Farmer's Perception of Climate Change and Coping Strategies in the Black Volta Basin, Ghana

Francis X. K. Mwinkom[1*], Lawrence Damnyag[2], Simon Abugre[3], Ebenezer K. Siabi[4], Moses Kabir[5], Samuel Kingsford Twene[1], Isaac Verbeck Mensah[1], Jacqueline Tanguo[6]

[1]Department of Social Science, St. Ambrose College of Education, Ghana
[2]CSIR-Forestry Research Institute of Ghana (FORIG), Box UP 63, KNUST, Ghana
[3]Department of Forest Science, University of Energy and Natural Resources, Sunyani, Ghana
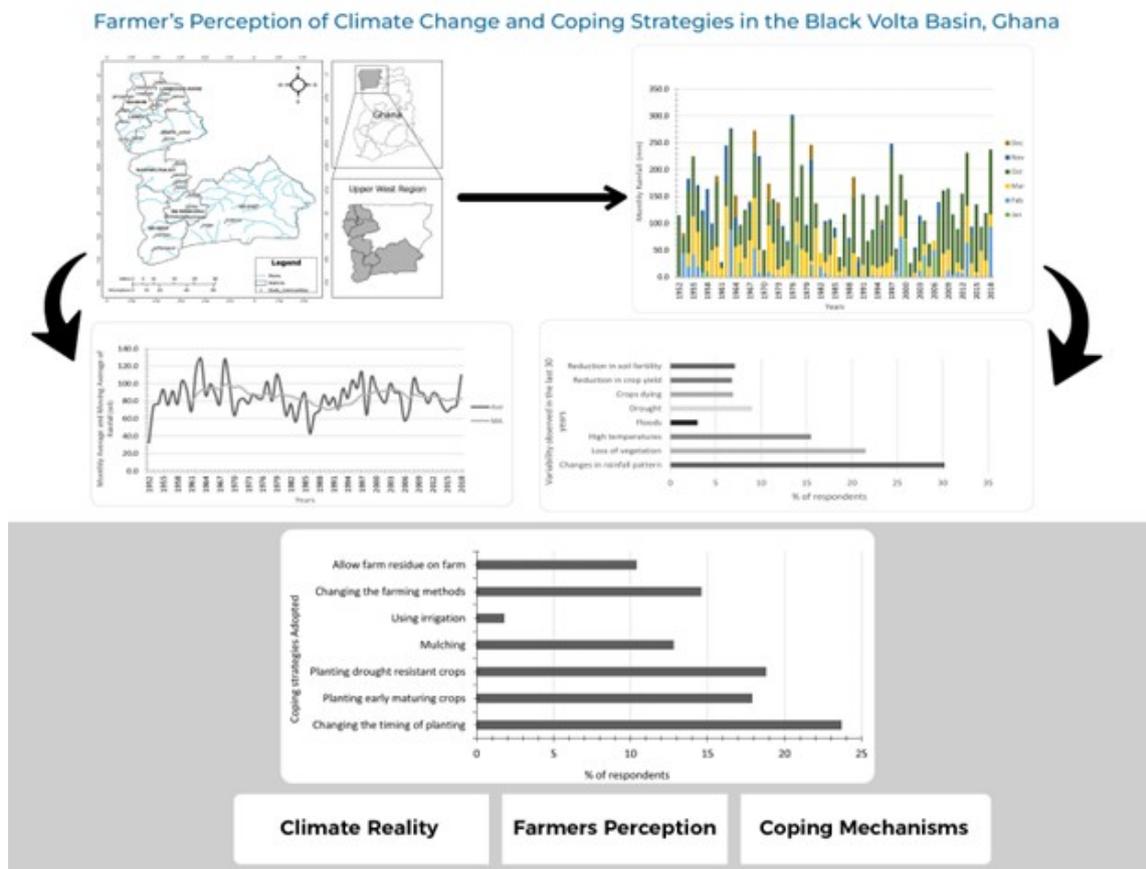[4]Earth Observation Research and Innovation Centre, University of Energy and Natural Resources, Sunyani, Ghana
[5]Department of Land Management, University of Energy and Natural Resources, Sunyani, Ghana
[6]Odomaseman Senior High School, Box 938, Odomase, Ghana
[*]Corresponding author: fmwinkom@gmail.com

Graphical Abstract

Farmer's Perception of Climate Change and Coping Strategies in the Black Volta Basin, Ghana

Francis X. K. Mwinkom[1*], Lawrence Damnyag[2], Simon Abugre[3], Ebenezer K. Siabi[4], Moses Kabir[5], Samuel Kingsford Twene[1], Isaac Verbeck Mensah[1], Jacqueline Tanguo[6]

[1]Department of Social Science, St. Ambrose College of Education, Ghana
[2]CSIR-Forestry Research Institute of Ghana (FORIG), Box UP 63, KNUST, Ghana
[3]Department of Forest Science, University of Energy and Natural Resources, Sunyani, Ghana
[4]Earth Observation Research and Innovation Centre, University of Energy and Natural Resources, Sunyani, Ghana
[5]Department of Land Management, University of Energy and Natural Resources, Sunyani, Ghana
[6]Odomaseman Senior High School, Box 938, Odomase, Ghana

[*]Corresponding author: fmwinkom@gmail.com

Abstract

This study investigates the impact of climate change on agriculture in the Upper West Region of Ghana, specifically among farmers along the Black Volta Basin. The area is a major food production hub, contributing significantly to regional and national food security. However, climate variability and change have resulted in food production shortages and changes in rainfall patterns, affecting farmers' livelihoods. A random sampling technique was used to select 600 farmers for interviews. The study found that the majority of farmers along the Black Volta Basin area lack awareness and capacity to adapt to climate change. The study highlights the need for climate change awareness initiatives and capacity-building programs to enhance farmers' adaptive capacity, increase resilience, and reduce vulnerability. The findings have significant implications for climate change adaptation policies and programs in Ghana, emphasizing the importance of supporting farmers in building their capacity to adapt to climate change. The study's results can inform policy decisions aimed at promoting climate-resilient agriculture and improving food security in the region.

Key words: Crop farmers, Climate change, Perception, Binary regression models, Black Volta Basin.

1   Introduction

In the Africa sub-region, the agricultural sector remains the sector that employs the highest of about 60% of the total population and contributes to the Gross Domestic Product (GDP) growth rate of about 30% [10, 46]. Despite the essential role agriculture play in the economies of many countries in the sub-region, the sector remains underdeveloped and unproductive. The main challenges of the agricultural sector in the region include dependence on natural support systems, low use of technology, low institutional support, poverty, land degradation and environmental deterioration, low adaptive capacity, and high climatic exposure [1, 54, 62]. The fast-changing climate has negatively impacted

the activities of smallholder farmers in sub-Saharan Africa. The FAO [24] report posit that, climate change is seen mainly as a key threat to Africa's agricultural growth and development. Human livelihood and well-being are seriously impacted as the incidence of climate change increases [7, 57].

