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Harnessing Traditional Ecological Knowledge of Smallholder Farmers for Climate Adaptation and Food Security in the Upper East Region of Ghana

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Abstract

Globally, researchers have attempted to address the adverse impact of climate change on food security, particularly through traditional approaches. This research investigates how smallholder farmers in Ghana's Upper East Region use traditional knowledge to address the impact of climate change on food security. A qualitative approach was used for data collection. We collected data from eight communities across four districts (Bawku West, Binduri, Tempane, and Talensi) through in-depth interviews with 32 smallholder farmers and 8 focus group discussions. Key findings highlight that farmers use sophisticated knowledge systems, including observations of celestial phenomena, to predict weather patterns and shape their farm management practices. Farmers employ adaptive strategies we observed, including cultivating drought-resistant crop varieties, adopting multiple planting times on multiple farm plots within the planting season, farming multiple locations across the district, and using zero-tillage practices. The research concludes that while TEK remains relevant for local climate adaptation, there is an urgent need to integrate indigenous practices with modern scientific approaches in locally friendly ways to

enhance smallholder farmers' adaptive capacity. Key barriers to effective integration and enhancing local climate adaptation include language barriers, limited access to capital and locally friendly technologies, poor road infrastructure, low literacy rates, and reluctance to adopt new farming techniques. The study recommends integrating both traditional and scientific knowledge to enhance adaptive capacity and improve food security.

Keywords: Traditional ecological knowledge, climate change, food security, smallholder farmers, adaptation, Upper East Region, Ghana, indigenous knowledge systems

1.0 Introduction

In a not-so-distant future, many households globally will become food- and water-insecure. Clear evidence shows that developing countries, particularly Sub-Saharan Africa [SSA], will be the worst affected (Adu-Boahen, 2023; IPCC, 2018; Owusu et al., 2024). This is attributable to climate change, which aggravates the already high rate of poverty, worsens vulnerability levels, and reduces adaptation capacities. Furthermore, many people in SSA depend on agricultural production for direct and indirect employment and income, and they will be among the most affected because of their exposure to climate change.

Agriculture in Ghana is largely rain-fed, and farmers usually plant crop varieties with little resilience to immediate climate effects, including rainfall variability, flooding, drought, and high temperatures (Owusu et al., 2024; Sidibe et al., 2016). Although limited in scale, the growing number of studies and engagements on climate change is driving a considerable number of climate impact assessments not only in Ghana but across SSA (Ariko et al., 2024; Daniel, 2018; Etwire et al., 2013; IPCC, 2021, etc.). However, these and many other studies generally conclude that

smallholder farmers in these regions will experience a significant reduction in crop and livestock production if no adaptation measures are implemented.

Smallholder farmers in rural communities in Ghana, especially in the Upper East Region, are constantly grappling with the adverse effects of climate change, particularly in recent years. According to Yiran et al. (2022), the impact of climate change in the region has not only increased, but its impact on crop production is becoming alarming. The region is also exposed to various climatic variables, as part of the savanna agro-ecology, dependence on rain-fed land-based livelihoods, and high poverty and food-insecurity levels. Many farmers and key institutions are concerned about climate change and ask: "What will be the food security status of smallholder farmers in the region in the future?" (Yamba et al., 2023; Kyei-Mensah et al., 2019; Jha & Gupta, 2021). The IPCC (2018) report indicates that the percentage of households with insufficient or no access to adequate food in the region increased from 10.9% in 2015 to 14.3% in 2020. It was established that most smallholder farmers cannot access sufficient food to feed their households because of limited information about climate change adaptation.

Traditional knowledge, cultural and religious beliefs play a crucial role in climate change adaptation strategies for food security and sustainable agricultural development, especially in indigenous and local communities (Ikpe, 2021). According to Berkes's (2012) definition, traditional knowledge is a cumulative body of knowledge, practice, and belief that evolves through adaptive processes and is handed down across generations about the relationships among living beings and their environment. Several smallholder farmers and local communities use traditional knowledge to promote crop farming across a wide range of ecosystems, including those affected by climate-related threats (Atubiga & Donkor, 2022; FAO, 2017). Traditional practices are tied to cultural traditions and biocultural dynamics. They can improve smallholder farmers' adaptation

strategies to climate change while increasing production of different food crop varieties. Local communities have used traditional knowledge to achieve food security (Kariuki, 2020; Kummu et al., 2021). Tetteh et al. (2022) also reported that the significance and value of traditional knowledge and practices in climate adaptation and mitigation have not been fully recognised. Meanwhile, local farmers and communities use indigenous knowledge as an adaptive capacity in its own right, providing an opportunity to enhance individual and community resilience.

Despite the relevance of traditional knowledge in increasing climate adaptation, few studies examine how traditional practices and indigenous knowledge systems enhance food security and increase agricultural productivity in the area (Mensah et al., 2025). Over the years, traditional practices have been marginalised in favour of more scientific practices in many climate-threatened communities in the area. This study and examines how farmers use traditional knowledge to address the effects of climate change on food security (Yeleliere et al., 2022). It is important to state that climate change adaptation of smallholder farmers through frameworks that facilitate the integration of indigenous knowledge and scientific systems is essential in promoting food security, local livelihoods, and long-term development opportunities (Jha & Gupta, 2021).

The study focused on three specific objectives. The first examined smallholder farmers' traditional practices in responding to the impacts of climate change. The second analysed the challenges of traditional knowledge in climate change adaptation. Finally, investigates the future implications of traditional knowledge for climate change adaptation.

This study contributes to debates on climate adaptation by showing how smallholder farmers' traditional ecological knowledge works as an integrated system for detecting environmental change and buffering food security, and by documenting how the reliability of that system is itself being eroded by the climatic changes it evolved to read.

The paper is structured into five sections. After the introduction, the paper reviews the relevant literature. The next section outlines the materials and methods used in the study. The next four sections present the results and discussion, while the final section concludes the study with policy and practice recommendations.

2.1 Integrating traditional knowledge systems in climate change adaptation

In recent years, scholars have called for integrating indigenous knowledge systems into climate change adaptation strategies (see Muchaku et al., 2023; Karki et al., 2017; Iloka, 2016). To ensure effective climate change adaptation, indigenous knowledge should be integrated with scientific knowledge to promote resilience and reduce vulnerability (Aniah et al., 2019; Bogale & Bikiko, 2017). Scientific knowledge can enhance and validate indigenous knowledge, making it more effective. To strengthen this policy, studies should be conducted to ensure sustainability and promote crop production. As part of an ongoing effort to combat climate change, smallholder farmers are encouraged to grow improved crop varieties to minimise the impact of climatic variability by complementing traditional planting knowledge with climate-resilient varieties that improve crop yield.

Smallholder farmers are generally innovative and have invented complex farming systems adapted to the local environment that have helped respond to climate change and improve food security (Egeru, 2012). Integrating such agricultural innovation in the form of traditional practices with scientific knowledge will foster local participation in combating climate change and promote food security (Donkoh et al., 2019). Knowledge from traditional practices can contribute significantly to sustainable food security, rural development, improved rural livelihoods, efficient use of natural resources, and improved community well-being to meet the needs of vulnerable rural farmers (File, 2015).

