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Cocoa and Climate Change: Insights from Smallholder Cocoa Producers in Ghana Regarding Challenges in Implementing Climate Change Mitigation Strategies

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Abstract: This study investigates the knowledge and perception of smallholder cocoa farmers on the potential impacts of climate change on cocoa production in Ghana. It addresses opinions on the inclusion of climate change mitigation strategies (such as Reducing Emissions from Deforestation and Forest Degradation—REDD+) into cocoa production, and potential obstacles and roles of stakeholders in ensuring community acceptance of such strategies in a unique multiple land use area—the Krokosua Hills Forest Reserve. Data from the Ghana Meteorological Agency and through survey of 205 cocoa farmers were assessed with Mann-Kendall, Kruskal Wallis and Mann-Whitney tests. Farmers' perceptions of changes in climate were notably diverse and did not always match historic weather data, but accurately described increases in temperature and drought which are linked to cocoa productivity. Farmers appreciate the importance of tree maintenance for ecosystem services but were skeptical of financially rewarding climate change strategies which favor tree protection. Cultural practices associated with cocoa production encourage carbon release and may pose a threat to the objectives of REDD+. Farmers' experience on the land, interactions with other farmers, government extension agents and cocoa buyers all influence cocoa agroforestry practices in the area, and communication through existing entities (particularly extension agents) presents a pathway to community acceptance of climate change mitigation strategies. The study recommends reforms in REDD+ strategies to adopt flexible and participatory frameworks to facilitate adoption and acceptability due to pronounced heterogeneity in community perceptions and knowledge of climate change and related issues.

Keywords: cocoa; Ghana; smallholder; perceptions; climate change; REDD+; stakeholders; participatory

1. Introduction

Cocoa (*Theobroma cacao* L.) cultivated under the shade of forest trees, in combination with annual food crops (i.e., cocoa agroforestry) on the same piece of land, is common for smallholder farmers across the cocoa-forest mosaic of tropical Ghana. Currently, Ghana is the world's second largest cocoa producing nation (behind Côte d'Ivoire). The cocoa industry employs about 3.2 million people along its commodity chain and accounts for 25% of foreign exchange earnings [1]. It is estimated that 800,000 smallholder cocoa farmers in Ghana derive between 70%–100% of their yearly income solely from cocoa production [2]. Benefits from cocoa agroforestry are multifaceted and include greater biodiversity than monocultures; societal and economic benefits of continuous food supply (food crops/staples); annual income from cocoa; and long-term financial reserves in timber.

Cocoa generally requires high temperatures, precipitation and humidity to achieve optimum productivity, and cultivation is restricted to the "cocoa belt" (20° N and 20° S of the Equator). Specifically, cocoa trees need temperatures between 21–23 °C and rainfall between 1000–2500 mm annually to achieve optimum yield. Cocoa production is sensitive to precipitation and is reduced by drought which may increase in Ghana under climatic changes. A temperature increase of about 2 °C and a 1% decrease in precipitation (1467 mm to 1455 mm) is projected by the year 2050 in Ghana with potential decreases in cocoa cultivation [3], particularly in areas bordering the cocoa growing suitability area to the north and south respectively [3,4]. Long-term trends in precipitation are lacking due to high variability along both inter-annual and inter-decadal timescales [5]. The impacts of the severe El Niño years of the early 1980's on cocoa yield in the entire West African sub region [6], provides a reference point for potential future impacts of increased drought under climate change projections.

A "climate-smart" [7] approach (i.e., agricultural strategies that foster sustainable production, resilience, mitigation, food security and development) is needed to counter the potential impacts of climate change on global cocoa production. Non-governmental organizations (NGOs) have made significant efforts in developing sustainable practices related to cocoa production and climate change across the West African sub region and other developing nations in the cocoa belt. However, the development of cocoa varieties with tolerance for higher temperature and low precipitation is needed [8], particularly in Ghana, where strategic climate change ameliorating strategies are essential to sustaining cocoa production [9]. Current and emerging climatic trends could render smallholder cocoa farmers vulnerable and pose a significant threat to livelihoods centered on cocoa production [10].

In 1995 Ghana ratified the United Nations Framework Convention on Climate Change—UNFCCC global alliance to reduce carbon emissions [11] and in 2008 adopted the Reducing Emissions from Deforestation and Forest Degradation (REDD+) program to foster carbon goals [12]. REDD+ aims to create financial value and incentive for activities which lead to sustainable natural resource management in developing nations [13]. REDD+ reinforces conservation, sustainable management of forests and enhancement of forest carbon stocks. Potential benefits envisaged include conservation of biodiversity, water and soil regulation, and direct human benefits including enhancing opportunities for participatory natural resource management. Ghana has made significant strides toward a national scale implementation of REDD+ and has submitted its Readiness Preparation Proposal (RPP) to the World Bank's Forest Carbon Partnership Facility (FCPF) in 2010 [14,15]. The National Forest and Wildlife Policy (2012) and National Climate Policy (2013) were passed by Ghana to offer a favorable policy pathway for climate change strategies, including REDD+. The integration of cocoa agroforestry within REDD+ (Cocoa Forest REDD+ program, [16]) aims at improving net carbon gains through the integration of trees on crop lands and subsequently providing an opportunity toward climate change mitigation. REDD+ funding differs from mainstream project funding where funds are provided before the initiation of a project. REDD+ is rather performance based with a built-in component of demonstrating the impact(s) of the project before funds are released [12]. Expectedly, REDD+ has a strict set of criteria which are essential to its implementation. Although Ghana's REDD+ pathway has received accolades, globally applicable issues pertaining to tree and land tenure, benefit sharing mechanisms, technical capacity and governance [12,17–19] are yet to be fully resolved.

Numerous studies have examined the perceptions of farmers on such topics as the impact of climate change on cocoa yields [8,9,20,21], smallholder choice of cocoa production systems [22–24], the potential benefits of cocoa agroforestry [25,26] and advantages of REDD+ in cocoa production [13,27]. There is however, limited information on how farmers perceive the inclusion of climate change mitigation strategies into their land/farm management objectives. Since agroforestry emphasizes "people" as its key element [28], understanding cocoa farmers' perceptions of issues such as tree planting, and local/indigenous knowledge on the role of climate on sustainable forest management and environmental conservation is important in answering questions on land use, land-use change (deforestation) and cocoa production. This suggests that, agroforestry is not just about the cocoa and associated shade trees [29], as there is a strong linkage between farmers' perception and management decisions on tree retention on cocoa farms in Ghana; positive perceptions of shade trees increase the probability that a farmer will retain trees on cocoa farms [30]. The importance of stakeholder perception on the success of conservation projects has been previously demonstrated; for example, in Kenya, stakeholder perceptions influenced adoption of new and improved strategies [31].

