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# *COCOA FARMERS' ADAPTATION TO CLIMATE EXTREMES IN ATWIMA NWABIAGYA NORTH DISTRICT, GHANA*

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## *ABSTRACT*

*This study examines the adaptation strategies of cocoa farmers to climate extremes. The study multistage sampling technique to sample 400 farmers from 10 communities. Primary data was gathered with the use of structured questionnaire and the data was analyzed using descriptive and inferential statistics. A significant proportion of respondents have experienced extreme climate events, with drought (73%), flooding (64.25%) and heatwaves (56.75%) being the most commonly reported experiences. The most commonly used adaptation strategies reported are mixed cropping (73.50%), planting improved crop variety (68.75%), and cover cropping (70%). Adopting mixed cropping was influenced by education and access to extension. The drivers of adopting improved plant/seed variety were farm size, number of farms owned by a farmer, access to extension, access to credit and membership in a farmer cooperative. Distance to farm, education extension access and membership in farmer cooperative influences the adoption of cover crops as means to mitigate extreme climate. In the event of flooding, farmers are likely to adapt all the three main adaptation strategies. The promotion of farmer cooperatives should be a top priority for the stakeholders in the cocoa value chain. Top priority should be also given to the breeding of crop varieties that are resistant to extreme climatic conditions.*

**Keywords:** *Adaptation Strategies, Climate change, Climate extreme, Drought, Flooding, Mixed Cropping*

## INTRODUCTION

Climate change affects how often, how intensely, where, when, and for how long weather conditions occur. It also has the potential to produce previously unheard-of extremes. Even though weather or climatic events are not statistically exceptional, they can still have extreme effects or circumstances if they reach a crucial threshold or if they happen concurrently with other occurrences (Seneviratne et al., 2012). By examining trends in events, it has been possible to evaluate the features of extremes or variations in extremes (Trewin and Vermont, 2010). It is estimated that the raining season in Ghana could begin in June or possibly later, between 2030 and 2039 (Jung and Kunstmann, 2007). Additionally, it is anticipated that this would have a higher deviation from the norm (Laux et al., 2008), indicating that the climate will

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not only change but also become more unpredictable (Laube et al. 2012). It follows that Ghana could experience more severe weather events like floods, dry periods, and droughts. Eventually, this condition will have an impact on human livelihoods, the environment, and agriculture. Particularly, it's expected that negative effects on the agriculture industry will increase the prevalence of rural poverty (Ndamani and Watanabe, 2015).

When comparing natural disasters around the world and in Europe, meteorological extremes are sorely essential, especially in terms of economic losses (Mika, 2012). Extreme climate is complicated, and it is important to take into account factors like vulnerability, exposure, and the physical dimensions of these events when assessing how climate change will affect extreme impacts and disasters. Climatic extremes are the rare occurrences that have a significant influence because one or more measured atmospheric variables persist for an extended length of time (Mika, 2012; Seneviratne et al., 2012). When a sequence of extreme weather lasts for like a season, it could be categorized as an extreme climate phenomenon (Solomon et al., 2007).

Extreme weather condition is location specific, both in terms of absolute temperature (for example, the temperature of a warm day for the tropics would differ from a warm day for the mid-latitudes) and possibly in terms of the amount of time it takes for society to adjust. During a longer period of time, an extreme climate event occurs. It might be the culmination of multiple meteorological occurrences, either extreme or not (e.g., the development of a season's worth of rainy days that are somewhat below average in total, resulting in dry conditions) (Seneviratne et al. 2012).

Extreme climatic event risks are a result of the interaction between physical hazard (such as rain and wind), degree of hazard exposure, the susceptibility of persons and groups, and the capability to plan for, manage, and recuperate from extreme occurrences (Ebi et al., 2021). Given that infrastructure and population are continuing to expand in places that are vulnerable to weather and climate extremes, there is little uncertainty that society in its entirety has grown increasingly sensitive to extreme weather (Mika, 2012).

Thus, adaptation techniques are required to enable agrarian communities cope with extreme weather situations brought on by climatic changes (Adger et al., 2003). The management of losses or the exploitation of opportunities brought about by a changing climate are both accomplished through adaptations, which involve changes or interventions. The process through which a farmer adapts to the consequences of recent or upcoming climate extremes is also referred to as adaptation. This is defined as the capacity to respond to climate change, including climate extremes and variability, to mitigate possible harm, to embrace opportunities, or to deal with the effects (IPCC, 2001).

Hence, adaptation strategies are preventative in nature (made to lessen the likelihood of negative consequences and benefit from anticipated changes in climatic variables) (Ndamani and Watanabe, 2015). Farmers' empirical data must be considered when talking about adaption strategies and adoption challenges. Since agricultural adaptation approaches are typically site-specific (Luni et al., 2012), it is essential to comprehend farmers' adaptation tactics. Focusing on farmers and their ongoing activities is crucial to ensuring their preparedness for extreme weather occurrences (Di Falco et al., 2012).

Many scholars (Mulenga and Wineman, 2014; Khanal et al., 2018; Below et al., 2012; Fosu-Mensah et al., 2012; Trinh et al., 2018; Belay et al., 2017; Shaffril et al., 2018; Feng et al., 2017; Khanal et al., 2021) have studied adaptation to climate extremes. Nhamo et al., (2014) conducted a study in Ghana's Volta region to see how much they knew about climate extremes and how they felt it affected agricultural activity. According to Bunn et al., (2019), cocoa in Ghana would experience unpredictable climatic conditions, such as a wetter and hotter climate.

