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RESEARCH ARTICLE

Examining the Implications of Climate Change and Adaptation Technologies on the Livelihood of Cocoa Farmers in Offinso Municipalities, Ghanas

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Abstract
Cocoa is highly sensitive to uncertainties in temperature and precipitation and is projected to be challenged by climate variability. This study examined the implications of climate change on the livelihood of cocoa farmers, and the adaptation technologies adopted to mitigate the impacts in the Offinso Municipalities. 210 cocoa farmers participated in the study, out of which 180 were selected randomly from the list of Kuapa Kokoo company. These people were interviewed with the help of questionnaires. The rest 30 were selected for focus group discussions held in two different communities. The study found deforestation, land degradation, and felling of trees for lumber and domestic fuel as the main causes of climate change. The socio-economic impacts were a reduction in crop yield and income, food insecurity, poor access to healthcare, poor water quality, drying up of streams, and reduction in labour supply. A positive revelation was that the farmers have realized a gradual increase in yield in the past three (3) years due to innovative measures adopted. Such innovations include agroforestry, good agricultural practices, crop diversification, frequent spraying, fertilizer application, adoption of hybrid varieties, and creation of fire belts. As a way of minimizing financial constraints, poor irrigation facilities, inadequate seed supply, and reduction in labour supply; the farmers receive some support from farmer organizations, the government, and cocoa companies. The study recommends that government institutions commit to the enforcement of laws on deforestation and illegal mining, ensure an effective supply of cocoa inputs, and promote adaptation measures in building farmer resilience in the study area.

Keywords: Climate Change; Causes of Climate Change; Socio-Economic Impacts of Climate Change; Adaptation Technologies; Barriers to Adaptation

Introduction

Agriculture accounts for 14 percent of the total GDP in Sub-Saharan Africa, and 70 percent of Africa's population is employed in the sector (Oxford Business Group, 2021). Cocoa was listed as leading Africa's Top-10 agricultural exports by value from 2016-2018 (Bouët, 2021). West Africa currently produces about 70 percent of the world's cocoa, with Ghana being the second world-leading producer after Cote d'Ivoire, followed by Nigeria,

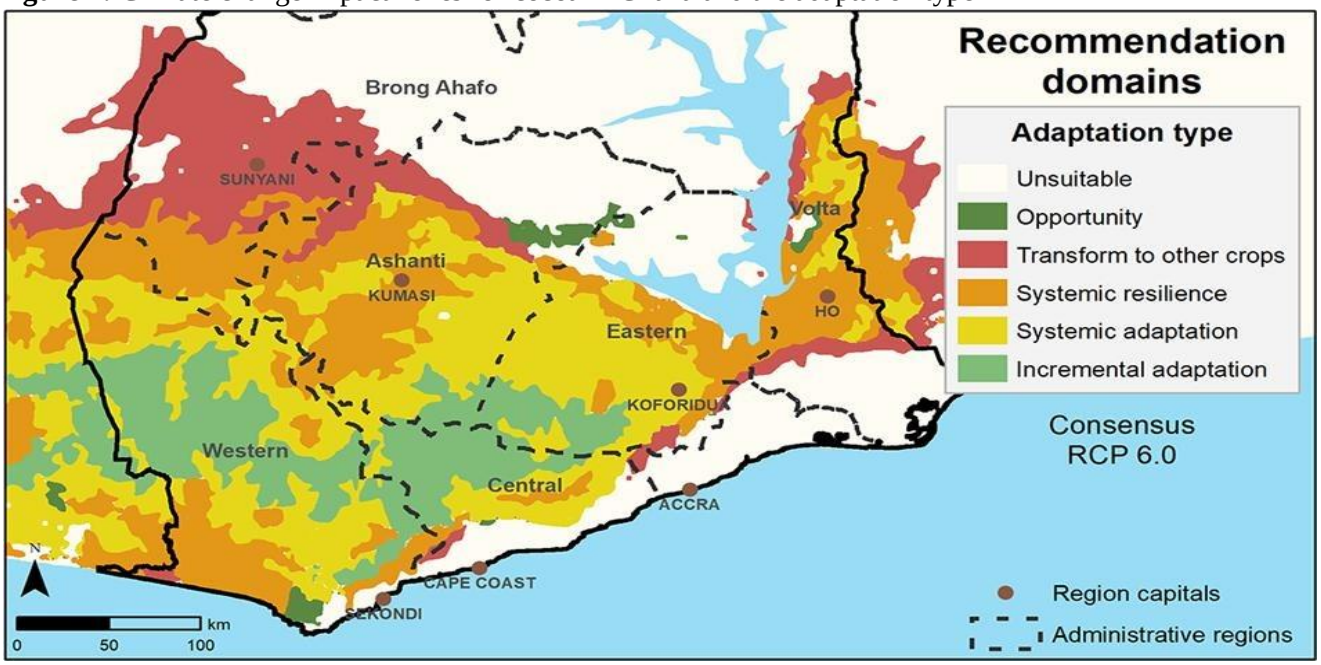
and Cameroon respectively (International Cocoa Organization, 2023). This, therefore, points to the importance of cocoa production in the agricultural sector of West African economies. In Ghana, cocoa is the main export cropwhich accounts for over 80 percent of all foreign exchange earnings from the agricultural sector. The crop also accounts for 70-100 percent of the farmers' household income, and 16 percent of the total GDP (Ghana Statistical Service, 2017).

The invaluable contribution of cocoa to Ghana's economy confirms the saying "Cocoa is Ghana and Ghana is Cocoa" (Gakpo, 2012). It, therefore, means that any development that would impede cocoa production in Ghana would have dire consequences for the economy. Unfortunately, cocoa is highly sensitive to changes in climate, particularly in temperature due to its effects on evapotranspiration (Anim-Kwapong & Frimpong, 2004). The Intergovernmental Panel on Climate Change (IPCC, 2014), defines climate change as any alteration in climate over time, whether due to human activities or natural process. Cocoa requires temperatures between 21–23 ◦C and rainfall between 1000–2500 mm annually in addition to rainforest trees that provide shade and protection from too much sunlight to achieve optimum yield (Schroth et al, 2016).

According to Ehiakpor et al. (2016), over the last two decades, Ghana's weather conditions have been unstable and unpredictable, and may experience a fall in the mean amount of rainfall in most of Ghana's cocoa growing areas by 12 mm, with most of the changes expected to take place after 2030. This change in climatic condition is one of the major challenges that cocoa farmers have experienced in recent years.

In a related study, Bunn et al (2019), developed a climate suitability map indicating climate gradient across the cocoa production zones in Ghana. The gradient showed that Southern Brong Ahafo, Northern Ashanti and the North and South of Volta will become transformational zones (See Figure 1). This finding is worth investigating because the study area is located in the transformational zone where cocoa production is recommended to be transformed to other crops.

Figure 1: Climate change impact zones for cocoa in Ghana and the adaptation type



Source: Bunn et al., (2019).

From the map, it is clear that climate change is a threat to Ghana's cocoa industry and immediate steps must be taken to mitigate its harmful effects. Adaptation technologies are integral aspect of building resilience in the face of climate change (USAID, 2018). However, empirical evidence revealed that only a few of Ghana's cocoa farmers adopt some form of adaptation technologies (Denkyirah et al, 2017). The reasons that account for this low response to adaptation technologies are unknown, and should be a course for concern to stakeholders in the cocoa industry because of the significant role the sector plays in the economy.