African traditional societies have developed local systems and practices over the years to adapt to the ravaging impact of climate change (Ifeanyi-Obi et al., 2017). In many rural communities in Africa, including Ghana, local knowledge has developed to address the impacts of climate change through different approaches. One of the most commonly used adaptive strategies developed over the period by local farmers is early warning systems. According to Ouedraogo et al. (2018), early warning systems include knowledge of the behaviour of animals, plants, and insects as key indicators for climate change adaptation strategies. Other indicators include variations in weather cycles and climate variability, as well as knowledge of crop varieties, livestock breeds, and resource management practices such as mixed cropping and crop rotation (Kupika et al., 2019). Although westernisation of culture has impeded the function of traditional knowledge in climate mitigation, a significant number of people continue to rely on their local community knowledge and technology systems to adapt to a changing climate and cultural values for food security (IPCC, 2014). These knowledge systems and practices play a critical role in food production and have been passed down through generations to support sustainability, food security, and empowerment within communities.

Although achieving sustainable food security is a major challenge for most developing countries, including Ghana, policy strategies that focus on harnessing the potential of traditional knowledge for sustainable food production are not fully exploited. Over the years, many improved strategies have been capital-intensive, making them difficult for smallholder farmers to afford (Morton et al., 2017). Evidence from many studies revealed that policy strategies formulated largely marginalise traditional knowledge systems, leading to their underutilization (Alhassan et al., 2018). For instance, Ansah & Siaw (2017) noted that farmers' long-term use of agrochemicals such as pesticides and fertilisers adversely affects the environment and the health of these vulnerable

farmers. This practice not only degrades the environment but, in the long run, will also affect agricultural production as agricultural labour declines. Most local indigenous knowledge aims to increase agricultural productivity and food security while responding to climate change.

Traditional knowledge comprises four dimensions. These are (i) bio-indicator and observational knowledge, i.e., plants, animals and celestial/weather cues used to forecast conditions; (ii) agronomic knowledge and practices, that is, crop choice, planting timing, intercropping and tillage; (iii) soil-fertility and land-management knowledge; and (iv) storage and post-harvest knowledge.

3.0 Methodology

3.1 Choice of the study area

The study was carried out in the Upper East Region of Ghana. The UER is located between latitudes 10•30' N and 11•10′04″ N and longitudes 0•02′E and 1•33′W (Fig. 3. 1), with a land size of approximately 8,842 km accounting for less than 4% of the overall total landmass of Ghana (Ghana Statistical Service 2014). The region shares a boundary to the north with the Republic of Burkina Faso, to the west with the Upper West Region of Ghana, to the east with the Republic of Togo, and to the south with the North East Region of Ghana (Fig.3.1). The region has a gentle topography that can be defined as undulating land with slopes ranging from 1% to 5% with sporadic rock intrusions.

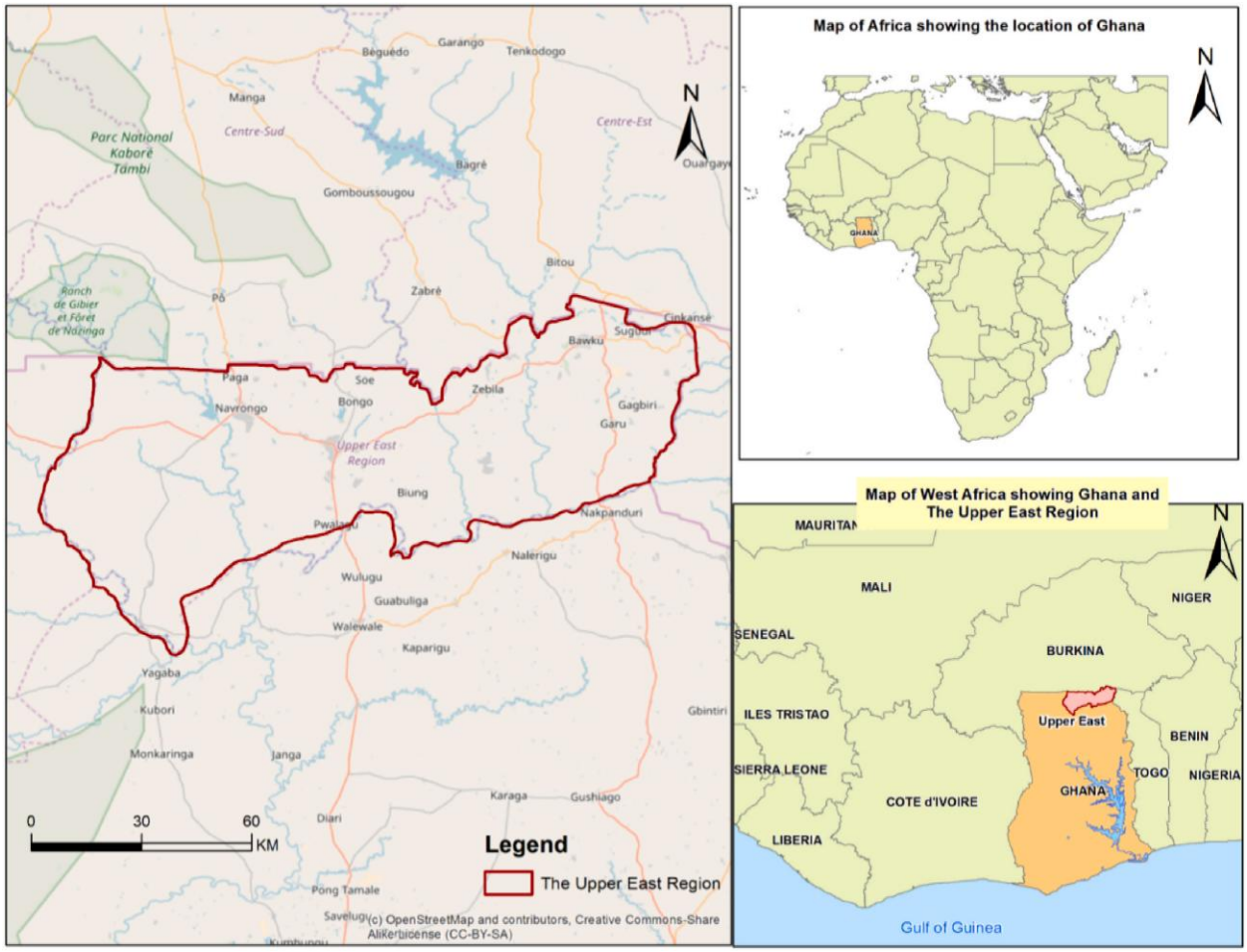


Figure 3.1: Locational map of the study area

Source: Adopted from Owusu et al. (2024)

Four out of the fifteen districts/municipalities (Bawku West, Binduri, Tempane and Talensi) in the region constituted the study districts. The districts and, by extension, the region experience nearly all of the climatic variability that occurs in the savanna ecosystem (National Disaster Management Organisation [NADMO], 2011). The districts also face a higher risk of desertification than other regions in the savanna ecological zone. As a result, smallholder farmers in the districts are virtually losing hope in agricultural activities due to the impact of climate change (Asamoah, 2018). Because poverty is highly endemic in these districts, even a small reduction in food production has a major impact on food supply and prices. This creates food insecurity, civil unrest and migration. These factors make it an excellent case study.