Globally, climate is changing in a faster rate than we assumed currently [28]. The situation is not as a result of different local weather but is changing the vegetation and the climatic elements of the globe causing major natural disasters. According to [29], climate change affects every individual the world over, but the impacts are more serious for the poorer regions. Droughts are destroying the crops reducing yields; while flooding and storms are causing excessive damage to the vegetative cover [25]. According to [59] and [5], issues on climate change globally is skewed towards development dimension but when it comes to issues like poverty, discussions are normally directed to developing countries in Sub-Saharan Africa, Latin America and Asia.

Developing countries and their people particularly those in the Sub-Saharan Africa Region whose livelihood depends mainly on agricultural production are more exposed to the impacts of climate change thereby raising their concern [48]. Additionally, the efforts of African countries to achieve the SDG 13, that is to combat climate action and its impacts may not come to light if adverse effects of climate change were not addressed. Sub Saharan African region is more vulnerable to the impacts of climate change due to the continents over reliance on rain-fed agriculture coupled with low technology, poverty and the perception of many African farmers towards climate change [6].

The study explores farmers' knowledge and perceptions of climate change, aligning with UN Sustainable Goal 13 (Climate Action) by investigating local understanding and adaptation strategies. The research alignment with nature-based solutions is observed in its assessment of how farmers' traditional practices and connection to nature inform their climate resilience approaches. By assessing farmers' perceptions, the study identifies opportunities for nature-based solutions that leverage local ecological knowledge, such as agroforestry, sustainable land management, and biodiversity conservation. This goal focuses on strengthening resilience and integrating climate measures into planning. Local knowledge may also empower farmers to adopt nature-based solutions, fostering community-led climate actions.

The enduring impacts of climate change include; changing rainfall patterns that results in the reduction in agriculture production and the reduction in food security, worsening water security, decreasing fish resources in large lakes due to rising temperatures and shifting vector-borne and it related diseases [44, 3]. Previous studies [7, 44], suggest that the adverse effect from climate change in the form of reduction of agricultural production ends up retarding the growth of countries in Africa, since a greater proportion of the national income of most African countries is from agriculture. Climate change is a serious threat to the semi-arid tropics, which is characterized by scanty and uncertain rainfall, infertile soils, poor infrastructure, severe poverty and rapid population growth [11]. [55] posit that local perceptions and adaptive behaviour provide better understanding and relevant information leading to a sustainable agricultural development and the protection of the environment.

According to [52], human awareness of climate change is complex and influenced strongly by elements such as expectations, which may have limited or no correlation with the true nature of climate. Farmers knowledge and perceptions of climate change relate more to the increased variability and uncertainty of specific weather parameters rather than long-term climate change [64, 43, 53, 42, 41]. Some of these perceptions include late onset of rains, shorter wet monsoons were categorized by slight but instance rainfall, strong winds with excessive rains, more summer heat and unpredictable in the patterns of the seasons [51, 49, 12, 39, 58].

Studies conducted in South Africa observed that farmers and other land users saw drought and extreme rainfall were not necessarily sufficient to determine the characteristics of climate variability [27, 65]. Studies conducted in two villages in the state of Uttarakhand in India, it was found that majority of almost all the households interviewed felt that rainfall had declined in quantity during the onset of monsoons [19, 13, 15, 16]. [35] in their study, observed that there was an increase in heat intensity. In addition, farmers felt that the monthly frequency of rains had decreased with an increased in dry spells as a result of the intensity with the heat [60].

In a study conducted in Ethiopia, [8], viewed the features of climate change to be drought, flood and soil degradation and suggested these were the major factors responsible for the low agricultural productivity in that country. Additionally, [9] reported that farmers living along the dry lowland areas perceived more change in climate than their counterparts in the wet lowland areas. The farmers perceived that there had been significant variations in the quantity and distribution of the incidence of rainfall over the last decade.

In formulating effective policies for climate change adaptation, the strategies in addressing the impacts of climate change on farmers must be taken into consideration the farmers knowledge and perception of climate change, their options for adaptation strategies, and the cultural barriers that affect the adaptation options [26]. Also, smallholder farmers low level of awareness adversely impacts on climate change as awareness was crucial in coping with preparing for climate variability and change. The level of smallholder farmers knowledge of their environment could be guided to respond effectively to the challenges of climate change to improve crop productivity [20]. Agriculture has since been an important sector and extremely relevant to the Ghanaian economy, employing about 55% of the population and contributing about 35% to Ghana's GDP, and also generating about 30–40% of the country's foreign exchange earnings [26].

According to [9], farmers in their study area perceive the change in climate and have devised a means to survive through implementing varied adaptation strategies for improved agricultural production. Food crop farmers in the two parts of the study areas were found to be similar with respect to some variables that affected perception and climate adaptation. The consideration of age is a way to reflect the importance of experience [43]. Farmers generally perceived climate change in terms of erratic rainfall distribution, reduction in the incidence of rainfall, and increasing temperatures over the last two decades [26].

Adaptation in the view of [47] is among the fast-growing policy directions to minimizing the negative impacts of climate variability and change in most developing countries that unfortunately contribute little to this phenomenon. The losses due to the incidence of

climate change are a bane and slows down the rate of development in many developing countries [34]. The highly variable rainfall, increasing temperature intensity, frequent floods and droughts are signs of climate change and variability which are experienced along the Black Volta Basin (BVB) areas leading to a greater uncertainty and increases the risks and potentials of farmers in the agricultural value of the traditional agricultural knowledge on agricultural production.

In this sense, adaptation becomes the only option for efficient changes in the impacts of climate change and this should be taken with all seriousness before farming conditions decline further. The IPCC [31], posit that climate change adaptation may be regarded as a response to the impacts of climate change. Climate change adaptation is the adjustment in ecological and socio-economic systems to the actual or anticipated climate change to reduce the negative and enhance the positive impacts of climate change [30].

In Ghana, climate change is manifesting in erratic rainfall patterns, increased temperatures, and more frequent extreme weather events [7]. Climate change expressed in high temperature, frequent floods, unpredictable onset of rains and droughts were constraints on agricultural production in Ghana [23, 33]. Various research works have been introduced along the BVB areas to upgrade the issue of climate change and the various adaptation options deemed fit by the smallholder farmers in the study areas. There is limited available literature regarding the perception of farmers on climate change and variability in the Black Volta Basin area [45, 40].