Annual cocoa production trajectory about the transformational zone (the study area) for the past decade has been fluctuating but has assumed a steady rise in production from 2018/2019 to 2020/2021 crop seasons. Table 1 shows the pattern of annual yields of cocoa from 2012-2021 crop season.

Table 1: Annual district cocoa production from 2012-2021 crop seasons

Crop season (yearly)	Total production (per 64 kg bag)
2011/2012	165,436
2012/2013	167,735
2013/2014	146,114
2014/2015	151,227
2015/2016	145,682
2016/2017	137,321
2017/2018	85327
2018/2019	104006
2019/2020	114945
2020/2021	162206

Source: Quality Control Company, Offinso Cocoa District (2022).

Questions that emerge from Table 1 are: what accounted for the fluctuations in yield? And what factors are responsible for the recent increase in annual yields? Answers to these questions are worth investigating. This research aims to examine the Ghanaian cocoa farmers' awareness of climate change impact on cocoa production, it's socio-economic implications on livelihood, and their current adaptation strategies in building resilience. Filling this gap would help equip cocoa farmers with the requisite knowledge and skills on climate change, and strategic methods required to improve cocoa yields for better livelihood under such challenging environmental conditions.

Literature Review

Crop yield response theory

The crop yield analysis consists of estimating the effects of altered environments on crop productivity levels. The method incorporates precipitation and temperature into multiple "aridity" indexes. The theory perceives that output is largely through a production function of land, labor and capital. However, the direct application of such a general function to agriculture disregards the existence of weather as an important exogenous factor. As a result, the theory considers rainfall, temperature and sun radiations as well as many other weather factors as non-cost inputs, into the production process (Kenneth, 2011). The basis of the theory is that the function incorporate both cost and non-cost inputs in the production analysis (Ibid). The most important aspect of the use of crop yield studies is that it allows for the incorporation of climatic variables as direct inputs into the production process. According to Amos (2007), the model allows researchers to isolate the impact on crops due to climatic factors from other factors. However, the arguments against this theory are that: firstly, separating the yield distribution from those of weather variables during all stages of crop growth is questionable. Secondly, adaptation measures adopted by farmers to reduce the negative effects of climate change is not accounted for in the theory (Mendelsohn, 2000).

Evidence of climate change impact on cocoa production in Ghana

According to the UNDP Climate Change Country Profile for Ghana in 2006, it is difficult to predict long-term trends for annual rainfall as it is highly variable between years and decades (Mcsweeney et al, 2010). This corroborated a data analysis done by the Ghana Meteorological Agency from 1960 to 2000 which revealed a continuous and perceptible rise in temperature with a concurrent decline in rainfall within all the agro-ecological zones in Ghana (Adjei-Nsiah & Kemah, 2012). From the above, there is no doubt that climate change is real and a threat to the future of Ghana's agricultural sector.

Brriers to adaptation technologies in cocoa production

Adaptation to climate change refers to the adjustment to actual or expected climate and its effects, which seeks to moderate or avoid harm and exploit beneficial opportunities (IPCC, 2014). Adaptation technologies are introduced to preclude any imminent effect likely to occur as a result of climate change. The success of adaptation technologies depends on the extent to which people believe that there have been some changes in the climate, their awareness of the type change, and the present and future technology (Kurukulasuriya & Rosenthal, 2003). Some of the adaptation technologies in cocoa production include: agroforestry, farm rehabilitation, diversification of crop and income, Good Agricultural Practices (GAP), irrigation, variety of planting materials/mixed cropping and improved variety (Kolavalli & Vigneri, 2011).

According to Deressa, Hassan and Ringler (2011), barriers facing adaptation to climate change include but not limited to; lack of weather information, labour shortage, lack of access to improved seedlings, inadequate financial resources, information gap, small landholding size, and poor irrigation facilities. In addition, some farmers may lack the capacity to use any adaptation strategies because of factors such as education, gender, non-farm income, farm size, free extension advice, and experience in farming (Deressa, et al, 2008). It is therefore relevant to identify and understand these barriers to adaptation strategies in order to put appropriate measures in place to address them.

Cocoa farmers' perception of the impacts of climate change on production

According to Adger (2006), perception forms a composite part of how farmers behave and respond to their environment. Therefore, analysis of farmers' perception of climate change is a prerequisite for assessing adaptation and the basis upon which knowledge is derived (Sraku-Lartey et al, 2018).

Ehiakpor et al. (2016), assessed the impact of climate change on cocoa production and approaches to adaptation and mitigation in Ghana and Costa Rica. The main goal was to understand the phenomena of climate change and its social, economic and environmental impacts on cocoa production as well as farmers' perception about the phenomenon. In the case of Ghana, the study concluded that weather changes were negatively affecting cocoa production and has actually decreased cocoa yields. They also mentioned premature flowering, plants and seedlings death as some of the negative effects. The study further indicated that it was hard for the farmers to know when to spray against pests and diseases unlike previously.

Osei (2017), in his study also analyzed the effects of micro-adaptation measures to temperature and rainfall variability on cocoa farmers' net farm income in Dormaa West District within Bono region of Ghana. The study observed that the farmers have perceived an increase in temperature and a decrease in rainfall in the districts. The study further concluded that, due to the increase in temperature and sunshine, new cocoa trees have come under stress and eventually dying off which is affecting production. Additionally, the condition also sometimes causes delay in maturity of the cocoa trees as well as introduction of unfamiliar pest and diseases that were not found in the area previously.

Sraku-Lartey et al. (2018), also conducted a study in the offinso municipality in Ghana and indicated that most farmers did not know what the concept of climate change was. Nevertheless, all of them were able to mention the prolonged drought and significant reduction in the amount of rainfall being experienced in the last 15 years. According to this study, farmers are unable to harvest the quantity of crops they used to harvest in the past. Despite these findings from the study area, a new trend from 2019 shows an increase in cocoa yield. Hence, this study is poised to investigate this new trend.

Socio-economic implication of climate change on farmers' livelihood

A study by Kimengsi and Tosam (2013), investigated climate variability and cocoa production in Meme Division of Cameroon. They observed an increase in cocoa pest and diseases attributed to climate change. Due to this change, farmers are unable to target when to apply chemical spraying, leading to higher crop maintenance cost. This in effect, has affected the farmers' net income from cocoa production at the end of every cocoa season.

Duru and Oladipo (2022), in their study also examined the effects of climate change on the livelihood of rural women in Ilorin South , Nigeria. The study indicated that climate change has affected the livelihood of the rural women in the areas of decreased farm income, inaccessibility to loan, increase in diseases and damage to properties.

A study by Sraku-Lartey et al. (2018) concluded that climate change had affected farmers crop yields in the Offinso districts of Ghana thereby having a significant impact on their food security. Those with large family sizes were particularly most affected. Also, Odame et al, (2018) in their study on the impact of climate variability in the same area mentioned that farmers reported loss of crops, food insecurity, poor access to healthcare, and housing hazards as adverse consequences of climate change on their households.