The region's climate is classified as dry sub-humid, with mean annual rainfall ranging from 900 mm to 1150 mm (Blench, 2006a). The Intertropical Convergence Zone (ITCZ) dominates the region's climate (Conway, 2008). The ITCZ stem from a low-pressure belt around the Equator where two trade winds converge from the southern and northern hemispheres (Conway, 2008). The meeting of these winds results in strong convection, clouds, and precipitation (Scott, 2013).

The region's vegetation is predominantly Guinea and Sudan savanna, characterised by a dry sub-humid or semi-arid climate (Owusu & Waylen, 2009). The area's grassland nature exposes it to intense farming, overgrazing, firewood and charcoal burning, bushfires, etc. (Tom-Dery et al., 2012; O'Higgins, 2007). This results in rapid desertification, insufficient quality grass and rafters for thatch and grassland for grazing, fewer trees, and an inadequate supply of firewood.

Land acquisition in the area is largely through inheritance (patrilineal inheritance), which has led to land fragmentation and an increase in small-scale farming in the districts (Yiran, 2016). Because of land fragmentation, small-scale farming is the main agricultural practice, but it has received little support (MOFA, 2009; Amikuzuno & Donkor, 2012). Also, most farmers' inappropriate land preparation has contributed to soil erosion and desertification. This has reduced soil fertility and, in turn, led to declining crop yields and food insecurity (O'Higgins, 2007).

3.2 Materials and methods

The study used a qualitative approach, which is well suited to exploring traditional ecological knowledge and strategies for adapting to climate change. According to Creswell and Poth (2018), a qualitative approach is best suited for studying local and indigenous knowledge. This approach reflects a careful methodological choice that acknowledges the unique characteristics of indigenous knowledge systems and the complex socio-environmental dynamics they entail. A multiple-case study design was used, targeting specific districts in the Upper East Region of Ghana: Bawku West, Binduri, Tempane, and Talensi. This approach allows for an in-depth examination of contexts where traditional knowledge systems still influence agriculture and climate adaptation strategies. The study selected two communities, for a total of eight communities. By focusing on communities that maintain land-based livelihoods and are vulnerable to climate change, the study captures relevant contexts where traditional knowledge remains active, avoiding areas where it has diminished or vanished. Also, the districts and communities were selected using NADMO hazard records, MOFA data on dependence on land-based livelihoods, and agro-ecological classification within each district. They were identified in consultation with district agricultural officers/community leaders based on continued reliance on traditional farming practices.

The sampling strategy employed in this study reflects a better understanding of how to engage with holders of traditional knowledge. The first respondent was selected using purposive sampling. Consultation was done with the agricultural extension officers before the selection of the initial respondent through the judgmental sampling. The remaining respondents were selected using snowball sampling. This method acknowledges that traditional knowledge is often concentrated among specific individuals who possess unique expertise, experience, or recognised authority in farming and environmental management. By focusing on farmers with at least thirty-five years of

experience, the study ensures participants have witnessed long-term environmental changes and can provide valuable insights into how traditional practices have evolved over time. This experience is crucial for understanding the impacts of climate change, as many environmental shifts occur gradually and may go unnoticed by younger or less experienced farmers.

Further criteria for selection included: (1) communities that still maintain traditional practices or economies, (2) rely solely on land-based livelihoods, and (3) are located in areas threatened by climate change and variability. In all, thirty-two respondents were selected for face-to-face, in-depth interviews (Table 1).

Table 1: Study communities and participants for data collection

District	Community	Participant	No. of respondents for in-depth interview
Bawku West	Timonde	Smallholder farmers	4
	Bulinga	Smallholder farmers	4
Talensi	Aruk	Smallholder farmers	4
	Pwalugu	Smallholder farmers	4
Binduri	Yalugu	Smallholder farmers	4
	Bansi	Smallholder farmers	4
Tempane	Basyonde	Smallholder farmers	4
	Yabrago	Smallholder farmers	4
		Total	32

Source: Fieldwork (2025)

The interview discussion centred on the study themes. The entire interview process was recorded using a tape recorder. Essential information during the discussion was also recorded in a field notebook to ensure nothing was missed. The interview session took between 40 minutes and one hour. This was done in a secure place to avoid any destruction during the process. The interviewees were informed ahead of time so they could prepare and choose a convenient place before the day, date, and time of the interview session.

We also held eight focus group discussions (FGDs), one from each community. The initial intention was to conduct sixteen group discussions. However, after the eighth group discussion, we reached saturation, as the information presented was largely the same. Besides, Guest et al. (2017) recommended that four to forty group discussions are enough for a study. We also collected secondary data from MOFA and NADMO officials on annual reports, smallholder farmers' adaptation strategies, seminars, and conference papers related to the use of traditional knowledge in crop yield and disaster management in the area. The discussions centred on the study's objectives and key themes. To select discussants, we consulted opinion leaders to ensure the participants represented the community in terms of gender and location. Each FGD consisted of eight members, including both men and women. This number (8) was significant because large FGDs are difficult to manage and can hinder effective deliberation (see Watukele, 2014). Before each FGD, discussants were encouraged to feel free and express their views openly. In this case, the atmosphere was friendly to all, including women, who sometimes, when mixed with men, feel reluctant to talk because of customs and traditions (Bempah, 2011). A facilitator led the discussions and maintained a friendly atmosphere that encouraged both men and women to express their views freely. The discussions used the Kusaal language, which is widely spoken and understood by most people in the area (Asamoah, 2018). The two trained assistants recorded the

proceedings in field notebooks. To ensure that no information was left out, the whole process was recorded again using a tape recorder. After the discussion, the recording was listened to and compared with what was in the field notebooks. Information in the recording that was not captured in the field notebooks was added immediately.

Field observations were also employed. This was done using a checklist. The case under investigation, the annual floods of the White Volta, is an issue that demands direct field observation. Observations included farming systems and practices, as well as traditional beliefs and practices related to farming.

A qualitative thematic method was used to analyse data from interviews, focus group discussions, and field observations. The in-depth interviews and focus group discussions were transcribed from Kusaal to English. The information was then sorted and sifted into functional categories. After coding, the data were organised into themes based on the concerns under investigation. Observational notes were also coded, organised, and incorporated into the discussion. This analysis was supported by tables, diagrams and photographs taken in the field.