Neiburg (2015) reported that many cocoa yields have decreased by half, drought has increased, young cocoa trees have died and severe rains have also caused landslides, depleted topsoil, and affected cocoa flowering. Despite the fact that farmers have been shown to benefit from mitigation strategies that include adaptation to climate extremes (Huang et al., 2014; Coulombe and Wodon, 2007), there has not been much empirical study on how extreme weather affects farmers' adaptation choices. Empirical evidence on the climate extremes experienced by cocoa growers is still absent.

The research argues that while developing policies for enhancing farmers' adaptation to climate extremes, it is ideal to know the types of climate extremes farmers confront, the adaptation strategies they employ, and their drivers. To our knowledge, there is very little empirical data regarding farmers' behaviour in adapting to the occurrence of extreme climatic circumstances and their drivers, thus it was against this backdrop that the study was undertaken. So, the study aims to offer empirical proof of the climate adaptation tactics used by cocoa farmers.

## METHODOLOGY

The Atwima Nwabiagya North District was chosen as the area of the study. The district is one of 43 Metropolitan Municipal District Assemblies in the Ashanti Region. It is located in the western portion of the Ashanti Region, with Barekese serving as its seat. The district is bordered by the Ahafo Ano South West District in the west, Atwima Nwabiagya Municipality in the west, the Offinso Municipality in the north, and the Afigya Kwabre South District in the east and the Kumasi Metropolis in the south.

The researchers used a multi-stage sampling strategy. The choice of district, the ten communities and the 40 farmers from each community were chosen at random, giving a total of 400 farmers. Simple random sampling was utilized throughout the sampling process to guarantee that all districts, communities, and farmers received equitable treatment.

This study's analysis employed data gathered from primary sources. The primary data was collected from 10th May to 30th June 2022 in the district. Following an explanation of the gathering's purpose, the research's goals, and the farmers' anticipated contribution to those goals, the researchers interacted with a group of farmers. This was done in an effort to raise understanding of the research efforts. In order to assure the clarification of any ambiguous topics, feedback was also sought from the farmers in the form of questions and replies with some justifications. Subsequently, using a questionnaire, each responder was personally questioned to gather information on their demographic and farm features, their experiences with harsh weather, their adaption tactics, etc.

After processing and computer entry, data were analyzed using quantitative analytic methods like frequencies, percentages, mean, standard deviation, multivariate probit model with Stata, version 17.

We used the multivariate probit model (MVP) to estimate the factors that influence the adoption of adaptation strategies for climate extremes by the farmers. The MVP was used because farmers use several adaptation strategies to combat climate extremes. The MVP accounted for potential correlations between factors that may not be directly observed in adoption decisions (Wainaina et al., 2016; Greene and Hensher, 2010; Temesgen et al., 2017). It can be expressed as:

$$Y_{ij}^{*} = W_{ij}\beta_j + \varepsilon_{ij};\ j = 1,2, \dots .6. \quad (1)$$

Where; $j = 1,2, \dots .6$ represents the adaptation binary options available (i.e., improved seed variety, mixed cropping, cover cropping, irrigation, pruning, planting shade); $W_{ij}$represents factors (see Table 1 for details), $\varepsilon_{ij}$represents the disturbance term, and $\beta_j$ represents coefficients to be estimated. From equation (1), assuming that a rational $i^{th}$ farmer has a latent variable ($Y_{ij}^*$) takes into account factors that are not observed or demand associated with the $j^{th}$ choice of adaptation strategies. The assumption of the latent variable is that the observed ($W_{ij}$) and unobserved (captured by disturbance term $\varepsilon_{ij}$) factors influencing the adoption of the $j^{th}$ strategy are a linear combination.

Consider the latent variable $Y_{ij}^*$, the computations based on observable binary discrete variables $Y_{ij}$ denoting whether a farmer adopts an adaptation strategy or not. Following the indicator function to transform the unobserved choice into an observed binary outcome equation for each strategy is specified as:

$$Y_{ij} = \begin{cases} 1 \; if \; Y_{ij}^* > 0 \\ \cdot \\ \cdot \\ 0 \; if \; Y_{ij}^* \leq 0 \end{cases} \tag{2}$$

As multiple adaptation strategies can be adopted, the error terms in Equation 1 follow a multivariate normal distribution with a zero conditional mean and variance normalized to unity. Thus $\varepsilon_{ij} \sim MVN\ [0, \Sigma]$ and covariance matrix ($\Sigma$) specified as:

$$\begin{pmatrix} \varepsilon_{1i} \\ \varepsilon_{2i} \\ \varepsilon_{3i} \\ \vdots \\ \varepsilon_{7i} \end{pmatrix} \sim \begin{pmatrix} 1 & \rho_{12} & \rho_{13} & \cdots & \rho_{17} \\ \rho_{21} & 1 & \rho_{23} & \vdots & \rho_{27} \\ \rho_{31} & \rho_{32} & 1 & \vdots & \rho_{37} \\ \vdots & \vdots & \vdots & & \\ \rho_{71} & \rho_{72} & \vdots & \vdots & 1 \end{pmatrix} \tag{3}$$

Using Equation (3), assuming a certain condition leads to the development of an MVP model which can collectively represent the decisions related to adaptation strategy adoption. This specific model includes non-zero off-diagonal elements, which facilitate the correlation between the disturbance terms of multiple latent equations. These equations pertain to the unobserved attributes that influence the selection of adaptation strategies.