This study therefore aims to investigate farmers knowledge and perception within climate change as well as the relationship between meteorological data and farmers' experience in the BVB areas. The study fills an important gap by producing empirical evidence needed to support context-specific climate smart policies for planning and to enhance climate-resilient smallholder farming systems in the BVB areas in Ghana.

2 Materials and Methods

2.1 Study Area

This study was conducted in the Upper West Region of Ghana (Figure 1). Eight districts were sampled for the study in the region. These districts were selected for the study based on the extent of climate impact on the agricultural activities in the area. The BVB lies between latitude 7°00'00"N and 14°30'00"N and longitude 5°30'00"W and 1°30'00"W, covering an estimated area of about 130,400 km² which is about 21% of the entire Volta basin area. However, the Ghana portion of the BVB area covers 18,384 km² constituting 14% of the basin [14, 4]. It covers about 1,350 km² from Burkina Faso to the Volta Lake with thirteen main tributaries and accompanying catchment draining into the BVB [14]. The BVB is composed of the Sahel, Sudan savannah from the upper part of the basin, guinea savanna and transitional zone at the middle portion, and moist semi-deciduous forest at the lower portions of the basin [14, 2].
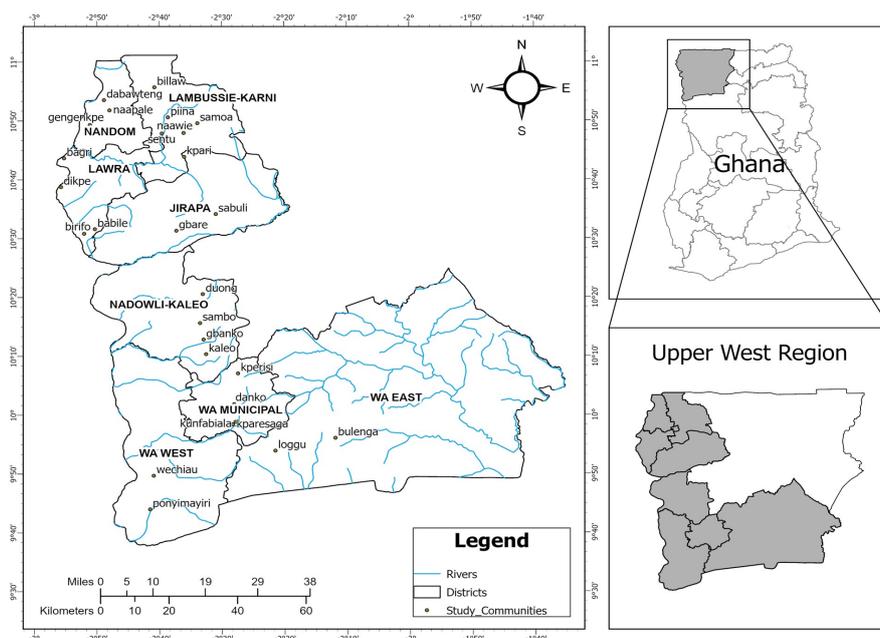
Figure 1: Map of Ghana indicating sampled districts for the study.

Humidity is high during the rainy season and low during the dry season. The mean annual temperature in the Black Volta Basin, Ghana is 26°C. Temperatures range as high as 44°C during the day and falls to as low as 15°C at night [14]. The rural population depends on natural support systems for their livelihoods. The major land use of the BVB is agriculture. Major food crops produced include yam, cassava, maize, sorghum, millet, groundnut, tomato, okra, cabbage, lettuce, pumpkin, and beans [14]. Livestock keeping is also an important livelihood activity. Eight districts (Lawra, Nandom, Lambussie-Karni, Jirapa, Nadowli-Kaleo, Wa West, Wa East, and Wa Municipal) in the Upper West Region with high exposure and sensitivity to climate variability were selected for the study.

2.2 Data Collection

Both primary and secondary data were used in the study. A survey was conducted to gather information from 600 smallholder farmers in 40 randomly selected farming communities from August to September 2018. The list of farmers for the study was generated through the various district Department of Agriculture offices and identifiable farmer groups. Selected communities for the study are presented in Table 1. A semi-structured questionnaire was used to gather detailed information on the respondents' experiences with climate change and their risk mitigation strategies. Informed consent was obtained from the individual farmers who participated in the questionnaire survey. Secondary data (Average monthly rainfall data from different weather stations in the Upper West Region for 66 years 1952–2018) was obtained from the Ghana Meteorological Agency in Wa. This data was used because some of the study districts did not have data on rainfall for the period specified. According to the Ministry of Food and Agriculture [38], districts in the Upper West Region have fairly similar characteristics typical of the Savannah agroecological zone of Ghana. This justified use of the average monthly regional data as proxy for the study districts.

Table 1: Sampled districts and communities in the Upper West region for the study

Districts	Selected Communities
Lawra	Babile, Bagri, Kunyukuong, Birifo, Dikpe
Nandom	Ketuo, Dabawteng, Tantuo, Gengenkpe, Naapaal
Lambussie-Karni	Pina, Billow, Naawie, Samoa, Sentu
Jirapa	Gbare, Sabuli, Kpari, Konzokala, Sangwia
Nadowli-Kaleo	Zukpari, Gbanko, Duong, Sombo, Kaleo
Wa East	Bulenga, Loggu, Dupari, Chaggu, Tuasaa
Wa West	Dabo, Tanduori, Ponyimayiri, Wechiau, Meteumeteu
Wa Municipal	Sing, Kparesagra, Kunfabiala, Danko, Kperisi

Source: Field Survey (2020).

In determining the sample size for the study from the sample frame, a simplified mathematical formula was adopted from [63] to calculate the sample sizes. Giving room for a minimal degree of error, the study operates a 95% confidence level with an error margin of 5%. Below is the mathematical illustration for the Taro Yamane method to determine the sample size from a given population:

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

where n signifies the sample size of the study, N is the total population under study, and α is the level of precision or the margin of error ($\alpha = 0.05$). Therefore, for the total registered households across the study districts ($N = 101{,}824$), the responsive sample size is:

$$
\begin{aligned}
n &= \frac{101{,}824}{1 + 101{,}824(0.05^2)} \\
&= \frac{101{,}824}{1 + 101{,}824(0.0025)} \\
&= 398.435 \approx 398.
\end{aligned}
\tag{2}
$$

According to [56, 63, 37], the responsive sample size was justified by employing the mathematical sampling method; with non-responsive sample size of 202, the total was $202 + 398 = 600$. A household farmer survey was undertaken from July 2018 to August 2020. Face-to-face interviews were employed with the help of semi-structured questionnaires to collect primary data from 600 smallholder farmer household heads in the Black Volta Basin area (Table 1).

