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Perceptions of Climate Variability among Smallholder Cocoa Farmers in Ghana

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***Abstract*— This study assessed smallholder cocoa farmers' perceptions of climate variability in Ghana. Through a survey of 600 farmers, findings indicate awareness of climate change, particularly in temperature, while perceptions of variability in rainfall and other climate variables were more neutral. Farmers identified deforestation and agrochemical use as key drivers of climate variability. The study emphasizes the necessity for targeted interventions to enhance awareness and adaptive capacity among farmers by recommending comprehensive adaptation strategies and equitable resource access. These insights aim to inform policymakers and stakeholders to promote sustainable cocoa production in Ghana.**

***Keywords*— Cocoa, Climate, Farmers, Perception, Variability**

I. Introduction

Th Climate variability involves fluctuations in climatic conditions over various timescales and is indicated by changes in mean temperature, precipitation, and weather trends due to internal processes or external factors [1]. Climate variability poses major challenges to global agricultural productivity and drives global hunger [2]. The FAO [2] reported that the 2015-2016 El Niño impacted over 60 million people, with 23 countries requesting over USD 5 billion in international aid. According to [3], while El Niño events occur every few years, climate change alters their patterns and impacts. Climate variability directly affects agriculture and crop production, endangering food security and livelihoods for the rural poor [4]. Consequently, climate variability reduces agricultural productivity and hinders food access as livelihoods which are dependent on natural resources are disrupted [5]. According to [6], agriculture is particularly vulnerable, with yields heavily impacted by temperature and precipitation changes. Porter et al. [7] note that global wheat and maize yields have been affected, and Ray et al. [8] estimate that climate variability accounts for about one-third of yield variability in key crops. Climate variability driven by El Niño−Southern Oscillation (ENSO) events significantly reduces crop yields [9], impacting all aspects of production – i.e., cropping intensity and cropping area [5].

Ghana is the second-largest cocoa-producing country after Côte d'Ivoire. The cocoa industry is crucial to the country's economic progress, contributing $2 billion, or 14.5% of GDP, in 2018 [10]. Despite this importance, climate change has increasingly impacted the cocoa sector [11], affecting farmers' livelihoods and productivity [12]. For instance, shifting weather patterns, including higher temperatures and erratic rainfall, compromise cocoa yields and quality, leading to lower incomes and increased food security concerns in Ghana [13]. Climate variability poses significant risks to vital sectors like agriculture, health, and water [6]. Agriculture, which relies on rainfall and traditional methods, is particularly vulnerable to the adverse impacts of climate change in developing countries such as Ghana [6]. The forecasted intensification of climate change is expected to increase the susceptibility of cocoa-growing areas to extreme weather events [14]. Prolonged droughts and severe flooding are likely to be key factors affecting crop yields and food security [15]. Climate-related stressors include rising temperatures, unpredictable rainfall, disruptions in seasonal patterns, and droughts [16]. These changes will also affect companion species in agroforestry systems and impact cocoa pollinators, pests, and diseases [17]. Shifts in climate patterns could heighten the vulnerability of cocoa regions to adverse weather [12], with floods and extended dry spells significantly impacting food security and cocoa yields [17].

Perception and awareness of climate variability are important for enhancing the resilience of smallholder farmers to climate change and variability. However, studies on climate variability and related topics in Ghana have largely focused on food or annual crops [18], [19], [20], with little focus on cocoa, which is the backbone of Ghana's economy [21]. Among the limited studies on climate variability in the cocoa sector, the negative impact of climate variability on cocoa production in Ghana has been reported. Still, little is known about how cocoa farmers perceive and respond to climate variability. Such a gap between perception and scientific literature can undermine the adaptive capacity of cocoa farmers and the effective implementation of climate-related policies and programs. Also, despite Ghana's estimated 800,000 smallholder cocoa farmers

[22], there remains a need for broader and more representative studies to capture the diversity of farmers' experiences and responses to climate variability [23].

To address these gaps and further enhance the literature on climate variability, this study assessed the awareness and perception of climate variability in Ghana's top three cocoa-producing regions. Specifically, the study: i. examined cocoa farmers' awareness and experience of climate variability; and ii. assessed the perception of cocoa farmers on climate variability. This study emphasizes climate variability rather than climate change because: i. while climate change unfolds over decades or centuries, daily life is more immediately impacted by climate variability, which overlays ongoing climate change; ii. climate variability can affect all aspects of food security and nutrition, including availability, access, utilisation, and stability, even in the short term [5].

II. Methodology

A. Study Area

This study draws on quantitative data collected in Ghana's Ashanti, Western, and Western North regions (Fig. 1). The Ashanti Region in Ghana, with a population of 5,440,463, is the second most populous region in the country [24]. It shares borders with six other regions and has a bimodal rainfall with 1,270 millimetres of annual rainfall. Particularly in rural areas, the region lends itself to agriculture. Cocoa farms account for the region's greatest proportion of crops grown (22.1%) [25]. The Western Region, which is home to about 2,060,585 people, is bordered by the Gulf of Guinea, Côte d'Ivoire, the Central, and the Western North [24]. It experiences annual rainfall between 1,250 and 2,000 millimetres, with two rainy seasons. The region has three main vegetation types: evergreen rainforest, deciduous forest, and coastal savannah. Its climate and vegetation make it suitable for tree crop production [26]. The Western Region alone produces more cocoa beans than any other region in Ghana, making it the country's leading cocoa producer [26]. The Western North Region in Ghana, bordered by Côte d'Ivoire and the Central Region, has a population of 880,921 [24]. Its tropical rainforest climate, with high temperatures and moderate to heavy rainfall, makes it ideal for agricultural activities. The region is a top producer of valuable cash crops like cocoa, with cocoa farms accounting for the majority of crops grown [26]. Historically, these regions have been the backbone of cocoa production in Ghana [27]. We adopted a cross-sectional survey design to assess awareness and perceptions about climate variability by focusing on cocoa farmers. This design enabled data collection at a specific time, offering a brief overview of the current situation among cocoa farmers in the study area, specifically the Western, Western North, and Ashanti regions.