Table 1: Description of variables, their measurement and expected signs used in the model

| Variables | Measurement | Expected sign |
|---|---|---|
| Gender (Sex) | 1 if a farmer is male, 0 otherwise | +/- |
| Marital Status | 1 if a farmer is married, 0 otherwise | +/- |
| Age | Years of a farmer | +/- |
| Farming experience | Years of farming experience | + |
| Education | 1 if a farmer is educated and 0 otherwise | + |
| Farm size | Farm size in acre | + |
| Number of farms | Number of farms owned by a farmer | + |
| Household size | Number of people in the farmer's household | +/- |
| Distance to farm | Distance from the farmer's homestead to the nearest farm | - |
| Access to extension | 1 if farmer access to extension services and 0 for otherwise | + |
| Access to credit | 1 if a farmer access credit and 0 otherwise | + |
| Cooperative | 1 if a farmer belongs to a cooperative and 0 otherwise | + |
| Drought | 1 if a farmer encounters drought in production and 0 otherwise | + |
| Flooding | 1 if a farmer encounters flood in production and 0 otherwise | + |

| | | |
|---|---|---|
| Heatwave | 1 if a farmer encounters heatwave in production and 0 otherwise | + |
| Windstorm | 1 if a farmer encounters a windstorm in production and 0 otherwise | + |

## RESULTS AND DISCUSSION

Table 2: Summary of demographic characteristics of farmers

| Categorical variables | Frequency | Percentage | | |
|---|---|---|---|---|
| Sex | | | | |
| Male | 396 | 99.0 | | |
| Female | 4 | 1.0 | | |
| Education | | | | |
| Educated | 282 | 70.50 | | |
| Uneducated | 118 | 29.50 | | |
| Access to extension | | | | |
| Yes | 269 | 67.25 | | |
| No | 131 | 32.75 | | |
| Access to credit | | | | |
| Yes | 248 | 62.0 | | |
| No | 152 | 38.0 | | |
| Cooperative | | | | |
| Yes | 260 | 65.0 | | |
| No | 140 | 35.0 | | |
| Land tenure | | | | |
| Yes | 373 | 93.25 | | |
| No | 27 | 6.75 | | |
| Hire Labour | | | | |
| Yes | 357 | 89.25 | | |
| No | 43 | 10.75 | | |
| Continuous variables | Mean | Std. Dev. | Min | Max |
| Age | 44.66 | 14.47 | 22 | 81 |
| Farming experience | 9.50 | 5.08 | 2 | 23 |
| Household size | 8.08 | 3.98 | 2 | 25 |
| Farm size | 4.88 | 3.32 | 1 | 13 |
| Number of farms | 1.54 | 0.79 | 1 | 6 |
| Distance to farm | 5.64 | 4.59 | 1 | 32 |

Source: Field data, 2022

Table 2 shows the distribution of categorical variables and the summary statistics for continuous variables of cocoa farmers. Looking at the categorical variables, we can see that the sample consists mostly of males (99%), educated individuals (70.50%), with access to extension services and access to credit (62%). The high percentage of farmers with access to extension services suggests that they may have received support and advice on best practices for farming, as well as information on new technologies to combat extreme climate circumstances. This could translate into higher productivity, increased income, and better overall welfare for these farmers. With access to credit, farmers will be able to make the necessary investments to improve their resilience to climate extremes. For example, they may be able to purchase drought-resistant seed varieties, invest in irrigation systems, or implement soil conservation practices to help mitigate the effects of flooding or drought. Additionally, climate extremes can have economic impacts on farmers, leading to reduced incomes and increased food insecurity. Access to credit can help farmers manage these risks by providing a safety net to help them maintain their livelihoods during times of extreme weather. Improving access to credit for cocoa farmers could be an important strategy for building their resilience to climate extremes.

Additionally, 65% of the sample was involved in a cooperative, while 93.25% were owners of their farmlands. Cooperatives can provide a range of benefits to their members, including access to credit, markets, and knowledge-sharing opportunities. By pooling resources and working together, cooperatives can help their members to better withstand climate extremes. For example, a cooperative might invest in irrigation facilities that individual farmers would not be able to afford on their own or provide training on sustainable farming practices that can improve resilience to droughts or floods. Farmers who are farm owners are more likely to invest in long-term improvements to their land, such as soil conservation measures or agroforestry systems. This is because they have the confidence that they will be able to reap the benefits of those investments over time. In contrast, farmers who lack secure land tenure may be hesitant to invest in their land, since they may be forced to leave if their tenure is challenged. Finally, 89.25% of respondents hire labour for their farming activities. Hiring labour can help farmers to increase their productivity and efficiency, which can be particularly important during periods of extreme weather. For example, during a particularly wet season, hiring additional labourers may help farmers to complete planting or harvesting activities promptly, reducing the risk of crop loss. Similarly, during a drought, hiring labourers to help with irrigation or other water management activities may help to maintain yields.