The number of farming households selected from each community and district was determined using the proportionate sampling technique. According to [22], proportionate sampling was employed due to the households that are largely different in number; the number of households was determined by their relative number to their entire population. The proportionate allocation is expressed as:

$$n_i = \left(\frac{N_i}{N}\right) n, \tag{3}$$

where n_i is the desired sample for district i, N_i is the number of registered households in district i, N is the total registered households in the study area, and n is the total sample size. For example, the desired sample size for Nandom Municipality is $n_1 =$

$(N_0/N) \times n_0 = (7417/101{,}824) \times 600 \approx 44$ households, as replicated in Table 2 for all districts.

In order to obtain a representative sample, the sample was proportionally distributed among the study communities. Systematic random sampling was employed: the first unit of the sample selected at random and the subsequent units were selected in a systematic way. If there are N units in the population and n units are to be selected, then $R = N/n$ [50, 61, 18], where R is the sample interval. The desired sampling interval for Nandom Municipality is $R = 600/44 \approx 14$th household, as replicated in Table 3 for all districts.

Table 2: Sample size by districts

Districts	Population	No. of Households	Sampled
Nandom Municipality	46,040	7,417	44
Lawra Municipal	100,929	16,617	98
Lambussie-Karni	51,654	7,524	44
Nadowli-Kaleo	94,388	15,210	90
Jirapa Municipal	88,402	13,911	82
Wa Municipal	107,214	18,891	111
Wa West	81,348	11,486	68
Wa East	72,074	10,768	63
Total	702,110	101,824	600

Source: Field Survey (2020).

Table 3: Sample interval for the study

Districts	No. of HH (N)	Sampled HH	Interval (R)
Nandom Municipality	600	44	14th
Lawra Municipal	600	98	6th
Lambussie-Karni	600	44	14th
Nadowli-Kaleo	600	90	7th
Jirapa Municipal	600	82	7th
Wa Municipal	600	111	5th
Wa West	600	68	9th
Wa East	600	63	10th

Source: Field Work (2020).

3 Results

3.1 Data Analysis

The data collected from the study was analyzed and interpreted descriptively using the Statistical Package for Social Science (SPSS) and Microsoft Office (Excel). The data from the questionnaires were coded and the pie charts and frequency tables derived and used for the interpretations. The model employed in this study was the binary logistic regression of the coping strategies of farmers in response to climate change and variability. Where coping strategy is dependent variable and independent variables are; age, gender, household size, farmland, knowledge/awareness of climate change and variability of climate change. The descriptive statistics of respondents are presented in Table 4.

3.2 Socio-demographic Characteristics of Respondents

Table 4 provides the socio-demographic characteristics of respondents around the Black Volta Basin areas. The mean age of respondents is 45.79 and 88% of respondents being males and 12% females. The results show 46% of respondents are Dagara people and 23.5% being Lobe-Dagara. Most of the respondents attained no formal education (29.5%), 26.6% had primary education and 16.7% attained middle school leaving certificate (ten years of schooling in the basic education). More than half (55%) of respondents belong to small households (one to ten members) whilst 40.8% belong to medium households (eleven to twenty members).

Table 4: Descriptive statistics of the socio-demographic characteristics of respondents (N=600)

Variable	Upper West
Age (years)	Mean=45.79, SD=7.509; Min=25, Max=69
Gender	Males (88%), Females (12%)
Ethnic Group	Lobe-Dagara (23.5%), Dagara (46%), Sissala (10.8%), Wala (9.8%), Mossi (3%), Chakali (6.8%)
Employment	Farmer (85.5%); Officially employed (0.8%); Casual laborer (0.5%); Farmer and employed (9.4%); Ranger (2.8%); Gardener (1%)
Education	Primary (26.6%), JHS (11.8%), Secondary (4.2%), Tertiary (3.5%), Technical/Vocational (7.6%), MSLC (16.7%), None (29.5%)
Marital status	Married (86.2%); Single (3.3%); Divorced (5.2%); Widowed (4%); Engaged (0.5%); Separated (0.8%)
Household size	1–10 (55%); 11–20 (40.8%); 21–30 (4.2%)
Occupation	Livestock (20%); Crop farming (67.6%); Fish farming (5.6%); Tree farming (2.4%); Gardening (4.4%)

Source: Field Survey (2020).

3.3 Perception of Farmers on Climate Change

The results show that 98% of respondents are aware of climate change (Table 5). The districts including Lawra, Lambussie-Karni, Nadowli-Kaleo, Jirapa and Wa Municipal have 12.5% each of the respondents who are aware of climate change; Wa West 11%, Wa East 12.3% and Nandom 12.2%. The results in Table 6 indicate that a larger percentage of farmers (95%) have their crop production being affected by climate change. Beans is the crop mostly affected (39.3%), followed by Maize (38.2%) and groundnuts (15.5%). How the current climate change affects farmers negatively appears to be severe; 97.7% of respondents reported it leads to low crop yield.

Table 5: Percentage of respondents' awareness of climate change

District	Yes (%)	No (%)
Nandom	12.2	0.3
Lawra	12.5	0
Lambussie-Karni	12.5	0
Nadowli-Kaleo	12.5	0
Jirapa	12.5	0
Wa Municipal	12.5	0
Wa West	11	1.5
Wa East	12.3	0.2
Total	98	2.0

Source: Field Survey (2020).

Table 6: Percentage of respondents whose crops are affected by climate change

Response	% of respondents
Yes	95
No	5
Total	100

Source: Field Survey (2020).

3.4 Rainfall Pattern

Most farmers (79%) have realized that there has been an increase in the rainfall level and 17.5% saying the pattern has been unpredictable as compared to the past (Table 7). Rainfall from secondary data sources shows significant maxima in the mid-1960s and late 1990s, with the trend line remaining at or above 90–100 mm. The most notable characteristic is the dramatic decline in the early to mid-1980s; the average line reaches its lowest point (about 40 mm) between 1982 and 1985. In the concluding years, the moving average stabilizes at approximately 80 mm, while the annual averages exhibit a considerable increase in 2018 (exceeding 100 mm).

