

CLIMATE CHANGE IMPACTS ON SMALLHOLDER FARMERS' LIVELIHOOD IN THE NORTH EAST REGION OF GHANA

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ABSTRACT

Climate change poses substantial challenges to smallholder farmers in Kubori, a community in Ghana's northeast region, where livelihoods are predominantly reliant on rain-fed agriculture. Using a mixed-methods approach that included a survey of 47 farmers and interviews with key informants from the community, such as assembly members, chiefs, and District Department of Agriculture officers, this study, guided by the Sustainable Livelihood Framework, investigates how climate change affects farmers' livelihoods and adaptive strategies. The findings indicated widespread awareness of climate change, with 87.2% of respondents reporting adverse effects on food availability, including reduced crop yields and increased food prices. The study further revealed irregular rains (42.6%) and drought (27.7%) hamper planting schedules and soil health. Although adaptive measures such as drought-tolerant varieties (27.7%) and diversification (19.1%) were used, economic constraints (38.3%) and inadequate supply of irrigation technology limit effective adaptation. In addition, 72.3% of farmers experienced decreasing incomes, resulting in 44.7% diversifying into off-farm activities. The study concludes that while farmers show readiness to switch, this is hindered by climatic uncertainty and structural barriers.

Keywords: Climate Variability, Livelihood, Agricultural Financing, Climate-resilient, Smallholder Farmers

INTRODUCTION

Globally, agricultural production is dominated by smallholder farmers, who typically operate on small pieces of land and capital and rely on rain-fed cropping (Thornton et al., 2011). Since they are highly integrated with the environment, they become more vulnerable to enduring the negative effects of climate change. Climate change is expressed in terms of a variety of phenomena, such as changes in rainfall patterns, increased frequency of life-threatening weather occurrences, warming temperatures, and changes in pest and disease regimes that pose significant challenges to the ability of smallholder farmers to sustain their livelihoods (Thornton et al., 2011). These changes conflict with traditional agriculture practices, risk crop yields, undermine animal productivity, and decrease natural resources availability, threatening the economic sustainability and resilience of smallholder farming households (Allison et al., 2009).

Socioeconomic factors like limited resource access, economic constraints, and lack of infrastructure exacerbate smallholder farmers' vulnerabilities to climate change. (Dixon et al., 2001). Furthermore, the effects of climate change reach beyond agricultural productivity to affect other drivers of smallholder farmers' livelihoods, including income security, food security, and overall well-being (Bryan et al., 2009). For instance, climate variability can degrade market access and reduce the ability of smallholder farmers to generate income, pushing them deeper into poverty (Dillon et al., 2011). In spite of these facts, climate change also facilitates environmental degradation, e.g., soil erosion and water scarcity, and thus increases the exposure of smallholder farmers, presenting them with long-term risks in terms of adaptive capacity and resilience (Müller et al., 2010).

The smallholder farmers in Ghana largely depend on rain-fed agriculture, which impacts their productivity, food security, and socio-economic well-being. For example, research by Chemura et al. (2020) points out how varying rainfall and rising temperatures are leading to the decline of crop yields and food security in Ghana. Again, it is evident that climate change-induced extreme weather conditions like floods and droughts disrupt agro-based livelihoods, especially in rural areas (Fosu-Mensah et al., 2012). In North Eastern Ghana, climate change has affected individuals' livelihoods by decreasing their production levels and yield outputs. For example, Atitsogbey et al. (2018) found that due to climate change, the yield for rice dropped from 2.8 tons/ha to about 1.9 tons/ha, and these impacts are based on the changing climate because of overgrazing by livestock, the cutting down of trees, and the burning of charcoal and bushes. The study region is located within an ecological zone that is noted for higher climate variability and erratic rainfall patterns, compared to other places in the country. Moreover, within the past three decades, there has been a regular occurrence of rainfall-related crop failure (Antwi-Agyei, 2012; MoFA, 2016a), yet limited attention has been given in terms of research (Asante et al., 2021). Meanwhile, farming households and/or communities in the study region rely primarily on rain-fed agriculture for their livelihoods. Consequently, any risk to stable/predictable rainfall patterns is a threat to their livelihoods, and hence, the need for systematic research.

Although there have been limited studies examining Ghanaian smallholder farmers' perception and response to climate-related livelihood insecurities, these have largely been at the national level, and there has been less focus on the community-level implications for the livelihoods of farmers and their adaptation reactions. This study, therefore, tries to fill this gap by providing localized information, mainly from the perspective of smallholder farmers in Kubori, that can better inform targeted interventions. To comprehend the complex smallholder farmers' livelihoods dynamics and climate change at local levels, there is a need to formulate sufficient adaptation and mitigation strategies for them to be more resilient, as well as to contribute to sustainable development. Additionally, to reverse the livelihood vulnerability of some groups to climate change, research must be community-focused to guide rural development. The general objective of the study is to examine the impacts of climate change on the livelihood of smallholder farmers. Specifically, the paper is structured around three key questions: (a) What are the smallholder farmers' perspectives on climate change and its main causes? (b) What are the effects of climate change on farming activities/practices and other livelihood sources? (c) How do smallholder farmers adapt and mitigate climate change impacts on their livelihoods? We investigate these questions in Kubori, a community in the Manpurugu Moaduri District of Ghana.

The main point of contention inspiring this paper is that the promotion of climate change adaptation for rural development is mutually beneficial to the enhancement of agricultural-related livelihoods of smallholder farmers. This will therefore enlighten policies and initiatives intended at promoting sustainable development and provide policymakers with valuable insights for designing effective policies and allocating resources to address the needs of vulnerable agricultural communities. This study also aligns with Ghana's National Climate Change Policy, particularly the priority area of making agriculture and food security systems more resilient to climate change, through the provision of local-level evidence to support more effective implementation (Ministry of Environment, Science, Technology and Innovation, 2013). At the global level, the study will help contribute to achieving the United Nations Sustainable Development Goals (SDGs), namely SDG 13 (Climate Action), SDG 2 (Zero Hunger), and SDG 1 (No Poverty), by its focus on the need for adaptive interventions and policy reforms that have the potential to immunize rural livelihoods from climate change. The remainder of the paper is structured to include a theoretical and empirical literature review, materials and methods, results and discussions, and a conclusion and policy implications of the findings.

THEORETICAL FRAMEWORK

Sustainable Livelihood Framework (SLF)

This study is guided by the sustainable livelihood framework (SLF) that focuses on how people, and more so smallholder farmers, make use of livelihood assets (natural, human, financial, social, and physical) within a context of shocks, trends, and seasonality. They make choices through structures like government or Non-Governmental Organisations (NGOs) and processes like laws, policies, culture, and institutions that lead to livelihood outcomes like income, well-being, or food and

livelihood security (Antwi-Agyei et al., 2014; Chambers & Conway, 1992; Solesbury, 2003). Livelihoods are often regarded as the root of any development that makes the sustainable livelihood perspective relevant. The framework can be described as a people-centred paradigm in real life because it integrates social, environmental, and holistic issues by considering people's capacities and knowledge. It is therefore considered a long-term and short-term coping capacity that enables individuals and communities to deal with a changing climate and other circumstances (Paavola, 2008).

