agriculture

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Assessing Maize Farmers' Adaptation Strategies to Climate Change and Variability in Ghana

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Received: 7 March 2019; Accepted: 24 April 2019; Published: 29 April 2019

Abstract: This study examined the adaptation strategies of maize farmers to climate change and variability in the Eastern Region of Ghana using primary data collected from 150 maize farming households by the administration of structured questionnaires. The results of the multinomial logit regression revealed that rainfall perception, access to credit, and farming experience significantly influenced the adoption of recommended agricultural practices, whereas the adoption of soil-related strategies is influenced by gender and rainfall perception. Farming experience and rainfall perception influenced the adoption of improved varieties strategies. This study highlights the need for the development of water resources for maize production in the context of the changing climate. In this respect, the crucial roles of the Ghana Irrigation Development Authority, the agricultural extension division of the Ministry of Food and Agriculture, and other international organizations such as the Japan International Cooperation Agency and the World Bank regarding the development of irrigation facilities and the associated capacity building of the farmers are very important. Finally, the formation of Water User Associations for the smallholder farmers regarding the usage and maintenance of the irrigation facilities would be a step in the right direction.

Keywords: climate change; adaptation strategies; Ghana; smallholder farmers; water resources

1. Introduction

The commencement of the raining season directly influences farm management practices from sowing to the last stage of crop development and this significantly influences the probability of droughts and crop yield [1]. For sowing, it is important to know whether the rains are continuous and enough to ensure enough and consistent soil moisture during planting in order to avoid total crop failure [2]. Over the past few years, climate-related crop failure due to episodes of late rains for planting, variability in the pattern and levels of rainfall, and intermittent droughts and floods in Ghana have been a common phenomenon [3–10].

The effect of climate change and variability is severe in the agricultural sector in Ghana. Over 70% of the farmers cultivate farmland of less than 3 hectares [11]. Smallholder agriculture is characterized by reliance on rainfall, limited use of improved seeds, fertilizer, and mechanization for production, thereby making productivity levels below the achievable levels [6–10].

Maize is among the world's leading crops with an estimated production of 1,016,740,000 tons in 2013 [12]. It is one of the important staple food crops in most Sub-Saharan African countries as it plays key role in food security and generates income for most farmers [13]. Maize is one of Ghana's leading staple food crops with increasing domestic demand. However, there has been a shortfall in the average supply of maize in Ghana by 11% in 2011 [14]. In the Eastern Region of Ghana, farmers are predominantly smallholders and usually involved in the cultivation of staple grains such as maize [15].

Although smallholders have considerable experience in dealing with climate variability and possess local knowledge to cope during difficult periods, the unprecedented and sustained levels of variability associated with long-term climate change are outside the realm of what traditional coping strategies can manage [16]. The Agricultural sector has the poorest occupational group in Ghana with food crop farmers being the worst group [15]. This makes the sector a major target for both food security and poverty reduction interventions in the country.

Models and information about climate variability are available at macro levels but little has been done at the micro level [17,18]. Yet, the impact of climate variability is felt at the household level and increases the risk faced by farmers in producing maize in Ghana. Without the appropriate policies or adaptive strategies in place, the smallholder farmers will find it extremely difficult to practice sustainable agriculture in an environmentally unpredictable climatic condition [19–22].

Maize is one of the main staple crops in Ghana and it forms a major component of several domestic diets. In addition, maize is a major ingredient in feed formulation for livestock and a possible substitute in the malt brewing industry [23]. Agricultural activities are rural-based in the Eastern Region of Ghana and the farmers are predominantly smallholders [15]. The rural agricultural households constitute approximately 69% of all agricultural households in the region and the region is the second largest producer of maize in Ghana, where about 19% of the maize is produced [24]. However, climate variability is expected to adversely affect food production in the region where much of the population, especially the poor smallholder farmers, rely on local supply systems that are sensitive to the changing climate [15]. Disruptions of the existing food system will have devastating implications for development and livelihoods and are expected to add to the challenges climate change already pose for poverty eradication [25].

In the literature, studies on climate change adaptation have been somewhat general without specific studies on how maize farmers, who are mostly smallholders and produce the nation's major staple are adapting to climate change and variability. One can imagine the effect on the national economy and food security in a year of complete crop failure for maize farmers due to climate-related stressors. Maize is Ghana's main staple crop and it is important that the maize farmers' adaptation strategies to climate change be examined to provide the relevant policy recommendations for adaptation. This study fills this gap in the literature.

Therefore, the objectives of the study are threefold as follows. First, to assess the percentage of the smallholder farmers adopting each of the identified climate change adaptation strategies; second, to determine the factors influencing maize farmers' adoption of the climate change adaptation strategies; third, to identify and rank the constraints militating against maize farmers' adoption of climate change adaptation strategies.

To the best of our knowledge, this study is among the earlier ones to examine the adaptation strategies of maize farmers to the effects of climate change and variability in the Eastern Region of Ghana. The climate conditions, topography, and mostly forest vegetative cover in the Eastern Region of Ghana are like those of some other regions globally. Therefore, the results of this study have international relevance for farmers' adaptation to the effects of climate change and variability. Domestically, the results of this study would unearth specific responses from maize farmers regarding the effects of climate change that would provide information for climate change adaptation policies and programs to boost the production of maize, which is one of the main staple crops in Ghana.