B. Some Common Mistakes

The study employed a quantitative technique, and the population for the study were all cocoa farmers in the Western, Western North and Ashanti regions. As of December 2022, data from the Cocoa Management System (CMS) of the Ghana Cocoa Board (COCOBOD) reported a total of 443,885 registered cocoa farmers in the three regions [28]. Since the population is known, the Yamane [29] formula was used to compute the sample size. The formula is given as;

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

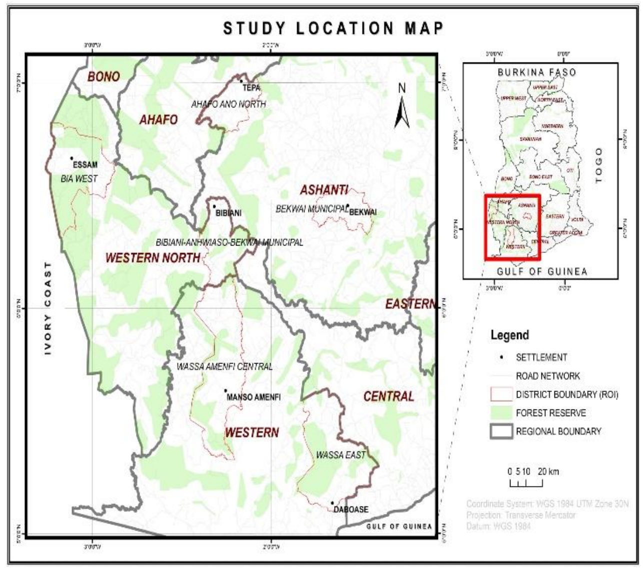

Fig. 1. Map of the study area

where N is the total population of cocoa farmers in the three regions, n is the sample size and using a 95% confidence level, e is the margin of error at 5%. Substituting N and e into the formula, we have:

$$n = \frac{443885}{1+443885(0.05)^2} = 399.64 \cong 400 \quad \text{.......(2)}$$

Hence, the minimum sample size for the stated population is 400. However, [30] proposed that oversampling by 40%-60% is required to account for non-responses and difficult or uncooperative respondents. As a result, the sample size was raised by 50%. Therefore, the total sample size (n) for the study was 600.

The study employed a multistage sampling technique. The first stage involved stratified random sampling to divide each region into two strata based on geographic locations, north and south districts/municipalities. We used simple random sampling to select one district from each stratum, resulting in two districts from each region. The sampled districts were Amenfi Central and Wassa East Districts from the Western Region, Bia West District and Babiani-Ahwiaso-Bekwai Municipal from the Western North Region, and Ahafo Ano North and Bekwai Municipalities in the Ashanti Region. In the second stage, we randomly selected four (4) communities from each of the six districts/municipalities. The final stage of sampling involves a simple random sample of 600 respondents from the communities.

The questionnaire was pre-tested on 15 farmers in Asanso in the Bekwai Municipal Assembly with similar characteristics to assess its clarity, accuracy, and coherence. The pre-test helped the researchers to review the instrument before the actual data collection. The actual data were collected between August and September 2023. To help with data collection, enumerators who were fluent in the Twi and Sefwi languages were engaged. They were trained on the instrument and data collection techniques before the survey. The study followed a standard ethical protocol for gathering primary data. Initially, we provided the respondents with information regarding the objective of the study. We also told them they could leave the interview anytime. We further explained the importance of maintaining the secrecy of the information they give. The privacy of the respondents was safeguarded, and their identities and records were kept confidential. All interviews were conducted at locations regarded as convenient and safe for the respondents.

C. *Data Analysis*

We analyzed the questionnaires using both descriptive and inferential methods. We used descriptive statistics to gain a general understanding of the sample characteristics and respondent distribution, including their awareness and experience with climate variability. We used a five-point Likert scale, ranging from 1 = strongly disagree to 5 = strongly agree, to determine cocoa farmers' perceptions of climate variability and its drivers in their farming system. We analyzed their perceptions using a perception index. Mean scores for each of the perception statements were computed as:

$$MS = \frac{\sum(Frequency_1 xcode_1)+\cdots+(Frequency_x xcode_x)}{N} \quad \text{.............(3)}$$

where MS is the mean score and N is the number of respondents. The perception index was computed by summing mean scores for each statement and dividing by the number of statements, and the formula is given as;

$$PI = \frac{\sum Mean\ Score}{N_{ps}} \quad \text{...(4)}$$

III. Results and Discussions

A. *Respondents' Demographic Characteristics*

The socio-economic characteristics of the respondents are presented in Table I. The majority of the respondents were males (72.5%) and married (80.7%). The dominance of males in cocoa production may stem from the relatively tedious nature of cocoa farming compared to food crops. Females often assist their husbands in cocoa farming [31]. This finding on marital status aligns with a study by [32] that reported that most cocoa farmers in Ghana fall within the married bracket. Naamwintone & Bagson [33] further explained that most married cocoa farmers see marriage as a supporting opportunity for farming activities, aside from its primary purpose. The majority of the respondents (73.0%) own the land they farm on. Ownership of land gives farmers a higher level of security and control over their farming operations compared to those who do not [34].

Most respondents (85.7%) as presented in Table I do not have access to skilled labour, and 66.2% lack access to climate information. This suggests that cocoa farmers have relatively low access to skilled labour, which could negatively impact their adoption of good agronomic or climate-smart practices, potentially affecting productivity [35]. Our findings on access to climate information contradict an earlier study by [36] which reported that a substantial majority of cocoa farmers have access to climate information services. Majority of the respondents (91.7%) are members of Farmer-Based Organizations (FBOs) (Table I). Being a member of the FBO is a requirement to receive subsidized inputs from the state through the Cocoa Health and Extension Division (CHED) of COCOBOD, which could potentially explain the high FBO membership rates among cocoa farmers. FBO membership can influence farmers' responses because members may have varying experiences and viewpoints compared to non-members, and they play a crucial role in spreading information and innovation [37]. Most of the respondents (66.8%) do not have access to formal credit (Table I), which aligns with studies by [38] indicating that most farmers in Ghana lack access to formal credit. Fiawoo et al. [37] reported that the majority of farmers in Ghana prioritize specific interventions and commercial goals over credit accessibility. The majority of respondents (84.7%) have access to input markets for agricultural supplies, and have access to agricultural extension services (85.8%) (Table I). Access to input markets and extension services among cocoa farmers not only boosts production but also helps them to be resilient against the negative impacts of climate change [39].