Adaptation technologies adopted by farmers to mitigate climate change

According to Adger et al. (2007), adaptation has the potential to alleviate adverse impacts, as well as influence new opportunities posed by climate change. According to Ehiakpor et al. (2016), some cocoa farmers in Ghana have adopted both on-farm and off-farm adaptation measures such as farm rehabilitation, agroforestry, good agricultural practices, and income diversification to mitigate the impacts of climate variability on cocoa production. They mentioned lack of capital as the main hindrance to the farmers from incorporating adaptation techniques. That notwithstanding few of the farmers believed that climate change is the work of God and nothing can be done to reverse its impact.

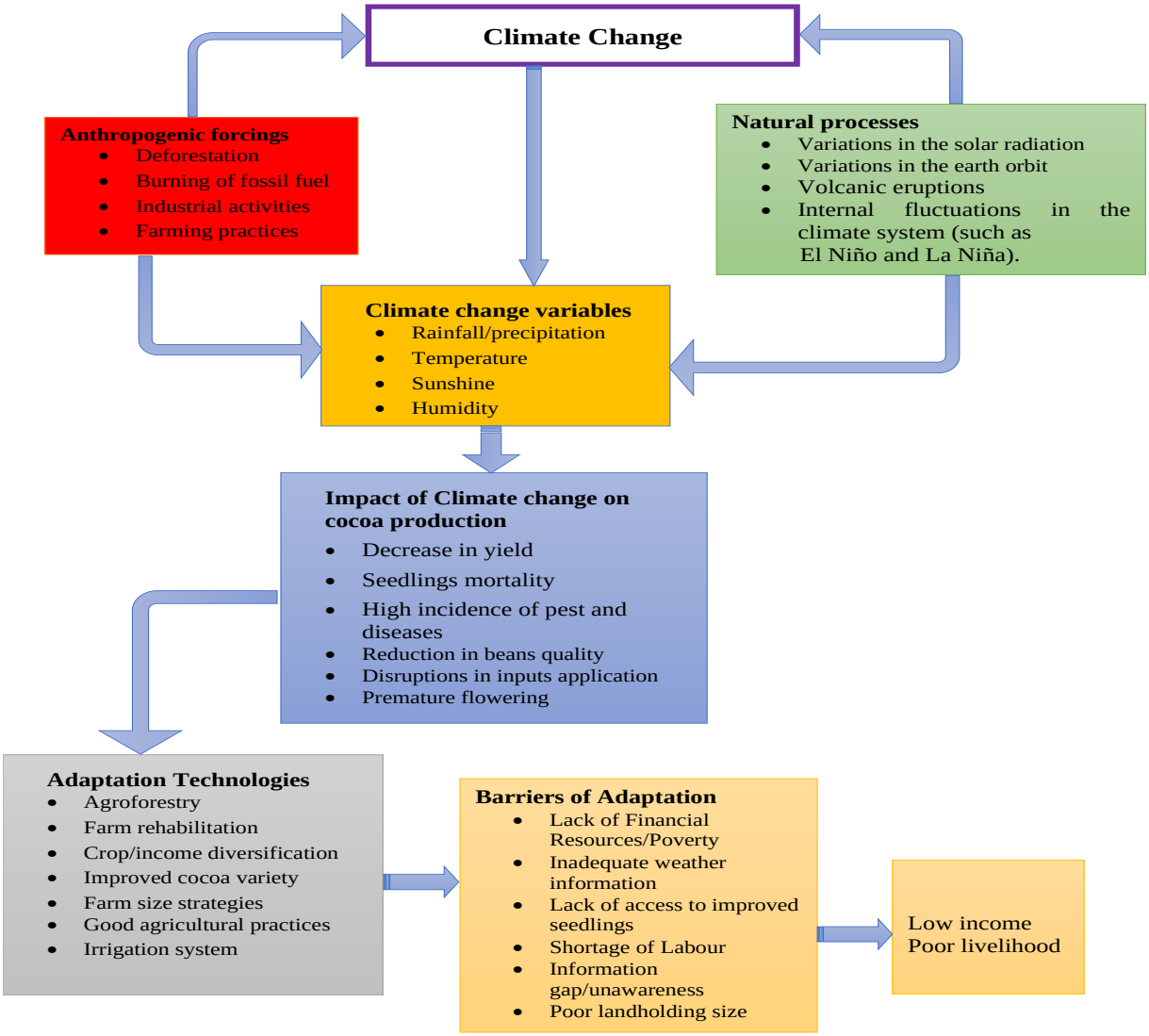
Osei (2017) in his study concluded that Ghanaian farmers have adopted diverse micro-adaptation measures. Adaptation measures adopted included improved variety, mixed cropping, agroforestry, inputs application, use of compost and manure, and crop diversification. Furthermore, Emmanuel (2016) also revealed that Ghanaian small-scale cocoa farmers were practicing on-farm adaptation strategies such as shade management, soil fertility management, land preparation strategies, lining and pegging strategies. The study further revealed inadequate financial resources as the most pressing barrier, and limited farm land as the least.

Oyekale (2021), conducted a study into the climate change adaptation and cocoa farm rehabilitation behaviour among cocoa farmers in Ahafo-Ano North District, Ghana. The study indicates that farmers have adopted some adaptation measures such as crop diversification, planting hybrid seeds, regular cocoa spraying, and changing planting periods. Oyekale (2021) also found that farm rehabilitation was low especially among farmers on sharecropping arrangement due to improper land tenure system.

Conceptual framework developed for this study

Climate change is mainly triggered through natural internal processes and anthropogenic activities. Figure 2 shows a conceptual framework on climate change developed for this study to highlight the climatic variables affecting cocoa production.