Therefore, conclusions derived from this model enabled conceptualisation and enhanced illumination of the livelihood processes of the research location, Kubori (Figure 2). Vulnerability is not simply a result of stress but a product of the socio-economic character of a population that defines the degree to which their life and livelihoods are endangered by a divergent and recognisable event in nature or society. In spite of these facts, the framework contends that households that rely on agriculture may be in a position to minimize their general vulnerability to climate change through diversification of the portfolio of livelihood. (Ellis, 2000; Fraser et al., 2005).

The sustainable livelihood framework has been criticised by Antwi-Agyei (2012) for failing to recognize allocation and distributional issues of resources by considering issues of equity, which is of paramount significance in coping and adapting to climate change. Therefore, this study bridges this gap, looking at climate change as a multi-scale vulnerability appraisal by mapping vulnerability at both household and community levels. Hence, this study followed a lead from the sustainable livelihood framework concept because of its ability to help in the measurement of livelihoods in relation to vulnerability of households/individuals and how they are susceptible to the impacts of climate change.

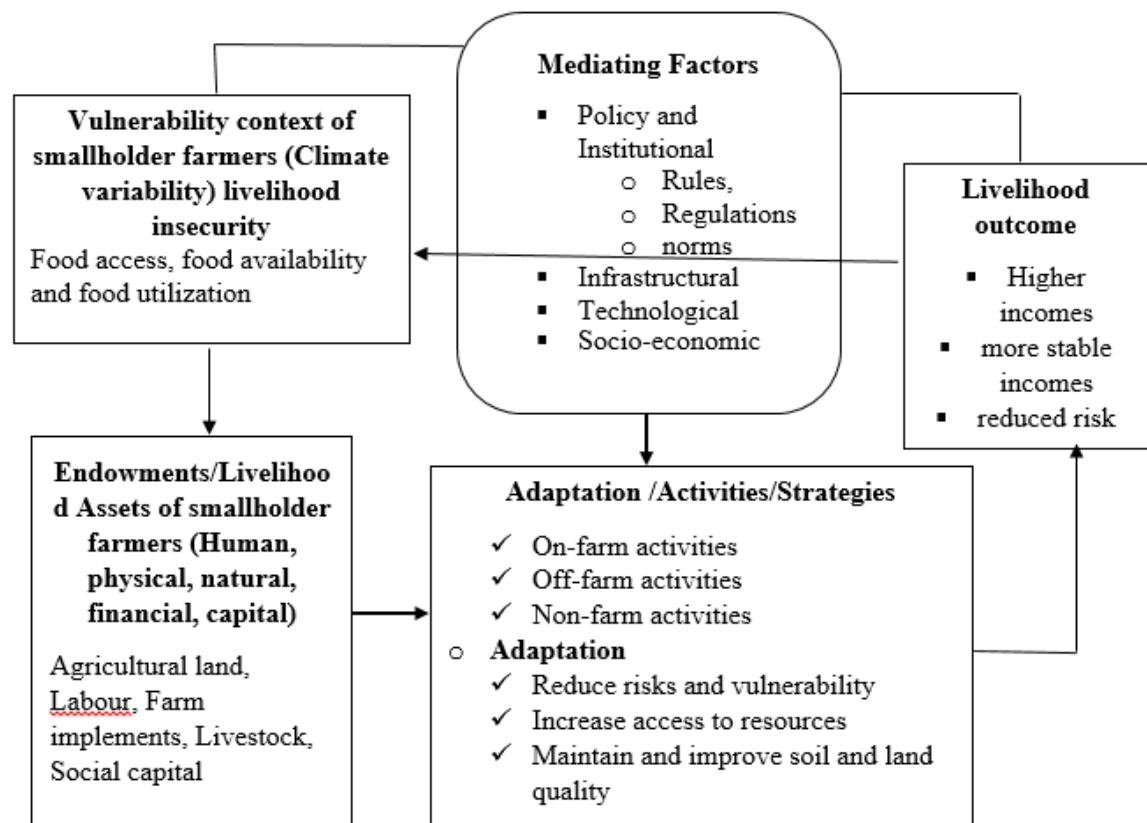


Figure 1: Sustainable Livelihood Framework

Source: Modified from Jufare (2008)

LITERATURE REVIEW

Impacts of climate change on livelihoods

Climate change is a global phenomenon, impacting livelihoods in various sectors of the economy and regions, especially among agriculture- and natural resource-based communities. At the global level, increased temperatures, unpredictable rainfall, and a higher frequency of extreme weather events such as floods and droughts have led to decreased agricultural productivity, food insecurity, and migration. According to the Intergovernmental Panel on Climate Change (IPCC, 2022), these impacts disproportionately affect developing and low-lying countries. According to the World Bank (2018), over 140 million climate change migrants are projected to arise in sub-Saharan Africa, South Asia, and Latin America by 2050 because rural livelihoods are becoming less viable.

In Africa, livelihood threats are particularly acute in light of the continent's susceptibility to rain-fed agriculture that supports nearly 60% of the population (Derbile et al., 2019). Widespread crop losses, animal losses, and heightening food insecurity have been the outcomes of frequent flooding and drought. East African nations have endured prolonged periods of drought, while zones in Southern Africa have experienced increased precipitation uncertainty and stronger storms (UNEP, 2020). These climatic stresses are intensified by inadequate access to climate-

resilient technologies, weak infrastructure, and weak institutional support systems that weaken effective adaptation.

The West African situation is no different from these continental issues. Desertification, volatile rainfall, and land degradation have grown in the region, particularly in the Sahel. Pastoralists and farmers are vying more fiercely over decreasing water resources and agricultural land, which breeds conflict and displacement (USAID, 2018). Major crops like maize and cocoa are increasingly affected by rainfall uncertainty, which causes consequent food security and export-led economies in countries like Ghana, Nigeria, and Côte d'Ivoire (World Bank, 2019). These problems have driven mounting rural-urban and even pan-national migration, propelling traditional livelihood systems into chaos (DeGraft-Johnson et al., 2010).

Climate change has already had quantifiable impacts on different areas of the Ghanaian economy, primarily agriculture, fisheries, and forestry. Smallholder farmers are the mainstay of Ghanaian food production and are experiencing reduced yields from changing rainfall patterns and rising temperatures (Nyantakyi-Frimpong & Bezner-Kerr, 2015). Recurrent floods and droughts have also resulted in enhanced crop loss, food insecurity, and loss of revenue (Derbile et al., 2019). Fisheries too are affected, as increased water bodies alter the migration and spawning of fish and thus decrease the catches and threaten fishermen's livelihood (Allison et al., 2009). In the forestry sector, unpredictable rainfall and increased wildfires are decreasing the forest resources and wood production (Guodaar, 2021). Ghana has recorded a 7.2% annual average reduction in agricultural production in the past decade (GSS, 2022), and rural water availability has similarly fallen by 30% (GWCL, 2021), thereby contributing to the livelihood threats.

Northern Ghana, characterized by its semi-arid conditions, is one of the most climate-vulnerable zones in the country. The region is experiencing increasingly erratic rainfall, longer dry seasons, and higher temperatures, which have resulted in a 30% reduction in crop yields over the past ten years (MoFA, 2016). Water scarcity has become more pronounced, limiting both irrigation and livestock watering. Pastoralists in the north have reported declining pasture quality and rising cattle mortality rates, with a 25% drop in herd sizes attributed to heat stress and drought. Climate-induced land degradation and poor resource availability have pushed many residents to migrate to southern cities, contributing to changing family structures, labour shortages in agriculture, and increasing urban poverty (Ahsan & Özbek, 2022).