Table 7: Respondents' description of rainfall levels

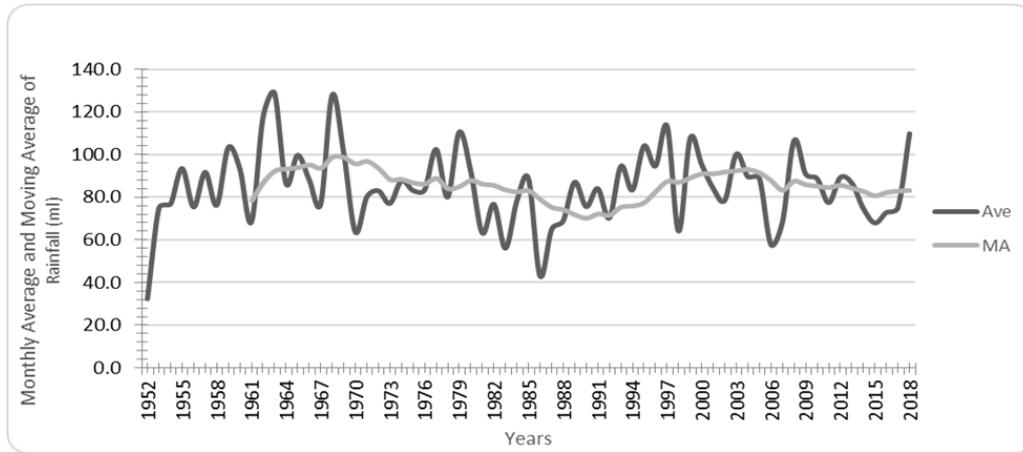| Perception on rainfall pattern	%
Unpredictable	17.5
No change	1
Increased	79
Decreased	2.5
Total	100

Source: Field Survey (2020).

Figure 2: Average rainfall (mm) in Upper West Region.

Dry season. October accounted for the majority of rainfall during this period, coinciding with the conclusion of the rainy season. January, February, and December exhibit minimal or negligible precipitation, indicative of the severe dry season (Harmattan) characterized by virtually complete absence of rainfall. March, generally marking the onset of the rainy season, exhibits fluctuations that indicate the unpredictability of the rains' commencement—some years receive early precipitation while others remain arid. In 1976, there was a significant increase in rainfall, approaching 300 mm during the off-peak months, primarily due to an exceptionally rainy October.
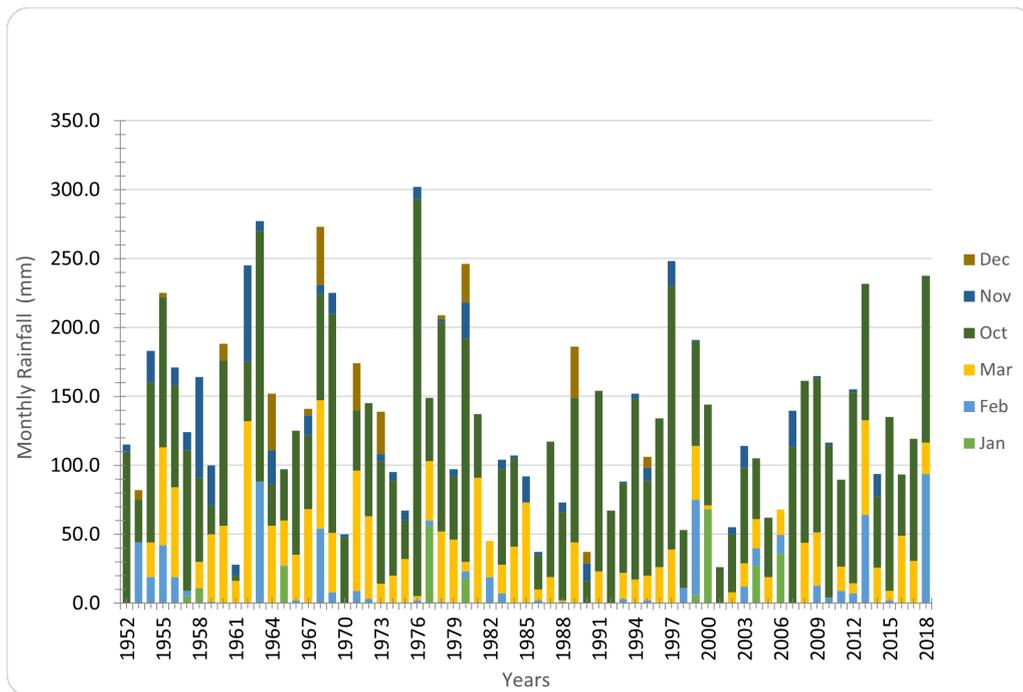
Figure 3: Rainfall (mm) from October to March between 1952 and 2018.

Wet season. August and September regularly recorded maximum precipitation, indicating that the most intense rainfall in this region generally occurs late in the season, which is vital for establishing crop maturation timelines. The segments for April and May are often smaller, signifying that the commencement of the rains is less intense and more erratic. Years such as 1963, 1968, and 1979 exhibit exceptionally high totals beyond

1200 mm, signifying potential for abundant harvests or flood hazards. A significant decline in total rainfall is evident in the early 1980s (1983–1985), falling below 600–800 mm, corresponding with the historical drought that impacted Ghana during that period.
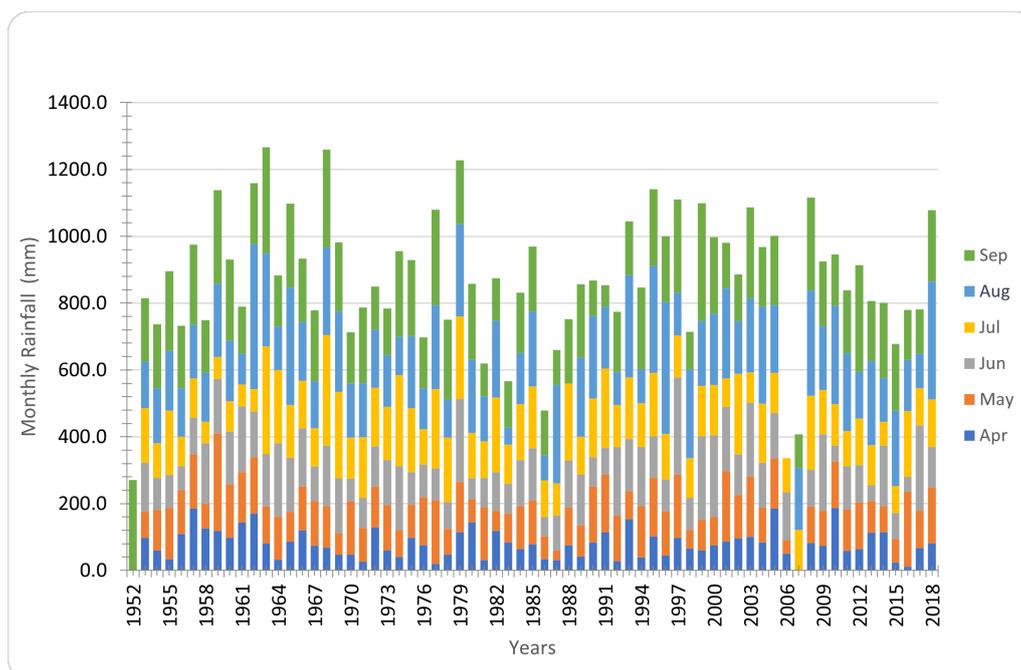

Figure 4: Rainfall (mm) from April to September between 1952 and 2018.

