku.ca

Name of Community/Organisation……
Position in this community/organisation …….

1. What are some of the main challenges the community face in the delivery the following food system activities - Production, harvesting, post-harvesting, storage, marketing, consumption?
2. Which climatic hazards occur in the district and how does the climate hazards you identified impacts/affects (positively and negatively) these food system activities - Production, harvesting, post-harvesting, storage, marketing, consumption?
3. How are farmers responding to/managing the impacts of climate hazards in order to feed their families and ensure food security throughout the year?
4. How are you supporting farming households to ensure that they can manage the climate hazard impacts? Note: supports in the form of both resources and services.
5. Have any institutions/organizations/groups also supported farming households vulnerable to climate hazard impacts?
6. Would you agree that climate hazards' impact on food security varies between various groups – women, men, elderly, youth, and children? a. Yes, b. No. What are your reasons:
7. How are you helping/supporting women and men differently?
8. What have been some of the challenges encountered in supporting farming households to respond to climate hazard impacts on food security?
9. What should be done to overcome these challenges?

Appendix B: Focus Group Discussion

Community:
Name of lead discussants:
Name of note takers:
Date and time:
Methods: Seasonal calendar, hazard mapping, and vulnerability matrix

Introductory remarks:

- Welcome and thank participants.
- Purpose of the discussion: to understand the context of food production, processing, storage, marketing, and consumption in the community in the face of the changing climate conditions.
- Duration: The discussion will take 1 hour and 30 minutes. There will be two sections, 45 minutes each and 5 minutes break.
- Benefit of the project/discussion: student research in partial fulfilment of the award of a degree in the University. Information from the discussion will be used publicly for academic purposes in teaching students, but no one's name will be mentioned in the process. So, please feel free to express yourselves freely. We encourage everyone to talk.
- Consent: We would record tape, video, and take pictures, if you agree. Any questions at this point? Do you agree for us to proceed to start the group discussion activities?

Questions:

1. Identify the key months within the year when you start to produce (ploughing, fertilizer application, sowing), harvest, store, sell, buy, and consume food?
   Note: <u>food security calendar</u> to allow the research to identify periods of food abundance and possible hungry months.

Key crop	Food production, harvesting, storage, market (buying and selling) practices.											
	Jan	Feb	Mar	Apri	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
a.												
b.												

2. What are the most important livelihood assets (human, physical, natural, financial, and social resources) and institutions (social, cultural, political agencies, organisations, rules, norms, taboos etc.) that facilitate the community's ability to produce, harvest, store, buy, sell, prepare, and consume food for healthy life?

(b) For each of the livelihood resources and institutions, what are the roles and limitations for food security?
(c) Also, who has access and who controls these livelihood assets and institutions, and who does not?
Note: At this point ensure that participants produce a resource analysis and an institutional analysis

Livelihood assets	Roles	Limitations	Control	Access	Restricted access
a.					
b.					

Institutions/agencies/organisations	Roles	Limitations	Control	Access	Restricted access
a.					
b.					