4.0 Results and Discussion

The results and discussion section is woven to cover farmers' utilisation of indigenous knowledge systems to predict climate change, farming and farm management, and climate adaptation to promote food security. The application of traditional knowledge was discussed under the following headings: evidence of climate change, local experience and observation of climate elements, evidence from agricultural products, and the feared future.

4.1 Evidence of Climate change –Traditional ecological knowledge

This study examined traditional ecological knowledge about the physical evidence of climate change using plants and animals. These indicators (plants/vegetation and animals) provide visible evidence of climate change, as well as the effects which are felt immediately by the farmers, since they constitute the major resource of the inhabitants.

4.1.1 Plants

The evidence of climate change was assessed from the perspective of plant cover using traditional ecological knowledge. Historically, rural communities have relied on traditional knowledge to guide their interaction with the natural environment. In the study, the smallholder farmers indicated that there has been a reduction in the quantity of plant cover, especially around their immediate environs. A significant number of respondents asserted that the availability of trees in their immediate environment has decreased. According to the farmers, in recent years, they have witnessed many trees like Adansonia digitate (baobab) and dawadawaParkia biglobosa), which can withstand harsh weather conditions, dying in large numbers. A farmer in Basyonde in the Tempane district stated that:

"I had five Dawadawa trees on my land and two baobab trees in my house, which provided shade for me and my household, but as I speak now, all of them have died. This is unprecedented. It has never happened before since the days of old".

Also, sacred groves, which served a traditional role and acted as windbreaks, have not been spared by these climatic events. Many of the plant species in these groves have died. Respondents reported that bushfires and other fires destroyed some of them, while others fell due to strong winds. Because climate change has destroyed trees, people's homes are now more frequently ripped off by windstorms than they were in the past, as the trees once served as windbreaks. This relates to

similar findings by Reed et al. (2008) and Stringer and Reed (2007), cited in Owusu et al. (2024), who stated that evidence of climate change can be inferred from a decrease in vegetative cover and a decline in indigenous tree species.

The study also identified firewood scarcity as an indicator that the plant population had decreased. The quantity and quality of firewood obtained were lower than in past years. The findings indicated that women now spend more hours walking longer distances in search of firewood than 30 years ago. In all the focus group discussions, the respondents noted that plant species which are of economic and medicinal value were disappearing gradually and becoming scarcer. According to them, these trees included Shea nut (Butyrospermum parkii), Dawadawa (Parkia biglobosa), Ebony, Blackberry (Vitex doniana), Baobab (Adansonia digitata), Fig (Ficus species), Acacia species, Siis, Kunkpera, neleg, Puopinlenga and Gbere trees. Reed et al. (2008) argued that the reduction in tree species indicated climate change. A study by Ifeanyi-Obi et al. (2017) in Botswana also reported a reduction in medicinal plants as an indicator of climate change.

Another indicator, as identified by the local people as evidence of climate change, was the scarcity of grass for roofing. Respondents revealed that thatch grasses were previously common and easy to obtain locally, but in recent times they have had to travel several kilometres to find grass. Many grass species have become shorter, which affects their use for roofing. According to the respondents, the quantity obtained also decreased compared to 30 years ago. They noted that this stems from several factors, including but not limited to: climate change resulting in bush burning, drought, increased distance to the location of thatch grasses, overgrazing, and indiscriminate farming practices.

During a focus group discussion at Bulinga, a discussant stated that: "*thatch grasses for roofing are almost becoming extinct. Because of that, they are very expensive compared to using roofing*

sheets. As a result, many people now prefer roofing sheets over thatch, as the cost is nearly the same". However, roofing sheets produce heat, especially during the dry season, making it difficult to sleep inside.

One interesting thing the farmers observed was that because of the scarcity of the plant species, especially thatch, they have now resorted to using low-quality grass, which ordinarily would not have been considered for roofing, a practice which affects the quality and duration of the hut. Recently, most thatch is bought from outside the region, especially in the Savannah region and parts of Burkina Faso. These findings corroborate Yiran et al. (2022), who argued that the Upper East Region of Ghana is rapidly experiencing desertification, which affects agricultural and livelihood activities.

4.1.2 Animals

Animal production is becoming one of agriculture's fastest-growing sub-sectors. Many farmers in Africa depend on animals for income, food, and also an insurance policy when climate change destroys their crops (Barron et al., 2015). The link between animal production and climate change is complex and multi-directional. It can be viewed in terms of (1) the contribution of animal production to climate change and (2) the impact of climate change on animal production (Hadley, 2011).

The findings indicate that local farmers have observed a significant decline in both the quantity and quality of fodder available for their animals, providing clear evidence of climate change. Respondents reported that their animals struggle to find enough grass to graze and are therefore forced to trek long distances each day in search of pasture. This situation was further aggravated by the growing trend among many farmers to convert grazing lands into arable fields to boost food

production. Additionally, harmful and unfamiliar weeds are invading the limited grazing areas. These invasive plants proliferate rapidly and pose a serious concern for the farmers, as their livestock often have no choice but to graze on this toxic foliage, which has at times led to fatalities among the animals. The invasive species farmers mentioned include Capparis tomentosa, Prosopis juliflora, Parthenium hysterophorus, and Solanum incanum. A respondent in Basyode emphasised this issue during a focus group discussion at Aruk, stating that...

"In the old days, one household's cattle could form a long queue, but due to deaths and poor growth, mostly caused by lack of pasture, they had to sell them, so you could hardly count 10 cows per household".

Decline in animal condition (weight loss), less milk, and increasing animal mortality were some consequences of the invasion of strange grasses in the range land of Botswana and Mali (Stringer & Reed, 2007; Dembele, 2006).

Strangely, they indicated that some weeds were very difficult to control, which retarded crop growth. They explained that these weeds did not exist years ago but emerged only in the last ten years. The weeds are fast-growing and can withstand drought or any harsh weather conditions. The farmers identified invasive grasses including Sttiga asiatica, Acacia mellifera, Striga asiatica, Xanthium strumariun, Schmidtia pappophoroides, Eragrostis, and Lehmannia. These weeds have reduced crop production and increased production costs. Respondents observed an increasing rate of temperature rise, leading to the drying of water bodies that limit animals' access to water and resulting in decreased milk production.

4.2 Local experience and observations of elements of climate

The literature is inundated with traditional experiences regarding climate variability and climate change (Clapp, 2018; Ayichew, 2014; Jabik, 2021). Evidence suggests that rural communities in

Africa have developed mechanisms to mitigate climate change over the years through local knowledge (Jabik, 2018; Owusu, 2018). These farmers rely largely on local knowledge for agricultural activities because conventional weather forecast outputs are technical, expensive to acquire, and therefore less accessible to smallholder farmers. This section explored the indigenous and traditional practices smallholder farmers use to predict weather elements and plan their farming activities accordingly.