Smallholders perceptions also take into account interaction between their farming activities and changes in microclimate, and their perceptions may determine whether mitigation/adaptation strategies are implemented [32]. In fact, the social acceptability of the agroforestry system at the individual farmer level, is influenced by: Community heterogeneity, perceptions towards trees, land and tree tenure arrangements, gender and other socio-cultural factors like age, labor and cultural habits [33]. Remarkably, a strong correlation between climate change, the level of concern for associated implications, and ultimately, farmers' decision to subscribe to climate change mitigation policies and projects exists, irrespective of the accuracy of farmers' experience with regards to individual perceptions of climate change and actual historical climatic trends [34]. For instance, people who believed that climatic changes were occurring and that changes were a result of human activities, were more likely to perceive temperature increases despite inconsistencies with available climate records. In the end, perceptions about climate patterns effectively determine actions of farmers irrespective of patterns determined through analysis of empirical climate data [35].

Based on previous studies, there is empirical reason to suggest that the aforementioned demographic profiles have an impact on perceptibility of climate change, and consequently, actions to be taken. In Ghana, for instance, smallholder farmers (both men and women) in different communities hold specific views of climate change which ultimately influences coping strategies [36]. Elsewhere, farmer age is a significant determinant of overall farming and climate experience [37,38]. Differences in access to information on climate change also correlates with climate change perception among male- and female-headed households, with the former more likely to be educated on climate-related issues [39]. Women, on the other hand are considered more susceptible to the impacts of climate change because they are generally less informed [40]. This connotes that education in general influences how farmers perceive climate change [22,41]. Additionally, the accumulation of knowledge and experience with both farming and climate makes farmer age an important factor in climatic change perception inquiry [42]. In Ghana, marital status among smallholder cocoa farmers influences access to information on climate change and ultimately, how individuals perceive climate change and adaptation strategies [22]. Lastly, comparisons between indigenous and migrant farmers, indicate that the former have a higher tendency to subscribe to long-term climate ameliorating programs and strategies. Lack of property rights is highlighted as a significant cause of this observation [43].

This study reports on findings of a survey conducted in smallholder cocoa communities in a major cocoa-producing area of Ghana. A semi-structured questionnaire was employed to collect demographic profiles, relevant information and opinions of individual farmers. In consonance with the study objectives, it is expected that different communities, and the gender, age, educational status, migrant status, and family/household status within communities will be tied to farmers' perceptions of climatic changes, potential causes, receptiveness to climate change mitigation projects and general opinions about climate change.

This paper investigates the perceptions of smallholder cocoa farmers on the inclusion of climate change mitigation strategies and payment for ecosystem services into land/farm management objectives. Specifically, this study:

1. Examines cocoa farmers' knowledge and perceptions of climate change in contrast with climate data and potential impacts of climate change on cocoa production;
2. Investigates the perceptions of smallholder farmers on the feasibility of including climate change mitigation strategies in cocoa farming;

3. Explores the roles of scientific and non-scientific actors (cocoa farmers and non-cocoa farmers) in promoting the implementation of climate change mitigation strategies in combination with cocoa production; and
4. Examines potential obstacles to incorporating climate change mitigation strategies into cocoa production.

2. Materials and Methods

2.1. Study Area

The study was carried out in the Krokosua Hills Forest Reserve (KHFR), in the Juaboso District of the Western Region of Ghana (Figure 1). Specifically, the study was conducted among smallholder cocoa farmers resident in communities that fringe KHFR, one of the major forest reserves in the Western Region. KHFR covers an area of about 481.61 km^2 (48,160 ha), situated at the east bank of River Bia and bisected by the Sefwi-Wiawso—Côte d'Ivoire border road (6°15′–6°40′ N and 2°40′–3°00′ W) [44]. Cocoa farming (agriculture) is the main source of livelihood for people living around the reserve [45]. Between 2006 and 2009, the population of thirteen large fringe communities was 66,766. For management purposes, KHFR has been designated into two major zones: (1) the production zone (where harvesting of timber and non-timber forest products is officially permitted for prospective Timber Utilization Contracts (TUC, a written contract signed by the Sector Minister and ratified by the Parliament of Ghana granting a timber harvesting right to its holder upon a successful competitive public bidding process) and permit holders respectively—23,639 ha) and (2) the protection zone (includes areas of high biodiversity conservation priority, areas recovering from past disturbances and no timber harvesting areas—24,521 ha) [44].

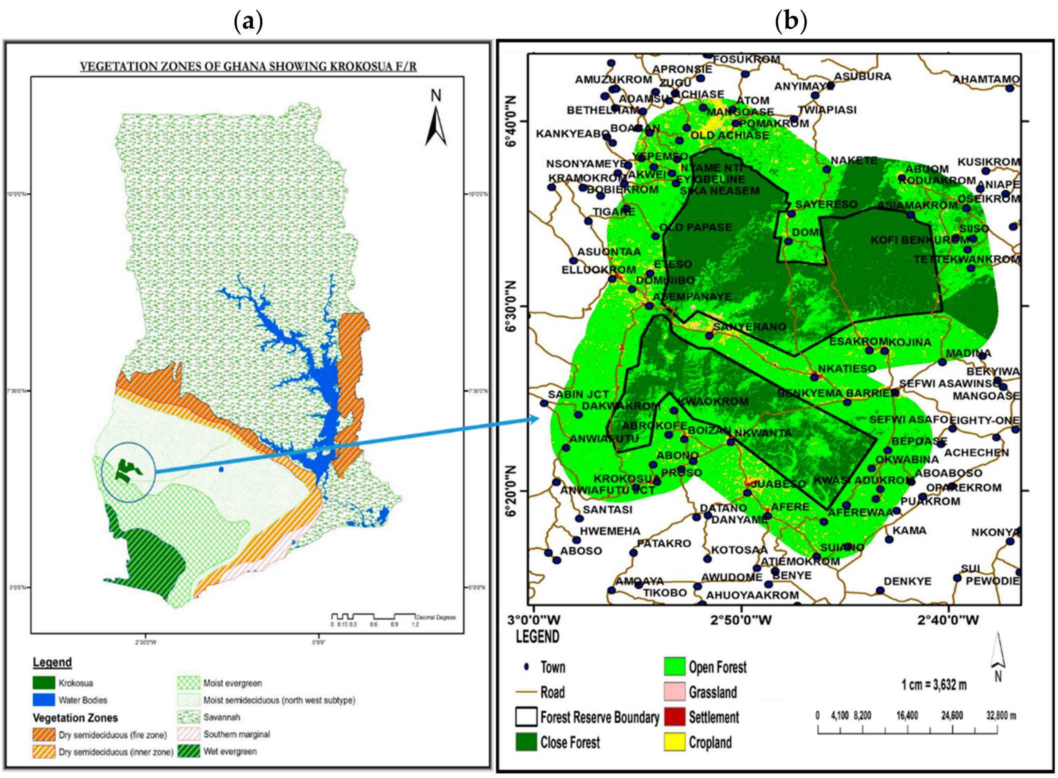

Figure 1. Ecological zones in Ghana highlighting the location of the Krokosua Hills Forest Reserve (KHFR) (**a**). Ecological zones correspond with the legend, with KHFR located in the moist semi-deciduous zone. Map of KHFR showing approximate locations of study communities is also shown on the right side of the figure (**b**).