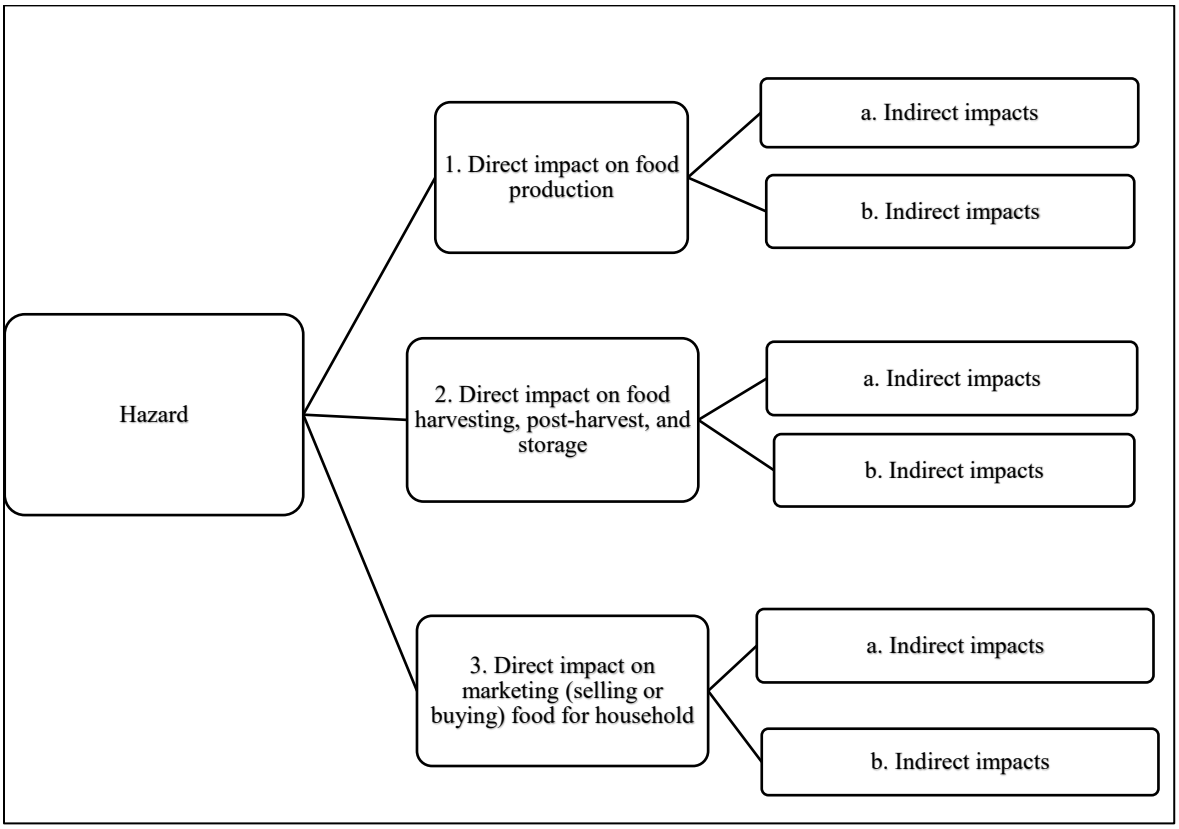
3. (a) Identify the pattern of current climatic conditions (including temperature, rainfall, winds, humidity) in the community throughout the year and compare with the past (last 10 years)?
(b) Which climatic hazards are associated with the changes in climatic conditions?
A hazard is a threatening event or a potentially damaging phenomenon, activity, or process within a given period and area.
Note: Produce a climate hazard calendar to allow the research to identify periods of hazard occurrences.

Answers:

Climate variables/conditions		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
a.	Current												
	Past												
b.	Current												
	Past												

Climate hazards	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
a.												
b.												
c.												

4. Identify the most important impacts (direct and indirect impacts) of each the climatic hazards on food production, harvesting, postharvest storage and processing, market, and consumption?
   Note: At this point ensure that participants produce an <u>impact chain</u>



5. (a) What is the intensity of impact of each climatic hazard on food production, harvest, storage, market, and consumption activities. Please explain.
   Note: At this point ensure that participants produce a <u>vulnerability matrix table</u> incorporating scores according to the following scoring system:
   0 = no impact,
   -2 = medium negative impact
   -1 = small negative impact
   -3 = strongly negative impact
   1 = small positive impact
   2 = medium positive impact
   3 = strongly positive impact)
   <u>Answers:</u>