The respondents' ages range from 23 to 83 years, with a mean age of 52 (Table I). This finding supports [40] 's assertion that smallholder cocoa farmers in Ghana are elderly. Due to the labour-intensive nature of cocoa farming, older farmers may struggle to perform certain agronomic tasks and may find it difficult to adopt modern innovations. This could result in a decrease in productivity, which could potentially impact Ghana's economy, given its reliance on the sale of cocoa beans. On average, respondents have approximately 8 years of formal education. The number of years cocoa farmers spend in formal education is not a requirement for cocoa farming. However, educated farmers are better at performing certain tasks and roles, and telling the difference between beneficial and undesirable investment areas can affect how they make decisions and use information [41]. This finding suggests that cocoa farmers are literate enough to engage in practices that reduce the impact of climate change [38].

Respondents have been involved in farming for an average of 23 years (Table I). A higher average number of years of farming experience indicates a farmer with a deep understanding of farming operations. For instance, this experience may allow farmers to respond to climate change. However, a higher average farming experience does not necessarily guarantee success in adapting to climate variability, as experienced farmers tend to be more hesitant in adopting modern innovations [42]. The mean household size is 7.06, suggesting that households typically comprise seven individuals. In their cocoa farmers' survey in Ghana and Nigeria, [43] and [44] found an average household size of 6.3 and 6, respectively, which is comparable to the average household size for this study. This implies that the respondents' family size was relatively large, which further suggests that there may be a high chance of available labour for farming activities, thereby reducing the labour challenges in cocoa farming [43].

Respondents have an average farm size of 3.76 hectares as presented in Table I. The results indicate that the respondents are mostly small-scale farmers, but the relatively wide range in farm sizes could also suggest that small-scale and larger-scale cocoa farms are in the study area. Crop diversification and practices may be more feasible for farms of larger sizes, which can enhance their resilience to climate variability [42], [43]. However, large farms may also encounter challenges in managing their land and produce. For instance, larger farms may encounter difficulties in farm maintenance activities such as weeding, pruning, and applying agrochemicals and fertilizers. Finally, respondents' average distance from their homes to their farms is 5 kilometers (Table I). Long commutes to farms can be costly and time-consuming, which may restrict farmers' capacities, such as their usual farm maintenance or monitoring, and pose difficulties in adapting to climate variability [42].

TABLE I. SOCIO-ECONOMIC CHARACTERISTICS OF RESPONDENTS

Discrete variables			**Frequency**	**Percentage (%)**
Sex	Male		435	72.5
	Female		165	27.5
Marital status	Yes		484	80.7
	No		116	19.3
Land ownership	Yes		438	73.0
	No		162	27.0
Access to skilled labour	Yes		86	14.3
	No		514	85.7
Access to climate information	Yes		203	33.8
	No		397	66.2
FBO membership status	Yes		550	91.7
	No		50	8.3
Access to formal credit	Yes		199	33.2
	No		401	66.8
Access to input market	Yes		508	84.7
	No		92	15.3
Access to extension service	Yes		515	85.8
	No		85	14.2
Continuous variables	***Minimum***	***Maximum***	***Mean***	***Std. Dev.***
Age	23.00	83.00	51.89	0.45
Education (years)	0.00	26.00	7.51	6.15
Farming experience (years)	3.00	55.00	22.51	10.01
Household size	1.00	25.00	7.06	3.52
Farm size (Ha)	0.32	14.98	3.76	2.52
Distance to farm (Km)	0.05	32.20	4.69	5.19

B. *Cocoa Farmers' Awareness and Experience of Climate Variability*

A substantial majority of respondents (88.7%) are knowledgeable about climate change and variability, indicating that climate change is widely recognized within this group (Table II). Ali & Erenstein [44] suggests that awareness of climate change plays a crucial role in agricultural development. It improves understanding of climate change and strengthens farmers' abilities to implement more effective, efficient, and appropriate interventions. The finding is consistent with [45], who reported that approximately 98% of cocoa farmers in Ekiti State, Nigeria, are aware of climate variability. However, this result contrasts with [46], who found very low awareness rates among some rural populations in Tolon and Kumbungu in Northern Ghana. It also differs from [47], who identified low levels of awareness in West Africa and sub-Saharan Africa, and [48], who noted that most respondents in rural Northern Ghana (Kassena Nankana District), particularly older individuals, had not heard of climate change. The study regions' status as project locations for various climate change-related programmes and projects, including the Ghana Forest Investment Programme (GFIP), Reducing Emissions from Deforestation and Forest Degradation (REDD+), and SNV Shaded Cocoa Agroforestry Systems (SCAFS), may account for the high awareness level. A high percentage of respondents (92.0%) report having experienced climate variability, which highlights the widespread impact of climate variability on their daily lives and farming practices. The high levels of awareness (88.7%) and experience (92.0%) with climate variability among respondents reflect a strong recognition and direct impact of climate change in their lives. This awareness and experience are crucial for understanding the adaptation strategies they employ and their need for support in addressing climate-related challenges. On average, respondents have been experiencing climate variability for approximately 6 years, with a range spanning from 1 to 21 years. The standard deviation of 3.925 years suggests considerable variation in the length of time respondents have been experiencing climate variability.

The results in Table II indicate that while some respondents have faced climate variability for a relatively short period, others have been dealing with these issues for much longer. This variability in experience duration might influence the respondents' perceptions and coping strategies. According to [49], past experiences and observations play an important role in farmers' awareness of changes in climate patterns. Given the high awareness and experience levels, there may be a need for targeted support and training programs focused on enhancing adaptive strategies and resilience. Addressing the specific needs of both long-term and more recent climate variability experiences can help improve such interventions. Understanding the depth of experience and awareness among respondents can guide policymakers and practitioners in developing more effective climate adaptation strategies and support systems tailored to the needs and experiences of the affected communities.