Figure: 2.1: Conceptual framework

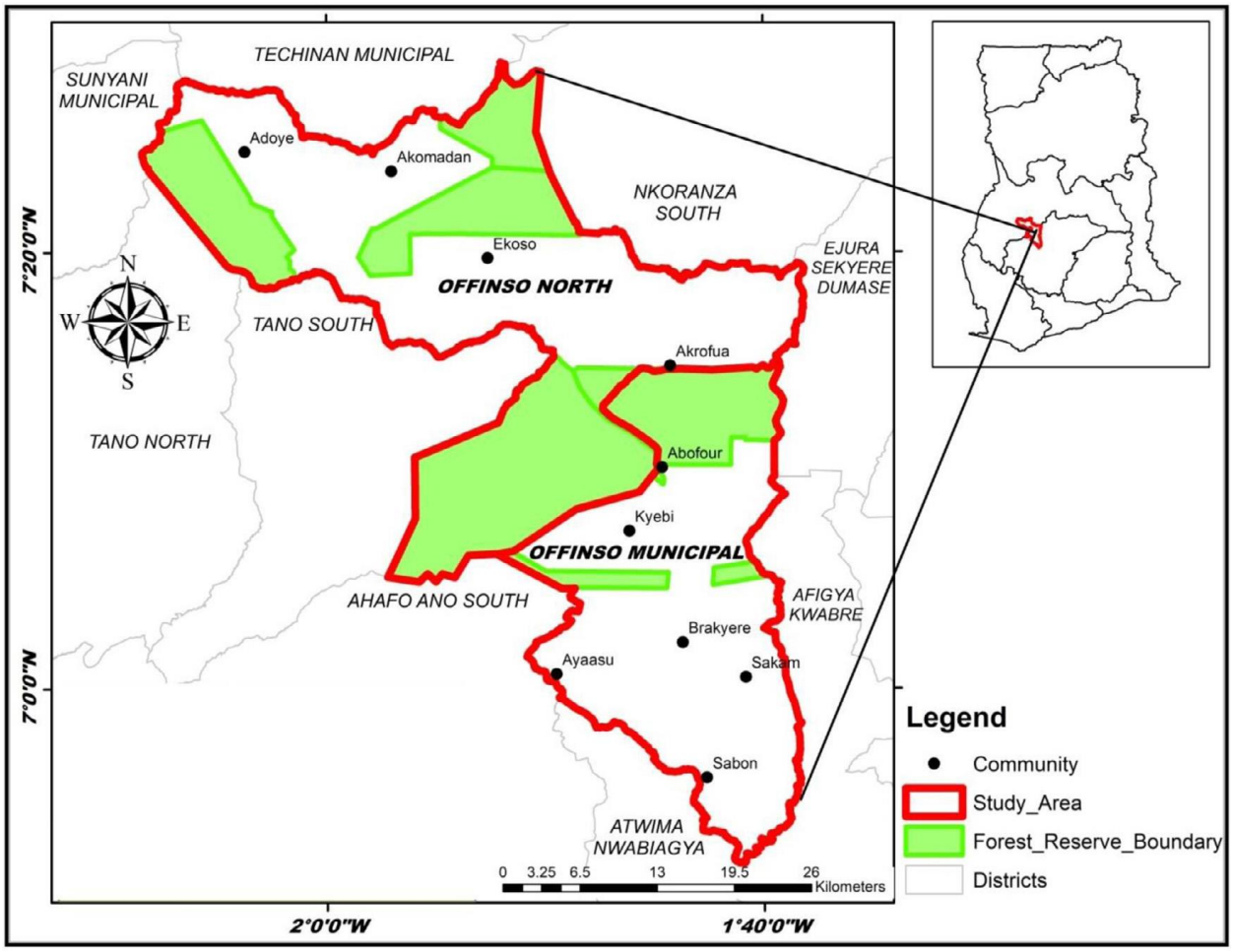


Source: Authors' own development based on (Emmanuel, 2016 & Ehiakpor et al., 2016).

Methodology

The study area

The study area: Offinso North District and Offinso Municipality are in the Ashanti Region of Ghana. For the purposes of this study, the two districts are referred to as Offinso Municipalities. These two districts fall within one cocoa district and therefore was combined to ensure easy data analysis. Offinso North district has a total land area of about 945.9 square kilometers with a population of 83,440. While Offinso Municipality on the other hand has a total land area of 585.7 square kilometres and a population of 137,272. Agriculture is the major economic activity for both districts with key crops being cocoa, tomatoes and other food crop (Ghana Statistical Service, 2021). Figure 3 represents the map of the study area.



Source: Adopted from Anyimah, Osei, & Nyamekye (2021).

Figure 3: Map of Offinso North District and Offinso Municipality

Research procedures

Mixed method was employed for this study to provide flexibility, objectivity, uniformity, in-depth understanding, and the ability to generalize research findings (Dawadi et al, 2021). The qualitative approach helped to gather the best information that actually describes farmers' perception and their adaptation technologies to climate change as well as how it has impacted on their livelihood. Similarly, integrating numeric approach to quantify data collected increases objectivity, and strengthens the overall study outcome (Creswell, 2016). Both open-ended and close-ended structured questionnaire, and interview guide were employed to gather primary data from cocoa farmers to supplement the existing relevant secondary data. Clearly, this is a survey that involved acquiring information about a group of people; their characteristics, opinions, attitudes, previous experiences, and beliefs. Therefore, the selected instruments were appropriate to achieve the study objectives.

To ensure replicability of this study, the researchers used cocoa farmers who registered with Kuapa Kokoo co-operative union within the two districts as the target population. This was because: first, information about members of this union can easily be accessed; second, this union is widely represented in the cocoa communities within the study area; third, farmers' information list from the union is suitable for the systematic random sampling technique adopted for the study. There are 2,026 cocoa farmers registered with Kuapa Kokoo company

across 30 rural communities in the two districts. The study used a sample size of 210 cocoa farmers, out of this, 180 farmers were systematically sampled for face-to-face interviews with the help of questionnaires. In addition, the researchers engaged the other 30 farmers; 15 from each of the two districts for Focus Group Discussion (FGD) aided by an interview guide. The selection of farmers to participate in the FGD depended on respondents' convenience; thus, availability, location, and interest.

Respondents were reached on Sundays since preliminary survey revealed their availability on this day. For better understanding, and to illicit appropriate responses, the study resorted to the use of the local language "Twi" which fortunately, the researchers are conversant with to interpret the questions to the respondents. Except for the FGD, each respondent was interviewed separately to avoid any influence. The FGD was employed to complement the interview method because it helps to bring in-depth understanding, and diverse views of farmers' reactions on climate change rather than a superficial presentation of the phenomenon (Nyumba et. al, 2018).

For selection of discussants, two separate visits were made to the Kuapa Kokoo farmers' union at their monthly meetings at Afrancho and Akomadan. The first visit was to inform and explain to the groups the researchers' intention to collect data, the purpose and benefits, and scheduled date and time for the inquiry. 15 cocoa farmers from each group who indicated their available and willingness for the discussion were selected with agreed dates and time. The selected sample size for the discussion is appropriate and consistent with recommendations by Steward and Shamdasani (2008). The second visit was the actual date for the discussion. The interview guide helped the moderators to stay focus on the main themes for the discussion. The moderators recorded the responses with the aid of notepads and voice recorders which were later transcribed and analysed.

The findings of the study were analysed both quantitatively and qualitatively. The quantitative analysis employed descriptive statistical methods such as frequencies, percentages and tables. In addition, a Chi-Square test was used to analyse how the socio-demographic characteristics of the farmers related to their understanding of climate change adaptation. Content analysis was applied to delve into the fine details of the open-ended questions and the focus group transcripts. Finally, the data was classified in line with the study objectives, patterns identified, and interpretations given.

Results and discussion

Socio-demographic characteristics of respondents

The Socio-Demographic characteristics of respondents were captured in Table 2.

From table 2, majority of the respondents (67.8%) were males with 32.2% being females. This is actually consistent with the opinion held by Onumah et al. (2014) who attributed male dominance in cocoa farming in Ghana to the traditional land systems which generally favour males' land ownership.

The age distribution showed that majority (49.4%) of respondents were 50 years and above. This confirms the aging population of cocoa farmers in Ghana which is a major concern for the future of cocoa industry. According to Vigneri (2007), this situation is due to the continuous migration of the youth from the cocoa growing areas to urban centres in search of greener pastures. However, there seems to be a gradual shift from this trend as the age distribution showed a 23.9% of the respondents within the youthful age bracket (30-39) giving hope for the sustainability of the cocoa sector. Arguably, this upsurge may be attributed to the intervention in the sector by recent governments to enhance productivity and farmers' income thereby attracting the youth into cocoa farming. These investments include free cocoa seedlings and subsidized fertilizer distribution, and pollination and rehabilitation support through government and cocoa cooperative companies.