In the North East Region, upon which this study was conducted, the effects of climate change are being felt and on the rise. In areas such as Kubori, rainfall has declined from a mean of 1,200 mm to less than 1,000 mm in some years, while mean annual temperatures have risen from approximately 27°C in the 1990s to approximately 29.5°C in recent years (GMet, 2021). Such climatic changes have caused alterations in the conventional agricultural calendars as well as lowering the outputs of crops like rice, maize, and millet. The local farmers relate these changes to man-induced environmental degradation through deforestation, bush burning, and charcoal production. As a result, many smallholder farmers are diversifying their

livelihoods more through off-farm activities such as trading, artisanal work, and livestock rearing to cope with declining agricultural production and income insecurity. These findings affirm the urgent need for targeted climate adaptation policies and locally grounded interventions in the region.

METHODOLOGY

Study area

The study was conducted in Kubori, a community in the Mampurugu Moaduri District of the North East Region of Ghana (see Figure 1), which lies between 10° 08' 40" N and 1° 17' 23" W. Kubori is about 5 kilometres from the District Capital Yagaba, and about 306 kilometres from the regional capital of the North East Region, Nalerigu. It is one of the biggest communities in the Mampurugu Moaduri District, and has an estimated population of about 3,358 (Mampurugu Moaduri District Assembly, 2022). The residents of Kubori are largely into smallholder agriculture and petty trading. In addition, the youth of the community, both males and females, have resorted to education and skill learning activities such as rearing of livestock and poultry, tailoring, and mechanic work (motorcycle and bicycle repairs), weaving of smocks, and dressmaking. The adult population, particularly men, is engaged in small-scale farming, including the cultivation of rice and charcoal production, while women are engaged in shea nuts collection and processing, as well as rice cultivation and processing (Mampurugu Moaduri District Assembly, 2022).

The average annual rainfall pattern of the district, including the Kubori community, often ranges between 1000mm and 1400mm, which occurs mostly between May and October, the peak of the rainy season. With respect to temperature, it ranges high all year round, with March being the hottest month, and ranges between 25.50 °C and 36 °C. The natural vegetation is classified as Guinea Savannah Woodland with Alluvial soil, clay soil, and sandy soil as the major soil types, which support the cultivation of rice, yams, millet, beans, cowpea, maize, and vegetables (Mampurugu Moaduri District Assembly, 2022).

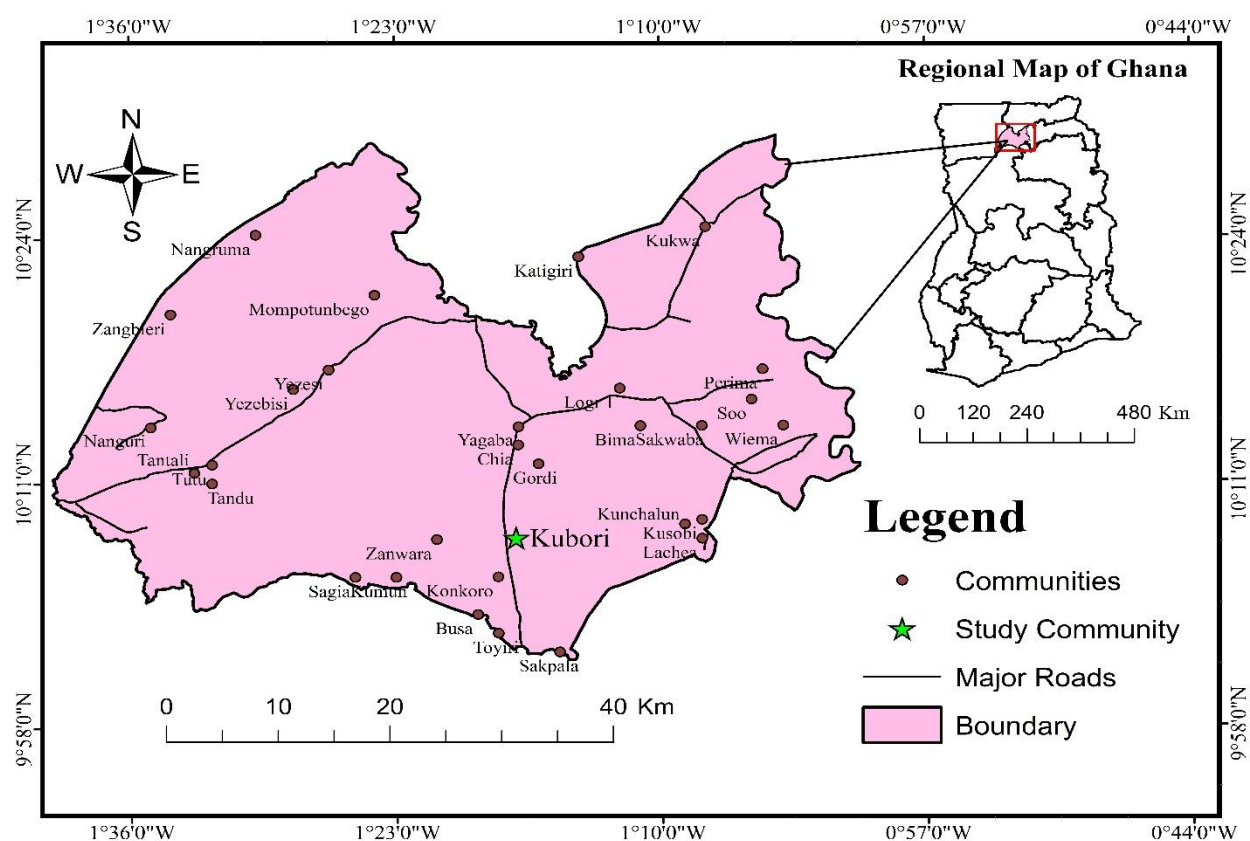


Figure 2: Map of Mampurugu Moaduri District showing the study community – Kubori.

Methods

This study employs a mixed method (Creswell & Zhang, 2009) to examine the impact of climate change on the livelihoods of smallholder farmers in Kubori using the explanatory sequential design. The study focused on Kubori, a prominent agrarian community in the Mampurugu Moaduri District of the North East Region of Ghana. The selection of only one community was purposive and strategic: Kubori is the most populous farming community in the district and represents the typical characteristics of smallholder farming and susceptibility to climate change in the district. This allowed for a comprehensive, context-specific examination of the issues under study.

In order to collect quantitative data, we employed a sampling method from (Cochran, 1942) to determine the sample size for the survey. That is, $n = \frac{Z^2 P(1-P)}{E^2}$ Where n = the sample size, N is the population of the study = 3310 (Mampurugu Moaduri District Assembly, 2022), E = margin of error 10% (0.10), Z is the confidence level of 90% = (1.645), and P is the estimated proportion (prevalence of climate change impacts) = an average of (15%, 25%, and 30%) $\frac{0.15+0.25+0.30}{3} = 0.23$ according to the existing literature on the prevalence of climate change on crops, animals, and biodiversity, respectively (GSS, 2013; MoFA., 2016a). The sample size for this study was calculated = $\frac{1.645^2 * 0.23(1-0.23)}{0.10^2} = 47$.