Prior to the official designation of the KHFR as a Forest Reserve in 1948, fringe communities utilized the land for agriculture and cocoa farming. After the reservation status was conferred, cocoa farms were given legal status to remain in the forest and were termed admitted farms. Per the most recent management plan, there are 38 admitted farms in the reserve. These admitted farms have footpaths as routes connecting farms and huts scattered within the forest. Over time, population growth and land scarcity have forced cocoa farmers to extend their farms further into the forest and outside the area demarcated for cocoa production (admitted farms) [44]. Cocoa farming is the leading driver of deforestation in the region [46].

2.2. Farmer Selection, Data and Analysis

The study targeted cocoa farming communities within a range of 2 and 5 km away from the KHFR. The distance varied to sample cocoa farmers who interacted with or specifically had cocoa farms within the KHFR. A mixed method approach (qualitative and quantitative methodologies) was used. Apart from the inherent trait of complementarity of qualitative and quantitative procedures, using mixed methods provides a platform for cross-checking and validation of collected data [47]. A list of farmers in the target communities was not readily available so the study identified farmers through community heads and leaders. Farmers were then stratified based on gender and randomly selected for interviews. A purposive sampling approach employing snowballing (i.e., respondent referrals) was also used to increase sample size and heterogeneity of respondents. A total of 205 face-to-face interviews were administered in 30 communities surrounding the KHFR between December 2016 and February 2017. Identifying information for responses given were not taken as per the instructions of the Institutional Review Board of the University of Washington. In each community, unequal samples were obtained, with at least 2 interviews in selected communities. Interviews were conducted at home and on farms and lasted between 60 to 90 min. Notes were taken as the interview progressed with corresponding answer choices checked as well. Questions were prepared in English but the local language, Twi, was used during the interview except in situations where respondents could understand English. Survey enumerators were given prior training in translation and the survey instrument.

Survey questions were structured into four different themes: (1) knowledge on climate change, (2) perceptions about climate change mitigation strategies, (3) roles of local and external stakeholders, and (4) potential setbacks to climate change mitigation strategies, and examined for demographic trends (e.g., gender, age, level of education and migrant status). Questions were designed to collect mostly quantitative data (structured) but also included qualitative data collection through semi-structured (open ended) questions to allow farmers to expatiate on opinions and in so doing verify answers given on structured questions.

Answers to survey questions were first summarized in Microsoft Excel and R statistical software was used for statistical analysis. Descriptive analysis such as modes, frequencies and percentages were used to summarize data. As responses from farmers did not follow a normal distribution, a Mann-Whitney and Kruskal-Wallis (KW) test were employed where variables had only two levels (gender, migrant and household status) and three or more levels (community, age and educational level) respectively. Individual questions on knowledge and perception of climatic changes, causes and related impacts (Table A1) were used as dependent variables. For statistically significant results on variables with three or more levels, a post-hoc Dunn Test using the Bonferroni-type adjustment of p-values (to reduce type I error) was used to determine which group(s) accounted for the significance.

Based on the four themes of the survey, Likert scale questions were utilized. Questions on five-point scales were converted to three groups; group one combined responses for agree and strongly agree, disagree and strongly disagree on group two and neutral responses on group three. Questions on 4-point Likert scales were converted into binary variables; e.g., not at all worried and not very worried were recorded as zero whiles somewhat worried and very worried were recorded as one for the binary variable [34]. Open-ended questions were categorized under the survey question themes and further sorted for recurring words and phrases (open coding, [48]).

Monthly means of maximum and minimum temperature and monthly precipitation climate data were collected from the Ghana Meteorological Agency for the period 1970–2017 from the closest weather station (Sefwi Bekwai), which is about 55 miles from the study area. Data were used to describe the physical environment and compare perceptions of climate change to climatic records. A Mann-Kendall (MK) test was used to determine monotonic trends in climatic variables over the period [49,50]. A cutoff of $\alpha = 0.05$ was used to determine significance in trends [51]. The weather data allows for comparisons with the experiences and observations of individual farmers and the overall community experience. To verify answers on perceptions regarding the length of dry and wet seasons (drought), the Standardized Precipitation-Evapotranspiration Index (SPEI) was used. SPEI is based on a combination of Palmer Drought Severity (PDSI) and Standardized Precipitation Indexes (SPI) [52]. SPEI incorporates temperature by finding the difference between precipitation (P) and potential evapotranspiration (PET) (using Thornthwaite's equation [53]) to produce an adjusted log-logistic distribution. Upon choosing an appropriate time scale, standard deviations of average values are calculated [54]. SPEI lends from SPI to classify drought severity in a range between no drought (≥ 0) and extreme drought (≤ -2) [55]. Estimation of SPEI was done using the SPEI package in R [56].

3. Results

3.1. Historical Climate Trends

3.1.1. Temperature

Based on the MK test on data from 1970 to 2017, temperature has significantly increased, a probable manifestation of climate change. Analysis of mean monthly minimum ($\tau = 0.285$, $p < 0.001$) and maximum ($\tau = 0.168$, $p < 0.001$) temperature both indicated statistically significant increased trends (Figure 2a,b). The mean temperature observed for the period 1970–2017 ranges from 22.6 °C to 32 °C for minimum and maximum respectively. Seasonal MK tests (SMK) also revealed an increasing seasonal temperature trend for minimum ($\tau = 0.395$, $p < 0.001$) and maximum ($\tau = 0.460$, $p < 0.001$). For recordings of mean minimum temperature, the lowest record for the period (1970–2017) was 18.2 °C which was in January 1975, while the highest record was taken as 27.7 °C in February 2011. Maximum temperature on the other hand, had its lowest record as 28 °C in August 1982 and highest record for the period as 37.2 °C in February 1995. Generally, low temperatures were mostly between August to January while February to June were the hottest months.