TABLE II. AWARENESS AND EXPERIENCE OF CLIMATE VARIABILITY

Climate Variability	**Yes**		**No**	
	Frequency	***Percentage***	***Frequency***	***Percentage***
Climate change and variabilit awareness	532	88.7	68	11.3
Experience of climate variability	552	92.0	48	8.0
	Minimum	***Maximum***	***Mean***	***Std. Dev.***
Duration of climate variability Experience (Years)	1.00	21.00	5.902	3.925

C. *Perceived Changes in Climatic Variables*

Fig. 2 presents the respondents' observations of changes in various aspects of climate variability. The results indicate that in terms of rainfall, the majority of the farmers (61.8%) perceive a decrease in rainfall, 31.7% of the farmers perceive an increase, and 6.5% of the farmers perceive no change in rainfall patterns. This agrees with that of [49], who reported that the majority of farmers perceive increases in rainfall as a sign of climate variability. Thornton et al. [50] argue that as climate variability increases, the frequency of human displacement due to extreme events, particularly floods, could also rise.

A significant majority (76.5%) of respondents, as shown in Fig 2 report an increase in temperature. In line with this study, [49] also reported that the majority of farmers who observed temperature changes reported increases in recent times. Most respondents (44.3%) observed an increase in harmattan conditions (Fig 2). Farmers report that prolonged dry spells are causing cocoa plants to wilt and dry up [49]. Climate change is apparent in both developing and developed nations, evidenced by shifts in precipitation patterns and unprecedented rises in temperatures, which pose risks to livelihoods and hinder socio-economic progress [51]. Extreme weather events like droughts and floods disrupt economic activities and heighten community vulnerability to further detrimental climate conditions [52].

D. Perception of Cocoa Farmers on Climate Variability

Table III presents the perceptions of cocoa farmers regarding various aspects of climate variability, including rainfall, temperature, wind, flooding, and harmattan conditions. The overall perception of rainfall changes has a mean score of 3.26, indicating a moderate agreement among farmers that rainfall patterns have not substantially changed. This suggests that respondents neither agree nor disagree with the statements related to rainfall variability. It implies that while some respondents may perceive rainfall patterns as somewhat predictable or consistent, others may perceive them as somewhat erratic or unpredictable. This middling perception could stem from experiences of both regular and irregular rainfall events, reflecting the variability inherent in local climate conditions. High-intensity rainfall (mean = 3.53) is perceived more strongly compared to other rainfall-related changes, suggesting that farmers are particularly noticing more intense rainfalls (Table III). Consistent with this research, [20] observed that farmers had a neutral stance on the variability in rainfall. However, [53] and [19] reported that farmers in Ghana perceived a change in rainfall patterns, which deviates from this result. In contrast, the perception of temperature changes has a higher overall mean (3.69), indicating a stronger agreement among farmers (Table III). This suggests that respondents may generally perceive temperature patterns as more consistent or noticeable compared to rainfall patterns. The higher mean score could imply that respondents are more attuned to changes in temperature, whether they perceive them as warming trends, increased heat waves, or other temperature-related shifts. frequent heatwaves (mean = 4.06) and increases in the earth's surface temperature (mean = 4.02) are particularly notable, reflecting a significant concern among farmers about rising temperatures and heatwaves (Table III). In line with the results, [53] found that most cocoa farmers in Ghana have observed a rise in average temperatures. Nevertheless, [20] found that farmers displayed a neutral attitude towards variability in temperature.

Wind-related variability, as presented in Table III, has an overall mean of 3.17. This suggests that respondents have a relatively neutral perception of wind patterns. Thus, they neither agree nor disagree with the statements provided. It implies that while wind variability may be observed, respondents may not perceive it as a significant factor influencing their farming practices or livelihoods compared to other climate variables. The perception of high wind speed (mean = 3.43) and change in wind direction (Mean = 3.30) are notable, indicating that farmers are experiencing and concerned about changes in wind patterns and speed. The findings differ from those of [20], who indicated that farmers were in disagreement regarding climate change variability related to wind.

The overall perception of flooding has a mean of 3.10, showing a moderate agreement. This suggests that respondents may perceive flooding events as less frequent or impactful than climate variables such as temperature. However, even though the perception is slightly lower, flooding events can still have significant agricultural consequences, including crop damage and infrastructure loss. Flash flooding (mean = 3.33) is more strongly perceived than unusual/extreme flooding (mean = 2.78), indicating that flash floods are a more immediate concern for the farmers. The results are at odds with those of [19] and [20], who found that farmers were opposed to statements regarding the variability of flooding.