The average age of the respondents was 44.66 years. The results show that farmers are relatively young. This implies that they may have the greater physical capacity to engage in farming activities, but may also have less experience and knowledge about traditional farming practices that are well-suited to the local climate. This could lead to challenges in adapting to climate extremes that require innovative approaches to farming. The average farming experience was 9.50 years. A higher average farming experience suggests that the community has a greater depth of knowledge and understanding of local agricultural practices. This experience may allow them to better anticipate and respond to extreme weather patterns, such as through crop rotation, intercropping, or other agroecological approaches that can increase resilience to climate extremes. However, a higher average farming experience does not necessarily guarantee success in adapting to climate extremes. If traditional farming practices are not well-suited to the local climate, or if they have been negatively impacted by external factors such as land degradation or market forces, then experience alone may not be sufficient to overcome these challenges.

The average household size was 8.08 people. Larger households may have more labour available for farming activities, which can increase productivity and resilience to climate extremes. Additionally, larger households may have a greater diversity of skills and knowledge, which can help them adapt to new challenges. They may also face greater challenges in accessing resources such as food, water, and land. In times of climate extremes, these challenges may be exacerbated, particularly if resources become scarce or prices increase due to market disruptions. The finding is bigger what Ankuyi et al., (2022) reported. The average farm size was four (4) acres hectares. Larger farms may have a greater capacity to diversify their crops and practices, which can increase resilience to climate extremes. They may also have access to more resources, such as machinery or irrigation systems, that can help mitigate the impacts of extreme weather events. On the other hand, larger farms may also face greater challenges in terms of managing their land and resources. For example, it may be more difficult to maintain soil health or prevent erosion on larger farms, particularly if they are highly mechanized or rely on intensive agriculture practices.

Respondents had an average of 2 farms. Having multiple farms can provide opportunities for the diversification of crops and practices, which can increase resilience to climate extremes. Multiple farms can also provide greater flexibility in terms of land management and resource allocation, which can help mitigate the effects of extreme weather conditions. On the other hand, having multiple farms may also require greater resources and management capacity, particularly if the farms are located far apart or have different soil types or land use requirements. Additionally, having multiple farms may increase the risk of resource depletion or overuse, particularly if farmers are not able to effectively manage their resources across multiple locations. The standard deviation of 0.79 farms suggests that there may be variability in the number of farms held by respondents within the community. Some respondents may have many more or fewer farms than the average. Finally, the average distance to the farm was 5.64 kilometres, with a standard deviation of 4.59 kilometres. Having a farm located far away may present challenges in terms of access and management. Farmers may have to travel long distances to get to their farms, which can be time-consuming and costly. This may limit their ability to carry out certain tasks, such as regular maintenance or monitoring, and may make it difficult to respond quickly to changing weather conditions.

**Cocoa farmers' experience with climate extreme**

Table 3: Extreme climate experiences

| Climate experience | Yes | | No | |
|---|---|---|---|---|
| | Frequency | Percentage | Frequency | Percentage |
| Drought | 292 | 73.00 | 108 | 27.00 |
| Flooding | 257 | 64.25 | 143 | 35.75 |
| Windstorm | 114 | 28.50 | 286 | 71.50 |
| Heatwave | 227 | 56.75 | 173 | 43.25 |

Source: Field data, 2022

Table 3 highlights that a significant proportion of respondents have experienced extreme climate events, with drought (73%), flooding (64.25%) and heatwaves (56.75%) being the most commonly reported experiences. These figures suggest that drought, flooding and heat waves are particularly prevalent. Mika (2012) and Nhamo et al., (2014) indicated that windstorms, heat waves, floods, and droughts are some of the examples of the extreme climatic phenomena. These extreme climate events can lead to crop failure, loss of livestock, and reduced productivity, all of which can have significant economic and social impacts on the community. Although only 28.50% have experienced windstorms, it also suggests that farmers can be vulnerable to other extreme climate events (windstorm), which can also have significant impacts on their livelihoods. According to Ndamani and Watanabe (2015), farmers in Northern Ghana adopted adaptation strategies in response to extreme climatic events including droughts and floods.

**Cocoa farmers' adaptation strategies**

Table 4: Adaptation strategies

| Adaptation strategy | Yes | | No | |
|---|---|---|---|---|
| | Frequency | Percentage | Frequency | Percentage |
| Mixed Cropping | 294 | 73.50 | 106 | 26.50 |
| Improved crop variety | 275 | 68.75 | 125 | 31.25 |
| Cover cropping | 280 | 70.00 | 120 | 30.00 |
| Planting shade trees | 250 | 62.50 | 150 | 37.50 |
| Irrigation | 164 | 41.00 | 236 | 59.00 |
| Pruning | 225 | 56.25 | 175 | 43.75 |

Source: Field data, 2022

Table 4 provides information on the adaptation strategies employed by the respondents. The most commonly used adaptation strategies reported are mixed cropping (73.50%), planting improved crop variety (68.75%), and cover cropping (70%). These strategies are popular and effective strategies for adapting to extreme climatic conditions. Mixed cropping, for example, helps farmers diversify their income and reduce their vulnerability to crop failure. Ndamani and Watanabe (2016) and Nhamo et al., (2014) agreed that using enhanced crop varieties and irrigation strategies can be useful for adapting to climate extremes. Other adaptation strategies reported in the table, such as planting shade trees, pruning, and irrigation, are used by a lower percentage of respondents. This suggests that these strategies may be less well-known or less accessible to the farmers. However, these strategies may still be effective in helping farmers adapt to extreme climate events. For example, irrigation can help farmers maintain crop yields during periods of drought while planting shade can protect crops from heat stress.