Therefore, a total of 47 respondents from the community were randomly selected using the stratified sampling method, where every 3rd household was skipped during the data collection to get the sample respondents for the quantitative data for the study through a survey using a structured questionnaire. While a Google online data collection tool (Google Form) was used to gather information from a section of the respondents who could read and write the English Language and/or could access the internet, face-to-face interviews were also conducted with those who could not read or write the English Language or access the internet. The respondents were both men and women who were engaged in smallholder farming or food crop production. After that, we conducted 10 semi-structured interviews with key informants, including smallholder farmer group leaders and District agriculture officers within the study area, to gather information to explain/supplement the quantitative data collected earlier.

The sample size of 47 respondents was determined using Cochran's (1942) formula, which is widely recognized for calculating sample sizes for large populations in survey research. The formula was applied using a 90% confidence level and a 10% margin of error, which are both acceptable standards for exploratory studies in rural or under-researched areas (Bartlett et al., 2001; Israel, 1992). These parameters ensure a reasonable balance between statistical reliability and fieldwork feasibility, particularly in contexts where data collection is challenged by geographical, logistical, and resource constraints. Although a lower margin of error (e.g., 5%) is often preferred in national-level studies, a 10% margin is considered adequate and scientifically valid for community-based or pilot studies, where the aim is to gain initial insights rather than make national generalizations (Miaoulis & Michener, 1976).

For the qualitative component, a purposive sampling technique was employed to conduct interviews with six key informants, including the assembly member and unit committee members in the study area, two Extension Officers, and two Respondents from the District Department of Agriculture, including the Crops officer and the District Director of the Department of Agriculture. In all, 10 participants were purposively selected for the interviews because of their knowledge and experience in smallholder farming as well as their willingness to share their experience with the researchers. These interviews, therefore, aimed at gathering in-depth insights into how climate change impacts the livelihoods of people in the study area, providing context and further explanation for the quantitative findings of the study.

In this study, 'livelihoods' has been considered an approach towards a living (Chambers & Conway, 1992) and was analyzed on the basis of the Sustainable Livelihood Framework (SLF), which considered five broad asset classes: human, social, physical, natural, and financial capital. The measuring tool of the survey gathered such indicators as sources and levels of income, availability of water and land, availability of farm inputs (physical), network in the community and support from agricultural extension (social), food availability and dietary habits (natural), and knowledge/farming skills (human). Following the context in section 2.1 and SLF asset types, we propose the following working definition of livelihood: a livelihood

encompasses the natural resource and non-natural resource-based activities required for the satisfaction of human basic needs. The natural resource-based aspects include food crops production, rearing of livestock and poultry, while the non-natural resource-based activities include petty trade (sales of farm inputs, outputs, and consumer goods), dressmaking and tailoring, weaving, construction activities, and mechanic activities (repairs of motorcycles and bicycles) (see Table 1 for details). These aspects permitted an integrated understanding of how climate change affects different dimensions of rural livelihood.

Table 1: Division of Livelihood Activities

Division	
Natural Resource-Based Activities	Non-Natural Resource-Based Activities
• Food crop production • Livestock rearing • Poultry farming • Collection or gathering	• Petty trading • Tailoring and dressmaking • Weaving of smock • Construction work • Repairs (motorcycle and bicycle)

Source: Authors' Construct Based on Various Literature

The quantitative data were coded and entered into Statistical Package for the Social Sciences SPSS (version 27) for statistical analysis. Descriptive statistics, including frequencies, percentages, and means, were computed and presented through tables and charts. Meanwhile, the qualitative data obtained from interviews were transcribed from audio recordings and organised into direct quotations, representing the interviewees' responses. The qualitative findings were then analysed thematically, corroborating the results derived from the quantitative analysis.

DATA ANALYSIS

Background characteristics of the respondents

To place the findings in context, it is necessary to be aware of the demographic composition of the respondents in the study. The background information on respondents' sex, age, education, religion, and years of farming experience of the 47 respondents who participated in the survey is presented in Table 2. This information is used to put into perspective the socio-economic and cultural situation of the farmers, which has the potential to influence their experience of and response to climate change impacts. The results showed that the majority (70.2%) of the respondents were males, while respondents in the age bracket of 31–40 years were the dominant age group (42.6%). In addition, the level of education of the respondents showed that a large proportion (48.9%) of them had no formal education. In terms of religion, the majority were Muslims (76.6%).

Table 2: Background Characteristics of the Respondents

Total respondent (N)	47	100
Sex of respondent		
Female	14	29.8%
Male	33	70.2%
Age of respondent	Frequency	Percent
21-30years	11	23.4%
31-40years	20	42.6%
41-50years	4	8.5%
51-60years	12	25.5%
Educational attainment of respondent		
JHS	5	10.6%
No formal education	23	48.9%
SHS/O/A Level	8	17.0%
Tertiary Education	11	23.4%
Religious status of respondent		
Christian	6	12.8%
Islam	36	76.6%
Traditional African Religion	5	10.6%
Years of experience in farming		
1-4 years	12	25.5%
10-14 years	13	27.7%
15-19 years	8	17.0%
20-24 years	4	8.5%
25+ years	6	12.8%

Source: Field Survey Data, 2024

Climate change awareness and perceptions among respondents

Understanding the degree to which farmers perceived the existence of climate change and their ability to respond to it is critical in evaluating their resilience. This is not to prove whether there is climate change in Manpurugu Moaduri District of Ghana. Figure 3 illustrates the levels of climate change adaptation among the surveyed smallholder farmers in Kubori. The responses are categorized into advanced, moderate, and limited adaptation, which vary according to the extent to which farmers are aware and have in fact utilized proper coping or adaptation strategies to mitigate the impact of climate variability on their well-being. The survey reported a greater awareness of climate change among the farmers in the study area as all the respondents agreed that they knew about climate change, recording a 100% extent of awareness among the 47 respondents for the study. As it is evident in Figure 3, when estimating the intensity of their awareness, 55.5% of the respondents described climate change prevalence as moderate, 21.3% believed climate change was limited, and 23.4% believed climate change was at its highest level in the study location.

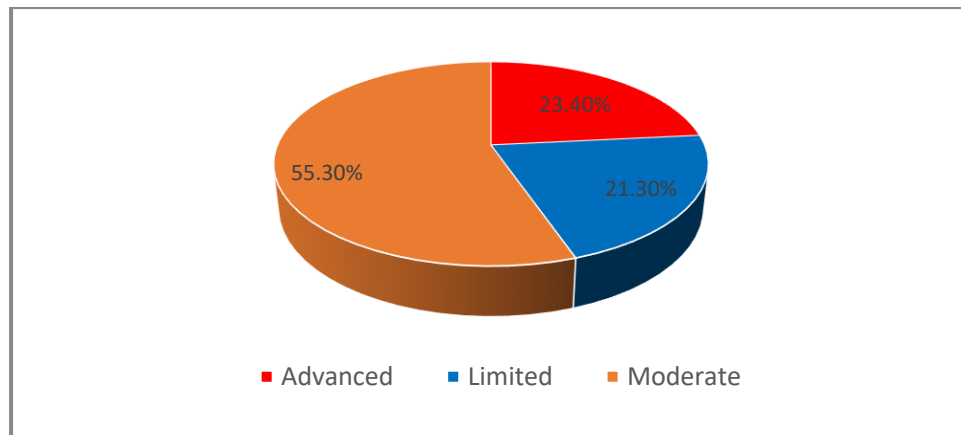


Figure 3: Respondent Description of Climate Change Prevalence

Source: Field Survey Data, 2024

In supporting the data from the survey, a respondent from the District Department of Agriculture and a key informant in the study community share their insights below;

“Talking about climate change, a lot of farmers are experiencing its impacts without their knowledge; we can talk about droughts, floods, and erratic rain, among others, which have immediate effects on farming output. For me, climate change has reached its advanced level in this district and precisely your study community (Kubori)” (District Agric. Crop Officer; September 2024).