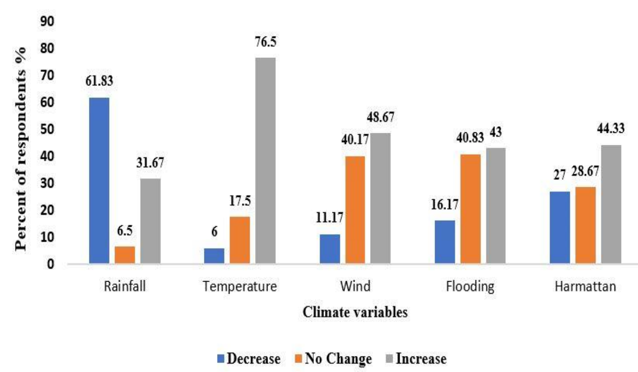

Fig. 2. Perception of changes in climatic variables

TABLE III. PERCEPTION OF COCOA FARMERS ON CLIMATE VARIABILITY

Perception statements	SD (1)	D (2)	N (3)	A (4)	SA (5)	Mean	Std. Dev.
Rainfall (Overall mean=3.26)							
Decreased rainfall days	91 (15.17)	130 (21.67)	70 (11.67)	176 (29.33)	133 (22.17)	3.22	1.40
Delay in the onset of rainfall	86 (14.33)	159 (26.50)	94 (15.67)	174 (29.00)	87 (14.50)	3.03	1.31
Erratic/unusual rain	85 (14.17)	133 (22.17)	75 (12.50)	174 (29.00)	133 (22.17)	3.23	1.38
High-intensity rainfall	60 (10.00)	88 (14.67)	79 (13.17)	219 (36.50)	154 (25.67)	3.53	1.29
Temperature (Overall Mean= 3.69)							
Increase in earth surface temperature	25 (4.17)	35 (5.83)	72 (12.00)	237 (39.50)	231 (38.50)	4.02	1.06
Frequent heatwaves	14 (2.33)	36 (6.00)	72 (12.00)	259 (43.17)	219 (36.50)	4.06	0.97
High sunshine intensity	23 (3.83)	39 (6.50)	104 (17.33)	262 (43.67)	172 (28.67)	3.87	1.02
Longer hours of sunshine	106 (17.67)	202 (33.67)	85 (14.17)	121 (20.17)	86 (14.33)	2.80	1.33
Wind (Overall Mean= 3.17)							
Erratic wind	79 (13.17)	176 (29.33)	135 (22.50)	134 (22.33)	76 (12.67)	2.92	1.24
Typhoon wind	83 (13.83)	129 (21.50)	164 (27.33)	144 (24.00)	80 (13.33)	3.02	1.24
Change in wind direction	48 (8.00)	108 (18.00)	146 (24.33)	210 (35.00)	88 (14.67)	3.30	1.16
High wind speed	45 (7.50)	100 (16.67)	128 (21.33)	209 (34.83)	118 (19.67)	3.43	1.19
Flooding (Overall Mean= 3.10)							
Rainstorm flooding	79 (13.17)	113 (18.83)	125 (20.83)	187 (31.17)	96 (16.00)	3.18	1.28
Flash flooding	70 (11.67)	101 (16.83)	131 (21.83)	156 (26.00)	142 (23.67)	3.33	1.32
Unusual /extreme flooding	137 (22.83)	83 (13.83)	194 (32.33)	147 (24.50)	39 (6.50)	2.78	1.23
Harmattan (Overall Mean= 3.17)							
Short-lived Harmattan	94 (15.67)	156 (26.00)	85 (14.17)	177 (29.50)	88 (14.67)	3.02	1.33
Early onset and early cessation of Harmattan	48 (8.00)	122 (20.33)	108 (18.00)	217 (36.17)	105 (17.50)	3.35	1.21
Early onset and late cessation of Harmattan	75 (12.50)	139 (23.17)	111 (18.50)	183 (30.50)	92 (15.33)	3.13	1.28

Note: SD=Strongly Disagree, D=Disagree, N=Neutral, A=Agree, SA=Strongly Agree

The perception of changes related to harmattan has an overall mean of 3.17, closely aligning with the perceptions of rainfall and flooding, indicating a neutral stance (Table III). This suggests that respondents may have mixed experiences or opinions regarding the effects of harmattan on their farming activities. While some may view harmattan as a regular occurrence with manageable impacts, others may perceive it as a significant challenge, particularly concerning crop health and productivity. The early onset and early cessation of harmattan (mean = 3.35) are particularly notable, indicating that farmers are observing shifts in the timing of this seasonal wind pattern. The results are inconsistent with [20], who reported that farmers rejected statements about variability in harmattan. The results indicate that cocoa farmers are perceiving significant changes in climate variability, particularly concerning temperature and rainfall patterns. The higher overall means for temperature-related perceptions suggest that changes in temperature and heat waves are more strongly felt and could be having a significant impact on cocoa farming practices. Rainfall and wind changes are also of concern, though to a slightly lesser extent. These perceptions highlight the need for agricultural interventions and support systems to help farmers adapt to these changing climate conditions. This might include the introduction of drought-resistant cocoa varieties, improved irrigation systems, and better forecasting and early warning systems to help farmers prepare for extreme weather events.

E. Cocoa Farmers' Perception of The Drivers of Climate Variability

Table IV presents cocoa farmers' perceptions regarding the drivers of climate variability. Deforestation was seen as the most critical driver of climate variability among the interviewed cocoa farmers (mean = 4.38, S.D. = 0.98). This strong perception could be due to the direct impact of deforestation on local microclimates, such as changes in rainfall patterns and temperature regulation. Efforts to reduce deforestation through sustainable farming practices and reforestation programs could help mitigate some of these perceived impacts. The finding is consistent with that of [49], who reported deforestation as a contributing factor to climate variability. Bush burning was also mentioned as a contributing factor to climate variability after deforestation (mean = 4.15; S.D. = 1.05). Bush burning is commonly used in agriculture to clear land, but is known to release significant amounts of greenhouse gases and reduce soil quality. The strong agreement among farmers highlights the need for alternative land management practices like no or minimum tillage that are less harmful to the environment. Kosoe & Ahmed [49], found bush burning to be one of the major factors influencing climate variability.

TABLE IV. COCOA FARMERS' PERCEPTION OF THE DRIVERS OF CLIMATE VARIABILITY

Drivers	SD (1)	D2 (2)	N (3)	A (4)	SA (5)	Mean	Std. Dev.
Deforestation	21 (3.50)	16 (2.67)	41 (6.83)	157 (26.17)	365 (60.83)	4.38	0.98
Bush burning	24 (4.00)	27 (4.50)	64 (10.67)	204 (34.00)	281 (46.83)	4.15	1.05
Population growth	24 (4.00)	39 (6.50)	81 (13.50)	217 (36.17)	239 (39.83)	4.01	1.07
Natural occurrence event	29 (4.83)	33 (5.50)	143 (23.83)	232 (38.67)	163 (27.17)	3.78	1.06
The use of fossil fuels (petrol, kerosene)	12 (2.00)	24 (4.00)	80 (13.33)	248 (41.33)	236 (39.33)	4.12	0.92
Excessive use of agrochemicals (pesticides, herbicides)	15 (2.50)	33 (5.50)	93 (15.50)	227 (37.83)	232 (38.67)	4.05	0.99
Excessive use of inorganic fertilizers	29 (4.83)	71 (11.83)	122 (20.33)	196 (32.67)	182 (30.33)	3.72	1.16