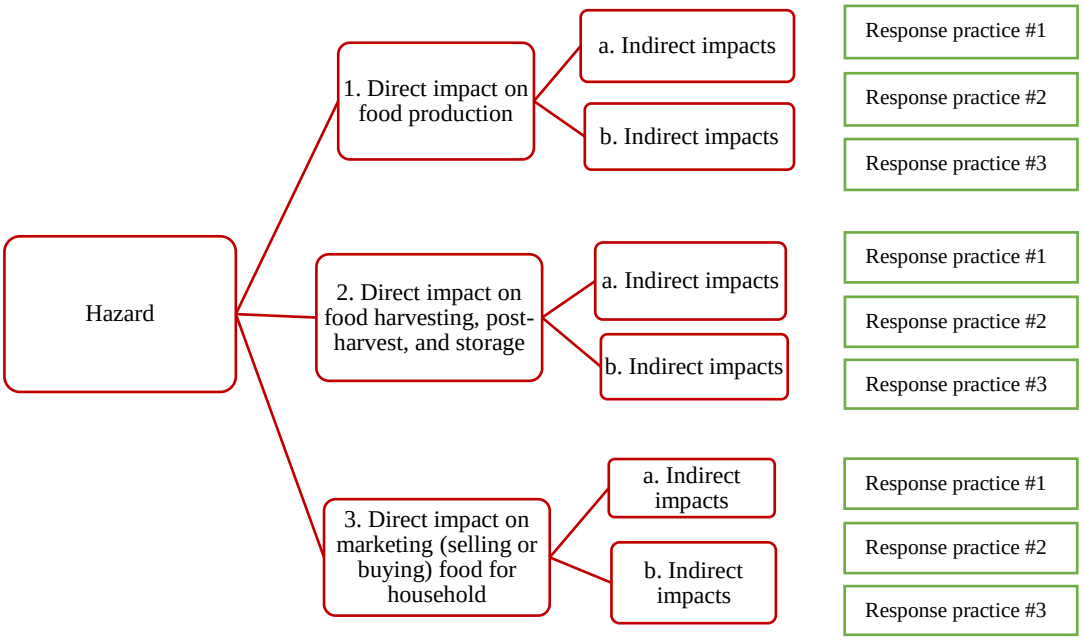
Hazard	Food system practices					
	Land preparation	Production	Harvesting	Post-harvesting	Storage	Marketing (selling and buying)
a. Dry spell	-3	-3	-2	-2	-1	0
b. Windstorms						

Participants must explain each score they allocate in the table.

6. a) How are the households responding (coping/adapting) to each of the climate hazard impacts?
   (b) Identify key resources and services that are crucial for adopting each response (coping/adaptation) option. Please explain how supportive these resources and services have been in the response/coping/adaptation process.

   Note: At this point ensure that participants produce a climatic hazard response pathway. You can add more than one if there are several main responses for each impact, but do not list more than three response strategies.

   Answers:



7. What factors facilitate the adoption of these response practices? What challenges do you face in adopting these response practices?

8. Which livelihood resources and services have depleted or diminished as a result of you (households) adopting these response practices? Please provide reasons.

9. What alternative response/coping practices would you like to adopt to manage the impacts of climate hazard without depleting the community's resources?

Role of moderator:

The role of moderator is the most important for encouraging participants to talk and for getting quality data. A major challenge for local facilitators is to grasp the role of the moderator, which involves:

1. The use probes at the appropriate time.
2. Participation in the discussion but without personal input.
3. Allocating equal time to each participant.
4. Reviving the discussion with the formulation of topic questions.
5. Learning to handle difficult participants and undisciplined participants who cut in.
6. Controlling participants who turn the topic into a political issue.
7. Keeping track of each participant's answers.

How should note takers record their notes?

Note takers should focus on three things:

1. Observations of the group. Are people excited or lacking in interest? Do people have a lot to say, or are they reluctant to speak? Are some people dominating the discussion while others are silent? Is the group cohesive or are there great differences of opinion?

2. Quotes illustrating the varied opinions being presented. There is much value in capturing the exact words that are used by participants. These words are the actual "data," the essence of the meeting. Try to capture as much of the conversation as possible using the exact words that people speak. These quotes will be included in the final report.