4.2.1 Precipitation and pressure systems

The study found that smallholder farmers in the Upper East Region associate climate change with rainfall variability. Different forms of expression such as "distorted patterns" ", uncertainty", "irregular", "unpredictability", "increasingly unstable", "erratic" were used to describe the behaviour of rainfall patterns in the area, particularly in recent years (Yaro, 2013; Owusu et al. 2024). Precipitation variability was determined using extreme wet and dry events, such as floods and droughts, which respondents also widely reported during data collection. The study found that smallholder farmers could predict rainfall likelihood using indigenous and traditional knowledge. These conditions included the onset and cessation of the rainy season. Respondents observed changes in how local beliefs and traditional knowledge are used to predict the likely consequences and outcomes of rainfall variability over time and across locations. These observations spanned from one season to another and from one location to another.

To predict rainfall variability, farmers used celestial phenomena such as wind direction, the appearance of the moon, and the position of certain stars to determine the likely occurrence of rainfall in the area. According to the farmers, the direction of the movement of the wind, like the south-west to north-east winds and the north-east to south-west winds, indicates a change from one major season to another. In their view, the onset of the rainy season is identified by the

prevailing south-west to north-east winds. They explained that the south-west to north-east winds cause clouds to accumulate in the east, bringing rain. They further indicated that the wind was initially experienced in March/April, but has now shifted to April/May, and its presence determines the onset of the rainy season. In addition, the winds were also used to predict the shift from the harmattan season (dry, dusty, and hot) to the rainy season. Thus, the intensity and duration of the winds (south-west) before the first rains determine the likelihood of dust storms that could occur during the initial rainfall period, as well as the volume of rainfall in that year. A farmer summarises this during a focus group discussion at Timonde by saying that:

"We learn from our fathers and grandfathers that before the early rains arrive, the wind usually blows to the east. As a result, when the winds begin to blow, we know the rainy season is approaching. Additionally, heavy rainfall tends to be associated with lighter winds. Therefore, when clouds gather without strong winds, we understand that there will be heavy rains in that particular year.

When north-east to south-west winds are experienced somewhere in October/November, it indicates that the end or cessation of the rainy season is near and the start of the dry season is approaching. Indigenous and traditional knowledge practices have improved smallholder farmers' resilience to climate change by ensuring high agricultural productivity and improving adaptive capacity and mitigation of climate change impacts.

Local farmers also used lunar months, named after specific moon shapes, to predict rainfall. Smallholder farmers, especially among the Kusasi people, used this for decision-making. The months have names that reflect the predominant weather conditions and the economic or social activities of each month. As such, the first few days at the onset of the new moon form the basis for predicting that month's likely weather conditions. If the moon at the onset appears as a sickle,

and depending on its orientation, it is used to predict favourable weather conditions, disaster, or inadequate rains during that lunar month. The sickle moon, concave to the south or north, is used to predict drought or floods, depending on how the moon is named.

The findings are similar to a report by Msaki et al. (2015), which asserted that applying traditional knowledge has helped smallholder farmers ensure effective management of the natural environment, including soil fertility, water conservation, disease control, and environmental protection, which increases productivity in the agricultural sector. The table below summarises the traditional knowledge.

Table 4.1 Traditional knowledge in weather condition predictions

Indicators	Traditional knowledge of prediction	Significance
Onset of rain	Presence of clouds with high wind pressure	Land preparation
Wind direction and intensity	Winds move from left to right /from south to north; indicate strong or light	Indicate that rain will be coming good season
Cloud	Presence of clouds but not windy	Indicates that copious rain will come
Smog and clouds in the morning	Observing the grass, leaves, and sky	Indicates no rain
Moon	The moon hides when it is going to rain	Readiness for receiving the coming rains
Colour of the sun	Red colour at sunrise indicates the coming of rain	
Bird	Sound and dancing/movement	Indicates the coming of rainfall
Frog	Sound	Shows that rain is coming
Colour of rivers/lakes	Black	Shows a good season
	Light/clear	Show a bad season
Cattle behaviour	Cattle refuse to get out, do not want to come back home, and eat wood instead of forage.	Indicates no rainfall and a bad season
Cattle behaviour	Stand, not interested in grazing and drinking	A bad season is expected
	Eat and drink normally.	A good season is expected.

Time of day of the rain	If it rained in the morning and again at night	It is believed that the season is good. If it rains at noon, the season is predicted to be bad.

Source: Fieldwork (2025)

4.2.1 Sunshine – temperature

The understanding of temperature was explored to gather evidence of climate change in the area. The temperature data observed over a period was used to predict the likelihood of rainfall occurring in the current year or the following year. The study found that warm temperatures at the beginning of the rainy season suggest a higher probability of heavy rainfall during the rainy period. In a focus group discussion in Bansi, one of the participants, who also serves as an opinion leader and an elderly man, stated that:

"Whenever there is intense heat towards the end of the dry season, followed by ongoing rain for three weeks, it indicates that this year will experience heavy rainfall. This is the knowledge that has guided us all in our farming system."

The colour of the water after the first rainfall, driven by temperature changes, was used to indicate either drought or the type of crops to plant that year. Respondents noted that whitish water has two meanings. On the one hand, it suggests a higher risk of drought, encouraging the planting of drought-resistant crops. It also indicates that crops like millet are likely to yield better in that year than other crops. If the water is observed to be black, then crops such as guinea corn are expected to produce good yields, as explained during one discussion:

"When the initial rainfall occurs, we observe the colouration of the water to determine which crop will perform well prior to the commencement of sowing. If the water appears white, it signifies that millet will produce a favourable yield; if it is black, it indicates that sorghum (naga red) will have a successful harvest. Subsequently, we cultivate a greater quantity of that particular crop".

4.2.4 Cloud formation and pattern

The study explored traditional ecological knowledge of cloud formation and patterns to determine the likely occurrence of a climatic event. This is essential because cloud cover availability determines rainfall in an area. The study found that one indicator farmers use to predict the onset of rain is a 'line of clouds' (north to south) observed in the sky at night. According to the farmers, this line divides the sky into two parts and is believed to be changing position within the season. As the rainy season approaches, the eastern half becomes larger than the western half, and as the dry season nears, the western half becomes larger than the eastern half. Also, the half to the east more stars than the half to the west. The respondents explained that the abundance of stars implies the various crops that are always abundant; the abundance of stars signals the various crops planted during the rainy season. When any of the above is observed, farmers begin to plan appropriately. When all these indicators are observed, farmers begin to prepare for the planting season or start dry-season farming activities. This confirmed Jabik's (2021) assertion that many farmers, especially among the Kusasi people of northern Ghana, used indigenous knowledge to predict the occurrence of the various seasons and prepare adequately for the farming season.

The study also identified the appearance and occurrence of certain natural phenomena, such as fog, the extent of heat in the warm season, lightning and thunder during certain periods of the year, the onset of the first rains, and hazy weather conditions, to predict the likelihood of climatic events. For instance, respondents said they used fog to predict two different likely weather outcomes, depending on the season in which the fog is observed in the community. When fog occurs or is observed around May and June (onset of the rains), rains are likely to set in soon, with a higher chance of a good rainfall pattern that year. This means that farmers can clear more land and increase production. Nevertheless, when the fog is observed around September, then the chances

of early cessation of rainfall are high. Farmers begin harvesting their crops early, particularly leguminous crops, to avoid ground hardening, which makes uprooting difficult. Farmers also use cloud formation to predict the likely occurrence of a windstorm or similar weather events. When it is about to rain, and the clouds appear red at the onset of the rainy season, the likelihood of storms being prevalent during the year is higher. Also, rainfall around September without heavy clouds indicates that the rains will cease early that year.