Table 2. Socio-demographic characteristics of the respondents

VARIABLE		FREQUENCY (F)	PERCENTAGE
Sex of Respondents	Female	58	32.2
	Male	122	67.8
Age of Respondents	30 – 39	43	23.9
	40 – 49	48	26.7
	50 – 59	60	33.3
	60 years and above	29	16.1
Educational Level	Middle Sch./JHS	86	47.8
	Non-Formal	33	18.3
	Primary	28	15.6
	SHS	24	13.3
	Tertiary	9	5
Number of Dependents	1 – 5	22	12.2
	6 – 10	67	37.2
	11 – 15	91	50.6

Source: Field data, 2022

With regards to education, less than 19% of the farmers received senior high school education or higher. According to Deressa et al (2008), the levels of education of cocoa farmers influence their ability to understand and assimilate information on adaptation technologies and their readiness to adopt. To confirm this view or otherwise, the researchers examined whether the levels of education of the respondents have any effect on their understanding of adaptation technologies (See Table 3) for details.

Socio-economic status is also influenced by individuals' household size. It emerged from the study that more than half (50.6%) of the total respondents had as high as 11-15 household size. This definitely would have dire consequences on the livelihood of the cocoa farmers in case of any drop in income.

Analysis of farm characteristics of the respondents

i) Farming Experience

The study shows that majority (64.4%) of respondents had at least 11 years of farming experience, followed by 19.5% who had 1-10 years farming experience. According to Deressa et al. (2008), such farming experiences are very relevant because they influence the ability of farmers to adapt to climate change.

ii) Farm Ownership

The study revealed that more than half (50.2%) of the respondents owned their cocoa farms, whiles 33.3% were shareholders with tenancy agreement of 1:1 or 1:2 output ratio between the tenant and the landowner. Only 9.4% of the respondents occupied farms that have been leased.

iii) Age of Cocoa Farm

The study result shows that majority (63.3%) of the cocoa farms are below 31 years old. This is followed by 12.8% falling between 31-40 years, and at least 3.3% above 41 years. It was not surprising that about 20.7% of the farms were aged between 1-10 years. This was because respondents indicated that they are gradually undertaking farm rehabilitation to replace the old cocoa trees due to low productivity. This trend is laudable because such effort will reduce deforestation and facilitate the speedy restoration of some degraded farmlands (Gockowski & Sonwa, 2011).

iv) Variety of Cocoa Plants Cultivated

This study further revealed that majority (67.2%) of respondents cultivated hybrid cocoa varieties. These breeds have higher yield potential and environmental resistance to drought, flood, and salinity. According to Kolavalli and Vigneri (2011), the hybrid type is sunshine tolerant, matures early and give higher yields compared to the Amazon and Amelonado types previously cultivated. This notwithstanding, 28.3% of the respondents still have the amelonado variety, while 4.4% had grown the hybrid alongside the traditional amelonado type.

Exploring farmers knowledge and understanding of climate change

Analysis of farmer's perception and understanding of climate change is a prerequisite for assessing adaptation (Singh, 2020). Based on this, the researchers assessed farmers' knowledge and understanding of climate change and how that influences their behaviour.

From this study, 63% of the respondents were knowledgeable and understood the concept of climate change. Respondents mentioned deforestation, land degradation among others as the main causes of variations in climatic conditions. Also, 35% of the respondents knew a bit about climate change and were able to describe changes they had experienced over the year mainly on temperature and rainfall. Only 2% of the respondents did not know exactly what climate change meant. They however alluded to the fact that farmers experience high temperature and decreased rainfall in recent years.

The above finding is contrary to the claim by Sraku-Lartey et al (2018). In their study in the Offinso Municipality, a part of to this study area, they concluded that most of the farmers did not know about the concept of climate change but could only describe the changes they had experienced in the climate over the last 15-30 years. This new finding could be attributed to the vigorous awareness creation about climate change through different media within the Offinso Municipalities the the past three (3) years.

Farmers' sources of information and observed variations in climate

According to Deressa et al. *(*2008), the ability of farmers to adapt to climate change can be influenced by the availability of climatic information. It is evident from this study that respondents received information on climate through radio (31.4%), television (21.4%), Agriculture extension officers (17.4%), fellow farmers (16.6%), friends (8.5%), and other sources (4.7%). They indicate that this knowledge helped their understanding of climate change in the last 10-15 years. Farmers experienced increase in temperature, decrease in rainfall, unpredictable rainfall pattern, and prolong dry season within the same period. This finding corroborates the results of Osei (2017) who found that farmers in the Dormaa West District in Ghana have experienced an increase in temperature and a decrease in rainfall in recent past.

Farmers' perception about the causes of climate variations

The perception of the farmers was sought on the causes of climate variability in the study area. Majority (62.3%) of the respondents ascribed the variation to cutting down of trees for lumber which they claimed has become widely spread in the Municipalities. Furthermore, whilst 20.1% of respondents mentioned the prevalent of land degradation through illegal mining, and harsh weather conditions as the major contributing factors to climate variation, 11.3% attributed the change to burning of firewood for domestic fuel due to the high cost of Liquified Petroleum Gas (LPG). Interestingly, a total of 6.3% of the respondents attributed the changes in temperature and rainfall patterns to God's plans and punishment for sins committed by humankind.

Results from Focus Group Discussion

To supplement the findings from interviews, FGD were conducted to solicit a collective view, and also as a follow-up to the interview results. The two groups made up of 15 discussants each from Afrancho and Akomadan were formed. The ages of the discussants ranged from 25 -64 years. An average of 65 minutes was spent on each group discussion. The results from the discussions did not vary much from the interview results except that: discussants mentioned 2017 and the early months of 2018 as their worst years in the past decade because, they experienced a prolong drought which actually reduced cocoa production, and agriculture in general. This claim by the farmers is consistent with cocoa production performance record for the districts over the last 10 years (See Table 1).

Again, deforestation and land degradation through illegal mining were mentioned as the causes of climate variability in the area. According to the farmers, the perpetrators sneak to their cocoa farms, fell the trees without their knowledge and runway with them. This exposes their cocoa farms to the harsh weather conditions, and destroys some of the cocoa trees in the process of felling and evacuation. Unfortunately, most of these illegal activities go unpunished since law enforcement is weak, and no compensations are received by the farmers. They also complained about how some of the cocoa farms have been converted to mining sites, and how the leaching of the chemicals used for washing the minerals eventually affects the trees, degrade the land, and pollute rivers the farmers depend on for spraying. A discussant noted:

"*Now, we have to carry water from the house or fetch water from long distances when spraying our cocoa farms because the nearby rivers have been polluted*",

This makes some of the farmers become skeptical about the future state of their cocoa farms since there seems to be no success from government regulatory measures to control these illegal mining and felling of trees.

The implications of climate change on cocoa yield and quality in the Offinso Municipalities

Studies from Emmanuel (2016) indicates that climate variability negatively affects cocoa yields. The results from Figure 4 confirms this finding.