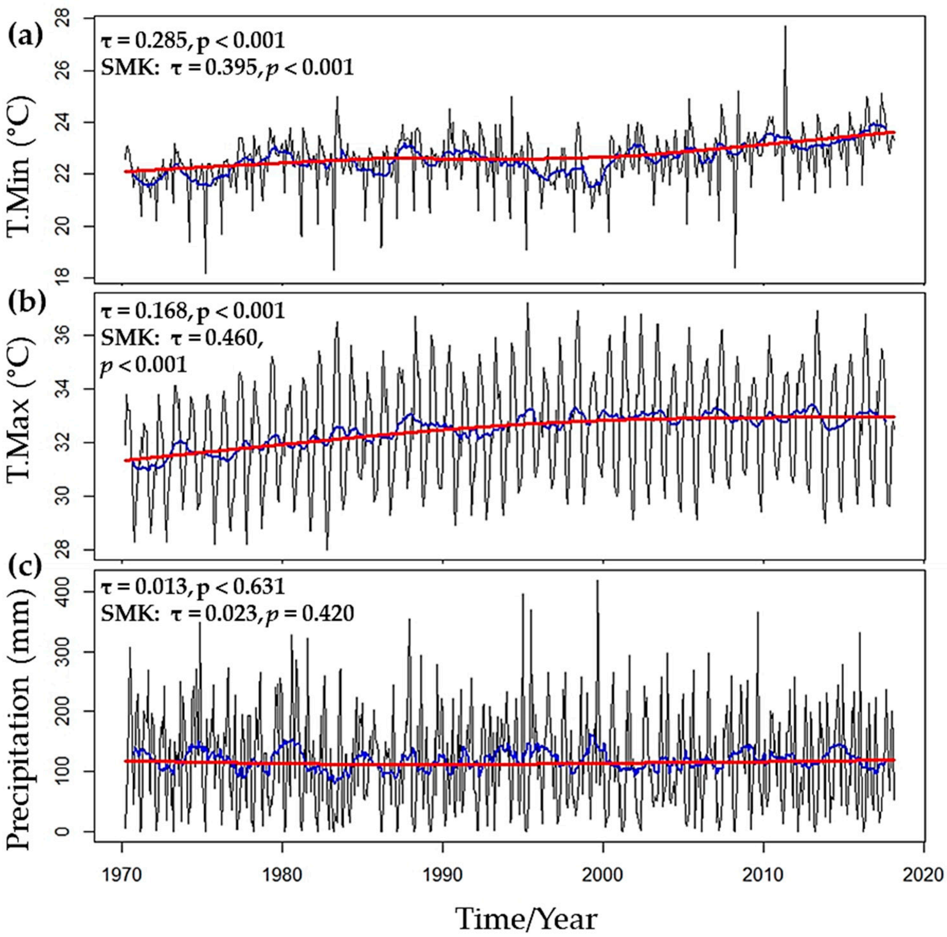

Figure 2. Monthly trend analysis of minimum and maximum temperature (**a**,**b**) in °C and precipitation in mm (**c**) at the Sefwi Bekwai weather station. Data was obtained from the Ghana Meteorological Agency (Kumasi, Ashanti Region, Ghana). Test for overall trend in data is shown by the red line with statistical test results indicated by Kendal's Tau (τ) and a resultant *p*-value. Tests for seasonality in data is indicated in blue and results shown with the Seasonal Mann-Kendall test (SMK). The "Kendall" package in R statistical software was used for the analysis.

3.1.2. Precipitation

Weather records indicated that since 1970, mean precipitation has consistently been above 1000 mm. Trend analysis however indicates an erratic rainfall pattern which is confirmed by the MK test. Specifically, the MK test detected no specific trend ($\tau = 0.013$, $p = 0.631$). Although Kendall's tau remained positive ($\tau = 0.013$), that is overall rainfall increased, the increase was not significantly different from zero. A seasonal MK test (SMK) further confirmed no seasonality trend in precipitation over the period ($\tau = 0.023$, $p = 0.420$) (Figure 2c). Apart from 1977, 1981, 1982, 1983, 1986 and 2016, all other years recorded rainfall greater than 1250 mm, the minimum value required for optimum cocoa production. The lowest and highest precipitation were recorded in 1983 (1071 mm) and 1980 (1826.5 mm) respectively. The most significant drought event in Ghana occurred in 1983, reinforcing the significantly low precipitation level for that year.

3.1.3. SPEI (Drought Severity)

Figure 3 shows SPEI values (using monthly data) for the study area, showing a decrease in extended wet periods. Periods of dryness on the other hand have increased, particularly from 2000–2017. There is indication that the area witnessed its worst drought (SPEI < -2) between 2014 and 2016.

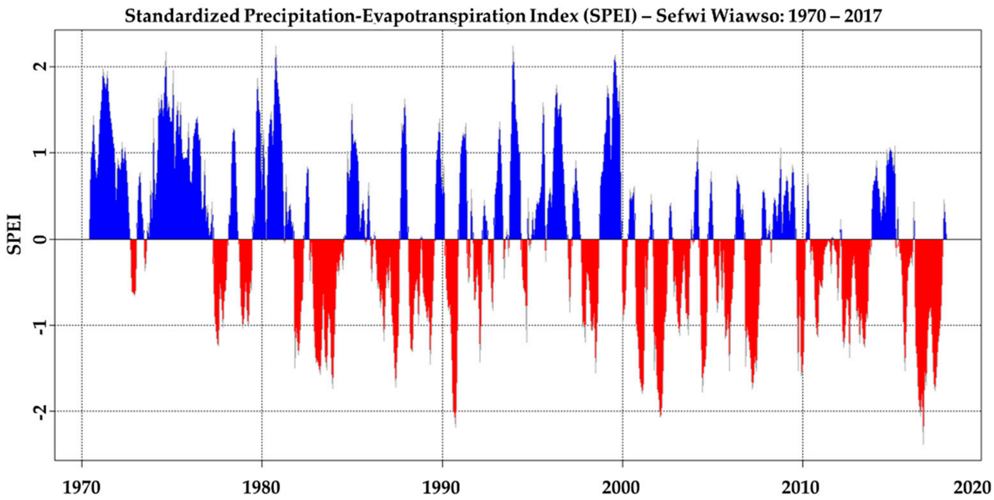

Figure 3. Time series of Standardized Precipitation-Evapotranspiration Index—SPEI values for Sefwi Wiawso (55 miles from study site): 1970–2017. Areas in blue indicate periods of no drought and red depicts periods of drought and corresponding SPEI values.

3.2. Characteristics of Respondents

Survey respondents were all adults (>18 years) mostly between 30–59 years; 67% were male and 33% female, a proportion epitomizing cocoa farming as a predominantly male-dominated activity. Approximately 65% of respondents were over 45 years-old. Educational levels ranged from basic (46%), to secondary (16%), to tertiary (7%) and no formal education (31%). Male farmers were generally more educated, 74% (compared to 61% of females) having received either basic, secondary or tertiary education. While females had similar basic education (51%) to males (49%), more males (19%) than females (6%) had received secondary education. Among male respondents, 87% were household heads. Only 23% of females were heads of their households. Natives of communities were generally more educated (71%) than non-natives (66%). Most respondents were married (86%), Christian (80%) and natives of their respective communities (71%) (Table A2).

3.3. Farmer Knowledge and Perceptions of Climate Change and Impact on Cocoa Production

Most farmers had perceived changes in climatic patterns over the last 20 years. Notably, farmers perceive rising temperature (88% of famers) and reduction in the amount of rainfall (89% of farmers) in recent times. Within the same period, the length of the wet season had reduced (81%), with a resultant increase in dry spells (89% of farmers) (Table 1). A small proportion (<1%) of farmers indicated they had witnessed spikes in cases of wildfires within the same period. Farmers overwhelmingly (95%) agreed that observed and experienced climatic changes over the past decade have had a negative impact on cocoa yields. The remaining respondents were evenly split on yields: some said they remained the same (2%) or improved (2%), respectively over the last decade.

Table 1. Respondent perceptions of climatic changes (n = 205).