3.5   Perceived Effect of Climate Change and Variability

Most farmers (30.2%) realized climate change causing changes in the rainfall pattern and 21.5% identified loss of vegetation. Also, high temperatures, floods, drought, dying crops, reduction in crop yield and reduction in soil fertility were identified by respondents.
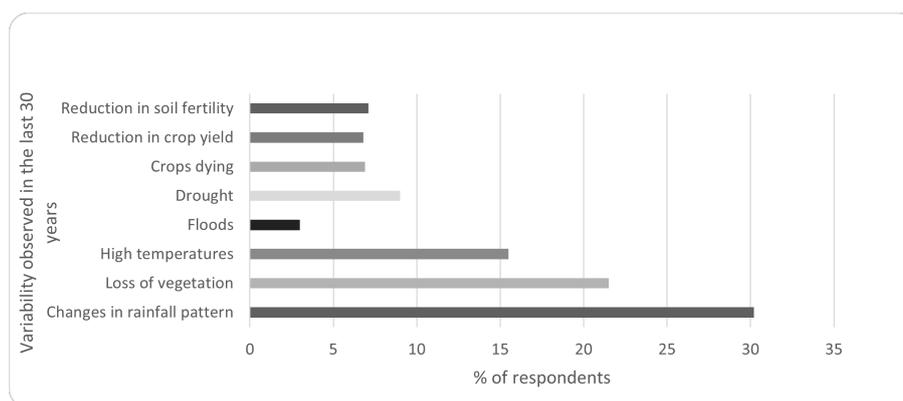
Figure 5: Climate variability experienced by respondents.

3.6   Farmers' Coping Strategies

Farmers' coping strategies in response to climate change saw 24% of farmers changing the timing of planting. Planting drought resistant crops as a coping strategy was supported by 17% of respondents (Figure 6). Respondents also revealed that 16% plant early maturing crops as a coping strategy useful for climate adaptation. Farmers (14%) adapted by changing farming methods as a coping strategy to climate change along the Black Volta Basin areas. About 13% of farmers use mulching as a coping strategy, while 11% allow

farm residue on their farms to reduce the incidence of climate impacts. The results revealed that farmers adopting irrigation (3%) was low, largely due to the lack of irrigation facilities in the selected communities; this helps explain seasonal out-migration to the southern parts of the country during the dry season.
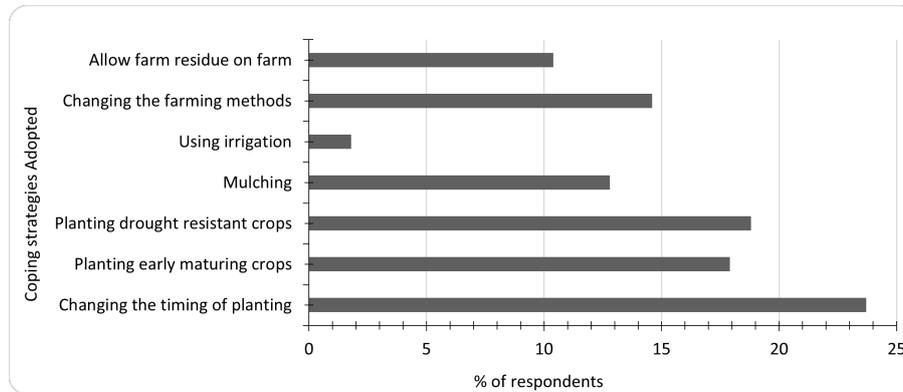

Figure 6: Coping strategies adopted by farmers during climate change.

The results indicate that out of the six socio-demographic characteristics, only three variables (age, household size and farmland) have a significant association with the coping strategies (Table 8). Age and farmland have a positive association; household size had a negative relationship.

Table 8: Pearson correlation analysis between socio-demographic characteristics and the coping strategies (N=600)

	Age	Gender	HH Size	Farmland	Know.	Var.	Coping
Age	1	−0.088*	0.076	−0.086*	0.044	−0.185**	0.093*
Gender	−0.088*	1	0.201**	−0.047	−0.053	−0.059	0.056
Household Size	0.076	0.201**	1	0.061	−0.101*	0.048	−0.133**
Farmland Size	−0.086*	−0.047	0.061	1	0.014	−0.017	0.176**
Knowledge	0.044	−0.053	−0.101*	0.014	1	0.058	−0.078
Variability	−0.185**	−0.059	0.048	−0.017	0.058	1	−0.011
Coping strategies	0.093*	0.056	−0.133**	0.176**	−0.078	−0.011	1

*p<0.05; **p<0.01 (2-tailed)

Source: Field Survey (2020).

3.7 Estimation of Factors Affecting Farmers' Coping Strategies

Binary logistic regression was employed to determine the factors that explain the coping strategies adopted by farmers (Table 9). The results show that four out of the six explanatory variables were statistically significant. The coefficient of age (B=0.045, p=0.003), gender (B=1.105, p=0.001), household size (B=−0.962, p=0.000) and farmland (B=0.213, p=0.000) were significant statistically. The analysis shows that these are the factors that actually influenced respondents when practicing coping strategies during climate change. The results revealed that the age of farmers had a positive coefficient, implying that the older the farmer, the more likely they were found practicing coping strategies; older farmers are 1.046 times more likely to practice coping strategies compared to younger farmers. Household size was significant but had a negative coefficient, implying that larger households are 0.40 times less likely to take up coping strategies compared to smaller households. It also revealed that the larger the size of farmland, the more likely farmers practice climate change adaptation since farm size is positively related to coping strategies.