“I believe that climate change has manifested in this community for a very long time, and we are already aware of its negative impacts on our lives as well as farming. Because of both the positive and negative impacts, I will describe its prevalence to be moderate” (Key Informant Kubori, September 2024).

Respondents’ perspective on the main causes of climate change

To better understand farmers’ perceptions of the drivers of climate change, respondents were asked to identify what they see as the most important causes of the phenomenon in the study area. Figure 4 presents the main causes of climate change as defined by the respondents. These results are crucial in assessing local beliefs and knowledge, which can affect communities’ response to climate issues. According to the respondents, the reasons for climate change in the area of study were grouped into five dominant causes, which are bush burning, change of season, charring/burning of charcoal, cutting of trees, and emission of harmful gases into the atmosphere. The study, therefore, validated (as noted in Figure 4 below) that 38.3% of the respondents believed that climate change in the study area was mostly caused by cutting down trees, while 23.4% also showed that climate change had been caused by bush burning in the study area. At the same time, 19.1% answered that charcoal burning/charring also causes climate change in the study site, while 8.5% answered that climate change was caused by the emission of gases into the atmosphere.

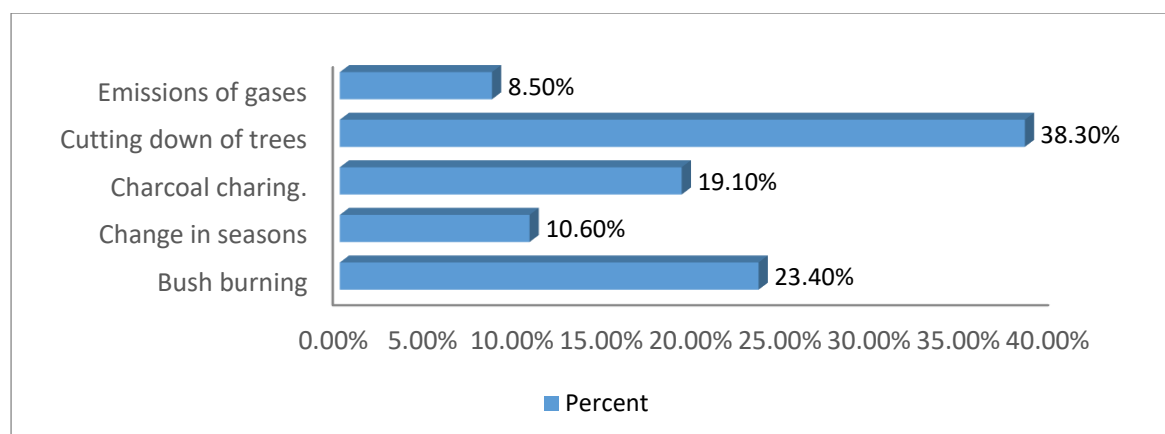


Figure 4: Main causes of climate change According to Respondents

Source: Field Survey Data, 2024

The Assembly member for the community and the District Director of Agriculture shared their views on the causes of climate change identified during the survey below;

"I will say climate change does not have specific causes, but there are leading factors from man's activities; otherwise, I will say climate change is caused by God, our maker. In my view, the major leading factors causing climate change in this community are the continued cutting down of trees and burning of charcoal by residents" (Assembly Member, Kubori; September 2024).

"[...] taking the district into consideration and your study area (Kubori), I have observed that climate change is mainly caused by continuous bush burning, cutting down of trees, and burning of charcoal. These activities are predominant here and studies have indicated that they are the major cause everywhere else in the world" (District Agric. Director (DoA); September 2024).

Climate change effects on the availability of Food

In ascertaining perceived effects of climate change on farming practices and food availability, respondents were asked about its impact on food production, selection of crops, and how frequent farmers encounter climate change effects. Table 3 shows the effect of climate change on food availability, the function of crop selection, and the frequency with which farmers experience the effects of climate change in farming operations. These responses provide valuable information on how climate change is affecting local food systems and farm selection in the study area. The results showed that a clear majority of the respondents (87.2%) are sure that climate change has effects on food availability in the study area. More than one-third (34%) of the respondents said that climate change might have been the cause of shortages of food, especially grains, vegetables, and fruits. The majority (36.2%) were of the view that climate change has often resulted in unfavorable agricultural produce. There was also evidence from the respondents' comments that 17% of respondents identified climate change as the reason for the cause of food price increase (with potential cascading impact on food availability), while 12.8% did not see any linkage

between food availability and climate change in the study area. In regard to how quickly respondents believed they were experiencing climate change, 48.9% reported experiencing it regularly (i.e., yearly). In addition, according to the study, 38.3% experienced climate change on an irregular basis (i.e., not yearly), but 12.8% believe that they never experienced climate change.

Table 3: Climate Change Effects on the Availability of Food

Effects on Food	Frequency	Percent
Food shortages (grains, vegetables and fruits)	16	34.0%
Increase in Food Prices	8	17.0%
Low production	17	36.2%
No effect	6	12.8%
influence on the Types of crops Respondents Cultivate		
Changed crop types	31	66.0%
No change	16	34.0%
Rate of Experience with Climate Change		
Frequently (every year)	23	48.9%
No experience	6	12.8%
Sometimes	18	38.3%

Source: Field Survey Data, 2024

Climate change Influence on farming activities

In addition to food production, climate change also has direct implications for farming activities/practices, as well as other livelihood sources. In view of this, respondents were asked how climate change has affected their farming activities, and whether they had resorted to other livelihood sources as a substitute or supplement. This section also explains the role of climate change in other livelihood options. Table 4 illustrates the reported effect of climate change on agriculture and other livelihood activities adopted by the respondents. The results have the implication of demonstrating the innovative agricultural activities and livelihood sources adopted by smallholder farmers in spite of climate change. These practices not only desire to innovate but are also being used increasingly in the context of climate change. One of the interesting observations of Table 4 findings is that climate change has a considerable impact on the farming activities of smallholder farmers (about 72.3%). The farmers identified crop diversification, frequency of manure application, the Zai pits planting system and rainwater harvesting as among those factors that climate change has on agriculture. The farmers reported that crop diversification, backed by more than half (51.1%) of them, was practiced both to offset crop failure in frequent cases and to take advantage of moisture retention. However, some of the farmers who listed crop diversification as a measure against climate change pointed towards one dominant problem, as seen in the following quote:

“Although intercropping, mixed cropping, or crop rotation help to improve yield, soil nutrients, and diversify the household diets, it is difficult to practice mainly because it is labour-intensive. One needs to handle each crop with the

appropriate attention and knowledge. Adopting them means painstaking planning of planting, manure application and weeding activities to coincide with household labour availability” (District Agric. Director, Kubori; September 2024).