3. Summary of key discussion points. As each question is posed, individuals will offer their opinions, but there is often some nonverbal communication that also relays the group's perceptions, feelings, and thoughts on the issue. These reactions should be captured by the note taker and summarized along with the general discussion. Note that the group does not have to reach consensus. The summary can give all sides of the issue

Appendix C: Household Questionnaire

Study Topic: Security in uncertainty: An analysis of climate risks, household responses, and sustainable food security in northern Ghana.
Researcher: Balikisu Osman, Faculty of Environment and Urban Change, York University, Canada
Email: bosman6@yorku.ca / Tel: 0557548819

SECTION A: BACKGROUND INFORMATION

Name of Community/Zone

a. Gingabnia/Doba
b. Gayingo/Doba
c. Gware/Manyoro
d. Akumbisi/Manyoro
e. Bawio/Pungu
f. Nimbasnia/Pungu
g. Kologo/Kologo
h. Zuo/Kologo
i. Korania/Navrongo
j. Tampola/Navrongo
k. Naaga/Naaga
l. Chaaba/Naaga

Questionnaire Administrator's Initials

a. Evelyn
b. Jacob
c. Louis A
d. Shirley
e. Percy

SECTION B: DEMOGRAPHIC CHARACTERISTICS

1. What is your household size?
   a. 1-3 people
   b. 4-6 people
   c. 7-9 people
   d. 10 or more people

2. What is your highest level of educational attainment?

a. No formal education
b. Basic education
c. High school
d. Tertiary

3. How long have you lived in this community?
   a. Less than 5 years
   b. 5-10 years
   c. 11-15 years
   d. 16-20 years
   e. 20+ years

4. What is your age?
   a. Less than 20yrs
   b. 20-30 years
   c. 30-40 years
   d. 40-50 years
   e. 50-60 years
   f. 60+ years

5. What is your gender?
   a. Male
   b. Female

6. What is your marital status?
   a. Single
   b. Married
   c. Divorced
   d. Widow(er)

SECTION C: FOOD SYSTEM AND FOOD SECURITY CONTEXT

7. On average, how many days in a week do you consume food from the groups specified below?

Food groups	Number of times								
	0	1		2	3	4	5	6	7
a. Cereal									
b. Tubers and root crops									
c. Pulses/legumes									
d. Meat									

e. Fish									
f. Vegetables									
g. Fruits									
h. Dairy									
i. Sugar									
j. Oil									

8. How will you rate availability of your top five food items (listed in Q8) throughout the year?
   Please use the codes: 0-Not Available, 1-Rarely Available, 2-Available, 3-Highly Available

Food items	Availability Rating											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Maize												
Millet												
Vegetables												
Guinea Corn												
Beans												
Rice												
Ground nut												

9. How do you get access to our top five food items (listed in Q8) in a typical year?
   Please use the following codes:
   0=None 3=Exchange (e.g; labour) 6=Hunting and gathering
   1=Own production 4= Assistance from family and friends
   2=Market 5= Food aid (Gov't, NGOs etc)

Food items	Food Access strategies											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Maize												
Millet												
Vegetables – Kenneth, pepper, okro												
Guinea Corn												
Beans												
Rice												

Ground nut												

10. Who contributes to the household's access to food (through production, buying, exchange, in-kind, hunting etc.)?
    a. Household Head
    b. Other Adult men
    c. Other adult women
    d. Young women
    e. Young men
    f. All the above

11. Which of the following factors is a key barrier to your household's access to the food?
    a. Inadequate finance/income
    b. Lack of better storage facilities
    c. Inadequate access to information
    d. Limited access knowledge and skills
    e. Climate conditions
    f. Cultural barriers – values, beliefs, norms, and taboos
    g. Gender barriers
    h. Age/Ethnic/Class barriers

SECTION D: Vulnerability context

12. Relative to other households in my community, my family is quite healthy.
    a. Strongly agree
    b. Agree
    c. Neither agree nor disagree
    d. Disagree
    e. Strongly disagree

13. Do you own any of these assets/resources?

	1=Yes	2=No
Motorbike		
Bullock for ploughing		
Livestock – example donkey/cow/sheep/goat		
Fowl – chicken, guinea fowl etc..		