Table 9: Logistic regression explaining the coping strategies (N=600)

Variable	B	S.E.	Wald	Sig.	Exp(B)
Age	0.045	0.015	9.124	0.003	1.046
Gender	1.105	0.327	11.433	0.001	3.020
Household size (No.)	−0.962	0.207	21.526	0.000	0.382
Farmland (ha)	0.213	0.043	24.108	0.000	1.238
Knowledge (CC)	−0.449	12018.21	0.000	0.999	0.000
Variability (Climate)	0.061	0.725	0.707	0.400	1.840
Constant	−3.06	0.785	15.207	0.000	0.047

Significant if p<0.05, Level of significance=95%

Source: Field Survey (2020).

4 Discussion

The Black Volta Basin area is typically an agrarian community in Ghana with low level of industrialization. This study noticed the impact of location on the climate of different areas along the study areas. The variations in the incidence of climate were also noticed from the perceptions of the sampled farmers about extreme climate effects and their impacts on crop production and yield. It was found that majority of the respondents in the study area were from the middle age brackets, who were found to be more experienced and aware of climate change and its impacts on food crop production [36]. Findings support [21], which revealed that older farmers were more likely to be seen practicing varied adaptation or coping strategies.

The study demonstrates that old aged farmers were likely to perceive climate change impacts on food crop production more efficiently than young farmers. Farmers with more farming experience were expected to be aware and to have better understanding of climate change [26]. Results revealed that a greater number of the farmers do not have formal or basic education. Education guides respondents to acquire varied information that enables them of their perception to climate change impacts [52]. [32] posit that education is positively and significantly associated with farmers' perception. From the results, the larger the size of the farmers farmland, the more likely that the farmers practice efficient climate change adaptation since farm size was positively related to coping strategies.

Farmers perception of climate change relates more to the increased variability and uncertainty of specific weather parameters rather than long term climate change [64]. Household size was significant but has a negative coefficient. Results identified effects of climate change on crop production which supports [43], that changing climate is a major cause in the changes in rainfall pattern, loss of the vegetation, high temperatures, floods, drought and drying of crops [17]. According to [9], farmers knew about extreme temperatures and variability in rainfall which is in agreement with the meteorological records. Findings from the binary logistic regression indicate that age, household size and size of the farmland had a significant association with the coping strategies. Age and farmland had a positive association with the adaptation strategies.

5   Conclusions

This study highlights the critical issue of climate change in the Black Volta Basin Area (BVBA) of Ghana, where farmers are facing significant challenges due to human activities and climate variability. Farmers in the study area lack adequate knowledge on climate change and its impacts on agriculture, leading to inadequate adoption of climate-resilient practices. The study also identifies demographic and socio-economic factors, such as poverty and lack of off-farm employment opportunities, as underlying causes of climate change in the area. Furthermore, the study reveals that illegal logging and deforestation are prevalent in the area, contributing to environmental degradation and negatively impacting agricultural productivity.

Based on the study's findings, the following recommendations were made: The Black Volta Basin Management Authority should intensify its surveillance and enforcement of laws to protect the available resources along the BVB areas. The establishment of Community Resource Management Areas (CREMAs) in resource-endowed communities along the BVBAs could boost tourism and attract tourist activities, thereby reducing poverty and promoting sustainable livelihoods. Also, farmers, fishermen, and other community members should be educated on the impacts of climate change and the benefits of adopting climate-resilient practices. Lastly, sustainable land use practices, such as agroforestry and conservation agriculture, should be promoted to reduce deforestation and promote environmental sustainability.

Declarations

References

[1] Aich, V., et al. (2017). Climate change in Afghanistan deduced from reanalysis and CORDEX—South Asia simulations. *Climate*, 5(2), 38.

[2] Akandi, A. J. (2013). Impact of small reservoirs and dugouts in Ghana on hydrology and water allocation in the Black Volta Basin. KNUST, Kumasi, Ghana.

[3] Altieri, M. A., & Nicholls, C. I. (2017). The adaptation and mitigation potential of traditional agriculture in a changing climate. *Climatic Change*, 140(1), 33–45.

[4] Annor, F. O. (2012). Diagnostic Study of the Black Volta Basin in Ghana. In-Service Training Centre, Upper West Region, Ghana.

[5] Antwi-Agyei, P., et al. (2017). Perceived stressors of climate vulnerability across scales in the Savannah zone of Ghana. *Regional Environmental Change*, 17(1), 213–227.

[6] Asante, F. A., & Amuakwa-Mensah, F. (2014). Climate Change and Variability in Ghana: Stocktaking. *Climate*.

[7] Asante, F. A., & Amuakwa-Mensah, F. (2015). Climate change and variability in Ghana: Stocktaking. *Climate*, 3(1), 78–99.

[8] Asrat, P., & Simane, B. (2017). Household and plot-level impacts of sustainable land management practices. *Agriculture and Food Security*, 6, 6.

[9] Asrat, P., & Simane, B. (2018). Farmers' perception of climate change in Ethiopia. *Regional Environmental Change*.

[10] Babatolu, J. S., & Akinnubi, R. T. (2016). Smallholder Farmers' Perception of Climate Change and Variability. *Journal of Petroleum & Environmental Biotechnology*, 7(3), 279–350.

[11] Banerjee, R. R. (2014). Farmers' perception of climate change in semi-arid regions of India. *Natural Hazards*.

[12] Banerjee, R. R. (2015). Farmers' perception of climate change, impact and adaptation strategies. *Natural Hazards*, 75(3), 2829–2845.

[13] Banerjee, R. R. (2025). [Indian village study on rainfall perception].

[14] Barry, B., Obuobie, E., Andreini, M., Andah, W., & Pluquet, M. (2005). Comprehensive assessment of water management in agriculture. IWMI working paper 57, Accra, Ghana.

[15] Bej, S. (2018). Water Security in India Threat Mapping: Impact of Climate Change.

[16] Bhushan, S., et al. (2018). Indigenous Knowledge Management for Disaster Mitigation. SSRN 3297971.

[17] Boko, M., et al. (2007). Africa: Climate Change 2007: Impacts, Vulnerability and Adaptation.

[18] Boomer, K., Werner, C., & Brantley, S. (2000). CO2 emissions related to the Yellowstone volcanic system. *Journal of Geophysical Research: Solid Earth*, 105(B5), 10817–10830.

[19] Chopra, R. (2014). [Uttarakhand village study on rainfall].

[20] Clayton, S., et al. (2015). Psychological research and global climate change. *Nature Climate Change*, 5(7), 640–646.

[21] Le Dang, H., Li, E., Bruwer, J., & Nuberg, I. (2014). Farmers' perceptions of climate variability and barriers to adaptation: lessons learned from an exploratory study in Vietnam. *Mitigation and Adaptation Strategies for Global Change*, 19(5), 531–548.