2. Literature Review

Climate change has become one of the major inhibitors of human systems globally. World institutions and agreements including the Intergovernmental Panel on Climate Change (IPCC) and the Kyoto Protocol are some of the key institutions working toward climate change adaptation and mitigation. Climate change adaptation is the adjustment in human or natural systems in response to actual or anticipated climatic stimuli or their effects, which lessens damage or exploits beneficial prospects. One of the most effective ways to reduce the impact of climate change on a system is to increase the physical resilience of the system to minimize the negative effects of unavoidable climatic stressors through actions targeted at the vulnerable system or seize new opportunities brought about by climate variability [26,27]. On the other hand, climate change mitigation involves actions that limit the magnitude or rate of long-term climate change through reductions in human (anthropogenic) emissions of greenhouse gases (GHGs) and human-induced global warming, increasing the capacity of carbon sinks, e.g., through reforestation [28,29].

Mitigation is a public good and climate change is a case of the "tragedy of the commons". Therefore, effective climate change mitigation will not be achieved if each agent (individual, institution, or country) acts independently. Therefore, there is the need for collective action. Some adaptation actions, on the other hand, have characteristics of a private good as benefits of actions may accrue more directly to the individuals, regions, or countries that undertake them, at least in the short term. Nevertheless, financing such adaptive activities remains an issue, particularly for poor individuals and countries [29]. Climate change mitigation is the subject of current studies [30–33]. Climate change mitigation and adaptation share the same ultimate purpose of reducing the undesirable impacts of climate change [34]. They are naturally related in the climate system as the more effectual mitigation undertaken now, the less need for adaptation in the future. In recent years, the idea of taking up adaptation and mitigation jointly in climate change projects and policies is gaining prominence. Climate change mitigation has been treated as an issue for developed countries, which hold the greatest responsibility for climate change, while adaptation is seen as a priority for the developing and emerging economies, where the capacity for mitigation is lower and vulnerability is higher compared to the developed countries. Synergies between mitigation and adaptation can be investigated by thinking through adaptation activities that have consequences for mitigation or mitigation activities that have consequences for adaptation [35]. If mitigation can be successful in keeping impacts at a lower level, then adaptation can be successful in coping with more of the resulting impacts [36].

Climate change impacts on Sub-Saharan African human settlements arise from several climate change-related causes, notably sea level changes, impacts on water resources, extreme weather events, food security, increased health risks from vector-borne diseases, and temperature-related morbidity in urban environments [37,38]. Proactive climate change adaptation and mitigation are urgently needed to minimize the effects of climate change on human systems, especially food systems in sub-Saharan Africa as this region is one of the most vulnerable to the effects of climate change globally [38,39]. Adaptation and mitigation are two of the three pillars of climate-smart agriculture, with the third pillar aimed at increasing food security through increased agricultural productivity [40].

Vulnerability and adaptation to climate change and variability is a complex and multidimensional process [16,18,21,41]. Climate-related adaptation process is in terms of type, scale, timing, and outcome of the responses, as well as the factors that influence adaptation [42]. Climate extreme events introduce numerous uncertainties for the livelihoods of smallholder farming households that depend heavily on the weather and climate [43]. Therefore, these farmers have been modifying their practices to better adapt to the changing climate. Several technologies and practices such as high yielding varieties, early maturing varieties, conservation agriculture and drought tolerant varieties are available for smallholder farmers to enable them to adapt better to the effects of climate change and variability. These technologies were developed by the Council for Scientific and Industrial Research (CSIR) and the universities in Ghana. Strategies for adapting to climate change and variability can be grouped into two, namely autonomous and planned adaptation strategies. Autonomous adaptation strategies involve actions taken by non-state agencies such as farmers, communities, or organizations and firms in response to climatic shocks while planned adaptation involves actions taken by local, regional, and national government to provide infrastructure and institutions to reduce the negative impact of climate change and variability. One can adopt strategies before climate hazards (anticipatory (i.e., proactive) strategies) or after (reactive strategies) [44]. Farmers' adaptation to climate change can be indigenous or introduced strategies. Indigenous adaptation strategies can be categorized into crop- and livestock-related strategies, soil-related practices, cultural practices strategies and other indigenous strategies [45,46]. Introduced adaptation strategies can be categorized into soil and plant health strategies, improved variety and breeds strategies, recommended agricultural strategies, and other introduced strategies [45,47].

Previous research identified strategies such as switching crops, shifting crop calendar, engaging new management practices for a specific climate regime, changing irrigation system and selecting different cropping technologies as adaptation strategies [48]. Vegetable farmers in the Upper East region of Ghana stored water for dry season farming as a measure to adapt to floods in the rainy season followed shortly by drought in the dry season [49]. Among the strategies adopted in Ghana include high yielding varieties, inorganic fertilizers, harrowing, planting of trees, early maturing varieties, compost, conservation agriculture, irrigation, drought tolerant varieties, herbicides, planting during recommended period, reduce farm size and planting in rows.

Research has shown that many factors influence farmers' decision to adopt improved technologies. The factors influencing the adoption of a technology were identified as the socio-economic characteristics of the farmers and the characteristics of the innovation [50]. Among the factors identified are farmers' educational level, age of the farmer, available family labor, non-farm income, farmers' perception about the innovation, farm size, frequency of extension visits, and accessibility of the new technology. A comprehensive survey also found that farm size, risk, human capital, labor availability, access to credit, and land tenure systems were the most important factors influencing farmers' decision on technology adoption [51,52]. The location of farmers, noticing increased temperature and decreased rainfall, farmer–farmer extension contacts, and availability of community markets are the significant determinants of farmers' choice of indigenous adaptation strategies in Northern Ghana [46].