**Factors that influence farmers' adaptation strategies**

Table 5: Multivariate probit

| Variables | Mixed Cropping | | Improved seed variety | | Cover crops | |
|---|---|---|---|---|---|---|
| | Coefficient | Marginal effect | Coefficient | Marginal effect | Coefficient | Marginal effect |
| Age | -0.015 | -0.005 | -0.018 | -0.002 | -0.025 | -0.005 |
| | (0.025) | (0.005) | (0.027) | (0.005) | (0.040) | (0.005) |
| Farming experience | 0.022 | 0.010 | -0.128 | -0.021 | 0.201 | 0.011 |
| | (0.044) | (0.014) | (0.141) | (0.014) | (0.124) | (0.013) |
| Farm size | 0.065 | 0.021 | 0.402* | 0.042* | 0.302 | 0.033 |
| | (0.054) | (0.024) | (0.215) | (0.025) | (0.440) | (0.022) |
| Number of farms | 0.123 | 0.030 | 0.208*** | 0.098*** | 0.184 | 0.042 |
| | (0.191) | (0.091) | (0.116) | (0.016) | (0.246) | (0.083) |
| Household size | 0.035 | 0.015 | 0.033 | 0.003 | 0.036 | 0.006 |
| | (0.021) | (0.019) | (0.047) | (0.019) | (0.036) | (0.018) |
| Distance to farm | 0.022 | 0.008 | 0.023 | 0.013 | -0.056* | -0.028* |
| | (0.031) | (0.015) | (0.029) | (0.016) | (0.030) | (0.015) |
| Education | 0.394*** | 0.019*** | 0.521 | -0.051 | 0.148*** | 0.074*** |
| | (0.025) | (0.045) | (0.393) | (0.251) | (0.040) | (0.020) |
| Access to extension | 0.065*** | 0.015*** | 0.347*** | 0.057*** | 0.102*** | 0.051*** |
| | (0.015) | (0.005) | (0.117) | (0.016) | (0.028) | (0.014) |
| Access to credit | -0.076 | -0.026 | 0.165*** | 0.054*** | -0.462 | -0.231 |
| | (0.149) | (0.030) | (0.062) | (0.015) | (0.284) | (0.142) |
| Cooperative | 0.055 | 0.012 | 0.123** | 0.033** | 0.186*** | 0.092*** |

| | | | | | | |
|---|---|---|---|---|---|---|
| | (0.149) | (0.021) | (0.061) | (0.015) | (0.026) | (0.014) |
| Drought | 0.077*** | 0.018*** | 0.070 | 0.035 | 0.391 | 0.197 |
| | (0.025) | (0.002) | (0.059) | (0.025) | (0.457) | (0.224) |
| Flooding | 0.028* | 0.009* | 0.197*** | 0.079*** | 0.078** | 0.037** |
| | (0.017) | (0.005) | (0.068) | (0.018) | (0.035) | (0.016) |
| Windstorm | 0.042 | 0.004 | 0.146*** | 0.058*** | 0.363 | 0.181 |
| | (0.182) | (0.008) | (0.058) | (0.020) | (0.389) | (0.165) |
| Constant | 0.327** | | 0.111*** | | 0.255*** | |
| | (0.141) | | (0.038) | | (0.097) | |
| Observations | 400 | | 400 | | 400 | |
| Pro>chi$^2$ | 0.000 | | | | | |
| Wald chi2(39) | | 162.04*** | | | | |
| rho21 | | 0.425*** | | | | |
| | | (0.091) | | | | |
| rho31 | | 0.624*** | | | | |
| | | (0.063) | | | | |
| rho32 | | 0.430*** | | | | |
| | | (0.088) | | | | |
| Likelihood ratio test of rho21 = rho31= rho32 | | 85.157*** | | | | |
| Log-likelihood | | -578.519 | | | | |

Source: Field data, 2022
*** p<0.01, ** p<0.05, * p<0.1.

Table 5 presents the results of a multivariate probit analysis of factors that influence farmers' adoption of the three main adaptation practices such as mixed cropping, improved variety and cover cropping.