Note: SD=Strongly Disagree, D=Disagree, N=Neutral, A=Agree, SA=Strongly Agree

The use of fossil fuels (petrol, diesel, kerosene) was also perceived to impact climate variability (mean 4.12; S.D. = 0.92). The burning of fossil fuels is a well-known source of greenhouse gases. Farmers' awareness of this issue indicates a broad understanding of the role of energy consumption in climate change. This could lead to support for renewable energy initiatives and cleaner technologies. The results are consistent with [54], who found that participants view human activities, such as the use of heavy machinery on land, in the air, and water, as significant contributors to climate change.

IV. CONCLUSION AND RECOMMENDATIONS

The study assessed the experiences of smallholder cocoa farmers with climate variability by investigating their awareness and perceptions. Using descriptive statistics and perception index, the study revealed that the majority of cocoa farmers are aware of climate variability. This awareness may be due to various climate-related programs and projects that the government, chocolate companies, and other international development corporations have implemented in the cocoa-growing communities in Ghana. The farmers perceived changes in climate variables, including a decrease in rainfall, an increase in temperature, wind, and harmattan, and a slight increase in flooding. In their overall perception of climate variability, the cocoa farmers agreed with statements about temperature variability. However, they did not agree or disagree with statements about rainfall, wind, harmattan, and flooding, taking a neutral stance. Deforestation, bush burning, the use of fossil fuels, and excessive use of agrochemicals are the foremost perceived drivers of climate variability among cocoa farmers.

Based on the study’s findings, there is a need to enhance awareness and education on climate variability in cocoa farming communities in Ghana. COCOBOD, NGOs, and other international development agencies should create targeted educational programs to raise awareness among cocoa farmers about climate change, since it negatively affects cocoa production. The awareness and education should not be limited to community extension agents of COCOBOD training; traditional media platforms should be employed. The study also suggests promoting comprehensive adaptation measures, given the farmers' experience with climate variability. Through their extension department, COCOBOD should encourage cocoa farmers to adopt a mix of adaptation measures that address various climate variability adverse effects. This can be achieved by supporting research and innovation to develop climate-resilient cocoa varieties and agronomic practices that are tailored to local farming conditions. COCOBOD should enhance the campaign and practice of afforestation, reforestation, and the cocoa agroforest system in cocoa farming communities since deforestation is a driver of climate variability. This can be achieved when the carbon trading model incentivizes trees in and around cocoa farms. Furthermore, there should be support from the government and other stakeholders to implement policies and programs that address socioeconomic disparities and promote inclusive access to resources and opportunities for all cocoa farmers. This can be done by providing financial incentives and support mechanisms to assist farmers, particularly those with limited resources, in adopting climate-smart agricultural practices. Finally, COCOBOD should collaborate with the Ghana Meteorological Service to create a platform that ensures cocoa farmers receive accurate and timely climate data regularly to inform some of their agronomic decisions.

REFERENCES

[1] A. Panda and N. Sahu, “Trend analysis of seasonal rainfall and temperature pattern in Kalahandi, Bolangir and Koraput districts of Odisha, India,” Atmospheric Science Letters, vol. 20, no. 10, Oct. 2019, doi: 10.1002/asl.932.

[2] FAO, 2018/19 El Niño High risk countries and potential impacts on food security and agriculture. 2018. [Online]. Available: http://www.fao.org/3/ca2530en/CA2530EN.pdf

[3] World Metrological Organization (WMO), “WMO Update: 70% chance of El Niño by end of 2018,” Geneva, Switzerland, 2018.

[4] T. Tanner et al., “Livelihood resilience in the face of climate change,” 2015. doi: 10.1038/nclimate2431.

[5] C. Holleman, F. Rembold, O. Crespo, and V. Conti, The impact of climate variability and extremes on agriculture and food security - An analysis of the evidence and case studies. 2020. doi: 10.4060/cb2415en.

[6] G. S. Malhi, M. Kaur, and P. Kaushik, “Impact of climate change on agriculture and its mitigation strategies: A review,” 2021. doi: 10.3390/su13031318.

[7] J. R. Porter et al., “Food security and food production systems,” in Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge, UK: Cambridge University Press, 2014, ch. Chapter 7, pp. 485–533.

[8] D. K. Ray, J. S. Gerber, G. K. Macdonald, and P. C. West, “Climate variation explains a third of global crop yield variability,” Nat Commun, vol. 6, 2015, doi: 10.1038/ncomms6989.

[9] T. Iizumi et al., “Impacts of El Niño Southern Oscillation on the global yields of major crops,” Nat Commun, vol. 5, 2014, doi: 10.1038/ncomms4712.

[10] Ghana Statistical Service (GSS), “Ghana Living Standards Survey round 7 (GLSS7), Main Report,” Accra, Ghana, 2019.

[11] G. Y. Yiridomoh, S. Z. Bonye, and E. K. Derbile, “Assessing the determinants of smallholder cocoa farmers’ adoption of agronomic practices for climate change adaptation in Ghana,” Oxford Open Climate Change, vol. 2, no. 1, 2022, doi: 10.1093/oxfclm/kgac005.

[12] E. K. Tham-Agyekum et al., “Resilience against climate variability: The application of nature based solutions by cocoa farmers in Ghana,” Environmental and Sustainability Indicators, vol. 20, p. 100310, Dec. 2023, doi: 10.1016/j.indic.2023.100310.

[13] M. Hirons, E. Boyd, C. Mcdermott, and R. Asare, “Understanding climate resilience in Ghanaian cocoa communities–advancing a biocultural perspective,” Journal of Rural Studies, Elsevier, 2018, Accessed: Jul. 14, 2024. [Online]. Available: https://www.sciencedirect.com/science/article/pii/S0743016718300482

[14] D. N. B. Buxton, “Climate Change Responses of Cocoa Farmers in Ghana,” International Journal of Environment and Climate Change, pp. 26–35, 2020, doi: 10.9734/ijecc/2020/v10i830215.