Table 4: Climate Change Influence on Farming Activities, Other Livelihoods and Incomes

Influence	Frequency	Percent
Decreased	34	72.3%
Increased	1	2.1%
Remained unchanged	12	25.5%
Specific Farming Activities/Practices		
Frequency of manure application	11	23.4%
Crop diversification	24	51.1%
Zai planning pits system	5	10.6%
Rainwater harvesting	7	14.9%
Alternative Income Generating Activities/Non-farm Activities		
Artisanship	6	12.8%
Construction work	4	8.5%
Tailoring/Garment making	1	2.1%
No alternative	15	31.9%
Rearing of livestock	10	21.3%
Trading	11	23.4%

Source: Field Survey Data, 2024

Even though it is not a very prevalent farming activity among the smallholder farmers, the zai pits planting system (10.6%) has been documented as one of the soil fertility recovery measures being adopted as an adaptation measure to the risks posed by climate change. The interviews also revealed that the zai pits system provides opportunities for farmers to improve crop performance in the wake of the changing climate. Besides, some of the farmers reported that while they had been using manure (organic and inorganic) on crops, climate change and its implications, such as drought, poor crop yield, and/or loss of crops, had forced them to use it more often (for a proper reading on how often manure is applied see Nyantakyi-Frimpong & Bezner-Kerr, 2015). Approximately 23% of the respondents interviewed were using more manure than previously. The farmers pointed out that while manure may increase soil fertility and increase production, its overuse (particularly inorganic manure) may contribute to soil degradation and soil compaction in the long run. As exemplified in the following testimony of one elderly smallholder farmer;

“..... if we continue to plant crops every season on the same piece of land, surely, the soil fertility and yield will start to decrease with time. Yes, the obvious solution is for us to apply more fertilizers or compost manure. Crop yield is not directly related to the amount and the frequency of manure I apply. But nowadays, I have realized that whenever I apply fertilizer and the rain stops, my crops are less likely to survive the drought because of root

burn. For me, the continuous use of fertilizers is rather destructive to the soil"
(An old Smallholder Farmer, Kubori, September 2024).

According to respondents, climate change has not only impacted their farming activities but also affected incomes from farming and other non-farm activities. Out of the 47 farmers selected for this study, 72.3% of them agreed that their incomes from farming activities have decreased due to climate change, and 25.5% reported that their incomes remain the same compared to their previous incomes. However, one respondent, representing 2.1%, reported that in the face of climate change, his farm-based income level has increased. It was further revealed that 68.1% of respondents resorted to non-farm activities or alternative income-generating activities mainly due to climate change, whereas 31.9% do not necessarily adopt any alternative income-generating activities to farming. The alternative income-generating activities were mainly in the area of artisanal work, livestock rearing, trading, construction work, and garment making to supplement income from their farming activities.

From the interviews, a female community leader and a farmer shared their thoughts, which confirm the results from the survey as shown below;

"The climate has continued to affect our farming activities, most especially on our rice and maize crop cultivation, affecting our incomes, which keep decreasing every year, and worsening our expectations to the negative. I remember when we weren't experiencing changes in rainfall patterns and the weather in general, my income was much better as compared to now. At first, I could earn approximately GHS5000 on average on my three-acre land, but now the story has changed as I could earn about GHS2000 to GHS1000 on the same land due to my inability to plant early, due to changes in rainfall patterns, and short-term droughts. Currently, to be able to get some other income, I have now engaged in rearing goats as a catalyst to support my vulnerable farm [...]" (KII Small-Holder Farmer Group Chairperson, Kubori; September 2024).

"[...] during the old good days, everyone in this community was farming, you could barely see anybody without going to the farm or not having a farm. But today, a lot of the youth and aged per my observation in this community have gone into the rearing of livestock while others, and majority of whom are women involved in trading and it is obvious that the farm has nothing much worth to offer compared to the olden days due to climate change" (KII; Women Group Leader, Kubori; September 2024).

Risk perception and adaptation strategies

It is imperative to understand farmers' mindset towards climatic hazards and adaptation mechanisms they adopt in order to quantify their preparedness and resilience. Farmers were asked to mention the major climatic hazards they face and the corresponding adaptation measures they adopt to deal with such issues. Table 5 presents farmers' attitudes towards climate change risks such as drought and unpredictable rainfall, and the adaptation strategies that they have undertaken, such

as changes in planting dates, crop diversification, and using drought-resistant varieties. These strategies provide us with some indication of local adaptation practices driven by perceived climatic risks. Climate change poses risks that are of concern to smallholder farmers, and this study uncovered that the main risks the respondents mentioned were erratic rainfall, drought, flood as well as pests and diseases where 42.6% of the respondents identified erratic rainfall as one of the main risk-related factors they envisioned and 27.7% mentioned drought as a main risk related factor of climate change. The study also noted the incidence of climate change-induced flooding (14.9%) and the incidence of climate change-induced disease and pests (14.9%). In a bid to be in a position to respond to the identified risk factors by respondents, activities like change in planting dates, crop diversification, uptake of drought-resistant crops, soil conservation practice, and improved irrigation practice were chosen by respondents. As shown in Table 4, 25.5% and 27.7% of the respondents proposed a change in dates of planting and planting drought-resistant crops as some of the measures to mitigate the impacts of climate change, respectively. Others proposed crop diversification (19.1%), planting drought-resistant crop species (27.7%), soil conservation (17%), and improved irrigation techniques (10.6%).

Table 5: Risk Perception and Adaptation Strategies

Risk Perception	Frequency	Percent
Drought	13	27.7%
Erratic rainfall	20	42.6%
Floods	7	14.9%
Pests and diseases	7	14.9%
Adaptation Strategies		
Change in planting dates	12	25.5%
Crop diversification	9	19.1%
Improved irrigation techniques	5	10.6%
Soil conservation practices	8	17.0%
Use of drought-resistant crops	13	27.7%

Source: Field Survey Data, 2024

During the interview, a farmer shared her insight regarding risk perception and adaptation strategy, which supports the findings of the above table. She remarked that;

“[...] as a crop officer since I came to this district, I realised that the climatic conditions of Kubori keep changing every year, especially rainfall patterns, the occurrences of drought and flood, as well as pests and diseases. For example, this year (i.e., 2024) we experienced the arrival of a flock of birds that destroyed farmers’ produce, especially rice farmers, and I believe all these are due to the changing climatic conditions in Ghana and the world at large” (KII; Small Holder Farmer Group Chairperson Kubori; September 2024).

Soil maintenance practices to mitigate the impacts of climate change

Soil management is among the utmost significant adaptation strategies in preserving agricultural production under changing climatic conditions. For understanding how farmers within the study area are coping with soil problems, respondents were asked to identify the soil maintenance practices employed by them to counteract the impacts of climate change. Figure 6 shows the set of practices used, which included mixed cropping, cover cropping, composting, and the use of fertilizer, and the percentage of respondents who said they do not know such practices. The findings help establish the awareness and adoption of sustainable soil management practices by smallholder farmers in Kubori. From the respondents, to minimize the impacts of climate change on their farms, they chose to advise practices that included legume crop planting and composting (12.8%), mixed cropping (10.6%), farm belt establishment (8.5%), cover crops (10.6%), and fertilization (25.5%). However, 31.9% of the respondents did not know how climate change effect mitigating activities could be practiced.