[22] Degye, G., Belay, K., & Mengistu, K. (2013). Measuring diet quantity and quality dimensions of food security in rural Ethiopia. *Journal of Development and Agricultural*

Economics, 5(5), 174–185.

[23] Dumenu, W. K., & Obeng, E. A. (2016). Climate change and rural communities in Ghana. *Environmental Science & Policy*, 55, 208–217.

[24] FAO. (2017). Towards the future we want: Agricultural and Food System. Rome, Italy.

[25] Fenby, C., & Gergis, J. (2013). Rainfall variations in south-eastern Australia. *International Journal of Climatology*, 33(14), 2956–2972.

[26] Fosu-Mensah, B. Y., Vlek, P. L. G., & MacCarthy, D. S. (2012). Farmers' perception and adaptation to climate change: Sekyedumase district, Ghana. *Environment, Development and Sustainability*, 14(4), 495–505.

[27] Gbetibouo, G. A. (2009). Understanding farmers' perceptions and adaptations to climate change: Limpopo Basin, South Africa. IFPRI Discussion Paper 00849.

[28] Hansen, G., Stone, D., & Auffhammer, M. (2013). Is there a curse of dimensionality for space statistical models of climate?

[29] Hayes, K., Blashki, G., & Reifels, L. (2018). Climate change, health, and the importance of human behavior.

[30] IPCC. (2014). Climate Change 2014: Impacts, Adaptation, and Vulnerability. Cambridge University Press.

[31] IPCC. (2016). Climate change adaptation.

[32] Islam, M. T., & Hossen, M. A. (2016). [Education and farmers' perception].

[33] Jost, C., et al. (2016). Understanding gender dimensions of agriculture and climate change. *Climate and Development*, 8(2), 133–144.

[34] Kellogg, W. W. (2019). Climate change and society. Routledge.

[35] Kelkar, U., et al. (2018). Vulnerability and adaptation to climate variability and water stress in Uttarakhand State, India. *Global Environmental Change*, 18, 564–574.

[36] Meijer, S. S., et al. (2015). The role of knowledge, attitudes and perceptions in the uptake of agricultural innovations. *International Journal of Agricultural Sustainability*, 13(1), 40–54.

[37] Miller, R. L., & Brewer, J. D. (2003). *The A–Z of Social Research*. Sage Publications, London.

[38] Ministry of Food and Agriculture (MoFA). (2016). Agriculture in Ghana facts and figures (2015). Accra, Ghana.

[39] Mishra, A. K., et al. (2018). Perception of Climate Change and Impact on Land Allocation. *Agricultural and Resource Economics Review*, 47(2), 311–335.

[40] Mngumi, J. (2016). Perceptions of climate change in Mwanga district, northern Tanzania. PhD thesis.

[41] Morton, L. W., et al. (2017). Upper Midwest farmer perceptions. *Journal of Soil and Water Conservation*, 72(3), 215–225.

[42] Mulenga, B. P., et al. (2017). Climate trends and farmers' perceptions of climate change in Zambia. *Environmental Management*, 59(2), 291–306.

[43] Mwinkom, F. X. K., et al. (2021). Factors influencing climate change adaptation strategies in North-Western Ghana. *SN Applied Sciences*, 3, 548.

[44] Myers, S. S., et al. (2017). Climate change and global food systems. *Annual Review of Public Health*, 38, 259–277.

[45] Nkem, J. N., et al. (2013). Profiling climate change vulnerability of forest indigenous communities in the Congo Basin. *Mitigation and Adaptation Strategies for Global Change*, 18(5), 513–533.

[46] OECD/FAO. (2016). Agriculture in Sub-Saharan Africa: Prospects and challenges.

[47] Opiyo, E. O. (2014). Climate variability and change on vulnerability and adaptation among Turkana pastoralists, Kenya. PhD thesis, University of Nairobi.

[48] Panthi, J., et al. (2016). Livelihood vulnerability approach to assessing climate change impacts. *Regional Environmental Change*, 16, 1121–1132.

[49] Quagraine, K. A. (2014). West African monsoon jumps and rain-fed agriculture in Ghana. Doctoral dissertation, University of Cape Coast.

[50] Rahi, S. (2017). Research design and methods: A systematic review. *International Journal of Economics & Management Sciences*, 6(2), 1–5.

[51] Rashid, M. H., et al. (2014). Climate change perception and adaptation in Southern Khulna, Bangladesh. *Applied Ecology and Environmental Sciences*, 2(1), 25–31.

[52] Roco, L., et al. (2015). Farmers' perception of climate change in mediterranean Chile. *Regional Environmental Change*, 15(5), 867–879.

[53] Shameem, M. I. M., et al. (2015). Local perceptions of and adaptation to climate variability. *Climatic Change*, 133(2), 253–266.

[54] Shimeles, A. A., et al. (2018). Building a Resilient and Sustainable Agriculture in Sub-Saharan Africa. Palgrave Macmillan.

[55] Simane, B., et al. (2016). Agro-ecosystem specific climate vulnerability analysis. *Mitigation and Adaptation Strategies for Global Change*, 21, 39–65.

[56] Singh, A. S., & Masuku, M. B. (2014). Sampling techniques & determination of sample size. *International Journal of Economics, Commerce and Management*, 2(11), 1–22.

[57] Sintayehu, D. W. (2018). Impact of climate change on biodiversity. *Environmental Systems Research*, 7, 7.

[58] Sung, J. (2019). [Seasonal pattern perception].

[59] Teye, J. K., et al. (2015). Local farmers' experiences and perceptions of climate change in Northern Savannah zone of Ghana. *International Journal of Climate Change Strategies and Management*, 7(3), 327–347.

[60] Vardan, R. J., & Kumar, P. (2014). Indigenous knowledge about climate change: Tamil Nadu. *Indian Journal of Traditional Knowledge*, 13(2), 390–397.

[61] Wang, W., et al. (2021). Will social capital affect farmers' choices of climate change adaptation strategies? *Journal of Rural Studies*, 83, 127–137.

[62] World Bank. (2011). Policy Brief: Opportunities and challenges for climate smart agriculture in Africa.

[63] Yamane, T. (1967). *Statistics: An Introductory Analysis* (2nd ed.). Harper and Row, New York.

[64] Yaro, J. A. (2013). The perception of and adaptation to climate variability/change in Ghana. *Regional Environmental Change*, 13(6), 1259–1272.

[65] Ziervogel, G., et al. (2010). Using climate information for supporting climate change adaptation in water resource management in South Africa. *Climatic Change*, 103(3–4), 537–554.