Climatic Variables	Increased (%)	Decreased (%)
Temperature	88	5
Rainfall	2	89
Length of Wet Season	9	81
Length of Dry Season	89	6

Descriptive examination of survey responses indicated that farmers believe that climatic changes are mostly as a result of human activities; precipitation (181: 88%) and temperature (175: 86%). This finding is consistent with farmers' belief that climatic changes are not just isolated climatic anomalies. Farmers mostly disagreed that both precipitation (71%) and temperature (75%) were climatic anomalies. Superstitious (curses/spells) association with climatic changes were mostly dispelled by respondents with respect to changes in precipitation (85%) and temperature (81%). On the possible human attributable causes of climatic changes, illegal logging (95%) was the most highlighted. Slash and burn agricultural practice in the area (84%) as well as pollution from vehicles (83%) were similarly pointed out as detrimental to the environment. According to 80% of respondents, widespread woodfuel harvesting could also contribute to climate change. Despite previous research on the potentially harmful environmental impacts of implementing full-sun cocoa systems (cocoa monocultures), the majority of farmers (65%) believed such systems do not contribute to climatic changes, as opposed to 30% who perceive a change to full-sun cocoa systems, a plausible climate change driver (Figure 4).

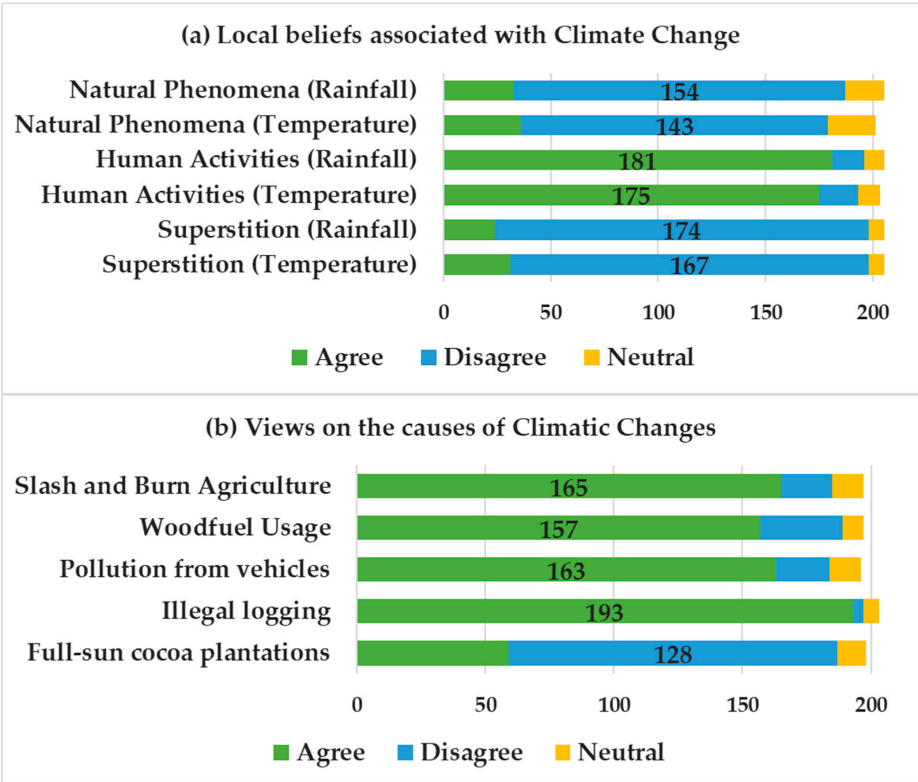

Figure 4. Number of survey responses to two questions on beliefs associated with climate change (**a**) and causes of climatic changes (**b**). A total of 205 responses were collected with few respondents choosing not to respond. Groups were created from a 5-point Likert scale in 3 categories: Agree, Disagree and Neutral. Each stacked bar depicts responses into 3 groups with the corresponding question listed in the left strip. Labelled bars indicate only the majority response.

Farmers' experience of climatic changes in recent times has heightened their fears about the future outlook of their main income earner, cocoa farming. Almost all farmers, 202 out of 205, expressed worry about changing climate. Concerns were mostly about reduction in cocoa yield (195), food crop loss due to droughts (181), increased rate of crop disease and pest infestation (135), increased wildfire incidents (127), and increased cocoa tree mortality associated with flooding (76). As a climate ameliorating mechanism, respondents held similar opinions on the role of trees in regulating temperature (94%) and precipitation (93%). According to respondents, specific climate change initiatives will mostly require a participatory approach (94%) as well as governmental interventions (78%). When farmers were asked to elaborate on what participatory approach they were specifically referring to, comments like "it is not any government, but we must get involved in the fight against climate change", "government and citizenry must make concerned effort in the fight against climate change", "government alone cannot fight the climate change menace so we must get involved", "government and stakeholder should all rise against climate change", and "all should participate in effort to combat climate change" were made. This suggests that farmers believe their active participation in developing/implementing climate change mitigation efforts is paramount to its eventual success. Farmers believe climate change is a reality and also agree, unanimously, that, interventions are vital to avert potentially devastating impacts on future generations (92%).

3.4. Information Related to Climate Change Mitigation Strategies and Perceptions of Farmers

Hybrid cocoa is the predominantly cultivated variety in the communities surveyed. More than 80 percent of farmers claim to plant this variety. Farm observations revealed that, such farms had a combination of trees, cocoa and food crops, with significant open patches in tree canopy to allow optimum level of sunlight. Some farmers (10%) had some of their farms with closed overhead tree canopies being described as traditional shaded cocoa stands. Other farmers (7%) also noted that they had some farm lands dedicated to cocoa monocultures. Cocoa lands were mostly acquired from relatives who were still alive or through inheritance (46% of farmers). Some farmers procured their own lands (42%), while others leased (15%) or had lands in multiple ownership categories. Farm sizes depicted the overarching Ghanaian smallholding cocoa farm/cultivation technique, revealing specifically that farmers mostly had 2 tracts of lands between sizes 0.4–2 ha, with cocoa trees ranging between one year to 19 years.

According to farmers, the choice of cocoa variety was mostly as a result of time to maturity (90%), resistance to pests and diseases (67%), expert advice from extension agents (62%), and availability (49%). Maintaining trees on cocoa lands seems plausible to many farmers (92%) in the study area by virtue of the inherent benefits to the environment. Interestingly, the idea of direct monetary benefits for tree maintenance on cocoa lands met a lesser response than preserving trees for their inherent value. Although the majority of farmers agreed to maintain trees on their farms for direct monetary benefits, a reduction of 17% was observed (a total of 75%) for farmers who answered yes. Farmers were almost even regarding their views on current tree tenure, which allocated ownership/benefits from trees differently based on location of tree within the forest reserve and outside it. It was specifically observed that 51% of 205 farmers were satisfied with the current tree tenure, in sharp contrast to the remaining 44%, who held a dissatisfied opinion of tree tenure.