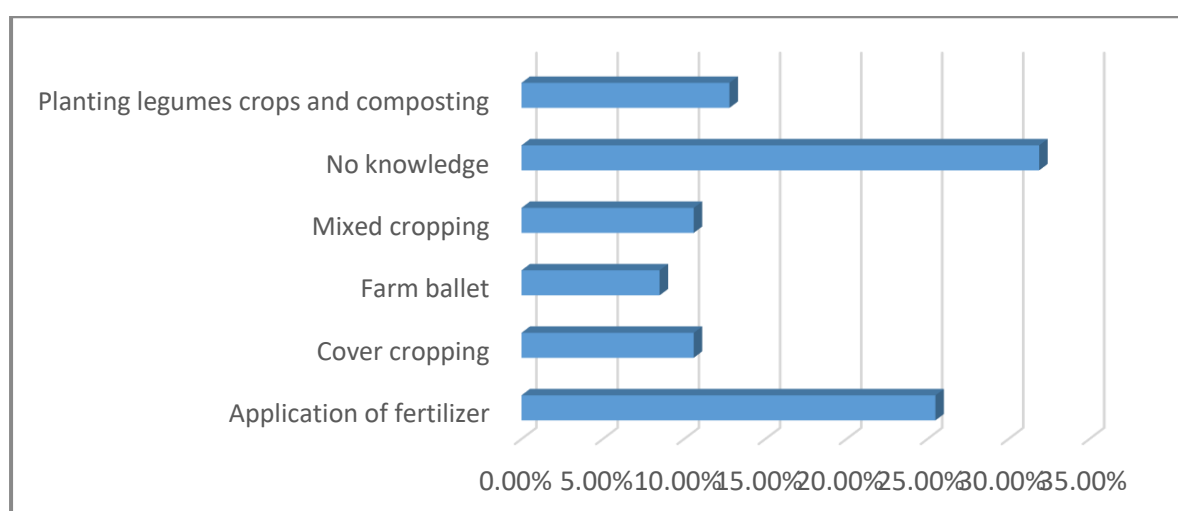


Figure 6: Soil Maintenance Practices to Mitigate the Impacts of Climate Change
Source: Field Survey Data, 2024

Strategies to protect livelihoods against climate change

Responding to increasing climate-related risks, smallholder farmers would have different strategies for safeguarding and maintaining their livelihoods. Attempting to find out such adaptations, the respondents were told to cite the most critical strategies they rely on in order to reduce and eliminate their vulnerability to climate impacts. Table 7 demonstrates evidence of protection measures by farmers, including access to financial services, use of early warning systems, and engagement in bottom-up approaches to managing resources. These are revealed the adaptation and coping capacity among rural farming households in the area of study. There is indication from the above that climate change has affected the income and production of smallholder farmers and food availability. This section thus aims to assess respondents' opinions concerning the steps to enhance livelihoods in the context of climate change (see Table 6). Almost half (48.9%) of the respondents concur that the smallholder farmer's livelihood can be ensured when their capacity to access financial services is enhanced. To increase access to significant agriculture-

related resources, 21.3% of the respondents mentioned the facilitation of a bottom-up approach to resource management strategy. Additionally, to prepare for climate change in a manner that would minimize crop failure, 17% and 10.6% of the respondents chose the adoption of an early warning system and rainwater harvesting (for supplemental irrigation), respectively. In the second instance, it is both a strategy and a common agricultural practice, as some 15% of the farmers in Table 4 indicated that they adapt to rainwater harvesting in the face of climate change. Alternatively, climate hazard mitigation (2.1%) is regarded as a critical strategic response that farmer households can adopt in an effort to protect their on-farm livelihood.

Table 7: Livelihood Protection Strategies Amidst Climate Change

Strategy	Frequency	Percent
Building capacity to access financial services	23	48.9
Early warning system	8	17.0
Rainwater harvesting	5	10.6
Bottom-up approach to resource management	10	21.3
Mitigation of climate hazards	1	2.1
Total	47	100

Source: Field Survey Data, 2024

During the key informant interviews, the Assembly Member and a middle-aged farmer shared their thoughts on the early warning system and bottom-up approach to resource management as indicated below;

“We need to act appropriately, and to do that means a system must be put in place to generate and disseminate timely and meaningful information to enable us to act swiftly. With the help of experts, we can be alerted about any climatic dangers to adjust our farming activities appropriately. Even if we cannot reverse any impending hazards, at least we will prepare our minds to cope with the consequences of climate and climate change on farming. Alternatively, timely warnings will help to reduce the possibility of loss or harm” (Assembly Member, Kubori; September 2024).

“[...] In many ways, climate-induced changes to resource flows can equally affect the viability of our livelihoods in this community. This may be addressed by putting a management team in place that understands how resources are mobilised to generate more income to meet our basic needs. Here, the bottom-up tactic that is rooted in the existing decision-making pattern of resource management should be the way to go. [...] When I say resources, I mean all the necessary things that make farming profitable, such as water, land, farming inputs and implements, etc. I believe in the bottom-up approach; it is more effective in achieving ecosystem restoration. More to the point, you cannot secure local buy-in when livelihood enhancement solutions are pushed down from the top” (Smallholder Farmer group Chairperson, Kubori; September 2024).

Climate change adaptation interventions respondents recommended

To identify locally relevant solutions for addressing climate change impacts, respondents were asked to suggest interventions they believe would enhance their ability to adapt. Table 8 presents the recommended climate change adaptation interventions proposed by farmers in the study area. These include calls for financial support, sensitization, training on climate-smart agriculture, and policy reforms. The responses highlight the community's priorities and provide a foundation for designing practical, farmer-informed adaptation strategies. It is revealed in Table 7 that a reasonable proportion (40.4%) of the respondents believed that financial support was a better intervention. While some proposed sensitisation on climate change (21.3%), others called for the training of community members on smart climate agriculture (19.1%) and the use of public policy intervention (17%) as the pathways to climate change adaptation. However, about 2% of the respondents think that agriculture education and training was the pathway to a fruitful climate change adaptation.

Table 8: Recommended Climate Change Adaptation Interventions

Intervention	Frequency	Percent
Agriculture education and training	1	2.1%
Financial support	19	40.4%
Policy intervention	8	17.0%
Sensitisation on climate change	10	21.3%
Training on climate-smart agriculture	9	19.1%
Total	47	100

Source: Field Survey Data, 2024

The interviewees expressed different worldviews, including the need for sensitisation on climate change, capacity building through training on climate-smart agriculture, and policy intervention. These perspectives, extracted from a smallholder farmer, the district Director of Agriculture, and the district crop officer, are captured below;

“People may be hearing about climate change, but most of us don’t appreciate its effect on human and animal life; I mean, everything. So, one of the things experts can do is to create awareness, not only about the causes of climate change but also its hazardous effects on farming and other nature-based livelihood activities. We need to do something about climate change, but first, we have to be sensitised to become aware of the benefits of cleaner water, air, and land. [...] we will, in turn, fight against excessive cutting of trees, or encourage tree planting, including economic trees. This will create a healthier and greener atmosphere” (KII; Smallholder Farmer Group Chairperson, Kubori; September 2024).

“To reduce risks, local stakeholders, including smallholder farmers, need to be trained to acquire knowledge in climate-smart agriculture. This calls for intensified use of land, restoration, and conservation of natural resources, mixed use of traditional and modern crop varieties and breeds, and increased

use of compost or green manure as well as diversification of production. At least two things can be achieved: building resilience to climate change and increasing the productivity and income of farmers through sustainable practices. Such practices include cover cropping and mulching. For climate-smart agriculture to have a buy-in from farmers, training should be organised for them” (District Agric. Director, Kubori; September 2024).