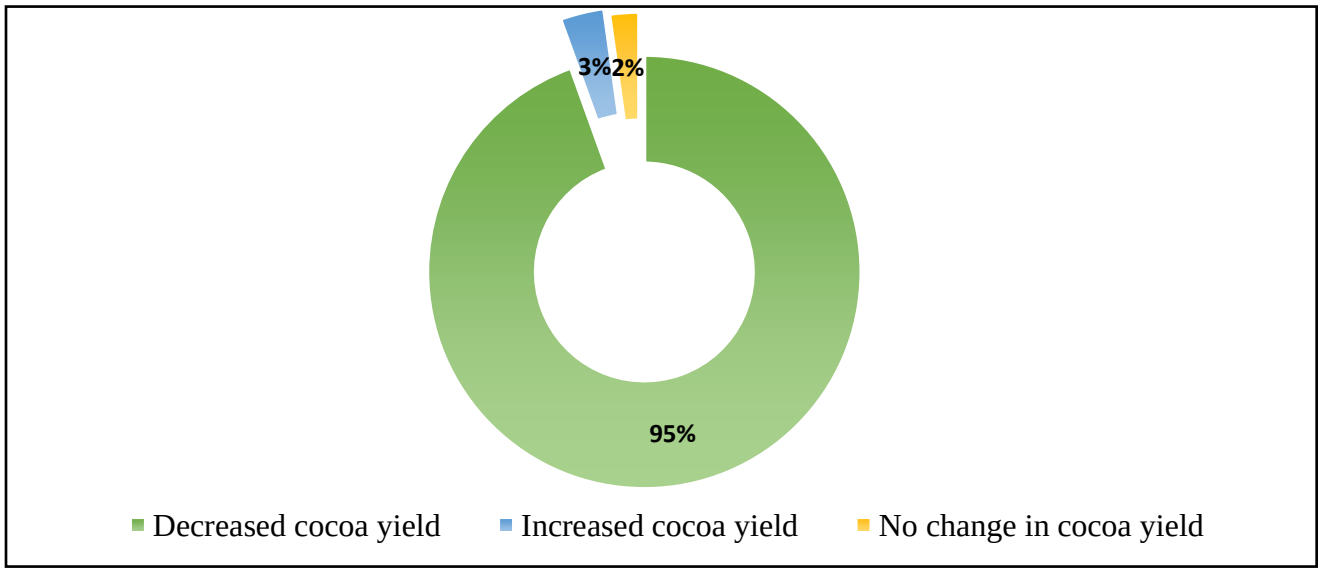


Figure 4. Impact of climate variability on cocoa yield

From figure 4, majority (95%) of the respondents indicated that climate change has negatively affected their cocoa yields over the past 10 years. But they acknowledged that they have observed a gradual increase in the last three (3) years which indicate a new production trend from the past seasons. They ascribe this change to the innovative adaptation technologies adopted over the years to improve yield.

Another impact of climate change on yields was the dying of cocoa trees, which about 20.3% of respondents expressed concerns. This finding is consistent with previous study by Osei (2017) who concluded that the rise in temperature and sunshine, had impacted negatively on new cocoa trees and subsequently reducing cocoa yields. A total of 31.3% of respondents experienced influx of unfamiliar pest and diseases, and a delay in the maturity of cocoa trees due to climate change. Again, this corroborated the finding of Osei (2017) who indicated that climate variability can cause delay in the maturity of cocoa trees.

Furthermore, 8.4% of the respondents revealed that appropriate drying of cocoa beans under good weather conditions allows acids in the cocoa to evaporate, but this has been negatively affected by climate variability. The situation increases the bitterness, astringency, and acidity of the cocoa beans, and consequently, lowers its quality and price. This finding aligns with the works of Oyekale et al. (2009) who concluded that, although higher rainfall is required for higher cocoa yield, a protracted wet season as a results of climate variability during post-harvest, adversely affects cocoa drying and processing.

Impacts of climate change on the socio-economic conditions and livelihood of cocoa farmers in Offinso Municipalities

The livelihood of cocoa farmers in Ghana heavily depends on the income they earn from the sale of cocoa (Anim-Kwapong & Frimpong, 2004). It is therefore important to tackle any condition or activity that impacts negatively on cocoa production so as to minimize its harmful effect on farmers' livelihood. In view of this, this study

examined the extent to which climate change has impacted on the socio-economic lives of cocoa farmers. The result is summarized in Figure 5:

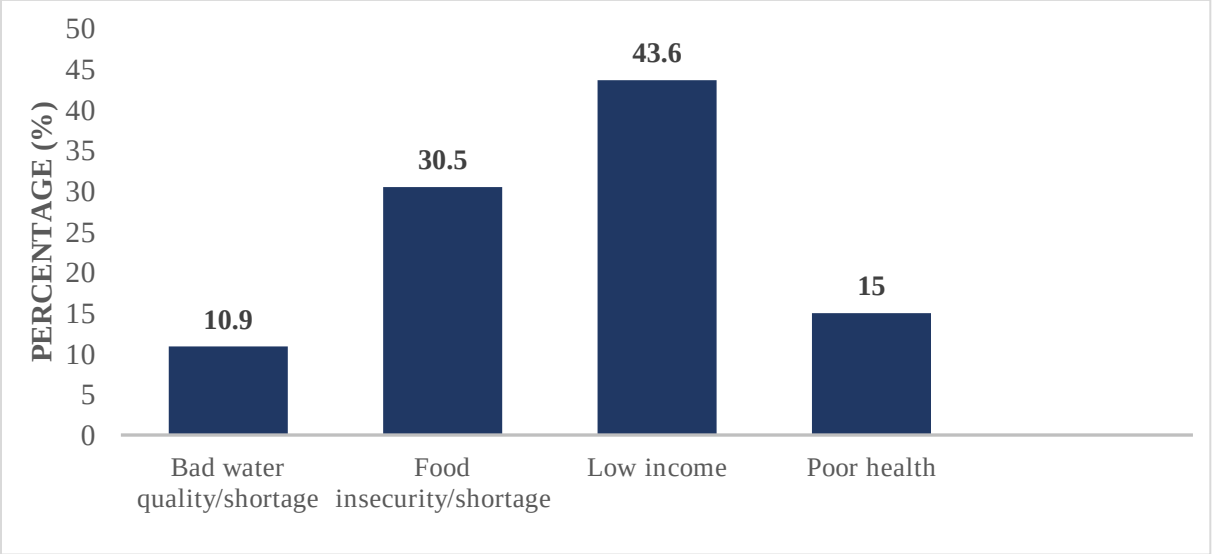


Figure 5. Impacts of climate change on the socio-economic conditions and livelihood of cocoa farmers in Offinso municipalities

Figure 5. shows that climate change and its associated human activities have lowered the income of cocoa farmers. It has also led to food insecurity; water shortage; poor water quality, and poor health. The farmers indicated that, since their household income have reduced, they are unable to seek proper health care from medical centers and therefore resort to self-medication with its negative consequences.

As expected, discussants from the focus group re-echoed the aforementioned impacts climate change have had on their cocoa production. According to these farmers, what is so disturbing is the high cocoa seedling mortality. They added that the unfavourable weather conditions have rather created favourable conditions for pest and diseases to thrive. Farmers' attempt to salvage the situation through chemical spraying is hampered by the unpredictable weather. This has led to indiscriminate chemical spraying and its cost implications. Worse, the pests and diseases have also become resistant to these chemicals, rendering them ineffective.