3.5. Investigation into the Role of External Stakeholders in Cocoa Farming and Pathways to Increased Acceptability of Climate Change Mitigation Strategies and Potential Setbacks

Results revealed that communities in the study area had witnessed substantial presence of extension agents from governmental organizations and initiatives on cocoa as well as that of non-governmental organizations. Overall, farmers were satisfied (84%) with the influence such stakeholders had had on cocoa farming. Farmers in general indicated their inclusion in any direct income earning climate change mitigation strategy will hinge on the details of such a strategy. A total of 81% shared this opinion. Farmers (89%) suggested that the presence of extension agents will be vital as a bond of trust for any such project. Ultimately, the provision of farming incentives (68%) and assurances on the sustainability (63%) of climate-related strategies are equally important to enhance farmers' interest.

The study shows that cultural practices of cocoa farmers tend to release carbon due to vegetation removal. Although this was not evident on the farms that were visited, 76% of farmers interviewed revealed they mostly cut down cocoa trees when they see significant reduction in yield. Cutting down illegally cultivated cocoa trees in the area has mostly been done by staff of the Forestry Commission (the government body in Ghana tasked with management and regulation of forest and wildlife resources) to combat further encroachment of farm lands into the forest reserve, making this finding surprising. Farmers (27%) also indicated that they removed some timber trees to open the canopy and subsequently allow more incident sunlight to cocoa trees, when cocoa trees begin to decline in yield. The remaining farmers either leave the cocoa farm/trees or abandon the land completely when cocoa yield declines beyond commercially acceptable levels.

During preparation of lands for cultivating cocoa and other agricultural crops, slash and burn is the preferred strategy (88% and 32% respectively). Illegal logging is quite prevalent in the study area and cocoa farms with economically attractive timber species are the prime targets. Farmers indicated that illegal logging is reported to the Forestry Commission (57%). Despite this observation, farmers indicated that response and actions to such offenses are not always effectively dealt with. Farmers are sensitive about this topic, since illegal loggers do not conform to any logging standards and almost always leave significant damage to cocoa trees in the process. As a safeguard strategy, farmers resort to inducing mortality (through girdling, burning and pouring hot water on roots) of economic tree species before they reach maturity or merchantable structure/form (23%).

3.6. Statistical Variations among Responses Based on Demographic Attributes

We found differences in responses among farmers based on socio-demographic attributes including: community, age, gender, educational status, migrant status, and family/household status. Variations among communities were the most prevalent. All thirty communities generally shared similar climate experiences, with the majority response of increasing temperature/length of dry season and decreasing rainfall/length of wet season contributing 87% of responses, in comparison to 13% of other responses ($p < 0.05$). Gender also showed statistical differences among responses to observed temperature ($p = 0.01$), and rainfall ($p = 0.03$) variations; male respondents were more likely to have experienced increasing temperature (93%) and rainfall (93%) than females (78% and 81% respectively). On the other hand, age, migrant, and household status appears not to be a significant contributor to responses on climate experience ($p > 0.10$ for all responses).

Despite near unanimous agreement (95% of community responses) on the potentially negative impacts of climatic changes, concern regarding climate change impacts on cocoa yields varied significantly ($p < 0.001$). Most communities (77%) believe that collection/harvesting of woodfuel contributes to climate change. Other respondents (23%) had an opposing view which was statistically different from the majority response ($p < 0.001$). Responses to questions on slash and burn as an agricultural practice that contributes to climate change (80% of responses) also varied significantly among communities ($p = 0.03$). The age of a respondent may also contribute to farmers' views on the contribution of illegal logging to climate change ($p = 0.06$); with respondents 18–29 years old more likely to believe this (100%) than those in other age groups (94%). Cocoa monocultures have been highlighted as a potential environmental degrading agent, however native farmers (59%) found this to be less of a problem than non-native farmers (72%; $p = 0.02$).

The association of traditional beliefs and myths (such as curses and natural causes) to climate change appears to be community specific ($p < 0.01$). However, farmers' thoughts on human activities effects on rainfall patterns were statistically uniform ($p = 0.22$). Gender ascription of superstition (e.g., curses) to changes in rainfall patterns as a result of climate change was found to be statistically significant ($p = 0.01$). Females were found to be more superstitious than men. To a lesser extent, gender also influenced perceptions on rainfall just being a natural weather anomaly ($p = 0.09$). Overall, there was a general consensus (98% of responses) on the immediate concern about climate change impacts on their livelihoods and social well-being. However, farmers' view of future implications of climate change varied significantly among the study communities ($p < 0.001$); 92% of community responses pointed to a high likelihood of negative impacts.

Farmers' responses showed no differences in the perceived ability of trees to regulate temperature ($p = 0.88$) but there was a difference in response to trees' role in regulating rainfall ($p = 0.04$). There was a general acceptability of cocoa production which includes tree maintenance for ecosystem services exclusively, and one that remunerates farmers for maintaining trees on their farms, however, answers varied significantly among communities ($p < 0.001$). Tree tenure has historically been a contentious issue particularly at the community level. Communities have different opinions on current tree tenure arrangements ($p < 0.001$); (51%) believed that current tenure patterns are satisfactory in contrast to those (44%) who hold a dissatisfied opinion about tree tenure. The educational and migrant status of farmers plays a significant role ($p = 0.02$ and $p = 0.04$ respectively) in respondents' opinions on existing tree tenure regulations. Post-hoc tests indicate statistical differences among respondents with basic education (58% satisfied) and those without any formal education (38% satisfied; $p = 0.01$). Native farmers (56%) were generally more satisfied with current tree tenure than migrant farmers (40%). Age ($p = 0.07$) and gender ($p = 0.09$) also contributed to respondent thoughts on tree tenure. Younger age groups were more satisfied with existing tree tenure arrangements than older generations. Lastly, although farmers believe the influence of external help (through extension services) has mostly resulted in positive on-farm cocoa production (84%), a section of responses disagreed (13%; $p = 0.03$). Education also influenced farmer impressions on the input of extension and related services ($p = 0.04$). Respondents with basic education (42%) were more satisfied whereas those with tertiary education (6%) were the least satisfied with the influence of external help.

4. Discussion

4.1. Variations in Climate Change Knowledge/Perceptions Based on Social Indicators and Potential Impacts

4.1.1. Accuracy in Climate Change Knowledge/Perceptions

Changes in climatic pattern were widely recognized by resident cocoa farmers in communities surrounding the Krokosua Hills Forest Reserve. Perceptions about increasing temperature patterns are consistent with trend analysis (Figure 2). Trend analysis of rainfall, however, did not conform with respondents' views. The trend analysis indicated no significant change in the amount of rainfall over the same period (1970–2017), contrary to popular respondent belief that rainfall amounts have reduced. These observations have been previously stated by [4] with regards to temperature. The problems associated with rainfall observations have also been highlighted in the literature [5].

The respondents' perceptions appear responsive to drought, which was captured by SPEI values. Prolonged dry spells, in particular are a major concern to respondents due to their close association to cocoa yield and productivity. Respondents suggest that plummeting cocoa yield in the area is a manifestation of climatic changes. These concerns have been raised previously by [3,8–10]. The correct observation of increasing temperature trends and length of dry season in this study also brings into perspective that farmers accurately perceive weather patterns in relation to crop production and tend to amend their farming practices accordingly [34].