Many frameworks and approaches have been developed to understand the barriers to climate change adaptations in sub-Saharan Africa. Barriers to climate-related adaptation strategies are defined as factors, conditions, or obstacles that reduce the effectiveness of those adaptation strategies [53]. Constraints to climate adaptation strategies can be grouped into financial, socio-cultural, institutional, informational, and technological barriers. The financial barriers due to lack of credit facilities are important obstacles hindering the implementation of climate adaptation strategies by farmers in Ethiopia [54]. This is supported by another research that financial constraint is a key constraint faced by smallholder farming households' adaptation to climatic shocks in Sub-Saharan Africa [55].

Socio-cultural constraints such as beliefs, cultural practices, and the worldviews of individuals or groups greatly influence the way farmers perceive climate change, and their subsequent adaptation strategies. Previous research revealed that people's response to risk might be greatly influenced by their pre-existing belief, values, and norms regarding that event [56]. This means that people who live in the same community with different cultural backgrounds may respond differently to risks related to the impacts of climate variability. Institutions play a key role in enhancing the ability of communities to cope with climate variability, which can help to shape the social and individual interactions within the society [57]. It can be concluded from the existing literature that institutional barriers are a key restriction on publications of adaptation strategies. Weak institutional capacity coupled with lack of policies on food security and lack of climate adaptation information place food security in Ghana and in many other communities across Sub-Saharan Africa under considerable threat.

Access to information on climate extreme event is a powerful tool that can be used to enhance the adoption and implementation of adaptation strategies by households in Ghana [55]. However, lack of appropriate climatic data has resulted in few climatic projections in the country. This has resulted in households relying on their own agro-ecological knowledge, based on experience. This knowledge allowed farmers to form complex mental models of the climate which can affect their farming operations negatively. Improvement in technology, for example, the development of improved crop varieties as well as developing irrigation technologies are very crucial to farmers' adaptation to climate change and variability, but limited availability of these technologies makes farmers rely on their own indigenous technology in reducing the impacts of climate change and variability on their livelihoods [55].

3. Materials and Methods

3.1. Study Area

This study was conducted in the Eastern Region of Ghana, specifically in the Yilo Krobo Municipal and Ayensuano District. Yilo Krobo Municipal lies approximately between latitude 60°30′ N and between longitude 30°10′ W, while the Ayensuano District lies within latitudes 5°45′ N and longitudes 15°45′ W [16]. The region has land area of 19,323 km^2 and it is the sixth largest region in Ghana. The Eastern Region is the third most populous region after Ashanti and Greater Accra with a population of 2,106,696 in 2010 [16]. The main occupation of the economically active population in the region are agriculture and related work (54.8%), sales (14.3%), transport, production and equipment work (14.0%), services (5.0%), and professional and technical work (6.9%) [16]. The region lies within the wet semi-equatorial zone characterized by dual rainy season. The temperature ranges between 24 °C and 36 °C. Figure 1 presents a map of Ghana showing the Eastern Region.

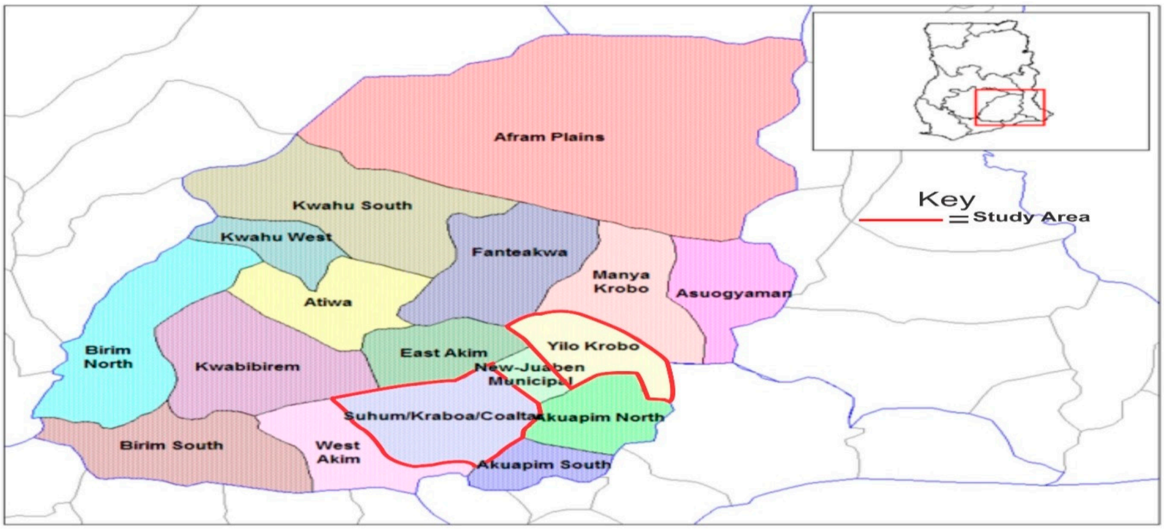

Figure 1. Map of Eastern Region showing Study Districts. Source: [58].