The probability of cocoa farmers' adapting to climate extreme through mixed cropping increases with education (p<0.01), access to extension (p<0.01), drought (p<0.01) and flooding (p< 0.10). The statement suggests that the probability of cocoa farmers adapting to climate extremes through mixed cropping is significantly influenced by their level of education, access to extension services, and the occurrence of drought and flooding. Farmers who have higher levels of education may be more aware of the benefits of mixed cropping as a climate adaptation strategy and are more likely to implement it on their farms. This finding is not surprising, as education equips individuals with knowledge and skills that can help them adapt to changes in their environment. This finding is consistent with a previous study by Khanal et al., (2018) that showed that education can increase farmers' knowledge and awareness of climate change and its impacts on agriculture. Access to extension is also found to be statistically significant in increasing the probability of cocoa farmers adapting to climate extremes through mixed cropping. Extension services can provide farmers with information on climate change, weather patterns, and other relevant factors, as well as advice on appropriate crop management practices (Zamasiya et al., 2017). The findings suggest that improving education and access to extension services for cocoa farmers may be important for helping them adapt to climate extremes through mixed cropping. The findings indicate that both drought and flooding are also significant factors in the relationship between mixed cropping and adaptation to climate extremes. This suggests that farmers who experience flooding and drought are more likely to adapt mixed cropping as a strategy. Khanal et al., (2018) also reported that experiencing a drought has a positive influence on farmers' attitude towards adaptation to climate change and variability. This is likely because mixed cropping can provide a more resilient and adaptable farming system that is better able to withstand and recover from extreme weather events. Addressing the impacts of drought and flooding may also be important for supporting adaptation. According to Khanal et al., (2018), farmers' experiences with the effects of climate change, such as drought and flood, influence their decision to implement climate change measures.

The probability of cocoa farmers' adapting to climate extreme through the use of improved seed variety increases with farm size ($p<0.10$), number of farms ($p<0.01$), access to extension ($p<0.01$), access to credit ($p<0.01$), cooperative members ($p<0.05$), flooding ($p<0.01$) and windstorm ($p<0.01$). According to the findings, farm size, number of farms, access to extension services, and access to credit are all statistically significant factors associated with the probability of cocoa farmers adapting to climate extremes through the use of improved seed variety, with p-values less than 0.1. This indicates that there is a relatively low probability that these relationships are due to chance alone, and suggests that these factors may be important for supporting cocoa farmers in adapting to climate extremes through the use of improved seed variety. This means that these factors are important predictors of the probability of cocoa farmers adapting to climate extremes through the use of improved seed variety. The finding that access to extension services, access to credit, and the number of farms is strongly associated with the probability of cocoa farmers adapting to climate extremes through the use of improved seed variety is not surprising. These factors are often considered important predictors of farmers' ability to adopt new agricultural technologies and practices. larger farms are more likely to adopt these improved seed varieties than smaller farms. Larger farms may have more resources available to invest in new seed varieties, such as financial resources or access to information and technology. Additionally, larger farms may be more resilient to the impacts of climate extremes, which could give farmers more flexibility to experiment with new seed varieties. Trinh et al., (2018) and Belay et al., (2017) found that farm size greatly increased the likelihood that farmers will adapt to climate change, supporting the conclusion. Farmers who have access to extension services and credit are likely to have more information about new seed varieties and be better able to afford them, respectively. According to Trinh et al., (2018), credit plays a significant role in how well farmers adapt to climate change. According to Abid et al., (2015), education affects farmers' decisions on adaptation measures, which is consistent with this study. The number of farms that a farmer has may also be an important predictor, as it may indicate a farmer's level of experience and resources. The finding that cooperative membership is associated with the probability of cocoa farmers adapting to climate extremes through the use of improved seed variety is also interesting. This suggests that cooperative membership may provide farmers with access to important resources or information that can help them adopt new agricultural technologies. According to Zamasiya et al. (2017) and Ndamani and Watanabe (2016), social group affiliation has a favorable impact on farmers' attitudes on coping with climate change and variability. Finally, the finding that flooding and windstorm are strongly associated with the probability of cocoa farmers adapting to climate extremes through the use of improved seed variety is also important. These climate extremes can have a significant impact on cocoa production, and the fact that the use of improved seed varieties is associated with the ability to adapt to these extremes suggests that improved seed varieties may be an important part of climate change adaptation strategies for cocoa farmers.

The probability of cocoa farmers' adapting to climate extreme through cover crops decreases with distance to the farm ($p<0.10$) while it increases with education ($p<0.01$), access to extension ($p<0.01$), cooperative members ($p<0.01$) and flooding ($p< 0.05$). The findings suggest that distance to the farm, education, access to extension services, cooperative membership, and flooding are the factors associated with the probability of cocoa farmers adapting to climate extremes through cover cropping. Distance to the farm is statistically significant, with a p-value less than 0.1. This indicates that there is a relatively low probability that the relationship between distance to the farm and the probability of cocoa farmers adapting to climate extremes through cover cropping is due to chance. The negative relationship between distance to the farm and the probability of cocoa farmers adapting to climate extremes suggests that farmers who live closer to their farms may be more likely to plant shade trees than those who live further away. This could be due to several factors, such as it takes more effort to transport and plant the trees, the convenience of having trees nearby, a greater sense of attachment, responsibility to the land when it is closer to home and the ease of monitoring the growth of trees. Farmers with higher levels of education may be more likely to have access to information and resources related to climate change adaptation. They may also be more likely to understand the importance of cover cropping. Education can help farmers understand the benefits and how to manage them effectively. The results are consistent with that of Trinh et al., (2018) who found that farmers' likelihood of adapting to climate change was significantly influenced by their educational level. Extension services can provide farmers with technical assistance, training, and access to inputs such as seeds and seedlings. Education can be delivered through various channels, such as workshops, field demonstrations, and mass media campaigns. Extension services can be provided by government agencies, NGOs, and private sector actors such as cocoa companies and cooperatives. Access to extension services can be facilitated through the establishment of farmer field schools, community-based organizations, and mobile advisory services. According to Below et al., (2012) and Belay et al., (2017), agricultural extension is the best strategy for enhancing farmers' ability to adapt to climate change. Cooperative membership could provide farmers with resources, such as seedlings and equipment, and connect them with other farmers who have successfully implemented this adaptation strategy. The finding that flooding increases the probability of cocoa farmers adapting to climate extremes through cover cropping is interesting. It suggests that farmers who experience flooding may be more aware of the need to adapt to climate extremes and may be more motivated to take action to protect their crops.