[15] N. T. Liliane and S. M. Charles, “Factors Affecting Yield of Crops,” in Agronomy - Climate Change and Food Security, 2020. doi: 10.5772/intechopen.90672.

[16] G. Schroth, P. Läderach, A. I. Martinez-Valle, C. Bunn, and L. Jassogne, “Vulnerability to climate change of cocoa in West Africa: Patterns, opportunities and limits to adaptation,” Science of the Total Environment, vol. 556, pp. 231–241, 2016, doi: 10.1016/j.scitotenv.2016.03.024.

[17] E. D. Okoffo, M. Mensah, and B. Y. Fosu-Mensah, “Pesticides exposure and the use of personal protective equipment by cocoa farmers in Ghana,” Environmental Systems Research, vol. 5, no. 1, 2016, doi: 10.1186/s40068-016-0068-z.

[18] D. C. Aidoo, S. D. Boateng, C. K. Freeman, and J. N. Anaglo, “The effect of smallholder maize farmers’ perceptions of climate change on their adaptation strategies: the case of two agro-ecological zones in Ghana,” Heliyon, vol. 7, no. 11, 2021, doi: 10.1016/j.heliyon.2021.e08307.

[19] G. P. Cudjoe, P. Antwi-Agyei, and B. A. Gyampoh, “The effect of climate variability on maize production in the ejura-sekyedumase municipality, ghana,” Climate, vol. 9, no. 10, 2021, doi: 10.3390/cli9100145.

[20] N. M. Martey, E. K. Tham-Agyekum, C. M. Ocansey, F. Nimoh, L. K. Kwarteng, and P. Padlass, “Analysis of smallholder maize farmers’ perceptions on climate change variability and adoption of adaptive agrarian strategies,” The Bangladesh Journal of Agricultural Economics, vol. 43, no. 1, pp. 31–49, 2022, Accessed: Jul. 14, 2024. [Online]. Available: https://ageconsearch.umn.edu/record/324629/

[21] J. O. Teye and Nikoi E., “The political economy of cocoa value chain in Ghana – Future agricultures,” FAC ICE Team - APRA blog, FAC blog. Accessed: Jul. 14, 2024. [Online]. Available: https://pdfs.semanticscholar.org/20d9/ec4167c9147acf77cd498d48ddfc92f40737.pdf

[22] D. Amuzu, B. Neimark, and C. Kull, “Bittersweet cocoa: Certification programmes in Ghana as battlegrounds for power, authority and legitimacy,” Geoforum, vol. 136, pp. 54–67, Nov. 2022, doi: 10.1016/j.geoforum.2022.08.002.

[23] V. A. Maguire-Rajpaul, K. Khatun, and M. A. Hirons, “Agricultural Information’s Impact on the Adaptive Capacity of Ghana’s Smallholder Cocoa Farmers,” Front Sustain Food Syst, vol. 4, Mar. 2020, doi: 10.3389/FSUFS.2020.00028/FULL.

[24] GSS (Ghana Statistical Service), “Ghana Population and Housing Census, General Report Volume 3A, Population of Regions and Districts,” Accra, Ghana, 2021.

[25] GSS (Ghana Statistical Service), “2010 Population and Housing Census. Regional Analytical Report, Ashanti Region,” Accra, Ghana, 2013.

[26] GSS (Ghana Statistical Service), “2010 Population and Housing Census. Regional Analytical Report, Western Region,” Accra, Ghana, 2013.

[27] J. E. Kongor et al., “Constraints for future cocoa production in Ghana,” Agroforestry Systems, vol. 92, no. 5, pp. 1373–1385, 2018, doi: 10.1007/s10457-017-0082-9.

[28] CHED, “Cocoa Management System data as December 2022,” Cocoa Health and Extension Division-Ghana (CHED), Cocoa Board, Cartography Department, Kingsway building, Accra, Ghana, 2023.

[29] T. Yamane, Statistics: An Introductory Analysis, Tokyo. Tokyo: Harper and Row, 1967.

[30] N. J. Salkind, “Exploring research,” in Organisational Research: Determining Appropriate sample Size in Survey Research”. Information Technology, Learning, and Performance Journal, 19(1), pp 43-50 (Spring)., 3rd ed., J. E. Bartlett, J. W. Kotrlik, and C. C. Higgins, Eds., Organizational ResearInformation Technology, Learning, and Performance Journal, 1997, p. 19(1), pp 43–50.

[31] K. Jaskiewicz and A. Laven, “Gender relations and innovation from below in cocoa and oil palm growing communities in Ghana,” no. May, p. 55, 2016, Accessed: Jul. 25, 2024. [Online]. Available: https://inclusivevcc.wordpress.com/wp-content/uploads/2015/07/gender-relations-and-innovation-from-below-in-cocoa-and-oil-palm-growing-communities-in-ghana.pdf

[32] J. Hainmueller, M. J. Hiscox, and M. Tampe, “Sustainable Development for Cocoa Farmers in Ghana,” International Growth Centre Working Paper, no. January, pp. 1–59, 2011, Accessed: Jul. 25, 2024. [Online]. Available: https://www.theigc.org/sites/default/files/2015/02/Hainmueller-Et-Al-2011-Working-Paper.pdf

[33] B. A. Naamwintome and E. Bagson, “Youth in agriculture: Prospects and challenges in the Sissala area of Ghana,” Net Journal of Agricultural Science, vol. 1, no. 2, pp. 60–68, 2013, Accessed: Jul. 25, 2024. [Online]. Available: https://www.academia.edu/download/76806229/13-023.pdf

[34] F. Place, “Land Tenure and Agricultural Productivity in Africa: A Comparative Analysis of the Economics Literature and Recent Policy Strategies and Reforms,” World Dev, vol. 37, no. 8, 2009, doi: 10.1016/j.worlddev.2008.08.020.