3.2. Sampling and Data

A multi-stage sampling technique was employed for the data collection. First, purposive sampling of the Region was done due to its high level of maize output in the country: it is the second largest producer of maize in Ghana [15]. Second, the Yilo Krobo Municipal and Ayensuano District were also purposively selected because of their highly agrarian nature and have the most of small-scale farms. Also, there has been little research in the two districts. Third, simple random sampling was used select five communities each from the Yilo Krobo Municipal and Ayensuano District making a total of ten communities for the study. The simple random sampling was done by writing the names of the communities in each of the two localities (i.e., Yilo Krobo Municipal and Ayensuano District) on pieces of papers and then ballots were made until the five communities in each locality was obtained. This was done for one locality at a time. Similarly, fifteen household heads were randomly selected from each community to make a sample size of 150 households. We have conducted the power test for the sample used in this study. The power of the test is the chance to reject the null hypothesis, given that the null hypothesis is false (i.e., given that the alternative hypothesis is true). It is the process of determining the sample size for a study. Given the intended power, we can derive the required sample size, and given the intended sample size, we can derive the resulting power. Following [59]: $n = (N/1 + Ne^2)$, where N denotes the total population of maize farmers in the Ayensuano District and Yilo Krobo Municipal, i.e., 3450 comprising 1800 in the Ayensuano District, and 1650 in the Yilo Krobo Municipal [60]; e denotes the margin of error of the sample, and n denotes sample size. The derived margin of error of the sample is 0.65% given the sample size of 150. This implies that there is 99.35% confidence in the results obtained from the sample used for this study. Therefore, the sample is highly representative, and the results can be generalized for the population of maize farmers in the two localities in the Eastern Region of Ghana.

Table 1 presents the sample size by communities. Primary data was collected in January 2016 from 150 farming households by administering a structured questionnaire. The questionnaire for data collection was initially developed and pretested to remove all ambiguities before finalizing for the actual data collection. By this process, we ensured that quality data is obtained for the analysis.

Table 1. Sample size of communities selected for the study.

Districts/Municipal (Locality)	Communities	Sample Size
	Agogo	15
	Akwapem	15
Yilo Krobo Municipal	Trawa	15
	Ocansere	15
	Brukum	15
	Sakra	15
	Anum Apapam	15
Ayensuano District	Mfranor	15
	Amanase	15
	Kofi Pare	15
Total		150

3.3. Data Analysis

3.3.1. Assessing the Determinants of Adoption of Adaptation Strategies to Climate Variability

Climate change adaptation strategies of maize farmers were analyzed using descriptive statistics. In determining the econometric model to employ in an adoption decision study involving more than two choices, two models traditionally utilized to evaluate qualitative dependent variables are considered: Multinomial Probit (MNP) and Multinomial Logit (MNL). Both models are similar in their formulation but MNL is preferred because its cumulative distribution function (CDF) is logistic whereas that of MNP is normal distribution. The MNP model also does not enable precision robustness as it fails to allow the researcher to adjust for covariates as in the case of MNL. Hence, the MNL model was chosen to determine factors influencing farmers' adoption of climate change adaptation strategies over the MNP [61].

Adaptation strategies, with four possibilities—no adaptation strategy, improved varieties strategies, soil-related strategies, and recommended agricultural practice strategies—were used as the dependent variable. In the Multinomial Logit model (MNL), a baseline alternative is chosen because the options must always be in the respondents' choice set to be able to interpret the results in standard welfare economics terms [61,62]. The choice "no adoption" was used as the baseline and compared with the other choice of adaptation strategies.

The functional form of the MNL model is specified in Equation (1) as [61]:

$$Prob(A_i = j) = \frac{e^{\beta'_j} X_i}{\sum_{k=0}^{k=j} e^{\beta'_k} X_i} \quad (1)$$

where A_i is the probability of farmer i choosing alternative j, J denotes the adaptation strategies (0 = no adaptation, 1 = recommended agricultural practice, 2 = improved varieties strategies and 3 = soil-related strategies), X_i denotes the independent variables and β is a vector of coefficients for each of the independent variables X_i, k specifically denotes the *no adaption* strategy which was used as the base category.

Equation (1) can be normalized to remove indeterminacy in the model. This is achieved by assuming that $\beta_0 = 0$:

$$Prob\left(A_i = \frac{j}{X_i}\right) = \frac{e^{\beta'_j} X_i}{\sum_{k=0}^{k=j} e^{\beta'_k} X_i} \tag{2}$$

If $k = 0$, then Equation (2) yields the j log-odds ratios of the form:

$$\mathrm{Ln}\left(\frac{P_{ij}}{P_{ik}}\right) = X'_i\left(\beta_j - \beta_k\right) = X'_i \beta_j \tag{3}$$

β_0 denotes the constant term, $\beta_1, \ldots, \beta_n$ denote the regression coefficient, and μ denotes the error term.