14. How many farm plots do you cultivate your food crops on during the main cropping season?
    a. 1 farm plot
    b. 2-4 farm plots
    c. 5-7 farm plots
    d. 8-10 farm plots
    e. More than 10 farm plots

15. What is your major means of accessing/securing the land for farming?
    a. Inheritance
    b. Purchase
    c. Gift
    d. Rent/lease
    e. Others

16. What is the average size of each land?
    a. Less than 2 acres
    b. 2-3 acres
    c. 4-5 acres
    d. 6-7 acres
    e. 8-10 acres
    f. More than 10 acres

17. What is the average total volume of harvest from each farmland you cultivate in the main cropping season?
    a. Less than 2 mini-bags
    b. 2-4 mini-bags
    c. 5-7 mini-bags
    d. 8-10 mini-bags
    e. More than 10 mini-bags

18. Do you usually sell part of your harvest from the main cropping season?
    a. Yes
    b. No
    c. Sometimes

19. What percentage of your total harvest do you sell?
    a. Less than 10%
    b. 10-30%
    c. 30-50%

d. 50%
e. More than 50%

20. Are you into dry season farming?
    a. Yes
    b. No
    c. Sometimes

21. How long do you travel to your dry season farm?
    a. Less than 1 km
    b. 1-3 km
    c. 4-7 km
    d. 8-10 km
    e. More than 10 km

22. Do you or any member of your household engage in an income earning activity such as trading, by-day, civil services – teaching, nurse, any NGO or government work?
    a. Yes
    b. No

23. Has any member of your household travelled to the south or to other places in the north for work?
    a. Yes
    b. No

24. Please identify weather you use the following farm inputs in your food production.

Farm inputs	1=Yes	2=No
Hoe and cutlass		
Bullock plough		
Tractor plough		
Fertilizer		
Improved seeds – early maturing and high yielding seeds		

25. What is your main form of transport to the market, either to buy or sell food items?
    a. Walking
    b. Bicycle
    c. Motorbike/Tricycle/MotorKing
    d. Car

26. How long do you travel to the market, either to buy or sell food items?
    a. 1-3 km

b. 4-7 km
c. 8-10 km
d. More than 10 km

27. Please identify weather you use the following inputs/resources during your post-harvest processing and storage of food crops?

	1=Yes	2=No
Threshing/shelling machine		
Pots/Gourdes		
Barn		
Storeroom/room		
Warehouse		
Chemicals for storing food produce		

28. Which household members are involved in the following food production, marketing, processing, storage, and consumption activities?

Activities	1=Men	2=Women	3=Both
Crop production – ploughing, weeding, harvesting etc..			
Buying or selling food items			
Threshing and shelling			
Winnowing and drying			
Packaging and storage			
Preparation/cooking of food			

29. Do you have access to these services available in the community?

Services	Yes	No
Credit/loans/savings		
Labour		
Ploughing		
Grinding mill		
Market		
Agro-inputs dealers		
Transport operators		
Information services		
Training services		

30. Do you have any of the following institutions, organizations, and agents are available in your community?

Institutions/organizations/agencies	Yes	No
Community groups		
Traditional council		
Government agencies/officers		

Civil society organisations (NGOs)		
Private sector agents/dealers		

31. How do these institutions listed above support your food production, marketing, processing, storage, and consumption practices (listed in Q13)?