## CONCLUSION

Cocoa farmers have experienced extreme climate changes in drought, flooding, windstorm and heatwave which have impacted cocoa production. To cope with these changes, farmers have adopted various strategies, mainly, growing cover crops, planting improved varieties and practicing mixed cropping. The use of mixed cropping is influenced by education, access to extension, drought and flooding. The use of improved seed variety is influenced by farm size, number of farms, access to extension, access to credit, cooperative membership, flooding and windstorm. The probability of cocoa farmers' adapting to climate extreme through cover crops is influenced by distance to the farm, education, access to extension, cooperative membership and flooding.

The study recommends that effective adaptation to climate extremes requires a combination of individual and collective actions, as well as supportive policies and institutions.

The farmers need access to credit and extension services to implement their adaptation strategies. The study suggests that cooperative membership could provide farmers with resources and connect them with other farmers who have successfully implemented adaptation strategies. Hence the promotion farmer cooperatives should be a top priority of the stakeholders in cocoa value chain. Extension services can provide farmers with technical assistance, training, and access to inputs such as seeds and seedlings. Therefore, there is the need to resource them with the needed resources so that they can effectively deliver on their mandate. Educating farmers on ways to mitigate and adapt to climate extreme is crucial to their livelihoods and global economy. This can be delivered through various channels, such as workshops, field demonstrations, and mass media campaigns. Government interventions should concentrate on creating better crop varieties and irrigation systems. The creation of dams and dugouts, as well as the breeding of crop types resistant to drought, should be given top priority. The feasibility of farm-level adaptation methods to climatic extremes is also recommended for further study.

## DAFTAR PUSTAKA

Abid, M., Scheffran, J., Schneider, U. A., & Ashfaq, M. J. E. S. D. (2015). Farmers' perceptions of and adaptation strategies to climate change and their determinants: the case of Punjab province, Pakistan. Earth System Dynamics, 6(1), 225-243. https://doi.org/10.5194/esd-6-225-2015

Adger, W. N., Huq, S., Brown, K., Conway, D., & Hulme, M. (2003). Adaptation to climate change in the developing world. Progress in development studies, 3(3), 179-195. https://doi.org/10.1191/1464993403ps060oa

Ankuyi, F., Tham-Agyekum, E. K., Aidoo, D. C., Bakang, J.E.A., Amankwa, K., Akowuah, A. K., & Makafui, W. T. (2022). Drivers of knowledge, attitude, practice, aspiration and perceptions of sustainable agriculture standard: evidence from certified cocoa farmers in Ghana. Russian Journal of Agricultural and Socio-economic Sciences, 11(131).

Belay, A., Recha, J. W., Woldeamanuel, T., & Morton, J. F. (2017). Smallholder farmers' adaptation to climate change and determinants of their adaptation decisions in the Central Rift Valley of Ethiopia. Agriculture & Food Security, 6(1), 1-13. https://doi.org/10.1186/s40066-017-0100-1

Below, T. B., Mutabazi, K. D., Kirschke, D., Franke, C., Sieber, S., Siebert, R., & Tscherning, K. (2012). Can farmers' adaptation to climate change be explained by socio-economic household-level variables? Global environmental change, 22(1), 223-235. https://doi.org/10.1016/j.gloenvcha.2011.11.012

Bunn, C., Läderach, P., Quaye, A., Muilerman, S., Noponen, M. R., & Lundy, M. (2019). Recommendation domains to scale out climate change adaptation in cocoa production in Ghana. Climate Services, 16, 100123.

Coulombe, H., & Wodon, Q. (2007, May). Poverty, livelihoods, and access to basic services in Ghana. In Ghana CEM: Meeting the challenge of accelerated and shared growth (pp. 1-86). Washington, DC: World Bank.

Di Falco, S., Yesuf, M., Kohlin, G., & Ringler, C. (2012). Estimating the impact of climate change on agriculture in low-income countries: Household-level evidence from the Nile Basin, Ethiopia. Environmental and Resource Economics, 52, 457-478.

Ebi, K. L., Vanos, J., Baldwin, J. W., Bell, J. E., Hondula, D. M., Errett, N. A., ... & Berry, P. (2021). Extreme weather and climate change: population health and health system implications. Annual review of public health, 42(1), 293-315.

Feng, X., Liu, M., Huo, X., & Ma, W. (2017). What motivates farmers' adaptation to climate change? The case of apple farmers of Shaanxi in China. Sustainability, 9(4), 519. https://doi.org/10.3390/su9040519

Fosu-Mensah, B. Y., Vlek, P. L., & MacCarthy, D. S. (2012). Farmers' perception and adaptation to climate change: a case study of Sekyedumase district in Ghana. Environment, Development and Sustainability, 14, 495-505. https://doi.org/10.1007/s10668-012-9339-7

Greene, W.H., & Hensher, D.A. (2010). Modelling ordered choices: A primer: Cambridge University Press.