The MNL coefficients are difficult to interpret and associating the β_j with the jth outcome is misleading. To interpret the effects of explanatory variables on the probabilities, marginal effects are usually derived as [63]:

$$\delta = \left(\frac{\partial P_j}{\partial P_k}\right) = P_j\left(\beta_j - \overline{\beta}\right) \tag{4}$$

Empirically, the model is specified as:

$$Y_i = \ln\left(\frac{P_{ij}}{P_{ik}}\right) = \beta_0 + \beta_1 Age + \beta_2 Gender + \beta_3 farmsize + \beta_4 Exp + \beta_5 Rainperception + \beta_6 Credit + \mu_i \tag{5}$$

where Y_i is the probability of ith farming household choosing a specific adaptation strategy. A major condition that must be satisfied in MNL is the assumption of the Independence from Irrelevant Alternatives (IIA). The IIA Property requires that the relative probabilities of two options being selected are unaffected by the introduction or removal of other alternatives in the model [64]. The IIA test was carried out to satisfy that condition. The explanatory variables used for the MNL regression analysis are described in Table 2.

3.3.2. Identification and Ranking of Constraints to Climate Variability Adaptation Strategies

The constraints militating against maize farmers' adoption of climate change adaptation strategies were identified by reviewing related studies. The constraints identified were then presented to the respondents for ranking. Numeric values were assigned for the ranking by scoring the most pressing constraint 1 while the less pressing constraint was scored 9. The total score of each respondent was calculated and the constraint with the lowest score was ranked the most pressing whereas the highest score was ranked least constraint.

The Kendall's coefficient of concordance (W) was then used to measure the degree of agreement among the rankings of the constraints by the respondents using the rank scores. The Kendall's coefficient of concordance (W) equals one when the ranks assigned by each farmer is the same as those assigned by other farmers and zero when there is a maximum disagreement among the farmers. Given that T represents the sum of ranks of each factor being ranked, the variance of the sum is given by Equation (6) [63].

$$Var_T = \frac{\sum T^2 - \frac{\sum T^2}{n}}{n} \tag{6}$$

The maximum variance of T is then given by Equation (7):

$$T = \frac{m^2(n^2-1)}{9} \quad (7)$$

where, m denotes the number of sets of ranking by the farmers and n denotes the number of specific constraints being ranked.

Table 2. Description, measurements, and a priori expectation of the variables used for the multinomial logit regression.

Variable	Description and Measurement	Expected Sign	Justification
Dependent Variables			
Recommended agricultural practices	Dummy: Adopt = 1, 0 Otherwise		
Improved varieties strategies	Dummy: Adopt = 1, 0 Otherwise		
Soil-related strategies	Dummy: Adopt = 1, 0 Otherwise		
Explanatory Variables			
Age	Age of household head (years)	-	As farmers grow older, they become weak in strength to undertake any intensive farming activity.
Gender	Gender of household head (1 = female, 0 = male)	-	Female household heads have less access to resources for adaptation.
Farmsize	Current farm size of household (hectare)	+/-	Smaller farm size is easily managed than bigger ones. However, wealthier farmers are those who can own bigger farms for cultivation and thus can adopt adaptation strategy to increase yield.
F.Exp.	Years of farming by household head (years)	+	More years of farming favors adaptation of a strategy due to knowledge of weather as well as the crop being cultivated.
Rainfall Perception	Perceived changes in amount of rainfall (1 = yes, 0 = no)	+	Household who perceived a change in rainfall amount are better able to adapt.
Credit	Households with access to credit (1 = yes, 0 = no)	+	Access to credit enable households adapt to climate hazards even if it is costly.

Source: Field Survey, 2016.

The Kendall's coefficient of concordance (W) is therefore given by Equation (8):

$$W = \frac{\frac{\left[\sum T^2 - \frac{\sum T^2}{n}\right]}{n}}{m^2(n^2-1)/9} \quad (8)$$

Chi-square test was used to assess the hypothesis and significance of the ranking as follows:

H_o: There is no agreement among the rankings of the constraints by the farmers.
H_a: There is agreement among the rankings of the constraints by the farmers.

The data was coded, entered, cleaned, and analyzed using Stata 13.0 by StataCorp LLC, College Station, TX, USA.

4. Results and Discussions

4.1. Demographic Characteristics of Farming Households

Table 3 presents the descriptive statistics of the demographic characteristics of the selected farming households. The results revealed that among the respondents, the aged are less involved in agriculture. This could be attributed to the fact that agriculture is labor-intensive. The youth constitutes about 15% while the adult constitutes 82% of the total population of the respondents. There is abundance of labor force and this serves as an opportunity for the agricultural sector in the area. The average age of both males and females was 45 years. The mean age of female respondents in Ayensuano and Yilo Krobo districts were 45 and 48 years, respectively, whilst that of the males were 47 and 44 years, respectively.

Table 3. Demographic Characteristics of Households.

Age Group	Ayensuano		Yilo Krobo		Pooled	
	Frequency	%	Frequency	%	Frequency	%
Gender						
Male	45	60.00	64	85.33	109	72.67
Female	30	40.00	11	14.67	41	27.33
Age						
<35	10	13.33	12	16.00	22	14.67
35–64	61	81.33	62	82.67	123	82.00
>65	4	5.33	1	1.33	5	3.33
Average Household size	6		8		7	
Access to extension service	15	20.0	71	94.67	86	57.33
Rainfall perception						
Unpredictable	19	25.33	19	25.33	38	25.30
No change	3	4.0	13	17.33	16	10.70
Decreased	50	66.67	43	57.33	93	62.00
Increased	3	4.00	0	0.00	3	2.00

A household is defined as a person or a group of persons, who share the same housing unit or compound and share the same house-keeping arrangements and constitute a single consumption unit [24]. The mean household size for Ayensuano and Yilo Krobo districts were 6 and 8, respectively. The average household size for the districts were 4 for both Ayensuano and Yilo, compared with 6 for the region [24]. Access to extension services is critical to improving the productivity of farmers. The farmers who had access to extension service during the farming season prior to the season in which the data was collected, had higher yields than those who did not.