Since the link between climate change perceptions and people's likelihood of subscribing to environmental protection strategies (in general) has already been established [34,35], we evaluated the level of accuracy with which local indigenous small holder farmer climate change knowledge compares with empirical weather data. Farmers' reliance on their indigenous knowledge and associated perceptions, leading into a defined climate experience, leads them into taking core decisions regarding their farming/cultural practices [30]. Ultimately, the accuracy of climate change perceptions, or specifically the potential for negative impacts of climate variability, are essential for maintaining cocoa agriculture [20]. Our findings suggest farmers do not always perceive climatic changes accurately, leaving room for further efforts to relay climate information to them.

4.1.2. Interplay between Social Indicators, Climate Experience and Potential Outcomes

A major observation of this study was that although communities were situated in the same geographic location, opinions on climate change and related occurrences vary considerably. Thus, community heterogeneity is of paramount concern in the enactment of any climate-based initiative since farmers' opinions and experiences differ within the least temporal and spatial differentiation, irrespective of geographical location [36]. Contrary to other studies [28,37,42], age did not have a strong influence on perception or knowledge on climate change. Age may however influence opinions on the causes of climate change, biological climate control methods, and tree tenure. Gender, on the other hand, significantly influenced overall farmer climate experience, demonstrating that gender influences knowledge and perceptions on climate change [39,40]. Similar to findings that determined male farmers generally have more access to climate information than female counterparts, male respondents were found to be more educated at higher levels than females. Although this study did not find a strong linkage between education and perception/knowledge on climate change among male and female farmers, education played a significant role in determining opinions and differences regarding current tree tenure mechanisms and ratings of external/extension help with cocoa farming. It was noted that these differences were mostly between educated and non-educated farmers.

The sensitivity of tree and land tenure was also observed in this study. Migrant farmers (non-natives) offered harsher criticism of existing tree tenure arrangement than natives. This is however not a surprising finding. A lack of property rights among migrant farmers may influence interest in long-term investments [43], like tree planting and management in this case. In addition, migrant farmers are more likely than native farmers to engage in cocoa monoculture. Since migrant farmers lack property rights, it heightens their propensity to engage in activities or cocoa farming practices (in this case), that may be detrimental to the environment.

4.2. Cocoa Farming for Livelihood and Climate Change Mitigation: Views of Smallholders

This study investigated how farmers felt about incorporating climate change mitigation mechanisms, like REDD+ into their farming activities. As seen in [13,27], the main attribute of climate change mitigation mechanisms is to improve livelihoods and concurrently, enhancement of environmental protection goals. Farmers in general, acknowledged the importance of environmental protection and correctly noted aspects of their farming activities that are detrimental to the environment. Farmers also appreciate the climate ameliorative ability of trees and tree maintenance on their farms. The addition of monetary incentives, however, was marked with skepticism among farmers. Fewer farmers appeared to understand how a system of tree maintenance on their cocoa farms was going to provide them direct income as against one that prescribes maintenance for environmental protection. The only direct mechanism known to farmers is one in which the tree is eventually harvested, and some proceeds are extended to a farm/tree owner (per prescribed benefit sharing arrangements; see [57]). Such a system clearly navigates away from the goals of REDD+ but seems to be the only plausible explanation, apart from maintaining trees for ecosystem benefits exclusively. Elsewhere in one of the very first REDD+ project sites in the Brazilian Amazon region, farmers' perceptions and eventual participation in the project was significantly improved with a decentralized approach. This approach fostered active farmer participation in the planning phase of REDD+, a move that promoted equity at both the community and individual farmer level regarding information on REDD+. This significantly influenced acceptability and success of the project in the area [58]. In essence, this study corroborates the findings of [33] which asserted that socio-cultural attributes significantly influence social acceptability of agroforestry systems. For purposes of this study, community heterogeneity and migrant status appear to be the significant factors for the adoption of climate change mitigation mechanisms in cocoa farming. Community heterogeneity in particular has been discovered to have a strong connection with social capital, which is the driving force for improved performance of mainstream developmental initiatives (like REDD+). Specifically, pronounced community heterogeneity may influence social capital [59].

4.3. Pathways to Integration of Climate Change Mitigation Mechanisms: The Role of Stakeholders (Extension, Forestry Commission, Farmers' Cooperatives/Community Based Organizations, Civil Society Organizations, Cocoa Buying Companies)

The essential role of agricultural extension has been reported in implementing a Climate-Smart Cocoa (CSC) approach [7]. The approach recommends broadening the scope of cocoa-related extension efforts to increase and improve the capacity of cocoa farmers [12] to adopt environmentally friendly mechanisms which also fulfill socio-economic goals. Within the CSC framework, this study noted that farmers generally held a satisfactory opinion regarding the influence of other stakeholders when it comes to cocoa farming.

Stakeholder influence has mostly been towards helping farmers make sound decisions from cocoa cultivation to final cocoa bean sale. The already established cordiality between cocoa farmers and other stakeholders presents an opportunity to disseminate information on climate change mitigation and could also act as a social safeguard for farmers willing to invest time and other resources towards mitigation strategies. An added benefit of such safeguards will see a reduction in costs of implementation and monitoring of climate change mitigation strategies [19]. The active participation of civil society organizations in general has been highlighted as a proponent of REDD+ related activities [19].

4.4. Potential Roadblocks to the Successful Incorporation of Climate Change Mitigation Strategies into Cocoa Production

Climate change related strategies generally prescribe mechanisms aimed at carbon neutrality. REDD+ in particular hinges on specific implementation criteria: (1) simplification of tree tenure and benefit-sharing mechanisms, (2) clear demonstration of the impact of REDD+ in comparison to scenarios without it (additionality), (3) assurance of adherence to REDD+ goals for as long as the project lasts (permanence and risk assessment) and (4) guarantees that REDD+ project sites do not promote carbon release in other areas (leakage) [12–14]. Cocoa farming in general, has had a checkered history when it comes to its association with forests, in fact spearheading massive deforestation since it became a mainstay of the Ghanaian economy [60,61]. This study showed that although cocoa farming communities around the KHFR recognize the importance of environmental protection and its relation to climate, their activities, per se, pose potential challenges for the implementation of a full-scale REDD+ project. Illegal logging on cocoa farms has necessitated an historical imperative for farmers to take preventative actions by inducing mortality in trees of economic importance before they reach maturity. Farmers often have several portions of fragmented cocoa farms. It is unclear how to make sure farmers maintain carbon neutrality on other portions of lands, especially in cases where they put only portions of their lands under REDD+. Cultural practices of farmers tend to favor carbon release in cases where cocoa productivity declines significantly due to age or shade. Farmers noted that tree removal was essential in such cases to reduce the level of shading to optimum levels. Undesirable cocoa trees are also removed during shade tree removal. The importance of tree tenure needs to be emphasized. A REDD+ project will need to develop ways to address all these challenges to facilitate full scale implementation and realization of its goals.

We identified a lack of willing participation in programs which provide payments for ecosystem services (PES). The skepticism of farmers on PES could lead to an eventual removal of intrinsic and altruistic characteristics relating to environmental conservation/protection. The motivation behind general environmental stewardship could potentially be reduced to how much can be earned, and becomes even more complicated when you place people receiving payments for ecosystem services in close proximity to those who are not [62].