“[...] Until public policy takes centre stage in the fight against climate change or creates a path for climate change adaptation, we are likely to toil in vain. The policy should centre on devising strategies and measures such as setting up farmers’ information centres and/or early warning mechanisms about the onset of the rainy season, the incidence of pests and diseases, seasonal climate forecasting, etc. As someone who works with farmers in the field, I often hear them air their concerns about policy intervention on the part of the government to tackle climate-related issues. Again, I believe the adoption of a new model like a policy-based approach could be of help to farmers in this district with respect to climate change impacts” (District Agric. Crop Officer, Kubori; September 2024).

DISCUSSION OF FINDINGS

Perceptions and awareness of climate change

The study found a significant level of awareness of climate change among Kubori respondents, with 55.5% considering it to be moderate and 23.4% as sophisticated. The study contributed to the international awareness of climate change in the global south and revealed that there exists significant awareness among the respondents, a great step towards adaptation, which is in line with Fosu-Mensah et al. (2012) and Nyantakyi-Frimpong & Bezner-Kerr (2015), who reported seeing the same trend in Ghana. While 55.5% of the respondents portrayed the magnitude of climate change as moderate and 23.4% as advanced, these differing perceptions are a reflection of the differing levels of exposure and vulnerability in the population. Diversity is supported in the SLF, since it does focus on the importance of local context in shaping vulnerability and adaptive capacity (Chambers & Conway, 1992). Hence, tailored education and sensitisation programmes need to be made available to boost farmers' awareness of climate dynamics in terms of knowledge and adaptation, given that farmers know that climate change exists but are vulnerable to adaptation and mitigation, and their specific implications to agriculture.

Impacts of climate change on livelihoods

The findings underscore major disruptions to farmers’ livelihoods, particularly in food availability and income levels. A total of 87.2% of respondents reported negative effects on food, including shortages, reduced production, and price hikes. These food shortages, reduced production, and higher prices, echoing Chemura et al. (2020), who identified similar challenges in Ghana due to altered rainfall and rising temperatures. Besides, 66% of the farmers have adopted crop diversification as an adaptation method, which is in line with Bryan et al. (2009), who are of the view that diversification builds resilience to climatic variability. The economic implications are

also large, as 72.3% of the respondents reported reduced incomes. This is in line with Antwi-Agyei (2012), who highlighted the economic riskiness of smallholder farmers. The emphasis is that fiscal constraints and rising input costs exacerbate these challenges, highlighting the imperative of judicious interventions, such as crop insurance and low-cost credit availability, to act as shock absorbers for farmers against climate-led losses and build economic resilience. Furthermore, unreliable rainfall was reported by 42.6% of the respondents as a major threat owing to climate change directly impacting planting calendars, yields at production, and soil health. This finding is supported by Müller et al. (2010), who noted the adverse effects of anomalous rainfall on farm production.

Adaptation strategies by smallholder farmers

Farmers, on their part, reacted to climate hazards using various adaptive strategies, including changing planting times (25.5%), using drought-resistant varieties (27.7%), and crop diversification (19.1%), which are proofs of locally proposed solutions by Nyantakyi-Frimpong & Bezner-Kerr (2015), showing that farmers are making moves to prevent the risks. Still, there are gaps in adoption that are seen. For instance, although 10.6% of the respondents applied improved irrigation practices, it was a reflection of systemic limitations, such as inaccessibility to irrigation infrastructure and technology. Hence, enhanced access to such resources through improved investment and capacity-building programs is essential to boost adaptive capacity and sustainable agriculture practices and outcomes.

Livelihood diversification/alternative livelihoods

To respond to dwindling agricultural production, farmers are increasingly turning to alternative livelihoods. Nearly 48.9% of the respondents proposed enhancing their access to financial services by rearing livestock or doing petty trade. These jobs provide critical alternative income sources, reducing dependency on climate-vulnerable farming in accordance with the SLF's emphasis on harnessing multiple livelihood assets to enhance resilience (Tambe, 2022). Therefore, improving off-farm opportunities, particularly among youth and women, will contribute to community resilience and also investments in skill development, entrepreneurship, and market access to enable farmers to diversify their income streams successfully.

Moreover, farmers were reported to be engaged in soil conservation methods such as cultivating legumes (12.8%) and applying fertilizers (25.5%) to mitigate climate impacts. These methods enhance soils' fertility and production, which is in line with research by Bryan et al. (2009) on the importance of sustainable land management. However, the study revealed that 31.9% of the respondents were not aware of such practices, emphasizing the necessity for training and education programs to spur their uptake. Therefore, enhancing knowledge and resource availability for sustainable land management can improve soil health and agricultural production, which can assist in overall climate adaptation efforts.

CONCLUSION

The research investigated the impact of climate change on the livelihood of the smallholder farmers in Kubori, measures of adaptation, and measures of mitigation.

From the findings, it is evident that climate change has had far-reaching impacts on some of the key livelihood assets, including reduced agricultural output, food insecurity, increasing input costs, and the lowering of incomes. Such impacts have increased the vulnerability of the smallholder farmers whose livelihood is primarily subsistence-based on rain-fed agriculture. Despite these constraints, farmers in the study area have demonstrated knowledge of climate change and are already employing a number of adaptation measures, including crop diversification, changes in planting dates, planting drought-resistant varieties, and engaging in alternative income-generating activities. More advanced forms of technology adoption, including irrigation and soil conservation, are, however, low due to financial resource constraints, limited access to inputs, technical capacity limitations, and institutional support weakness. These issues will need to be addressed through a multi-faceted approach, comprising targeted policy interventions, capacity-building initiatives, investment in rural infrastructure, and improved access to credit and extension services.

RECOMMENDATIONS

Although Ghana's National Climate Change Policy and Adaptation Strategy outline climate-resilient agricultural practices, this study finds a persistent gap between national policies and local implementation in Kubori. Farmers continue to face challenges such as poor access to irrigation, extension services, and climate-smart inputs, indicating that the policy benefits are not trickling down effectively.

Therefore, this study recommends strengthening the local implementation of existing climate agriculture frameworks. Specifically:

- The Ministry of Food and Agriculture (MoFA), in partnership with the Environmental Protection Agency (EPA), should operationalize localized climate-resilient agriculture programmes tailored to rural districts like Mampurugu Moaduri.
- District Assemblies and the District Departments of Agriculture should be resourced and empowered to translate national strategies into community-based actions, such as training farmers in climate-smart practices and enabling access to better-quality inputs and technologies.
- The National Development Planning Commission (NDPC) should ensure that district medium-term development plans (DMTDPs) incorporate and prioritize climate change adaptation actions outlined in national policies.
- Additionally, NGOs and development partners working in agriculture and the environment should support these institutions through technical assistance, funding, and monitoring mechanisms.

Therefore, strengthening institutional coordination and local delivery, this approach will bridge the gap between policy intent and on-the-ground impact, improving the resilience and efficiency of smallholder farmers in Kubori and similar climate-vulnerable communities.

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Author Representations

I confirm that I have reviewed and complied with the relevant Instructions to Authors, Ethical Approval, Declarations of Interest, Informed Consent noted below

Competing interests

The authors declare no competing interests.

Ethical approval

This article does not contain any studies with human participants performed by any of the authors.

Informed consent

There are no human participants in this article and informed consent is not applicable.

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