Respondents were also asked about their perceptions on rainfall for the past 10 years. From the data analyzed, 67% of respondents in Ayensuano perceived a decreased in amount of rainfall, 4% perceived an increased, 25% perceived an unpredictable rainfall, and 4% perceived consistent amount of rainfall. For Yilo Krobo, 57% perceived a decreased, 17% perceived rainfall to be consistent, 25% perceived an unpredictable amount of rainfall, but no one perceived an increased in the amount of rainfall for the past 10 years. For the pooled data, 62%, 2%, 11%, and 25% perceived a decreased, increased, consistent, and unpredictable amount of rainfall, respectively. The responses from the respondents are supported by the previous findings that the climate has changed in Ghana as in other parts of the world [65,66].

4.2. Identified Climate-Related Adaptation Strategies

The results revealed that maize farmers adopted different climate adaptation strategies. Thirteen (13) different strategies were identified; 90% of the sample adopted three of the identified strategies and the remaining 10% did not adopt any of those strategies. Maize farming in Eastern region of Ghana is solely rain-fed. Hence, all farmers rely on the rainfall before planting. Irrigation is not practiced by the respondents and hence, timing of the rainfall was not considered as an adaptation strategy in this study. Planting in rows was the most widely adopted climate adaptation strategies (approximately 24% of the farmers) followed by mixed cropping (approximately 16%), and then land rotation and tree planting being the least adopted strategies by the farmers (approximately 2% each). Based on the literature, the various strategies were grouped into soil-related strategies, recommended agricultural practice strategies and improved varieties strategies. In this respect, approximately 27% of the farmers adopted soil-related strategies, 36% of the farmers adopted the recommended agricultural practice strategies, and approximately 38% of the farmers adopted the improved varieties strategies (Table 4). The sum of the percentages is more than 100 as the farmers adopted a combination of these adaptation strategies.

Table 4. Identified climate change adaptation strategies of farming households.

Soil-Related Strategies		Recommended Agricultural Practice Strategies		Improved Varieties Strategies	
Sub-strategies	**%**	**Sub-strategies**	**%**	**Sub-strategies**	**%**
Mounds/ridges	5.60	Land rotation	1.77	Mixed cropping	15.63
Manure/compost	5.60	Spacing	8.55	Livestock rearing	5.60
Inorganic fertilizer application	6.78	Planting in rows	23.64	High yielding varieties	6.19
				Drought tolerant varieties	7.67
Insecticides	8.55	Tree planting	1.77	Early maturing varieties	2.65
Total	26.53	Total	35.73	Total	37.74

Source: Field Survey, 2016.

Farming households in the communities surveyed uses a wide range of adaptation measures in response to climate variability. The dominant strategy for adapting to climate change is using improved varieties (38%). Several improved maize varieties such as Okomasa, Obatanpa, and Dadaba with different maturity periods have been developed and released to farmers by the Council for Scientific and Industrial Research—Crops Research Institute (CSIR-CRI) of Ghana to meet the needs of growers in the different ecological zones of Ghana [67]. These strategies guard against crop failure as the farmers cultivate different crops with different climatic requirements as well as varieties that can withstand climatic shocks. The strategies also aid to bridge the "hunger gap" before the longer maturing plants are harvested.

The percentage of farmers who adopted recommended agricultural practices such as spacing, planting of trees, and planting in rows was approximately 36%. The recommended spacing for maize cultivation is 90 cm apart and 40 cm between plants, and 75 cm × 40 cm depending on the variety [68]. All plants require a certain amount of nutrients, water and space for better growth and development. If the space needed for their development is to some extent occupied by weeds that rob the cultivated plants of nutrients, moisture, and sunlight, the plant cannot thrive well and then the yield from the crop would be low.

Soil-related strategies play an important role in climate adaptation strategies by rendering the adopters of those strategies less vulnerable. Approximately 27% of the farmers adopted the soil-related strategies. The best soils for maize are normally deep, medium-textured, well-drained, loamy soils rich in humus with a high water-holding capacity [69]. Availability of soil moisture at the time of tasseling is essential to produce high yields and that is achieved through manure and mounds construction. Farmers can use organic or chemical fertilizer on continuously or previously used lands in southern Ghana [68]. Farm productivity can only be limited by non-availability of nitrogen in the soil if water and temperature conditions are satisfied for the development of maize [70,71]. This makes it necessary for nitrogen fertilizers to be applied in order to enhance productivity.

4.3. Determinants of Farmers' Adoption of Climate Change Adaptation Strategies

A household was considered as adopting a category of strategy if it adopted at least one of the sub-strategies under the major strategy. In the MNL regression model employed for this study, we used the *no adaptation* as the base category and evaluates the other adaptation strategies as alternative to this option. The Hausman test of independence of irrelevant alternatives (IIA) assumption was carried out to determine the assumption of IIA. The results revealed that the IIA assumption has not been violated, thereby justifying the application of the MNL model to the dataset (Table 5). Also, Spearman's rank correlation was used to test for correlation among the independent variables before the model estimation. The variables years of education, temperature perception, and access to agricultural extension services were found to be highly correlated and were omitted from the MNL regression model.