Interestingly, the discussions revealed an adverse impact of climate change on labour supply. A group member had this to say:

"*Now we are unable to work in the afternoons due to the unbearably high temperature. We now spend more days in the farms or hire additional labour to accomplish a task we could previously do by ourselves within a short period".*

On the issue of climate change impact on yields, the farmers reiterated that, it is the main challenge they have been battling with because their yields have been fluctuating leaving no room for adequate planning. Regrettably, the low yield translates into low income. They also complained that the water bodies they depend on for watering their crops, and for spraying have dried up due to the limited rainfall and high temperature which further exacerbated their already precarious situation. This revelation is consistent with the findings of Kimengsi and Tosam (2013), who mentioned that farmers were confused about when to apply chemical spraying, and therefore resulted to frequent spraying which consequently increased production costs. In this regard, the study explored in detail how cocoa farmers are adapting to the threats of climate change.

Adaptation technologies adopted by farmers against climate change in Offinso Municipalities

Crops growth and development is affected by climate change and for that matter presents a great concern to farmers (Challinor & Wheeler, 2007). It is for this reason that the concept of adaptation has become important in the area of agriculture. The overall objective of adaptation is to safeguard farm production from climate change threats through production systems modification. This research again examined farmers' understanding of climate change adaptation, the kinds of adaptation technologies being employed, and the impact of such technologies on cocoa yields over time.

As a starting point, farmers understanding of climate change adaptation was assessed. The researchers found that, majority (63.3%) of the respondents were very knowledgeable in climate change adaptation. Additionally, 22.8% were a bit knowledgeable about climate change adaptation, whiles the remaining were not.

Although the majority of the respondents were knowledgeable about climate change adaptation, the researchers sought to find out if the level of education of the respondents had some significant association with their understanding of climate change adaptation. From Table 3, it was found that (at degrees of freedom = 8) there was no significant association between the level of education of respondents and their understanding of climate change adaptation since P-value (0.724) was greater than the significance level (P>0.05).

Table 3. Chi-square test showing respondents' level of education and their understanding of climate change adaptation

Level Of Education	Cannot tell	Know a bit	Very knowledgeable	Total
JHS	10	20	56	86
Non-Formal	7	5	21	33
Primary	4	9	15	28
SHS	2	5	17	24
Tertiary	2	2	5	9
Total	25	41	114	180
	Pearson Chi^2 (8)	5.3118		
	P-value			
		0.724		
	Alpha value	0.05		

Source: Field data, 2022

Adaptation technologies adopted by farmers in the last 10 years in the Offinso Municipalities

Adoption of adaptation technologies is an integral aspect of building resilience in the face of climate change (USAID, 2018). A previous study by Denkyirah et al. (2017) revealed that only few farmers have adopted some form of adaptation technologies despite the benefits that come with such measures. However, the findings from this study have shown otherwise. It was realized that all (100%) the respondents have implemented at least one adaptation measure to support their cocoa farms against the impacts of climate change. This could be attributed to the fact that majority of the respondents have observed the impacts of climate change on cocoa production, are knowledgeable about the concept of climate change adaptation, and have realized the need to mitigate and adapt to it. Even for those who perceived climate change as a punishment from God, they had implemented at least one adaptation measure. The adaptation measures commonly adopted are shown in Figure 6.

Figure 6. Adaptation technologies adopted by farmers in the last 10 years in the Offinso Municipalities
Source: Field data, 2022

It was realized that majority (88.9%) of the respondents had adopted agroforestry as the main adaptation measure in building resilience against the impacts of climate change in their cocoa farms. This finding actually buttresses the earlier claim by the respondents that the main cause of climate change is the indiscriminate felling of trees. Replacing the lost trees with agroforestry systems present a distinctive opportunity to enhance carbon stocks in the terrestrial biosphere (Albrecht & Kandji, 2003). Aside from this, shade trees in cocoa farms also provide alternative sources of income that give economic relief to farmers through farm diversification with timber and non-timber products (Schroth & Ruf, 2014).

The study also realized that 81.7% of the repsondents actually adopt good agricutural practices such as weeding, pruning, and mulching against climate change. This finding supports Ehiakpor et al (2016) which mentioned that there are various Climate-Smart Agricultural (CSA) techniques like integrated nutrient management, that contribute to effective soil management practices including mulching, organic and inorganic inputs, intercropping, and irrigation. Respondents (66.7%) further adopted income and crop diversification such as petty and skilled trade, planting of drought resistant crops that can withstand temperature stresses and take maximum advantage of prevailing rainfall.

Chemical application is considered to provide maximum protection to cocoa farms due to the unpredictable rainfall pattern (Oyekale, 2015). From Figure 6, 48.9% of respondents adopted frequent spraying of cocoa farms to reduce the impacts of climate change and pest and disease infestation. The study further shows that 48.4% of participants increased fertilizer application as an adaptation measure, which aligned with recommendations by Asare and David (2009). Furthermore, 38.3% of the respondents adopted the use of improved (hybrid) cocoa varieties that are sunshine tolerant, resistance to multiple stresses, mature early, and give higher yields as compared to the traditional Amazon variety.

According to Asare and David (2009), one surest way of safeguarding the cocoa farm especially young cocoa from high temperature is by providing shade cover through the practice of mixed cropping. In this study, 30.6% of respondents engage in mixed cropping to reduce cocoa seedling vulnerability to climate change. Crops such as plantain, cassava and maize are planted since they have short maturity period and serve as food for consumption all year round. According to Asante et al. (2017), planting of plantain suckers serve multiple purposes of protective cover for young cocoa plants against extreme sunshine, as food for the family, and a source of household income from the sales of the crop.

The farmers (15%) also engaged in either cultivation of new cocoa farms or expansion of the existing ones for income security against any fall in expected yields. This practice of expanding cocoa farms has been criticized in recent past to be a contributor to deforestation as farmers continue to clear new lands and cut down trees (Anim-Kwapong & Frimpong, 2004). There should be a policy in place to rehabilitate and restore cocoa farms for sustainable production (Ibid).

Some respondents (14.4%) created fire belts around their cocoa farms as a way of protecting the crop against bushfires, while others (5%) migrated to their new farm sites as an adaptation measure against climate change.

Interestingly, as part of belief systems, some of the farmers (13%) believed that climate change is the work of God and for that matter nothing can be done to reverse it, therefore, fighting it means fighting God. One respondent commented: *"I seek help from God through prayers to change the situation because the battle is the Lord's".*

It is important to mention that majority of the respondent (73%) confirmed that they have experienced a steady rise in cocoa yields in the last three (3) cocoa seasons. The farmers generally attributed this gradual increase to the aforementioned adaptation practices. Cocoa is a perennial crop unlike other crops and therefore requires constant maintenance to improve yields.

Adaptation measures revealed in the focus group discussion

As is expected, discussants did not reveal any technique different from those of the interviewees. They however revealed that, as a result of the gradual increase in cocoa yields in the last three (3) years, their household income has begun to improve as compared to previous years.

Barriers to climate change adaptation

Adaptation to adjust to the impacts of climate change is not without limitations. From this study, farmers indicated various challenges they face in the implementation of adaptation technologies. The findings are summarized in Figure 7.