5. Conclusions

The novelty of climate change mitigation strategies has been heralded by the international scientific community as a gateway to the implementation of desirable forest governance mechanisms with significant potential to influence the livelihoods of developing economies. This notwithstanding, such mechanisms are prone to several obstacles which could work against implementation. Since the inception of REDD and REDD+ ideologies into scientific platforms in Ghana, several attempts have been made to move beyond pilot projects towards full scale implementation. While these attempts are laudable, this study provides data to support a bottom-up approach to effectively manage the challenges surrounding climate ameliorating strategies in general.

There is reason to recommend a REDD+ strategy that takes into consideration specific community needs. This study revealed that even within the same geographical location, perceptions and knowledge on climate change vary significantly. The cocoa growing mosaic presents an entirely new challenge to the implementation of REDD+. Cocoa has historically driven the economies of communities in these areas and though farmers welcome other livelihood and environment enhancing opportunities, there is ripe skepticism about the potential success and sustainability of such 'new ideas'. As farmers suggested in this study, climate change mitigation efforts need to effectively ensure the participation of farmers in initial project designs. A "think big, but start small" approach has the potential to help formulate community- or location-specific strategies towards implementation of REDD+. With that in mind, the global community needs to deliberate on measures to implementing an adaptable REDD+ program moving away from the strictly national-scaled orientation of strategies. There are several ecological zones in Ghana, each with unique physiography, biological assemblages, and agroforestry capacity. It remains to be determined if a single definition of a forest is equally applicable to all such ecosystems. This study suggests REDD+ and other climate change mitigation strategies may need to adopt a significant degree of flexibility and focus more on the human dimensions aspect, especially in areas where cocoa production is interwoven into general forestry practice. See Table A3 for a summary of major findings of the study.

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Appendix A

Table A1. Kruskal Wallis and Mann Whitney test results indicating statistical differences ($p < 0.05$) between farmer groups/responses based on variables: community, age, gender, education, migrant status and household status.

Description of Variable	Groups	Community	Age	Gender	Education	Migrant Status	Household Status
Section 1							
Observed climatic changes							
Temperature	Increased Decreased Same Don't know	<0.001 *** → 0.004 **	0.588	0.009 **	0.464	0.703	0.178
Rainfall		<0.001 ***	0.852	0.034 *	0.425	0.184	0.124
Length of Wet Season		0.007 **	0.897	0.801	0.343	0.089 ·	0.187
Length of Dry Season		<0.001 ***	0.972	0.936	0.935	0.840	0.260
Climatic impacts on cocoa yield	Positive Negative No impact Not sure	<0.001 ***	0.920	0.088 ·	0.677	0.228	0.125
Views on causes of climatic changes							
Cocoa monocultures	Agree Disagree Don't know	<0.001 ***	0.838	0.248	0.354	0.024 *	0.518
Illegal logging		0.015 *	0.056 ·	0.811	0.988	0.764	0.277
Vehicular pollution		0.081 ·	0.885	0.952	0.391	0.141	0.198
Woodfuel usage		<0.001 ***	0.356	0.653	0.658	0.140	0.544
Slash and burn agriculture		0.032 *	0.150	0.837	0.835	0.984	0.798

Table A1. *Cont.*

Description of Variable	Groups	Community	Age	Gender	Education	Migrant Status	Household Status
Climate change beliefs							
Curses (Temperature)	Agree Disagree Don't know	0.009 **	0.568	0.223	0.357	0.545	0.880
Curses (Rainfall)		0.002 ***	0.288	0.009 **	0.806	0.913	0.348
Human activities (Temperature)		0.002 ***	0.899	0.833	0.780	0.479	0.481
Human activities (Rainfall)		0.223	0.486	0.416	0.419	0.637	0.884
Natural occurrence (Temperature)		<0.001 ***	0.657	0.261	0.520	0.566	0.237
Natural occurrence (Rainfall)		<0.001 ***	0.488	0.088 ·	0.510	0.529	0.218
Tree regulation of climate change							
Temperature regulation	Agree Disagree Don't know	0.877	0.091 ·	0.501	0.596	0.210	1.000
Rainfall regulation		0.042 *	0.098 ·	0.289	0.325	0.416	0.216
Concern about climate change	Yes No	0.691	0.364	0.193	0.785	0.859	0.136
Future implications of climate change	Yes No	0.001 ***	0.256	0.130	0.109	0.489	0.987
Section 2 *Tree maintenance for ecosystem services*	Yes No Maybe	0.002 ***	0.580	0.916	0.253	0.106	0.734
Tree maintenance for payment	Yes No Maybe	<0.001 ***	0.190	0.697	0.403	0.030 **	0.563
Rating of tree tenure	Good Bad Neither	<0.001 ***	0.071 ·	0.099 ·	0.013 **	0.044 *	0.103
Section 3 *Rating of external help*	Good Bad Neither	0.029 *	0.468	0.925	0.044 *	0.282	0.262

Significant difference: *** = $p < 0.001$; ** = $p < 0.01$; * = $p < 0.05$; · = $p < 0.1$

Table A2. Demographic characteristics of cocoa farmers in communities surrounding the KHFR ($n = 205$).

Attribute	Category	Percentage of Total Respondents
Gender	Male	67
	Female	33
Age	Less than 18	0
	18–29	3
	30–44	32
	45–59	49
	>60	16
Highest Level of Education	Basic	46
	Secondary	16
	Tertiary	7
	No Formal Education	31
Marital Status	Married	86
	Single	6
	Divorced	4
	Widowed	4
Migrant Status	Native	71
	Non-native	29
Religion	Christian	80
	Muslim	10
	Traditionalist	5
	Other	5

Table A3. Summary of major findings.

Findings	Implications/Recommendations for Climate Change Mitigation
Farmers accurately perceive changes in climate (particularly temperature and drought).	Perceptions guide farmers in choosing farming practices.
Farmers' perceptions on precipitation and length may not always be consistent with empirical weather data.	It is prudent to accurately inform farmers about climate since this may have implications for environmental protection in general.
Population/community demographics play a major role in climate perceptibility and subsequent actions to take regarding cocoa farming.	Mitigation strategies need to zero in on specific community/population attributes to foster effective implementation.
The concept of payment for ecosystem services, which has been adopted by most climate change mitigation strategies, has not been fully explained.	There is a need to adopt strategies that engage farmers in designing climate change mitigation strategies or better still, improve their capacity to understand the concept.
Cocoa farmers share a cordial relationship with extension services and other stakeholders associated with cocoa farming.	This presents a practical opportunity to relay information on climate change mitigation strategies to cocoa farmers.
The current situation of illegal logging on cocoa farms may exacerbate carbon release.	Pertinent measures are needed to curb illegal logging on cocoa farms.
Cultural practices favor removal of overhead shade to facilitate productivity/yield of cocoa.	Strategies need to emphasize practices that favor tree retention on cocoa farms.

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