Supports	Community groups	Traditional council	Government agencies/officers	Civil society organisations (NGOs)	Private sector agents/dealers
Land					
Labour					
Credit/loans/savings					
Ploughing					
Grinding mill					
Market					
Agro-inputs dealers					
Transport operators					
Information services					
Training services					

32. Which of the following factors is a main challenge to your food production, marketing, processing, storage, and consumption practices (listed in Q13)?
    a. Inadequate finance/income
    b. Lack of better storage facilities
    c. Inadequate access to information
    d. Limited access knowledge and skills
    e. Climate conditions
    f. Gender barriers
    g. Age barriers
    h. Class barriers/inequalities

SECTION E: ASSESSMENT OF KEY CLIMATE HAZARDS AND IMPACTS

33. Is any of the following climatic hazard events common in your community?

Climatic hazards	1=Yes	2=No
Extreme temperature/heat		
Drought/dryness		
Floods		
Windstorms		
Erratic rainfall (unpredictable and out-of-season rains)		

34. How often does each of the climatic hazard events occur?

Occurrence	Climatic hazards

	Extreme temperature/heat	Drought/dryness	Floods	Windstorms	Erratic rainfall
Always					
Thrice in a year					
Quarterly					
Ones in a year					
Ones in 2yrs					
Ones in 3yrs					
Ones in 5yrs					
Ones in 10yrs					
Other (specify)					

35. What are the impacts of climate hazard events on your household's ability to cultivate/produce food?
    a. Reduce water resources
    b. Erode topsoil
    c. Increases rate of crop wilt
    d. Increases cost of ploughing
    e. Increase cost of labour (Outmigration)
    f. Others: …….

36. What are the impacts of climate hazard events on your household's ability to sell or buy food from the market ?
    a. Damages to roads
    b. Loss of foot and motorbike paths
    c. Increase cost of transport
    d. Increase food prices
    e. Others: …….

37. What are the impacts of climate hazard events on your household's ability to dry, thresh, shell, and store food crops after harvesting up to the next harvesting season?
    a. Damages to storage infrastructure
    b. Limits drying and milling operations
    c. Increase cost of threshing and shelling crops
    d. Spoils stored crops/seeds
    e. Others: …….

38. What are the impacts of climate hazard events on your household's ability to properly prepare, eat, and get the full benefit/energy from food, including the quality, quantity, and nutrition content?

a. Loss of crops/unemployment/loss of income
b. Increases food rotting and contamination
c. Reduce household food availability
d. Incidences of malnutrition
e. Starvation/Hunger
f. Others: …….

39. How will you rate the overall intensity of impacts of climatic hazard events on your food production, marketing, processing, storage, and consumption practices?
Scoring Guide: 0=No Impact 1=Very Low 2=Low 3=Moderate 4=High 5=Very High

Hazard	Intensity of impacts			
	Food production	Food marketing	Food processing and storage	Food consumption practices
Extreme temperature/heat				
Drought/dryness				
Floods				
Windstorms				
Erratic rainfall				

40a. How will you rate the overall intensity of impacts of climatic hazard events on your food production activities, including land preparation, sowing, crop germination, and harvesting?

Climate hazards	0=No Impact	1=Very Low	2=Low	3=Moderate	4=High	5=Very High
Extreme temperature/heat						
Drought/dryness						
Floods						
Windstorms						
Erratic rainfall						

40b. How will you rate the overall intensity of impacts of climatic hazard events on your food marketing activities, including pricing of food, transport network, and cost of transportation?

Climate hazards	0=No Impact	1=Very Low	2=Low	3=Moderate	4=High	5=Very High
Extreme temperature/heat						
Drought/dryness						
Floods						

Windstorms						
Erratic rainfall						

40c. How will you rate the overall intensity of impacts of climatic hazard events on your post-harvest processing and storage of food, including activities such as threshing, shelling, drying, winnowing, packaging, and storage?

Climate hazards	0=No Impact	1=Very Low	2=Low	3=Moderate	4=High	5=Very High
Extreme temperature/heat						
Drought/dryness						
Floods						
Windstorms						
Erratic rainfall						

40d. How will you rate the overall intensity of impacts of climatic hazard events on your ability to properly prepare, eat, and benefits from food, including the quality, quantity, and nutrition content of the food you mainly consume in the household?