[35] D. Agyapong et al., “Assessment Of Labour Concerns And Perceived Effects On Cocoa Farm Operations In Ghana,” International Journal on Food, Agriculture and Natural Resources, vol. 5, no. 2, pp. 95–103, 2024, doi: 10.46676/ij-fanres.v5i2.314.

[36] E. K. Tham-Agyekum et al., “Harnessing climate information service use for cocoa farming sustainability in Ghana,” Clim Dev, pp. 1–14, 2024, doi: 10.1080/17565529.2024.2359984.

[37] H. D. Fiawoo, E. K. Tham-Agyekum, F. Ankuyi, C. Osei, and J. A. Bakang, “Rice farmers’ adoption of climate-smart agricultural technologies and its effects on yield and income: empirical insights from Ghana,” SVU-International Journal of Agricultural Sciences, vol. 6, no. 1, pp. 120–137, Mar. 2024, doi: 10.21608/svuijas.2024.268924.1342.

[38] K. Opoku-Acheampong, E. K. Tham-Agyekum, F. Ankuyi, E. L. Okorley, J. E. Andivi Bakang, and F. Nimoh, “Effect of adoption of conservation agriculture on household food security of smallholder maize farmers in Ghana,” Environmental and Sustainability Indicators, vol. 23, p. 100436, Sep. 2024, doi: 10.1016/j.indic.2024.100436.

[39] J. Avilesh, H. Shane, and R. Arvind, “Accessibility and relevance of extension methods and information and communication technologies among farmers in Mauritius,” 2017. [Online]. Available: www.eajournals.org

[40] M. Kodom, S. B. Azumah, N. A. Boateng, E. M. Tsekpo, K. B. Mensah, and E. Boateng, “Changing the perceptions and attitudes of rural Ghanaian youth towards cocoa farming,” Dev Pract, vol. 32, no. 7, pp. 958–967, 2022, doi: 10.1080/09614524.2022.2086218.

[41] D. B. Bawa and A. O. Ani, “Analysis of Adoption of Improved Maize Production Technology among Farmers in Southern Borno, Nigeria,” Research on Humanities and Social Scicence, vol. 4, no. 25, pp. 137–142, 2014.

[42] E. K. Tham-Agyekum et al., “Cocoa Farmers’ Adaptation to Climate Extremes in Atwima Nwabiagya North District, Ghana,” SSRN Electronic Journal, vol. 8, no. 1, pp. 283–297, 2024, doi: 10.21776/ub.jepa.2024.008.01.24.

[43] [43] L. Lipper et al., “Climate-smart agriculture for food security,” 2014. doi: 10.1038/nclimate2437.

[44] A. Ali and O. Erenstein, “Assessing farmer use of climate change adaptation practices and impacts on food security and poverty in Pakistan,” Clim Risk Manag, vol. 16, pp. 183–194, 2017, doi: 10.1016/j.crm.2016.12.001.

[45] L. O. Okojie, Olowoyo, R. A. Sanusi, and A. R. Popoola, “Cocoa farming households’ vulnerability to climate variability in Ekiti State, Nigeria,” International Journal of Applied Agricultural and Apicultural Research, vol. 11, no. 2, pp. 37–50, 2015, Accessed: Nov. 11, 2024. [Online]. Available: https://www.ajol.info/index.php/ijaaar/article/view/141561

[46] E. Nyadzi, “Climate Variability Since 1970 and Farmers’ Observations in Northern Ghana,” Sustainable Agriculture Research, vol. 5, no. 2, p. 41, Apr. 2016, doi: 10.5539/sar.v5n2p41.

[47] M. Bello, S. E. S., O. E. Galadima, and A. I., “Knowledge, Perception and Adaptation Strategies to Climate Change Among Farmers of Central State Nigeria,” Sustainable Agriculture Research, vol. 2, no. 3, p. 107, 2013, doi: 10.5539/sar.v2n3p107.

[48] I. Eguavoen, “Climate change and trajectories of blame in northern Ghana,” Anthropological Notebooks, vol. 19, no. 1, pp. 5–24, 2013.

[49] E. A. Kosoe and A. Ahmed, “Climate change adaptation strategies of cocoa farmers in the Wassa East District: Implications for climate services in Ghana,” Clim Serv, vol. 26, 2022, doi: 10.1016/j.cliser.2022.100289.

[50] P. K. Thornton, P. J. Ericksen, M. Herrero, and A. J. Challinor, “Climate variability and vulnerability to climate change: a review,” Glob Chang Biol, vol. 20, no. 11, pp. 3313–3328, Nov. 2014, doi: 10.1111/GCB.12581.

[51] C. S. Mbuli, L. N. Fonjong, and A. J. Fletcher, “Climate change and small farmers’ vulnerability to food insecurity in Cameroon,” Sustainability (Switzerland), vol. 13, no. 3, pp. 1–17, 2021, doi: 10.3390/su13031523.

[52] N. Kilimani, J. Van Heerden, and H. Bohlmann, “Water resource accounting for Uganda: Use and policy relevancy,” Water Policy, vol. 18, no. 1, pp. 161–181, 2016, doi: 10.2166/wp.2015.035.

[53] D. S. Ehiakpor, G. Danso-Abbeam, and J. E. Baah, “Cocoa farmers’ perception on climate variability and its effects on adaptation strategies in the Suaman district of Western Region, Ghana,” Cogent Food Agric, vol. 2, no. 1, p. 1210557, 2016, doi: 10.1080/23311932.2016.1210557.

[54] F. Codjoe, Y. Nana, C. K. Ocansey, D. O. Boateng, and J. Ofori, “Climate change awareness and coping strategies of cocoa farmers in rural Ghana,” Journal of Biology, Agriculture and Healthcare, cocoa.kit-ipp.org, vol. Vol.3, no. No.11, 2013, Accessed: Jul. 14, 2024. [Online]. Available: http://cocoa.kit-ipp.org/cocoa/sites/default/files/publication/Climate Change Awareness and Coping Strategies of Cocoa.pdf