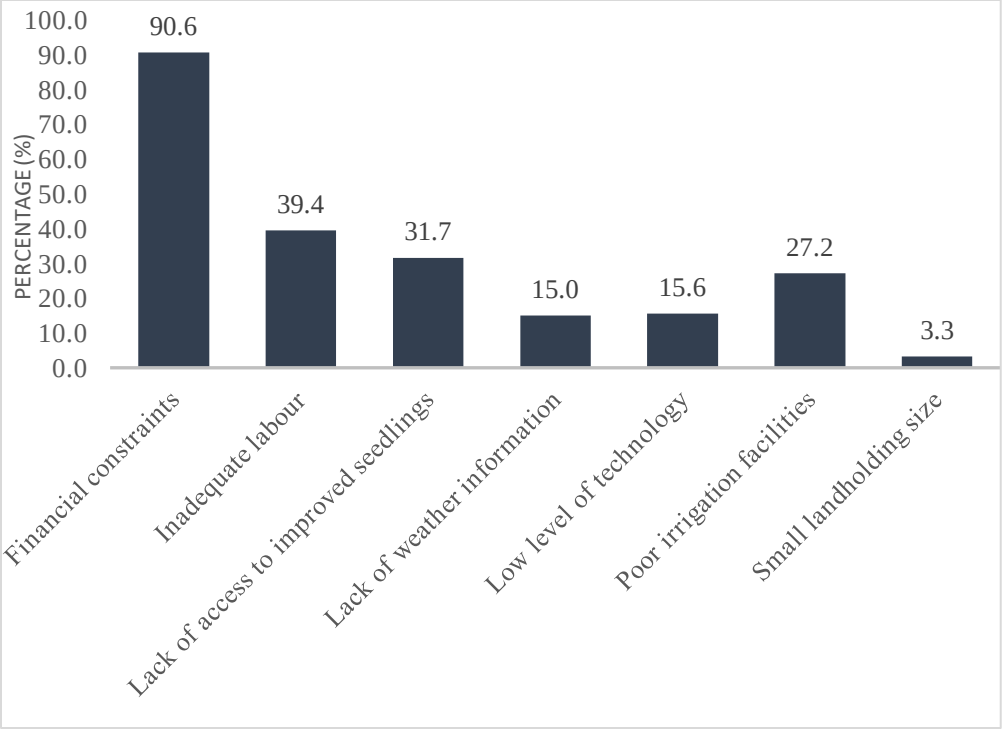


Figure 7. Barriers to the adoption of adaptation technologies by cocoa farmers in the Offinso Municipalities

The outcome of the FGD also provided additional information on the challenges the farmers face in their efforts to implement adaptation technologies. The farmers added that due to their old age coupled with the high temperature which has affected their working hours, they resort to hire additional labour. *"But unfortunately, labour is currently expensive due to the competition from other sectors such as the mining sector, and the migration of the youth to the cities.* One discussant retorted. Other limitations mentioned include high cost of irrigation systems, delay in input supply, and frequent breakdown of government's cocoa spraying machines.

Another challenge the farmers raised was that although they are planting shade trees in their cocoa farms as part of their climate change mitigation measures, and also serving as additional source of income, they don't clearly understand the tree tenure policy of the country. Moreover, they are not aware of any procedure to follow to ensure that the trees planted are properly registered. They believe that because these measures are not in place, they fear that in future, they may not be able to claim ownership of these trees. Lack of these measures also encourage indiscriminate felling of cover trees by unscrupulous individuals.

Although respondents mentioned that they have received some support from cocoa farmers' cooperatives, government agencies including Ghana Cocoa Board, and Forestry Commission, these support base if strengthened can go a long way to ease the adaptation constraints faced by cocoa famers.

Conclusions

Climate change is a major concern to farmers, especially cocoa farmers in Ghana. This study assessed the impacts of climate change and its implications on the socio-economic lives of cocoa farmers in the Offinso Municipalities. Firstly, the study analysed farmers' understanding of climate change and its impacts on cocoa production. The results show that most of the farmers have knowledge and understanding of the concept of climate change and were also aware of climate variabilities in the study area. Majority of the respondents observed high temperatures,

decreased rainfall, unpredictable rainfall patterns, and prolonged dry season in the last 10-15 years. The causes of these climate variabilities included deforestation, land degradation mainly through illegal mining, and burning of firewood for cooking. As a belief system, some regarded the climatic change as a punishment from God. Radio, television, agriculture extension officers, fellow farmers and friends were their main sources of climate information for decision-making.

Secondly, the research delved into the socio-economic implications of climate change on the livelihood of cocoa farmers in the study area. A decrease in cocoa yield was the major impact of climate change except that the farmers have started experiencing a gradual increase in yield in the last three (3) years due to the adaption measures they have adopted. The farmers also experienced dying of cocoa trees, occurrences of unfamiliar pests and diseases, delay in crop maturity, seedling mortality, resistance of pests and diseases to pesticides, and reduction in post-harvest quality of cocoa beans. Regarding the impact on socio-economic lives, most respondents experienced reduction in income. Other livelihood impacts included food insecurity; poor access to healthcare; bad water quality; drying up of streams; and reduction in labour supply.

Thirdly, to address the negative impact of climate variability on cocoa production and livelihood, the study focused on the adaptation technologies adopted by the farmers. The study revealed that majority of the farmers understood climate change adaptation, and that, years of farming experience influences adaptation choices. The study further revealed that the farmers have adopted some form of adaptation measures perceived to be effective in reducing the adverse impact of climate change. The adaptation measures commonly adopted and ranked in descending order according to the findings are: agroforestry, good agricultural practices, crop diversification, frequent spraying and fertilizer application, adoption of hybrid varieties, farm expansion, creating fire belt, praying for God's help, and migrating to different farm lands. As a result of these measures, gradual increase in crop yield over the last three (2018/2019 to 2020/2021) cocoa seasons was observed. This revelation is consistent with the annual cocoa production performance of the districts within the same period.

Lastly, the study identified the barriers to cocoa farmers' adaptation drive. These include financial constraints, inadequate labour supply, poor access to improved seedlings, poor irrigation facilities, low level of technology, inadequate weather information, small landholding size, and the absence of tree tenure policy. It however, came to light that most of the respondents received support (though inadequate) for their adaptation efforts from farmer organizations, government, NGOs, and Licensed Cocoa Buying Companies.

In conclusion, cocoa farmers in the Offinso Municipalities have experienced a gradual increase in cocoa yields in recent years which is attributed to the various adaptation technologies implemented. This implies that adopting adaptation technologies is the surest way of reducing the impacts of climate change on cocoa production and improving household income of cocoa farmers. It is therefore recommended that stakeholders in the cocoa industry pay more attention to adaptation technologies and encourage more farmers to adopt such measures. In addition, a collaborative effort from government agencies and institutions and traditional leaders is needed for law enforcement against deforestation and illegal mining. Lastly, adequate education to cocoa farmers on agroforestry, good agricultural practices, and other adaptation techniques should be enhanced to improve productivity. Since this study covers only cocoa farmers, future research should consider examining the impacts of climate change on other crops like food crops, and the implications of that on the farmers' livelihood in the study area.

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Authors contribution: Megbetor, Elias: Provided the overall guidance and conceptualization of the study, played a significant role in the determination and development of the methodology and analysis, and editing the entire work.

Boateng, Solomon: Played part in the conceptualization of the study, reviewed literature, participated in the instrument design, and led the data gathering process.

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