Climate hazards	0=No Impact	1=Very Low	2=Low	3=Moderate	4=High	5=Very High
Extreme temperature/heat						
Drought/dryness						
Floods						
Windstorms						
Erratic rainfall						

40. What factors contribute to the impacts of climate hazard events on your food production, marketing, processing, storage, and consumption practices?
    a. Poor infrastructure
    b. Limited financial resources (credit and savings)
    c. Inadequate labour
    d. Inadequate knowledge, skills, training
    e. Inadequate access to market and climate information
    f. Others: …….

SECTION F: IDENTIFICATION OF RESPONSE OPTIONS AND FACTORS

41. Do you engage in any of these practices as a way to manage and cope up with the impacts of climate hazard events and ensure that your household have enough and quality food to eat throughout the year?

Response practice	a. Yes	b. No
Mulching/animal manure/fertilizer application		
Irrigation		
Avoiding bush burning/cutting down trees		
Drought resistant		
Flood resistant varieties		
Early maturing crops		
Labour jobs (by-day)		
Trading/business activities		
Migration/travelling to work in the south or other places/areas in the north		
Not selling portions of harvested crops		
Reducing the amount of food consumed in a day		
Changing diet/eating other foods that are usually not common in the household		
Supervising grain/food allocation and handling more strictly		
Relying on heavily on women's contributions of food for the household		
Relying on families and friend for food or money to buy food		
Selling farm animal		
Weather insurance		
Others: ……		

42. Please tell us whether you usually receive any help and support from the organisations/agencies below when you are adopting practices to manage and cope up with the impacts of climate hazard events. And what form of support do you receive?

	a. Nothing	b. Helping hands or labour	c. In-kind food or money support	d. Credit, savings, loans	e. Education and training	f. Information services
Family and friends						
Collective groups						
Traditional council						
Local government						
NGOs						
Others: ……						

43. Which of these factors is a great challenge when adopting practices to manage and cope up with the impacts of climate hazard events?

    a. Lack of financial resources – credit, savings, loans
    b. Poor access to climate information
    c. Lack of institutional support
    d. Complex land tenure systems

e. Gender issues
f. Social-cultural barriers
g. Lack of ready markets
h. High cost of and limited access to improved crop varieties
i. Lack of farm implements and machinery

SECTION G: ASSESSMENT OF THE CLIMATE HAZARD IMPACT RESPONSE PRACTICES TOWARDS SUSTAINABLE FOOD SECURITY

44. Do the practices/actions you adopt to survive/cope up with the impacts of climate hazards enable you to get more food for your household throughout the following months?

Practices	a. Never	b. Sometimes	c. All the time
Soil and land management			
Crop management			
Livelihood diversification			
Dietary management			
Insurance practices			
Others – hire labour, ban on noise, farm less			

45. Do the response practices/actions negatively affect someone within or outside your household?
    a. Elderly women
    b. Elderly men
    c. Adult women
    d. Adult men
    e. Children
    f. None
    g. All the above

46. Which livelihood resources are depleting as a result of the practices/actions you are adopting to survive/minimize the impacts of climate hazard events?
    a. Water bodies – rivers, streams, dam
    b. Land size
    c. Soil fertility
    d. Human resources/labour
    e. Livestock
    f. Capital assets – machines/implements

g. Income
h. Savings at home or bank

47. Which well-being issues are encountered in the process of adopting practices/actions to survive the impacts of climate hazard events?
    a. Human health
    b. Water pollution
    c. Air pollution
    d. Land degradation
    e. Housing destruction

48. Which of the following agencies/organisations could be most important in your decision/plans to adopt the alternative practices/actions listed above?
    a. Collective groups in the community
    b. Local government
    c. Local civil society (NGOs)
    d. International civil society (NGOs)
    e. Traditional council
    f. Private sector agencies/agents

Thank you for your time.