4.3 Evidence from agricultural production

Evidence suggests that climate change affects agriculture through several factors. Local people associate the decline in agricultural production with the factors discussed below.

4.3.1 Changing crops, cropping, and survival

Rural communities and smallholder farmers have adopted a variety of crop species using their traditional knowledge during the growing season to ensure food security in the face of climate change. The study's findings indicate that the crop varieties used by respondents are crucial for adaptation as the climate shifts, especially because modern agriculture depends on a limited selection of crops and varieties. Throughout the focus group discussions held in various communities, farmers highlighted that extensive planning and decision-making are essential when selecting which crops to cultivate and determining the cropping patterns for the rainy season. They believe these choices stem from their traditional understanding of climate variability and historical planting trends.

The Upper East Region is home to several staple food crops, including rice, millet, guinea corn, maize, sorghum, groundnuts, beans, and soybeans (Sidibe et al., 2016; Atubiga & Donkor, 2022). Rainfall variability during the season influences the decision to plant specific crops. Respondents

explained that when rainfall at onset is unpredictable, they tend to plant crops with shorter growing cycles that require less water. They said these crops include early millet, beans, and various vegetables. Supporting this, Motsumi et al. (2012) noted that in regions with limited rainfall, farmers tend to prefer drought-tolerant crops such as sweet potato, cassava, millet, and sorghum to enhance food security. During the focus group discussion, participants said they prefer indigenous grains such as millets and sorghum because they are more drought-resistant than maize and produce high-yielding varieties. In an interview with a 65-year-old man at Timonde, he opined that: *"I usually prefer crops that can withstand drought, like the indigenous finger millet variety, as it ripens very fast.*

They are also harvested when most households have little or no food. In this community, we regard the early millet as a hunger breaker.

One intriguing report from cultivating these crops was that, apart from providing food for households, the stalks are used as cooking fuel and sometimes provide extra income for farmers. The respondents further explained that seasonal remnants from these crops are used as mulching material, which helps conserve water and control weeds. According to the respondents, they also use the stalks to prepare compost for fertilisation.

Mixed cropping and intercropping were assessed to identify how traditional knowledge is applied in cultivation to avert the impact of climate change. Regarding the farming system, respondents said they always want to spread their risk; that is, the failure of one crop does not necessarily lead to the failure of other crops. They argued that this farming system also allows them to maximise land use, since land is becoming smaller due to population growth, resulting in land fragmentation (Yaro, 2004; Akudugu et al., 2012). The practice was also noted to reduce soil erosion and weeds.

4.3.2 Soil fertility and tillage

Soil nutrients are crucial for crop yield and overall sustainability (Darfour & Rosentrater, 2016). Local inhabitants have linked diminished crop yields to soil nutrient depletion and shifts in climate variability. Throughout the focus group discussions, respondents from all study communities articulated concerns regarding soil infertility. One farmer encapsulated the current condition of his land by stating, *"My farm has become bare land because it no longer has food for the crops".*

This statement highlights the severe loss of fertility, rendering the land incapable of supporting crop growth and optimal yields. In in-depth interviews, several respondents estimated that crop production has plummeted to less than one-third or more than half of what they previously harvested from the same plots. They noted that only those who could invest in fertilisers and animal manure on their farms experienced stable yields. Farmers viewed the decrease in production as a clear indication of deteriorating soil nutrients. These findings align with Stringer and Reed (2007), who indicate that a decline in crop production indicates insufficient soil fertility.

To reduce the impact of climatic risks on crop production, many respondents reported employing zero tillage techniques in land preparation. They believe that zero tillage not only reduces costs but also helps maintain robust harvests while simultaneously protecting the environment. According to Raphel et al. (2012), zero tillage is particularly suited for farmers in developing countries such as Ghana. Research indicates that the Upper East Region suffers from shallow soil nutrients, with many areas exhibiting low soil fertility (Kusimi and Yiran, 2012, cited in Yiran et al., 2022). As a result, respondents mentioned utilising simple tools like hoes, cutlasses, and ploughs, often employing bullocks and donkeys for ploughing, in order to conserve the declining soil fertility (Fig. 4.2). The challenge, however, was that in recent times, because of the decline in

pasture, many of the households have sold their animals and are without any. Most farmers therefore resort to using tractors, which, in their view, contributes to the decline in soil fertility.



Figure: 4.1 Donkeys used for ploughing

Source: Field work (2025)

Mulching and other soil management practices, such as using cow dung and poultry droppings (Fig. 4.2), also help. Farmers noted that these organic materials moderate soil temperature and preserve moisture content. However, because of the introduction of chemical fertilisers, most farmers now show less interest in organic fertiliser, which studies have shown can reduce GHG emissions (Sterk & Stoorvogel, 2020).



Figure 4.2: Cow dung collected for manure

Source: Field work (2025)

4.3.3 Incidence of disease, pest, and post-harvest losses

Since the domestication of crops several years ago, farmers have faced numerous threats from pests and diseases, leading to significant yield losses (Nyong et al., 2007). Almost all respondents reported experiencing postharvest losses. The findings revealed that farmers consistently encounter various pests and diseases. According to the farmers, the distribution of these pests has recently increased, destroying millions of hectares of farmland.

Notwithstanding, the respondents argued that some of the pests were controlled using the hoe during weeding. They identified and removed plants affected by pests and diseases. Interestingly, respondents noted that they used intercropping, slash-and-burn techniques, and crop rotation to control these issues. They also indicated that they used plant and animal parts, along with other products, to manage pests such as insects, birds, rodents, and nematodes, which threaten both cultivated crops and stored seeds. In the focus group discussion, participants explained that after

harvesting, they store food in a barn (Fig. 4.3) built from stones and wood. This design helps prevent ants and rodents from damaging the crops. These findings align with Shoko and Shoko (2013), which stated that using traditional knowledge for pest and disease management is a viable and ecologically friendly approach. Furthermore, Suiven et al. (2019) noted that employing traditional knowledge and practices reduces the reliance on toxic, non-biodegradable chemicals in the environment and waterways.



Figure 4.3: Barn for storing crops at Timonde
Source: Field work (2025)

Further, sticks with plastic bags or cans are tied around them and planted in the field, such as rice, millet, groundnut and many others,to drive away rodents and birds. When the wind blows, they produce sound that scares rodents and birds. For instance, respondents argued that to drive away field rats, palm fronds are placed at strategic locations on farms, especially rice farms, in an upside-down position resembling a cobra or an owl, which scares birds and other pests. Although hand-picking is not common in all communities, people used physical methods to remove adult

insects/caterpillars by hand-picking and crushing them. Further, cats and ducks were used as biological control agents of rodents and molluscs, respectively.