The marginal effects and the corresponding *p*-values derived from the coefficient of the MNL of the factors influencing the adoption of climate-related adaptation strategies among smallholder maize farming households in the Eastern Region are presented in Table 6. The MNL results showed that farming experience, rainfall perception and access to credit are the factors that significantly influenced the adoption of recommended agricultural practice strategies whilst rainfall perception and farming experience also influenced the farmers' adoption of improved varieties. The adoption of soil-related strategies is significantly influenced by gender of household head and rainfall perception.

Table 5. Hausman test of independence of irrelevant alternatives (IIA) assumption.

Adaptation Strategy	Chi-square	*p*-Value
Recommended Agricultural Strategies	1.795	0.877
Improved Variety Strategies	0.434	0.980
Soil-Related Strategies	0.677	0.982

Ho: Odds are independent of other alternatives.

Table 6. Results of the marginal effects of the multinomial logit regression of the factors influencing the choice of adaptation strategies.

Variables	Recommended Agricultural Practice		Improved Varieties Strategies		Soil-Related Strategies	
	Marginal Effects	*p*-Value	Marginal Effects	*p*-Value	Marginal Effects	*p*-Value
Age	−0.002	0.299	−0.011	0.117	0.012	0.281
Gender	−0.078	0.712	−0.042	0.536	−0.131 *	0.074
Farm size	−0.039	0.251	−0.002	0.128	−0.0542	0.132
Farm experience	0.001 **	0.046	0.010 **	0.010	0.008	0.528
Rainfall perception	0.129 ***	0.000	0.076 ***	0.000	0.039 ***	0.000
Access to credit	0.050 *	0.093	0.026	0.151	0.002	0.161
Diagnostic statistics						
Number of observations			150			
Log pseudolikelihood			−173.755			

*, ** and *** Statistical significance at 10%, 5% and 1% respectively.

Farmers' access to credit increases the probability of adopting the recommended agricultural practices by 5% to curb the negative effects of climatic change, relative to not adopting any of the strategy. Access to credit of farming households enables farmers to make use of all the available information to change their management practices in response to climate change and variability. This is supported by the previous studies [72,73]. As expected, the study revealed a positive relationship between perceived changes in rainfall and the adaptation by faming households. The probability of adopting the recommended agricultural practices, improved varieties strategies, and soil-related strategies increased by approximately 13%, 8%, and 4%, respectively, when the maize farmers perceive changes in rainfall amounts, relative to no adaptation. That is, farmers who noted changes in rainfall amounts are more likely to adapt a strategy to minimize the impact of climate change compared to those farmers who did not perceive changes in rainfall amounts. The possible reason for this positive relationship is that farming in the Eastern Region of Ghana is dependent on rainfall, and therefore, decreased precipitation in such an area is likely to constrain farm production and hence the need to adapt to the changing climatic conditions. The finding is consistent with [74].

Next, being a female-headed household decreased the probability of adopting soil-related strategies by approximately 13%. This result is to a large extent consistent with previous study that being male-headed household positively influenced the adoption decision of climate-related strategies [75]. The finding of this study is contrary to the results of another previous study that household gender does not significantly influence farmers' decisions to adopt climate adaptation strategies [76]. The disparity in findings could be attributed to location differences with differences in cultural implications on gender of household head as in the case of Northern Ghana [77].

A year increase in farming experience increased the farmers' likelihood of adopting the recommended agricultural practices and improved varieties strategies by approximately 0.1% and 1%, respectively, relative to no adaptation. Thus, more years of farming increased the farmers' awareness of the potential benefits of adaptation to climate change. Experienced farmers have more knowledge and information about climate change and agronomic practices that they can use to reduce the negative effects of climate variability on agriculture production [78].

4.4. Constraints to Adoption of Climate Change and Variability Adaptation Strategies

Farmers adapt to climate variability differently. In the process of adopting strategies to cope with the impact of extreme climatic events, farmers encounter several challenges all the way from personal to institutional constraints. Based on the literature and focus group interactions with the respondents, nine constraints were identified, pre-tested and finally presented to the farmers for ranking using a simple ranking technique. The results of the ranking are presented in Table 7.

Table 7. Ranking of constraints to climate adaptation strategies by respondents.

Constraints	Yilo Krobo		Ayensuano		Pooled	
	Mean Score	Rank	Mean Score	Rank	Mean Score	Rank
Inadequate and limited access to credit	2.86	1st	3.18	1st	3.02	1st
Inadequate drought tolerant varieties	5.25	5th	3.42	2nd	4.31	2nd
Low literacy rate	4.59	2nd	4.45	3rd	4.52	3rd
High cost of labor	4.65	3rd	5.21	4th	4.94	4th
Inaccessible and high cost of input	5.49	7th	5.24	5th	5.36	5th
Poor access to meteorological information	5.40	6th	5.45	6th	5.43	6th
Land tenure	5.09	4th	5.92	7th	5.52	7th
Inadequate knowledge of climate-related strategies	5.70	8th	5.97	8th	5.84	8th
Poor extension	5.96	9th	6.16	9th	6.06	9th
Diagnostic statistics						
Number of observations	59		62		121	
Kendall' W	0.113		0.159		0.117	
Chi-Square calculated	53.291		79.011		113.522	
Chi-Square critical	15.507		15.507		15.507	
Degree of freedom	8		8		8	
Asymptotic Significance	0.000		0.000		0.000	