Huang, J, Jiang, J, Wang, J and Hou,L. (2014). Crop Diversification in Coping with Extreme Weather Events in China. Journal of Integrative Agriculture. 2014, 13(4): 677-686. Science Direct.

IPCC (2001). Climate Change 2001: Impacts, Adaptation, and Vulnerability. Intergovernmental Panel on Climate Change; Cambridge University Press: Cambridge, UK, 2001

Jung, G., & Kunstmann, H. (2007). High-resolution climate modelling for the Volta region of West Africa, journal of. Geophysics Research, 112, D23108. https://doi.org/10.1029/2006JD007951

Khanal, U., Wilson, C., Hoang, V. N., & Lee, B. (2018). Farmers' adaptation to climate change, its determinants and impacts on rice yield in Nepal. Ecological Economics, 144, 139-147. https://doi.org/10.1016/j.ecolecon.2017.08.006

Khanal, U., Wilson, C., Rahman, S., Lee, B. L., & Hoang, V. N. (2021). Smallholder farmers' adaptation to climate change and its potential contribution to the UN's sustainable development goals of zero hunger and no poverty. Journal of Cleaner Production, 281, 124999. https://doi.org/10.1016/j.jclepro.2020.124999

Laube, W., Schraven, B., & Awo, M. (2012). Smallholder adaptation to climate change: dynamics and limits in Northern Ghana. Climatic change, 111, 753-774. https://doi.org/10.1007/s10584-011-0199-1

Laux, P., Kunstmann, H., & Bárdossy, A. (2008). Predicting the regional onset of the rainy season in West Africa. International Journal of Climatology: A Journal of the Royal Meteorological Society, 28(3), 329-342. https://doi.org/10.1002/joc.1542

Luni, P. I. Y. A., Maharjan, K. L., & Joshi, N. P. (2012). Comparison of adaptive capacity and adaptation practices in response to climate change and extremes among the Chepang households in rural mid-hills of Nepal.

Mika, J. (2012). Weather and climate extremes in light of the IPCC SREX (2011) and beyond. Aerul si Apa. Componente ale Mediului, 25.

Mulenga, B. P., & Wineman, A. (2014). Climate Trends and Farmers' Perceptions of Climate Change in Zambia (No. 186605).

Ndamani, F., & Watanabe, T. (2015). Farmers' perceptions about adaptation practices to climate change and barriers to adaptation: A micro-level study in Ghana. Water, 7(9), 4593-4604.

Ndamani, F., & Watanabe, T. (2016). Determinants of farmers' adaptation to climate change: A micro-level analysis in Ghana. Scientia Agricola, 73, 201-208. https://doi.org/10.1590/0103-9016-2015-0163

Neiburg, O. (2015). Devastating impact of climate change on cocoa can't be ignored. https://www.confectionerynews.com/Article/2015/12/21/Climate-change-Impact-on-cocoa-production-devastating

Nhamo, N., Donald, M., & Fritz, O. T. (2014). Adaptation strategies to climate extremes among smallholder farmers: a case of cropping practices in the Volta Region of Ghana. British Journal of Applied Science & Technology, 4(1), 198-213.

Seneviratne, S. I., Nicholls, N., Easterling, D., Goodess, C. M., Kanae, S., Kossin, J., ... & Zwiers, F. W. (2012). Managing the risks of extreme events and disasters to advance climate change adaptation: Changes in climate extremes and their impacts on the natural physical environment. https://doi.org/10.7916/d8-6nbt-s431

Shaffril, H. A. M., Krauss, S. E., & Samsuddin, S. F. (2018). A systematic review on Asian farmers' adaptation practices towards climate change. Science of the Total Environment, 644, 683-695. https://doi.org/10.1016/j.scitotenv.2018.06.349

Solomon, S., Qin, D., Manning, M., Averyt, K., & Marquis, M. (Eds.). (2007). Climate change 2007-the physical science basis: Working group I contribution to the fourth assessment report of the IPCC (Vol. 4). Cambridge university press.

Temesgen, F., Emana, B., Mitiku, F., & Gobana, E. (2017). Application of multivariate probit on determinants of sesame farmers market outlet choices in Gimbi District, Ethiopia. African Journal of Agricultural Research 12(38):2830-2835.

Trewin, B., & Vermont, H. (2010). Changes in the frequency of record temperatures in Australia, 1957–2009. Aust Meteorol Oceanogr J, 60, 113-119.

Trinh, T. Q., Rañola Jr, R. F., Camacho, L. D., & Simelton, E. (2018). Determinants of farmers' adaptation to climate change in agricultural production in the central region of Vietnam. Land use policy, 70, 224-231. https://doi.org/10.1016/j.landusepol.2017.10.023

Wainaina, P., Tongruksawattana, S., & Qaim, M. (2016). Tradeoffs and complementarities in the adoption of improved seeds, fertilizer, and natural resource management technologies in Kenya. Agricultural Economics 47:351-362.

Zamasiya, B., Nyikahadzoi, K., & Mukamuri, B. B. (2017). Factors influencing smallholder farmers' behavioural intention towards adaptation to climate change in transitional climatic zones: A case study of Hwedza District in Zimbabwe. Journal of environmental management, 198, 233-239. https://doi.org/10.1016/j.jenvman.2017.04.073