4.4 The feared future

Climate variability has affected the lifestyles and livelihoods of indigenous people as environmental hazards change.

4.4.1 The fear of relying on traditional ecological knowledge

Several constraints have limited the application of traditional ecological knowledge (Nyong et al., 2007). Many obstacles hindered the effective use of indigenous knowledge to mitigate climate change in the Upper East Region. For instance, traditional knowledge faces threats from urbanisation and the influence of Western education, which hinders the transmission of indigenous knowledge in food crop production.

Another issue respondents raised was that almost all traditional practices in the study communities face social, economic, and/or political marginalisation, which limits their capacity to rely on these practices for climate change adaptation. Tambo (2016) explained this point, stating that perceptions of social exclusion and political influence on traditional knowledge are not conducive to promoting the application of traditional practices. Further, the influx of technology into the region has undermined the indigenous ways of life and the coping strategies of smallholder farmers. In a group discussion, respondents contended that global changes such as Western education, technology, and most religious bodies were pressuring their traditional climate-adaptation practices. The situation is exacerbated by traditional leaders' inability to systematically document and conserve the traditional knowledge system. They explained that the younger

generation has little interest in or attachment to the traditional knowledge system; as a result, retaining oral traditions in the same way as older generations has become a challenge.

Also, the study identified political factors that impede the adaptation to climate change using traditional knowledge. Because traditional authorities were not included in the environmental governance process, climate change adaptation using traditional knowledge did not receive the attention and authority it needed.

4.4.2 The fear of relying on traditional coping mechanisms

As reported earlier, the study identified several traditional coping mechanisms smallholder farmers use to deal with the effects of climate variability. Research has shown that traditional knowledge can provide a baseline for effective adaptation mechanisms to increase crop yield (Napogbong et al., 2021). However, the study observed fear and uncertainty about relying on traditional knowledge coping strategies. One fear raised by respondents was that the timeliness of the practices could not be justified. It was revealed that, because of the changing climate, it was very difficult to associate some predictions and practices of traditional knowledge with a particular weather condition. According to the respondents, a major challenge was the inability to document the fundamentals of the traditional system. The practices are passed on through oral tradition and from generation to generation. Because the practices are not documented, distortion and misrepresentation of facts become evident. This confirms the report by Ocko et al. (2018) that traditional knowledge can lead to unrealistic reporting of facts and practices due to distortion and misrepresentation.

The study further explained thatrelying on local farmers to increase food production was not accurate. Farmers' responses confirm the findings of Ocko et al. (2018). Nyong et al. (2007) noted

that applying traditional knowledge for climate mitigation is constrained by uncertainty and non-context- and location-specific variability in climatic elements. Again, according to Tambo (2016), fear of relying on traditional knowledge for climate change coping mechanisms stems from levels of socioeconomic status, capacity, engagement, participation, knowledge, and policy.

Traditional knowledge is becoming less feasible because of changing environmental ecology, modernisation, shifts in religious beliefs, and rural–urban migration. Also, as religious beliefs shift and modernisation increases, the application of these practices is rapidly eroding. This was the greatest impediment to reliance on traditional knowledge.

4.4. 3 Food insecurity and future livelihood sustainability

The study explored food insecurity and livelihood sustainability among smallholder farmers in the region. The findings revealed that the region produces several foodstuffs. Many of these food crops have cultural and traditional significance. However, the region faces multiple climatic events. According to the study's findings, the farmers were aware that their crop production was decreasing due to extreme climate events. In a focus group discussion, respondents revealed that the region has already experienced rising temperatures, erratic rainfall, heat waves, and prolonged dry spells, all of which adversely affected agricultural yields. Farmers further stated that they had noticed a decrease in the pattern and volume of rainfall in the wet season, indicating that the rains have become insufficient to cultivate and sustain crops. This finding confirms Jiri et al. (2016), who found that several farmers in northern Ghana face climate stress that could lead to chronic household food insecurity.

The study highlighted that extreme temperatures from heatwaves, droughts, and dry spells significantly hindered smallholder farming activities and contributed to food insecurity.

Respondents noted that fluctuations in temperature were key factors behind the substantial decline in crop yields, thereby affecting food supply, accessibility, and utilisation, essential components of the food security framework. Previous research has shown that climatic events have adversely affected crop yields and led to livelihood losses. Additionally, poverty is directly correlated with food insecurity and livelihood sustainability. Participants reported that households with stable incomes were better able to improve food security and livelihoods. In contrast, those reliant on rain-fed agricultural practices faced significant food insecurity. Notably, most livelihood activities in the region are sensitive to weather variability, casting doubt on the future sustainability of these livelihoods amid climate risk. The study aligns with an FAO (2017) report, which confirmed that climatic events have had a detrimental impact on agricultural activities and the livelihoods of rural communities.

4.4. 4 Ability to read and write

Smallholder farmers' ability to read and write is crucial for adapting to climate change. Literacy significantly impacts information dissemination, understanding of climate risks, and the ability to implement new technologies and practices. The study found that literate smallholder farmers are generally better informed about climate change and more effective at adopting adaptation strategies than their illiterate counterparts. It also found that farmers with reading and writing skills have easier access to financial support systems, enabling them to purchase agricultural inputs and seeds. Respondents noted that literate farmers can secure capital more readily because they can provide collateral. In contrast, some illiterate farmers have formed credit groups to collectively mobilise funds for loans. However, they acknowledge that the financial resources generated are often insufficient due to the limited number of group members.

Education level influences farmers' ability to access and understand climate data. The findings showed that many of the farmers were illiterate. As a result, many rely on agricultural extension officers, the information service department, and community radio stations for information. However, they noted that this information is often not timely and sometimes not received at all.

An assessment of smallholder farmers' knowledge of promoting soil fertility through sustainable land management shows that literate farmers are better able to implement effective coping strategies. These include cultivating a variety of crops, such as drought-tolerant options, and engaging in tree planting or agroforestry. These practices help conserve soil and rehabilitate degraded lands. Literate farmers also show flexibility in coping with climate change by adopting new strategies, such as reduced or zero-tillage practices, adjusting planting dates, exploring alternative cultivation methods, and improving post-harvest management. Consequently, they tend to achieve greater food security compared to their illiterate counterparts.

4.4.5 Access to capital and market

Agricultural financing plays a crucial role in fostering food security and ensuring economic growth in developing countries. The research identified inadequate financial services as a major challenge facing smallholder farmers in the area. Participants reported rising production costs and the effects of climate change. Access to capital for farming was notably limited because of the scarcity of financial institutions in the area. The credit sources available to farmers could be categorised into three types: formal, informal, and semi-formal. Formal credit sources include commercial banks and credit funds, while informal sources consist of family members, relatives, individual lenders, and associations like the Susu box. The semi-formal sector encompasses microfinance institutions, NGOs, and government-supported lending programs targeting specific populations. In the

communities studied, informal credit was the predominant source of capital. Farmers most commonly borrowed through the Susu box, where they pooled resources and sometimes received additional support from NGOs. Respondents expressed that improved access to credit would enable them to boost production by affording necessary technologies and essential inputs for their farming operations.