Farmers in the Yilo Krobo Municipal rank inadequate and limited access to credit, low literacy, and high cost of labor as the most pressing constraints. This empirical result is consistent with the results of previous study that lack of finance hinders farmers from getting the necessary resources and technologies that would facilitate the adoption of climate-related adaptation strategies [79]. Lower education level of the farmers limits access of climate-related information available from various sources and poor understanding of it increases the vulnerability of these farmers to climate extreme events [80]. The hypothesis that there is no agreement among the ranking of constraints by the respondents is rejected at 1% significance level. The ranking of constraints in the Ayensuano District is same as for the pooled sample. Inadequate and limited access to credit, inadequate drought tolerant varieties, and low literacy rate are ranked the most pressing constraints by the respondents in the Ayensuano District. The use of drought tolerant varieties is another adaptation measure to reduce the effect of climate variability. However, this strategy requires additional amount of inputs and credit because it comes with a cost. The null hypothesis that there is no agreement is rejected at 1% significance level.

Some of the farmers argued that poor access to meteorological information and its low reliability are major obstacles to practice adaptation measures to minimize the shocks of climate variability. The study revealed that farmers lack the technical knowledge on climate variability, its consequences, and adaptation strategies to curb the negative impacts of climate-related disaster. Respondents expressed that small landholdings due to extended families sharing the lands (land fragmentation) and low annual income were other constraints to adopting the various coping measures such as soil and water conservation measures and cultivating drought tolerant varieties. The findings are consistent with the previous finding that absence of location specific climate forecasts, poor reliability and failure of the climate forecasts, coupled with poor extension service on climate prediction were major problems confronting farmers in Borno State, Nigeria [81].

5. Conclusions and Recommendations

This study examined the adaptation strategies of maize farmers to climate change and variability in the Eastern Region of Ghana using primary data collected from 150 maize farming households by the administration of structured questionnaires. Specifically, this study assessed the percentage of the smallholder farmers adopting each of the identified climate change adaptation strategies using descriptive statistics; determined factors influencing farmers' adoption of climate adaptation strategies using a multinomial logit regression model; and identified and ranked the constraints militating against maize farmers' adoption of adaptation strategies using the Kendall's Coefficient of Concordance.

The farmers adopted combinations of the adaptation strategies. However, most maize farmers adopted improved variety strategies to adapt to climate change and variability. More years of farming experience and access to credit ensures that farmers have the information for decision making and the means to take up adaptation measures. Other enabling factors that have significant potential for promoting climate adaptation strategies were rainfall perception and gender of household heads. Women were found to be less likely to adopt soil-related strategies such as inorganic fertilizer application and construction of ridges and mounds, among others. The main constraints militating against maize farmers' adoption of climate-related adaptation strategies include limited access to credit, low literacy rate, high cost of labor, inadequate drought tolerant varieties, and poor access to meteorological information.

This study recommends that maize farmers in the Eastern region of Ghana should be provided with improved varieties of maize through the Government of Ghana flagship program of planting for food and jobs to assist farmers improve their yields. This would reduce the probability of farmers losing crops due to climate change and variability, and hence make them less vulnerable. The smallholder farmers would require enough supply of water for the crops especially during the dry season. Therefore, it is imperative that the government assist the farmers to construct irrigation facilities and improve the existing ones for all year-round maize production. In this respect, the leading roles of the Ghana Irrigation Development Authority, the Japan International Cooperation Agency, and the World Bank regarding the development of irrigation facilities and the associated capacity building of the farmers are very important. The formation of Water User Associations for the smallholder farmers regarding the usage and maintenance of the irrigation facilities would be a step in the right direction. The challenges regarding the Water Use Associations are lack of unity and conflicts that arise among the members of these associations, resulting in underutilization and poor maintenance of these facilities. Also, the Ghanaian Ministry of Food and Agriculture should revamp agricultural extension services by resourcing the institution and employing more officers and agents to perform the agricultural advisory services. This will make agricultural extension services widely available to the smallholder farmers in order to boost the adoption of climate change adaptation strategies that will make them less vulnerable to climate shocks. Finally, it is imperative that the Government revamp financial institutions by assisting to bring financial services to the largely unbanked population including the smallholder maize farmers. This would make credit more accessible to these farmers and enable them to adopt the climate change adaptation strategies, thereby making them resilient to climatic shocks.

Author Contributions: M.A.S., R.M.A.-H. and J.K.M.K. designed the research. M.A.S. collected and analyzed the data. S.I.A. and M.A.S. drafted the manuscript. J.K.M.K., R.M.A.-H., M.A.S., and S.I.A. worked on the flow, clarity, organizational structure, discussions, conclusions, and reviewed and revised the manuscript. J.K.M.K. served as the corresponding author.

Funding: This research received no external funding.

Acknowledgments: The authors gratefully acknowledge role of the Agricultural Extension Officers in the Yilo Krobo and Ansah Suhum districts for their assistance during the field survey. We also gratefully thank the farmers in the local communities for their patience, time, and the information provided during the field survey.

Conflicts of Interest: The authors declare no conflict of interest.

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