Respondents identified their inability to access credit primarily as a lack of farm records and limited or undocumented collateral, such as land titles and other valuable assets that could be used as security. The study found that educated household heads were generally more informed about the credit market than their non-educated counterparts. Additionally, educated farmers often have alternative sources of income beyond agriculture, which enhances their ability to secure loans from banks and other financial institutions. Furthermore, households with many animals could more easily access credit, as these animals could serve as collateral.

Gender also plays a crucial role in household access to credit. The study's findings indicated that women could more readily obtain credit from NGOs or certain government institutions compared to men. This is largely because the amounts provided are relatively small and do not require substantial collateral. In a focus group discussion, women participants noted that men, as landowners, have the advantage of using their land as collateral for bank loans. In contrast, women without land ownership do not have this option. Consequently, microcredit often focuses on assisting vulnerable groups, including women.

The findings revealed the dire condition of the roads as a significant barrier to accessing markets and market services. Many roads connecting communities to farms and major market centres were in poor condition (Fig. 5.1). This created challenges in transporting produce from farms to homes and marketplaces. In all communities visited, respondents noted that, in some instances, they had

good harvests; however, because the roads were deteriorating, they could not transport their produce to homes or find buyers, resulting in spoilage on the farms.



Figure 5.1: Partial damage to roads linking farms and market centres
Source: Fieldwork (2025)

They explained that the poor condition of the roads makes it tedious for sellers to bring food items to the market, limiting food accessibility.

4.4.6 The fear of trying new things – the uncertainties

Agricultural production in rural communities plays a crucial role, significantly contributing to food security and local employment. However, farmers in this area still face challenges in responding to changing weather conditions. The study found varied perspectives among respondents on climate change adaptation. This uncertainty is largely attributed to longer dry seasons, unpredictable rainfall timing, and erratic precipitation patterns in recent years. During a focus group discussion in Bansi, one participant encapsulated this sentiment with the following remark:

"*Nowadays, the dry season is frequently extending to 10 months per year; when I was younger, it rained for more than 6 months per year, but that is not the case now."*

Because of changing climatic patterns, it became difficult to adapt to new farming methods. In their view, information regarding climate adaptation in the area was limited. The respondents revealed that most smallholder farmers lack adequate knowledge of improved varieties, planting methods, and other practices that ensure crop yield. As a result, many respondents indicated that this made it difficult for them to shift to new farming methods.

Again, many smallholder farmers were used to cultivating indigenous staple crops such as millet, sorghum, and rice. Some respondents stated that their forefathers cultivated these crops and that it would therefore be difficult to adopt new crop varieties such as maize. In their opinion, they have cultivated these crops since time immemorial and cannot abandon them for crop varieties about which they have limited information. Some respondents further stated that "Tuo Zaafi" (TZ) prepared using the new maize variety is not nutritious because of the application of chemical fertiliser. Also, the indigenous crops do not require chemical fertiliser for production. However, almost all new crop varieties cannot produce sufficient yield without chemical fertiliser. The high cost of fertiliser makes it unaffordable. As a result, they prefer to continue cultivating indigenous crops, even though climate change is devastating their yields. This corroborates the findings of Godfray et al. (2010), who reported that climate change dynamics will lead to declining crop yields and national food security in poor countries.

5.0 Conclusion and Recommendation

This study enhances the existing body of knowledge by examining traditional practices for addressing climate change and the effects of climatic variables on food production in the Upper

East Region of Ghana. Traditionally, communities have relied on indigenous knowledge to mitigate the impacts of adverse climatic conditions, including floods, dry spells, droughts, crop failures, and land degradation, while also adapting to evolving weather patterns over time. Several pieces of evidence, including the presence of specific plant species and livestock management, were used to identify climate change in the region. By leveraging traditional knowledge, these farmers made crucial decisions about which crops to cultivate and the optimal timing for planting. While the study highlighted the continued relevance of traditional knowledge and practices in the face of climate change, it also noted that some aspects have become difficult to observe and are no longer significant for weather prediction due to shifts in societal values. Many local farmers showed reluctance to adopt modern farming techniques needed to address climate change, mainly because of limited knowledge and a strong attachment to traditional farming methods. The study concluded that integrating traditional knowledge and practices with contemporary methods is urgently needed to strengthen smallholder farmers' adaptive capacity. This need arises because scientific climate forecasting can be expensive, often inaccessible, and sometimes unclear for farmers. Based on these observations, the following recommendations were proposed:

- As a result of the close link between traditional knowledge and community cohesion, social capital, and social-ecological resilience, there is a need for effective programs for traditional knowledge sustenance, which will play a vital role in maintaining smallholder farmers’ adaptation strategies in climate change mitigation.
- There is also a need for the inclusion of traditional knowledge in policy formulation to ensure a holistic climate change adaptation measure. Recently, climate change mitigation policies often overlook the contributions and rights of indigenous knowledge and practices, leading to the erosion of these environmentally friendly practices.

- Stakeholders should share ideas about predicting and responding to climate change with the local community. Community acceptance of local knowledge, linked to scientific analyses, would improve climate change prediction and response.

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I declare that there is no competing financial interest that could appeared to hinder the publication of the manuscript. Therefore, there is no potential conflicts of interest that may arise as from the work as a result of financial interest.

Conflict of interest

We declare that there are no known competing financial interests or personal relationships that could appear to influence the work reported in this paper. The authors self-financed the work.

Data availability

The datasets generated during and/or analysed during the current study are not publicly available due to the confidentiality and anonymity of the respondents, but are available from the corresponding author on reasonable and formal request.

Ethics declaration

Not applicable. The data for the study were collected using in-depth interviews and focus group discussions. The University of Education, Winneba Research Ethics Review Committee granted approval in accordance with the university's Research Ethics Policy, which aligns with the principles of the 1964 Helsinki Declaration and the 1976 Belmont Report. It was in this regard that

the participant consent forms were issued and duly signed by the respondents and study participants. Participation in the study was voluntary and their right to withdraw from the study at any stage of the data collection process was duly; their right to withdraw at any stage of the data collection process was respected. Participants selected for the study received invitation letters communicating the date, time, and venue of the discussion. The study team also followed the necessary community entry procedures in all study communities before the start of the interview or focus discussion. Participants were assured that their views would be kept confidential and used purely for academic purposes. They were given the opportunity to ask questions before the start of the discussions to clear any doubts about the study. These invitation letters would be made available upon request.

Consent to participate declaration

Informed consent to participate in the study was obtained first from respondents. Participants were also informed that participation was voluntary and that they could decline at any time. We respected respondents who opted not to take part.

Consent to publish declaration

Not applicable

Clinical Trial Number

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